Research Article

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Ringing Tone and Drumming Sages in the Crevice Cave of Pirunkirkko, Koli, Finland

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Abstract: Pirunkirkko (“Devil’s Church”) is one of the famous caves in Finland. Tradition says that this crevice leading into the mountain was a meeting place for sages, who typically used sound to contact the spirit world. Today, the place is visited by practitioners of shamanism, who organise drumming sessions at the back of the cave. This article examines Pirunkirkko and the related traditions from the perspective of acoustics, hypothesising that the acoustic characteristics of the crevice might have played a role in the ritualisation of the place and the power of its rituals. Methods employed include impulse response recording, spectrum analysis, archival research, and interview of a shamanic practitioner. The results indicate that the back of the cave houses a distinct resonance phenomenon. A standing wave between the parallel walls generates a ringing tone at 219–232 Hz that stays audible after sharp impulses or vocalisations at the same frequency. The local folklore or the interviewed practitioner does not mention this phenomenon at all. Instead, they speak about the “spirit of the cave,” “special energy,” or “new horizons” opened up by drumming. This leads to reflection on cultural frameworks of thought that guide sensory perceptions leading to differing experiences and interpretations.

Keywords: archaeoacoustics, resonance, caves, vernacular healing tradition, contemporary shamanism

1 Introduction

The Koli mountain range situated in the province of North Karelia (Eastern Finland) is a mythical place for Finns. For well over a 100 years, the views from the mountain tops to Lake Pielinen and vast woodlands have brought artists and tourists to the area, and the awe the landscape provokes has resulted in innumerable paintings, photographs, and written works (e.g. Lovén & Rainio, 2000). The attractions of the Koli National Park also include Pirunkirkko (“Devil’s Church”), one of the largest and most well-known caves in Finland. The cultural history of this cave – a natural crack in the mountain – is unexplored, but widespread and common tradition states that it used to be a gathering place for sages, known in Finnish as tietäjä, velho, or noita (e.g. Metsähallitus, 2020; Tuononen, 1993). Nowadays, the cave is sometimes used by shamanic practitioners, who hold rituals containing drumming and singing at the back of the cave (e.g. Väänänen, 2018). This modern usage is still largely unknown to the ordinary visitors.

The sages were spiritual specialists in Finnish and Karelian agricultural communities over the past centuries. Their main task was to make contact with the spirits in the environment, heal the sick, and solve various problems caused by imbalances or disturbances between people, nature, and the spirit world (Honko,
1959; Piela, 2010; Tuovinen, 1984). The sages often performed in an ecstatic state of mind, which links their profession to shamanism and contemporary shamanic practitioners, who can be seen as continuing the tradition. In their rituals, the sages shouted, raged, jumped, kicked, and trembled, as if fighting with or intimidating invisible forces (Haavio, 2020, pp. 315–341; Siikala, 1994, pp. 206–208; Tuovinen, 1984, pp. 14–19). In addition, they incanted, sang, spat, shot with guns, and made other loud noises (Haavio, 2020, pp. 323–325; Siikala, 1994, pp. 84–85, 174, 226–228; Tuovinen, 1984, pp. 32–39). Unlike contemporary practitioners, the Finnish–Karelian sages did not use the drum, at least in recent centuries. However, their original equipment may have included this instrument, as the old Finnish name for the drum, kannus, resembles the Sámi name for the drum, kuomdes/kiomdes, which was expressly a shamanic instrument and the most important tool of Sámi shamans (Leisiö, 2020, pp. 190, 193; Siikala, 1994, pp. 236–238). Moreover, it should be noted that the Sámi lived in Eastern Finland until historical times, alongside Finns and Karelians. According to a written document, a person to be interpreted as Sámi used the drum in Savo, the province next to North Karelia, as late as the mid-seventeenth century (Siikala, 2012, p. 371). Since there are traces of Sámi in the place names of Koli and Pielen (Räisänen, 2007; Saloheimo, 2000, p. 17), it seems likely that shamans in this area used the drum as well.

This article seeks to explore the Pirunkirkko cave, its physical properties, and past and present uses from the perspective of acoustics. The purpose is to determine whether some acoustic phenomenon or effect in the cave could explain – or contribute to – its mythical reputation and popularity as a venue for sonic rituals. Our study is inspired by recent archaeoaoustic research that has found powerful echoes, reverberation, and resonances in places associated with religious beliefs and ritual activities. These places include prehistoric rock art sites (Díaz-Andreu & García Benito, 2012), Roman oracles (Iannace & Trematerra, 2016), and early Christian churches (Tronchin & Knight, 2008; Valière, Rainio, 2021; Waller, 1993), megalithic structures (Till, 2017; Watson & Keating, 1999; Wolfe, Swanson, & Till, 2020), and Sámi used the drum in Savo, the province next to North Karelia, as late as the mid-seventeenth century (Siikala, 1994, pp. 83–86; see also e.g. Alarcón-Jiménez, Jiménez Pasalodos, & Díaz-Andreu, 2023). Another possible reason for the silence about environmental contexts is that the sages were reluctant to tell all details of their practices, fearing that these would lose their power in the wrong hands (Tuovinen, 1984, p. 41). Moreover, the ritual sites had to be kept secret and secluded, for from the seventeenth century, the church had condemned the sages, declaring them allies of the devil (Siikala, 1994, pp. 68–70; Tuovinen, 1984, p. 16). Local priests destroyed sacred rocks, trees, and mountain springs, according to stories also in Koli (Eronen, 1931b; Kesäläinen & Kejonen, 2017, pp. 109–110). Ritual sites are said to have been located in the woods, mountains, cliffs, ravines, and caves, and in the home environment also in the sauna (Harva, 1929; 1948, pp. 263–319; Kesäläinen & Kejonen, 2017; Siikala, 1994, pp. 68–70, 153–166). Many of these sites appear to bear names referring to devils, which should be understood as demonised versions of the old gods and spirits (Purola, 2011, pp. 9–10; Tuovinen, 1984, p. 25).

Studies of contemporary shamanism in Finland are still quite rare. Research on shamanism started in Finland in the first half of the twentieth century with an emphasis on the Siberian and Finno-Ugric connections and arctic shamanism and its belief traditions (Donner, 1933; Lehtisalo, 1924). After this, the research focused on the basic ideas of shamanism, its cultural-historical background and worldviews, symbolism in the associated objects, and ideas of shamans’ psychophysical state or techniques of ecstasy (e.g. Hultkranz, 1998; Pentikäinen, 1998a, pp. 91–100; Siikala, 1978, pp. 42–194). In the last decades, shamanism has globally been studied mainly in the context of indigenous people (e.g. Ellis, 2015; Mills, 2007, 2012; Ruboli & Torri, 2014; Znamenski,
Nevertheless, some research on contemporary shamanism does exist (e.g. Wallis, 2001; Wallis & Blain, 2004), including the doctoral dissertations of Remes (2005) and Svanberg (2003), as well as articles by Hytönen-Ng (2016) and Kouri (2020) and some that they have written together (Kouri & Hytönen-Ng, 2022; Hytönen-Ng & Kouri, 2020). The term “shaman” comes from the Tungus language and has been taken up by academics to describe somewhat similar practices in different cultural contexts (Harvey, 2005, p. 139). In this article, taking into account the Finnish cultural context, both the historical figures and contemporary practitioners are not referred to as shamans but as sages (tietäjä) or practitioners.

2 Pirunkirkko Cave

2.1 Site Description

The Koli mountain range has a unique and diverse geologic history that includes ancient Archaean bedrock, white exposed quartzite peaks, and several caves and rockfalls. The caves, representing the crevice and boulder types, were formed as a result of tectonic and glacial activity during the Last Glacial Period and immediately after that (Kohonen & Vuollo, 2000; Kohonen, Marmo & Vuollo, 2000; Rainio, 2000). At least 13 caves are mentioned in the area (Figure 1) (see NA; SKS; Kejonen, Kesäläinen, Kielosto, Lahti, & Salonen, 2015, pp. 269–272, 412). Four of them bear names referring to the devil, such as Pirunkirkko (“Devil’s Church”), Pirunluola (“Devil’s Cave”), Pirunvaara (“Devil’s Mountain”), and Pirunkallio (“Devil’s Rock”). Seven caves of

![Figure 1: Locations of the known caves and the sacrificial crack in Koli. The Pirunkirkko/Pirunluola cave located on Hattusaari is to the north of the map.](image)
the crevice and boulder types in the Kirkkokallio (“Church Cliff”) and Repouuro areas form a dense cluster at the southern end of the mountain range, near the shore of Lake Pielinen (Kejonen et al., 2015, pp. 269–271, 412).

The largest one of the Kirkkokallio caves is the famous Pirunkirkko. It is a crack or crevice around 34 m long, consisting of three corridors in the form of the letter Z, leading inside the mountain (Figure 2) (Kejonen et al., 2015, pp. 269–270, 412). The walls of the corridors are vertical and smooth. The roof is formed of an overhanging cliff and boulders that have fallen from the cliff and wedged into the crevice. Part of the cave is open from the top. The floor consists of rock, stones, and loose soil mixed with moraine, peat, and coal. No archaeological excavations have been carried out in the cave so far. So-called cave winds, controlled by outdoor temperature fluctuations, occur in the cave, a phenomenon that is rare in Finland (Kejonen et al., 2015, pp. 269–270, 412).

Figure 2: Ground plan of the Pirunkirkko cave at Kirkkokallio, Koli.
The entrance to the cave is only 1 m × 1.3 m in area, bordered by upward and downward bulging boulders (Figure 3a). A roundish stone acts as a threshold above which one must bend to crawl. The first outer corridor is 6.4 m long, 1 m wide, and 1–2 m high (Figure 3b). It ends in a rectangular corner that is the darkest place in the whole cave (Figure 3c). The floor descends at an angle of 15–20° from the cave mouth.

The second middle corridor, opening around the rectangular corner, is 10 m long and only 0.7 m wide (Figure 3d). The floor continues descending and has several protruding stones and steps that impede passage. The roof rises to a height of 5.4 m and disappears completely from view at the end of the corridor. A light opening, a kind of “window,” brings light to the next narrow corner that is no more than 0.4 m wide. A “hanging” boulder wedged in the crevice makes this place difficult to pass.

The third inner corridor, opening after the “hanging” boulder, is also 10 m long and 0.6–0.9 m wide (Figure 3e and f). It points in the direction of the magnetic field. The corridor walls are extremely even, smooth, and parallel, but tilted to the west at an angle of 80–84°. An even roof covering the end part of the corridor is 6.4–7 m high. In the middle of the corridor, a tightly trampled floor suddenly breaks into a pit more than 2 m deep, on which a pair of wooden planks have been placed as a bridge. The eastern wall has an inscription written by painter Eero Järnefelt in 1893 (and rewritten later):

One secret, one spirit
One happiness for both of us
The sacred glory of this church
We shall remember forever
(Signboard at Koli National Park.)

The inner corridor ends at a stone pillar rising to a height of 2.2 m. A ledge on top of the pillar forms a kind of shelf, table, or seat. At this height, the cave continues for several more metres, widening and turning a bit. There is a light hole somewhere at the top, but it does not give enough light to see exactly where the cave ends.

2.2 Spirits and Sages in Koli’s Past

For centuries, the Koli mountain range has been considered a place where spirits reign and reside. Ukko-Koli and Akka-Koli, the names of the mountain peaks, refer to the pre-Christian thunder god and his spouse (Kesäläinen & Kejonen, 2017, pp. 109–110; see also Siikala, 2012, pp. 395–402; Harva, 2019/1948, pp. 74–122). In turn, the names of the caves, such as Pirunkirkko, Pirunkallio, and Pirunluola, refer to devils, demonised spirit beings of the Christian period (see Tuovinen, 1984, p. 25; Purola, 2011, pp. 9–10). Archival sources from the Finnish Literature Society (SKS) tell of “mountain elves,” “invisible fairies,” and “great lords” that move in the area:

The inhabitants of the mountain only play and yell there, and walk through the woods, and dance and play and drive with the bells along the mountain ravines. There’s a kind of crack where they play and walk. It is said that an iron road passes via the crack through the mountain of Koli, all the way from Taipale (along this road they have been heard to drive many times). (SKS/ Krohn, 1885, nr. 8928, our translation)

Gifts for these various spirits were offered to the cracks, especially to a deep vertical crack near Ukko-Koli that was said to continue until the heart of the mountain (see also N.N., 1884; Taskinen, 2000, pp. 101–102). The rumble caused by a falling stone, coin, ring, or other valuables lasted as long as it took to render the Lord’s prayer. Several stories also tell of human sacrifices or people falling into the ravines (SKS/Kolehmainen, 1938, KT148, nr. 4; SKS/Pohjanvalo, KRK151, nr. 216). Such a place was too gloomy for human settlement, but many sages are said to have lived there, such as Kinolainen, Eronen, Kukkonen, Kontkanen, Siponen, Kananen’s mother-in-law, and others (see also Eronen, 1931a,b).

According to archaeological and historical sources, the Koli area was settled permanently in the mid-eighteenth century, that is, somewhat later than the surrounding areas by Lake Pielinen (Kilpeläinen, Hintikka, & Saloheimo, 1954, pp. 55, 100–101, 361–362; Poutiainen, Sepänmaa, & Jussila, 2020; Saloheimo,
Figure 3: Photographic tour in the Pirunkirkko cave: (a) Entrance to the cave; (b) outer corridor seen from the north. The “threshold” stone in the foreground; (c) a view from the darkest place; (d) middle corridor seen from the west. The “window” out at the back; (e) inner corridor seen from the north (upper part). The ledge at the back; (f) inner corridor seen from the north (lower part). The plank bridge and researcher Rainio in the foreground, the ledge at the back. Photos: Julia Shpinitskaya.
Figure 3: (Continued)
had a farm at the foot of the mountain (KA; Kilpeläinen et al., 1954, p. 361). These new archival finds prove that he was born in 1800 in Koli, the son of a peasant Matti Eronen and his wife, Elina Tossavainen, who were said to be sages. The stories about Koli's sages gathered to negotiate with each other and the devil (SKS/Nevalainen, 1936, KT152, nr. 3). The most powerful of these Pirunkirkko sages was a man called Kinolainen (SKS/Saarelainen, KKR172, nr. 653; Tuononen, 1993, pp. 8–9). His real name is said to have been Tossavainen. He spoke little, but could do many kinds of magic. For example, he raised the dead from the graves, made the mountain spring water boil, and fought with the mountain elves so the trees fell (SKS/Partanen, 1936, nr. 745; SKS/Kolehmainen, 1938, KT148, nr. 4). He also healed a sick man tormented by nine devils by taking him in the night to Lieksa Church (located 30 km from Koli):

_When they had come to the door and bowed once, the door opened. Then they went in and to the altar. A speaker came there and asked, “What’s the matter?” “I don’t care about you, the other one must come here,” Kinolainen said, kicking with his foot. Then another one, a bigger one, the main boss came there and advised what to do._ (SKS/Partanen, 1936, nr. 558, our translation)

Another time Kinolainen took an apprentice to a church whose name and location remain unspecified:

_[He] took that man on his back and then put on a big coat and so he went to the door of the church and said, “Open the door”._

_Someone from the church answered, “There are two of you.” Kinolainen said, “No, only one.” Again the answer was, “There are two.” Kinolainen exclaimed, “Let it be, but open the door now.” Then the door opened and Kinolainen jumped very quickly over the threshold and the door slammed shut right after him. There was an ugly man inside and Kinolainen asked where it itself is. The bridge plank rose out of place and an even uglier man began to rise from there. Kinolainen exclaimed, “Not you, but let it itself come.” Then the ugly creature sank again under the bridge, and a really ugly horned creature rose and said to Kinolainen, “What do you have on your back?” Kinolainen said, “It is a man.” That ugly creature said, “Why did you bring him here?” Kinolainen said, “He will submit to your will to receive the same gifts as I have.” The ugly said, “Well, put him down.” Then Kinolainen put him down, and the principal goblin took the Bible, large in size, opened it on the floor and commanded the man to stand on it. But he trembled all the time watching this hustle and bustle, and when he should have gone on the Bible and sworn the oath, he did not want to do that at all, but wanted to rush out. But the door was locked and could not be opened. They raged at him and cursed him, and they raged at Kinolainen for bringing him, and Kinolainen raged at him that I doubted you and asked you to swear and you promised to fulfil everything. And with Kinolainen’s help he then got out of the church._ (SKS/Kortelainen, 1961, TK45, nr. 5, our translation)

Eventually, in one fight, the elves killed Kinolainen (SKS/Partanen, 1936, nr. 745). After his death, several miracles were reported: a thunderstorm rose, church bells fell, and his magic purse, which was tried to get rid of by burning, jumped off the campfire (SKS/Saarelainen, KKR170, nr. 96, 226). In addition, he was seen in Pirunkirkko (Kejonen et al., 2015, p. 269). Many of these stories are widespread in Finland and told in connection with other sages too. Thus, their motives are general and not related exclusively to Kinolainen. However, the stories are extremely revealing, for they tell of general thoughts, experiences, and practices related to sages in recent centuries. Although the full name of Kinolainen, alias Tossavainen, is never mentioned, the parish books reveal that a family named Tossavainen lived in the Koli village since the mid-eighteenth century (Kilpeläinen et al., 1954, p. 361). In the early nineteenth century, members of this family
established a farm called Kinola in the northern part of the mountain range. Thus, sage Kinolainen could be connected to this house and era, and his reputation could be based on a historical figure. It is also worth noting that three Kalevala-metre healing spells – for a lizard bite, wasp sting, and childbirth complications – were collected in 1854 from a person named Tossavainen from Koli (SKVR, 1931–1933, VII3, nr. 970, 1281, VII4, nr. 3066).

### 2.4 Other Pirunkirkko Caves and Similar Places

The name Pirunkirkko is by no means unique to Koli. The Names Archive (NA) contains information on 108 places called Pirunkirkko across Finland (for a detailed list of sources, see References). Places called Pirunvuori, Pirunkallio, Pirunpesä ("Devil’s Nest"), Hiidenkirkko ("Hiisi’s Church"), Hiisivuori ("Hiisi’s Mountain"), and Hiidenkallio ("Hiisi’s Rock"), totalling about 500, seem to be very similar in their characteristics. These places are mountains, cliffs, boulders, caves, or rock slides, located in remote areas far from villages and settlements. Many of them contain several of the mentioned terrain elements as well as rock formations resembling church benches, pulpits, or altars. Interestingly, strange noises are often reported at these places: devils shout and preach, hiisi (a kind of elves) howl and sing, and invisible ravens cry. Sometimes a natural explanation is given to these findings by saying that it is actually an echo, fox, or wind that replies. In the case of Pirunkirkko in Lavia, it is said that the terrible echo in the cave, reminiscent of church acoustics, has given the place its name.

These places, generally regarded as the abodes of devils or other spirits, were important operation environments for sages tasked with contacting, communicating, and dealing with the spirit world. Such places seem to have been used for rituals and healing across Finland, although most of the information found in the Finnish Literature Society Archives (SKS) comes from Eastern Finland, the provinces of North Karelia, Ladoga Karelia, and Savo (for a detailed list of sources, see References). When preparing for the ritual, the sage went to the mountain, cliff, or cave with the patient or client and called the spirit by striking the rock with a wooden stick and shouting, "Is there power in the mountain?" "Is the master at home?" Sometimes the sage struck a wooden altar-like table or rack, or recited or sang a longer Kalevala-metre spell: “Get out the Devil of the nest, Hiisi out of Hiisi’s room [...]” After the spirit had announced itself by answering in a hollow voice, a strange tense conversation began between the sage and the spirit. For example, the spirit asked, “One or two?” And the sage, hiding the client behind his back, yawned, “One.” The origin of the disease or problem was inquired by arguing with the spirit or by listing possible causes and listening to the spirit’s reactions (see also SKVR, 1931–1933, VII4, nr. 1976). Once the cause of the problem was identified, the sage expelled the malicious factor by praying, conjuring, cursing, raising a thunderstorm, firing a gun, or something similar (see also SKVR, 1931–1933, VII4, nr. 1976; Siikala, 1994, pp. 172–174; Tuovinen, 1984, pp. 32–39). According to the healing spells, the sages of Lake Pielinen expelled diseases to mountains, rocks, cracks, and cavities in the stones (SKVR, 1931–1933, VII3, nr. 161, 1173, 1281, VII4, nr. 2781), which were common places of expulsion in the Finnish as well as wider European and North Asian traditions (Herva & Lahelma, 2020, pp. 32–35; Rozwadowski, 2017; Siikala, 1994, pp. 153–164).

These stories are strikingly similar to the accounts of Kinolainen and his nightly visits to churches to consult the devil. Could it be that the churches in the accounts of Kinolainen, as well as in similar accounts of other sages, actually refer to Pirunkirkko type of places, and not necessarily to parish churches? This would be logical and provide valuable additional information about what was happening in the numerous mountains, rocks, and caves considered to be the abodes of devils and spirits. Let’s take a closer look at the abundant stories about the sages in the churches spread across the country: the sage, patient, and client always went to the church at midnight. The door opened when the sage knocked or kicked the door or sometimes blew a keyhole with a bone whistle. All visitors jumped over the threshold at the same time, and the door slammed shut after that. The visitors walked along the church corridor in a row, the sage being the first and the others behind his back. The church was full of spirits hissing and rustling restlessly, but the sage had advised their companions to remain calm and quiet, and to respond only by spitting. The sage greeted the spirits by handing
them a wooden stick. As the visitors approached the altar, an enormous dark figure, the devil himself, rose from under the floor and began talking in a humming voice. The voice was audible but so vague that only the sage could interpret it. They argued fiercely, and the sage started to wave his hands in an excited state. The church roared like thunder. To expel the cause of the disease, the sage shot with a gun or struck the patient with a piece of clothing (see also SKVR, 1931–1933, nr. 1980). Finally, the visitors fled the church at the speed of a bullet or a flying bird. These modes of movement, as well as the variations in rowing without oars or traveling in a dream, suggest trance visions, emphasising that the stories should not be taken as realistic travel descriptions to parish churches, public places under lock and key. Rather, the events may have taken place in the Pirunkirkko type of place acting as substitutes for the real churches or their counterparts where other types of gods were served. In some stories, the sage goes to the rock right after the church, or to the church right after the rock – this suggests that these two places were sometimes seen as separate, albeit very similar in use. Miniature coffins containing animal remains, randomly found under the floors of parish churches, bear witness to magical rituals in real buildings (Hukantaival, 2015).

3 Methods

3.1 Acoustic Fieldwork

Acoustic characteristics of the Pirunkirkko cave were explored by impulse response measurements (e.g. Stan, Embrecht, & Archambeau, 2002), which researcher Rainio and her team carried out in September 2019 and July 2020. To obtain a comprehensive view of the acoustics, the measurements were taken in different parts of the cave: at the entrance (recording point 1), in the middle corridor (recording point 2), and the inner corridor (recording points 3, 4, and 5) (Figure 2). The recording points 1, 2, 3, and 4 were situated at the height of 1.5 m from the ground, whereas the recording point 5 was situated on the ledge at the back of the cave, at the height of 2.5 m. In addition to these mapped points, audio recordings for demonstration purposes were performed in acoustically interesting places, situated at the back of the cave, between recording points 4 and 5.

To excite the acoustics of these spaces, we used balloon pops. Latex balloons were inflated to a diameter of 40 cm and detonated at a distance of 5 m from the recording points. Their pops provide loud instantaneous broadband signals that are constant and repeatable enough for measurement purposes. Furthermore, we planned to use logarithmic sine wave sweeps to excite the acoustics, but the dodecahedron loudspeaker of the University of Helsinki Music Research Laboratory turned out to be too large to be fitted at the back of the cave, that is, the acoustically most interesting place (Figure 4). The loudspeaker could only be used in the front parts of the cave, which precludes the use of these impulse responses in the comparative analysis. For the audio demonstrations, we used human voice, handclaps, a frame drum 40 cm in diameter, as well as a wooden percussion plate. The latter three provide loud instantaneous broadband signals that are too uncontrollable for measurement purposes, but can be used for playing rhythmic sequences and musical passages.

The impulses and the acoustic responses of the spaces were recorded with a pair of Neumann KM 183 omnidirectional condenser microphones that capture sound evenly from all directions. The microphones were attached to a 1.5 m high rack placed at the recording points. The audio demonstrations were recorded with the same equipment, supplemented with a pair of Neumann KM 185 directional condenser microphones that pick up sound efficiently from the front, leaving sounds from behind and the side quiet. These hypercardioid microphones were directed (a) towards the cave wall and (b) along the axis of the corridor. From the microphones, the sound was transferred to two Zoom F8 multichannel audio recorders to be stored at a 96 kHz sampling rate and 24 bits per sample resolution.

To draw a floor map, the physical dimensions of the cave were measured with a Leica laser distance metre and a Suunto optical sighting compass. In addition, the fieldwork comprised photography and video recording.
3.2 Spectrum Analysis

The impulse responses recorded in the Pirunkirkko cave were examined with standard audio signal analysis methods. The analyses were made using the Spectutils Signal Analysis and Visualisation Toolkit which provides functions for creating spectrograms, oscillograms, and other graphic representations of audio files (Lassfolk & Uimonen, 2008; Lassfolk, 2016). The spectrograms allow an examination of both spectral and temporal characteristics of the Pirunkirkko impulse responses. Most of the plots presented in this article were made with the Spectutils function sonogw() that creates two-dimensional “frequency versus time” spectrograms, where the amplitude of sound is represented by the intensity of the greyscale. Sonogw() has up to 12 parameters, such as time offset, number of Fast Fourier Transform points, window length, window type, folding of consecutive windows, low frequency limit, and high frequency limit. The parameters in all presented spectrograms are roughly the same, in Figure 5a–e, they are identical. In addition, a couple of the presented plots, in Figures 5f and 6a, were made with the Spectutils function amp2dt() which creates two-dimensional “amplitude versus time” sound pressure level plots. Amp2dt() has five parameters, such as time offset, duration of the amplitude measurement window, and plotting of either the RMS or peak level graphs.

Figure 4: Preparing for acoustic measurements in the inner corridor of the Pirunkirkko cave on 23rd of July 2020. The dodecahedron loudspeaker in the foreground, researcher Rainio at the back. Photo: Julia Shpinitskaya.
3.3 Ethnographic Fieldwork and Discourse Analysis

Researcher Hytönen-Ng visited the Pirunkirkko cave on the 13th of March 2020 with a shamanic practitioner, who uses the cave sporadically for ritual purposes. In the cave, the practitioner performed a drumming ritual to acknowledge their presence and honour the spirits. The ritual did not have any other reason, as the cave was initially entered at the researcher’s request. Later, the practitioner pointed out that the drumming was a thank you for the cave. In the winter conditions, even the possibility of entering the cave was seen as an important sign as we were allowed access. The practitioner and the researcher spent altogether about an hour in the cave.

Hytönen-Ng recorded the drumming and singing that took place within the cave. These acts were performed on the ledge at the back of the cave, in a place that corresponds roughly to the space where the shamanic practitioners would normally perform their rituals. During the ritual, the participating practitioner was sitting at the inner end of the ledge, while the researcher with the recording equipment was sitting at the outer edge of the ledge, yet the practitioner was aware of the recording. As the space was narrow and the practitioner was in front of the researcher, the researcher was unable to see what was happening behind her back in the space at the end of the ledge, described by the participant as the “altar.”

Recordings were made with a Zoom H4n audio recorder using its internal microphones. The recorder was roughly 1 m away from the practitioner, the microphones being either behind the practitioner or on their side. As the ledge was quite narrow and tight for two people, it was impossible to sit there comfortably for longer, particularly as you had to fit in there with the drum, rattles, backpacks, and recording equipment. Two separate recordings were nonetheless made: the first one included drumming and singing with rattles, and the second one was a prayer. The recordings were later handed to Rainio, who analysed the 10 min recording of the drumming and singing with the Spectutils software.

In the snowy conditions, exiting the cave and making one’s way up from the entrance to the car park, where the researcher’s car was parked, took roughly half an hour. When the researcher and practitioner were in the car leaving the site, the researcher asked the practitioner a few questions about the importance and meaning of the cave. The interview, which lasted about 20 min, was recorded using the Zoom H4n recorder. Some additional and more specific questions were asked later during spring of 2022. Informed consent was obtained from the practitioner to analyse all these materials. The participant knew the interview would be used for research purposes. The interview was done in Finnish which was the native language for both parties.

The interview was analysed using discursive psychology (DP), a form of discourse analysis interested in the role that language has in constructing our social reality. When using DP, the researcher demonstrates how language builds and defines social interaction as well as diversifies social worlds. Scholars such as Potter and Wetherell (1987, pp. 1–2) and Wiggins (2017, pp. 5–7) use DP to examine how social texts construct our social world and life within social interaction, and the way experiences are being reproduced in speech (see also Edwards & Potter, 1992). The three central principles of DP are that “discourse is constructed and constructive,” “situated within a social context,” and “action-oriented” (Wiggins, 2017, p. 9). In addition to the practitioner’s contribution, Hytönen-Ng’s own experiences have been reflected in the research data and the questions asked. Autoethnographical notes about participating in the ritual performed are also an important part of the study.

4 Results

4.1 Acoustic Analysis of Pirunkirkko

Audio signal analysis of the Pirunkirkko field material indicates that each part of the cave has its own acoustic characteristics. The spectrogram in Figure 5a shows the impulse response at recording point 1, situated at the entrance to the cave, in the open air. The excitation signal, that is, a balloon pop, is displayed as an intense pressure peak that covers the selected frequency range of 40–4,000 Hz and lasts 0.1 s. The acoustic response of the place is displayed as the subsequent attenuating tail that loses higher frequencies quickly, but lasts longer.
Figure 5: Impulse responses in different parts of the Pirunkirkko cave: (a) Spectrogram from recording point 1, outside the cave; (b) Spectrogram from recording point 2 in the middle corridor; (c) Spectrogram from recording point 3 in the inner corridor; (d) Spectrogram from recording point 4 in the inner corridor, on the plank bridge; (e) Spectrogram from recording point 5 in the inner corridor, on the ledge; (f) Sound pressure level plot from recording point 5 in the inner corridor, on the ledge. A = excitation signal, B = early reflections, C = late reflections, D = distinct frequencies ringing after the impulse.
Figure 5: (Continued)
than the 2-s plot can show. This type of response, consisting of countless overlapping reflections from surfaces farther apart, is typical of outdoor spaces, such as forests and semi-open landscapes, where the sound spreads relatively far.

The spectrogram in Figure 5b shows the impulse response at recording point 2, situated inside the cave, in the middle corridor. The excitation signal is displayed as an intense pressure peak that is broadband as in the previous measurement location, but lasts longer, approximately 0.25 s. Because the balloon pops in all locations were identical, the jagged end part of the pressure peak must be composed of early reflections projecting from the corridor walls. Due to the narrowness of the corridor, these reflections arrive quickly and disappear in less than 0.3–0.4 s. Only very faint reverberation can be seen after that. This type of response, where the reflections combine with the excitation signal making it louder or heftier, is typical of small enclosed spaces.

The spectrograms in Figure 5c–e show the impulse response at recording points 3, 4, and 5, situated in the inner corridor. At all three points, the excitation signal with early reflections is displayed in the same way as in the middle corridor. However, the rest of the response is peculiar. After the broadband pressure peak, a few distinctive sound frequencies remain vibrating for 0.75 s, almost 1 s. These frequencies ring alone, becoming louder and more numerous at recording points 4 and 5, towards the end of the cave. The frequency rates vary somewhat by location, but seem to be, from below: 219–232 Hz, 442–462 Hz, 659–666 Hz, and 873–901 Hz, which are expressed in western note names as follows: A3–A#3–8, A4–A#4–8, E5–E5–8, and A5–A#5–8, respectively. Because the three higher frequencies are approximately integer multiples of the lowest frequency (219–232 Hz), the frequencies together form a harmonic series, a spectrum, that in the human auditory system is perceived as a single musical tone, in this case a pitch between A3–8 and A#3–8.

This type of acoustic phenomenon is known in standard acoustics as resonance, alternatively as room resonance or room mode (Everest, 2001, pp. 240, 317–352; Kuttruff, 2001, pp. 35–36; Verdult, 2019, pp. 281–290). Resonance occurs when sound waves bouncing between two relatively close and smooth parallel walls form a standing wave, a kind of temporary storage of acoustic energy. The wavelength of this standing wave corresponds to the distance between the parallel walls, or more precisely, is twice the distance. The standing wave results in amplification and prolongation of the corresponding sound frequency, called the natural frequency or resonant frequency of the space (Everest, 2001, pp. 317–352; Ermann, 2015, pp. 112–113; Kuttruff, 2001, pp. 64–71). Because the amplification and prolongation also apply to the harmonic partials of the natural frequency, the end result is a musical tone.

Based on the spectrum analysis, it seems evident that the Pirunkirkko cave houses a pronounced resonance phenomenon. The smooth parallel walls of the inner corridor extract their natural frequency from a given broadband signal, amplifying and prolonging it into a ringing tone. The fundamental frequency at 219–232 Hz indicates that the standing wave causing the phenomenon is 1.48–1.56 m long, whereas the corridor in the resonant locations is 0.74–0.78 m wide. This is in line with the size measurements taken at the end of the inner corridor. The scatter in the frequency rates, wavelengths, and calculated measurements can be explained by inharmonicity and small irregularities along the naturally formed cave walls. Furthermore, the sound pressure level plot in Figure 5f shows that the amplitude of the resonant tone is fairly low, −40 to −75 decibels relative to the signal. The reverberation generated by the signal seems to drop to −60 decibels in 0.38 s.

### 4.2 Practical Implications of Resonance

The resonance phenomenon of the Pirunkirkko cave is readily audible in the inner corridor. During the acoustic fieldwork, we noticed it at once from the unusual metallic tone colour of the first balloon pop. This drew attention to the ringing tone in the response. Moreover, the resonance phenomenon can be heard after a handclap, drumbeat, or clang of a wooden percussion plate, that is, any type of instantaneous impulse-like broadband signal. However, the partial structure of the resonant tone is emphasised in different ways, due to the varied spectra of these non-standard signals. During a rapid clapping or drumming session at approximately 160–200 beats per minute, the ringing tone fills the gaps between the claps or beats, creating an illusion.
of a continuous tone humming, buzzing, or hoovering in the space (Sound sample). This effect appears to function well everywhere at the back of the corridor, including the high-up ledge, as seen in the spectrogram in Figure 6a. On the other hand, the effect is much weaker at the beginning of the corridor, north of the plank bridge.

Once the correct pitch has been detected by ear, the resonance phenomenon can be excited simply by singing the same tone, either the fundamental frequency or one of the partials, such as the second one at 442–462 Hz. Even soft humming – in some cases almost mere blowing – is enough for this purpose. When the pitch is correct enough, the vocalised tone is instantaneously captured by the corridor: amplified and

Figure 6: Audio experiments in the inner corridor of the Pirunkirkko cave: (a) Spectrogram showing three drumbeats (A) and a ringing frequency at 231 Hz (B). The drummer was sitting on the ledge, while the microphones were placed on the plank bridge; and (b) Spectrogram showing three vocalised tones with fundamentals at 420, 470, and 523 Hz (A) and a ringing frequency at 451 Hz (B) after the midmost tone. The singer as well as the microphones were situated south of the plank bridge, close to the western wall.

1 Online supplementary material available at https://youtu.be/Tebdx6wXcZA. Clapping in the inner corridor of the Pirunkirkko cave, south of the plank bridge. Of the three resonant frequencies 221, 442, and 666 Hz, the highest is by far the strongest. The recording was made with a Neumann KM 185 hypercardioid microphone directed towards the eastern wall of the corridor. The recording was compressed to reduce the volume difference between the claps and the ringing tone. For the best experience, headphones are recommended.
prolonged by it for 0.75 s, as seen in the spectrogram in Figure 6b. This creates the impression that the corridor is responding or joining the singing. On the other hand, when the pitch is incorrect, such as a step below or above the correct one, there is no reaction from the space. The corridor remains silent. This effect appears to function everywhere at the back of the corridor. By ear and by comparison with the directional microphones, the effect is clearly strongest next to the walls. This supports the interpretation of the resonance phenomenon, since the antinodes of the standing wave are always located next to the reflecting surfaces (Everest, 2001, Figures 15–2, 15–5).

4.3 Analysis of the Observation and Interview Data

The day was wintery with snow piled up against the hill. The sky was half sunny, but at the entrance to the Pirunkirkko cave the shadows from the hill above were obstructing the sun. The temperature was around −10° C. It was unsure whether the cave could be reached as sometimes the snow actually prevented the entrance during the winter. The participating shamanic practitioner considered it a good sign that we were able to get to the cave and enter it even with all the snow.

The entrance to the cave was nonetheless very small as can be seen from the photo in Figure 7. The entrance is not very big even during the summer, and Hytönen-Ng and the practitioner had to crawl in as the opening was partly blocked by the snow. After entering, the cave floor extends downwards and Hytönen-Ng had to progress inwards by crawling and sliding as standing was impossible. She was only able to stand up straight in the middle corridor after the rectangular corner. Progressing deeper and deeper in the cave caused an almost claustrophobic feeling, as during the winter, the narrow corridors were slippery with ice. Hytönen-Ng

Figure 7: Researcher Hytönen-Ng at the entrance to the Pirunkirkko cave on the 13th of March 2020. Photo: Practitioner N.N.
Ng described being concerned about getting out of the cave. These realisations proved to be useful in the study as when coming out of the cave, the researcher was feeling freedom, which could be described as feelings of rejuvenation and healing, as the practitioner later noted in the interview.

Inside Pirunkirkko, the practitioner performed a ritual by drumming and singing. The ritual was done at the very far end of the cave, on the ledge, which most people do not go to as you have to climb up 2 m to get to it. The ledge was perhaps easier to reach during the winter as the snow had piled up against the side of the ledge so that it was not as high as during the summer. The practitioner had to instruct the researcher on where to put her feet to get up. This demonstrated the difficulty of getting up to the ledge. Later, in spring 2022, when Hytönen-Ng asked the practitioner separately if they always used the end of the ledge or preferred to stay closer to the edge, the participant pointed out that they always went to the very end of the cave. They described the end of the cave, at the end of the ledge higher up, as a place where the “altar” was, and the edge of the ledge as a “table” which to set things onto.

In the interview, done after the ritual, Hytönen-Ng asked the practitioner why the Pirunkirkko cave was important to them. The participant pointed out that the cave felt like a “spiritual home” and started to explain how within the cave they were almost as within the ancient mountain. They described the cave as the womb of Mother Earth. When analysed, this would seem to highlight that within the cave, the practitioner not only feels safe and deeply connected with the surroundings but also feels protected by the ligaments of the mother. The connection while within the cave is, therefore, exceptional and deep.

It was also explained to Hytönen-Ng that the cave itself had a very “special energy” within which the practitioner felt it was easy to be within. The energy inside the cave was described as “strong, rooting and balancing.” This highlights that the connection with nature, while being within the cave, is deeper than normal.

In addition, the participant highlighted the connection that one had with their roots. This connection could refer to either the physical heritage or the spiritual roots. Although the historical connections of the cave with local sages (tietäjät) are well-known in present-day Finland, the connection with the living practice of shamanism has largely been lost during the nineteenth and twentieth centuries with the influence of Christianity. Neoshamanism only gained awareness in Finland towards the end of the 1980s. The first shamanic workshops were arranged in the early 1990s and the shamanic association was established in 1994. Therefore, it seems that there is no direct link between the shamanic or folk religious practices and the archival materials of the late nineteenth and early twentieth centuries, but rather a break in the tradition, similar to the use of the shamanic drum among the Sámi (for more information on the Christian missionaries’ work among the shamanic societies, see Pentikäinen, 1998b, pp. 39–41).

The break in the tradition would imply that the interviewed practitioner is referring more to their spiritual roots, while the physical roots, even when existing in the North Karelian, are less important. The paganistic tradition is still widely dismissed in mainly Lutheran Finland, and even today Akka-Koli, one of the peaks of the Koli mountains, is marked with a Lutheran cross. The old cross was replaced with a new one in 2022, but there were no discussions between the church and the people practising other beliefs. This irritated those who maintain the pagan tradition today. This act serves as an example of how pagan traditions and shamanism are still largely ignored or seen as forbidden. In this environment, the cave offers a place where spirituality can be expressed and practised freely. The cave offers the practitioner “breathing space.”

When the researcher asked the practitioner if Pirunkirkko seemed to include any special dimension that would make the drumming in the cave more rewarding, they described how the drumming induced altered states of consciousness or, as it is also called, the shamanic consciousness. More importantly, the practitioner pointed out that the drum was a tool for celebration and thanking “the spirit of the cave.” The drum also gave the power to healing. In the practitioner’s speech, the drum is described as a powerful ritual tool and the participant’s capability of performing healing is in some degree related to it. While the cave offers the ritual some power, the practitioner gives back something in exchange through drumming. There seems to be some form of mutual transaction between the human and other-than-human aspects of the natural environment, or nature, that is mediated by the drum. The use of the drum was described to be opening up “new horizons” for the practitioner.

Even though in the interview, the practitioner pointed out that they did not need to drum in Pirunkirkko, it was later on noted that they nonetheless most of the time did enter the cave with a drum. Drumming seemed,
in the practitioner’s description, to bring forth different qualities and dimensions from the cave. The “new horizons” opened up by drumming could unconsciously reflect the resonance phenomenon created during the sonic rituals. Later, when asked separately, the practitioner pointed out that they were unaware of any special acoustic phenomenon when drumming and singing within the cave. Moreover, the participant did not have any particular melody that they would use, but they would sing intuitively whatever felt like it needed to come out (personal communication with the practitioner in May 2022). However, it would seem likely that the way that the cave responds to the practitioner’s drumming and singing is intuitively invoking them to use certain sounds that are more likely to resonate with the space. In the analysis, the mutual transaction between the human and other-than-human participants becomes important as it offers the practitioner a meaningful dialogue that cannot perhaps be reached in this form anywhere else.

5 Discussing the Resonance of Pirunkirkko

Resonance is not an unusual phenomenon. Resonances or room modes are commonly found in relatively small, built-up spaces with hard and smooth parallel surfaces, such as living rooms, bedrooms, and bathrooms (Everest, 2001, pp. 319–320; Ermann, 2015, p. 122). However, they are rarer or even surprising in natural environments where shapes are mostly uneven and asymmetrical. The distinct resonance in the Pirunkirkko cave is caused by the long, high, and extremely narrow inner corridor where the rock walls are unusually smooth and parallel. The input of acoustic energy bounces between these walls and generates a standing wave manifesting itself as a ringing tone at 219–232 Hz. Such a distinctive, distinguishable resonance is not an obvious phenomenon in all caves. We did not observe any resonance in the middle corridor of Pirunkirkko, neither in the neighbouring caves in the Kirkkokallio and Repouuro areas, nor in any of the randomly tested Finnish caves, whether of the crevice or boulder type.

In standard room acoustics, resonances are generally avoided because the amplification of specific frequencies is thought to interfere with listening to music (Everest, 2001, pp. 346–351, 406–409; Ermann, 2015, pp. 109–114; Verdult, 2019, pp. 281–311). However, research in the field of archaeoacoustics has shown that in cultures of the past, views and preferences may have been different. Resonances have been reported in Palaeolithic caves in France, where they appear to coincide with concentrations of human-made paintings (Reznikoff & Dauvois, 1988; Reznikoff, 2002; Scarre, 1989; Till et al., 2017). Resonances have also been reported in megalithic tombs in the British Isles, where people gathered to perform memorial rituals (Devereux & Jahn, 1996; Watson & Keating, 1999). In Malta, it appears that an entire underground temple was modified to produce a specific series of resonant tones (Wolfe et al., 2020; see also Debertolis, Coimbra, & Eneix, 2015; Reznikoff, 2014; Till, 2017). These studies suggest that the physical space was supposed to be somehow involved in ritual sound or music making, to make a contribution to them.

Based on the ethnographic archival sources, Pirunkirkko was a place to contact the spirit world and negotiate with the various spirits, devils, and elves living inside the Koli mountains. The resonance phenomenon must have been present in these ritual encounters, because they were loud and contained sonic elements suitable for excitation. The sages made many instantaneous impulse-like noises: they shouted, raged, jumped, trampled, shot with a gun, and struck the rock with various objects. The cave must have responded to these frightening noises with the soft musical tone A3 – A#3 that rang in the corridor for a moment and always remained the same. If the sages made a rhythmic sequence out of the noises, the cave formed a continuous tone that hummed in the background for as long as the stimuli lasted. The cave seemed to recommend this one single tone as the right level to tune oneself. If the sages or the patients started humming the same tone, the experience could be reminiscent of modern sound therapy, where simple humming, so-called toning, is used to relieve stress and create balance and harmony (e.g. Snow, Bernardi, Sabet-Kassouf, Moran, & Lehmann, 2018). Furthermore, listening to or humming the same stable tone, in an underground natural resonator, could evoke images of restored peace and order or constructive reciprocal interaction with the spirit world. Such imagery was needed to provide the sick with experiences of healing, as sicknesses were traditionally thought to be caused by imbalances or disturbances with the spirits in the environment (Haavio, 2020, p. 341; Honko, 1959;
Piela, 2010, pp. 44–54, 87–90; Tuovinen, 1984, pp. 25–34). The purpose of the healing ritual was to restore order and mend the relations between the worlds.

As for the performance of the contemporary shamanic practitioner, the audio analysis of the field recording proves that the resonance phenomenon is present in the ritual. From the first slow drumbeats to steady drumming accelerating from 120 to 240 beats per minute, the resonant frequency of 218–222 Hz appears to ring in the background. However, the practitioner’s frame drum has its own distinct natural frequencies that remain ringing after the beats for almost a second. These frequencies overlap with the natural frequency of the cave mixing with it. Thus, using this type of sonorous drum, space-related resonance is difficult to detect. However, in connection with drumming, the practitioner also sings a melody consisting mainly of three different tones. These tones are F#3, A3, and H3, while their fundamental frequencies are 186, 224, and 253 Hz, respectively. Surprisingly, the middle tone is practically the same as the natural frequency of the cave. The plots in Figure 8 show that the amplitude – sound pressure level – is higher during this tone than

![Figure 8: A 8 s clip of the recorded ritual: (above) Sound pressure level plot showing 13 drumbeats (A) and the amplitude increase between beat numbers 6, 7, 8, and 9; (lower) spectrogram showing the same drumbeats and three vocalised tones with fundamentals at 253 Hz (B) and 224 Hz (C). The practitioner and the microphones were situated on the ledge at the back of the Pirunkirkko cave.](image-url)
during the other tones. The difference is not enormous, about 5 dB, but it is distinct and repeats the same throughout the singing. This higher volume suggests that the middle tone of the melody excites the resonance phenomenon at the back of the cave and is amplified by it. An increase of 5 dB should be audible to most listeners (Everest, 2001, p. 61).

Given all this, it seems strange that the local folklore or the interviewed practitioner does not say anything about the resonance or other acoustic phenomena in the Pirunkirkko cave. Although soft, the ringing tone is audible. However, it must be remembered that people, as a rule, make observations and interpretations of the environment from their own perspectives, personal experiences, and cultural frameworks of thought. While making the acoustic measurements in the cave, we focused on listening to the impulse response of the space, expecting to find something like resonance. The ritual practitioners of the last centuries did not think about acoustics, but focused on encountering spirits, devils, or elves and solving serious problems with them. Because ethnographic records from Koli and throughout the country say that the spirits primarily expressed themselves aurally – vocalising, humming, hissing, mumbling, or thundering (e.g. SKS/Juvonen, 1937, KT127, nr. 25; SKS/Räsänen, 1961, TK89, nr. 149; SKS/Toiviainen, 1961, TK104, nr. 23) – the sensation of their presence seems to have involved an auditory perception. Most logically, this perception consisted of strange, inexplicable sound coming from an ambiguous or unspecified source. These characteristics match with resonance, reverberation, and other reflection-based phenomena. Thus, acousmatic beings and acoustic phenomena are conceptually not so far from each other.

Similarly, the contemporary ritual practitioner focused on the religious experience, paying more attention to internal sensations than external reality. When talking about the “strong, rooting, balancing” and “special energy” in the cave, they actually come close to the definition of resonance, which defines the phenomenon as the temporary storage of acoustic energy. As sound itself is a manifestation of energy, the drumming and singing practitioner and the cave responding to them are literally and factually exchanging energies with each other. In addition, the participant’s expression about “new horizons” could well describe such a transaction or new elusive characteristics or effects that resonance brings to a sonic performance: the selection, amplification, and repetition of one particular pitch, in so much that it may shape and restructure the chosen scales, melodies, and other musical structures. While writing this article, we contacted the interviewed practitioner again asking whether the pitches, scale, and melody used in their ritual were pre-planned or freely improvised. The practitioner answered that they did not have any particular melody to use within the cave, but would intuitively sing whatever needed to come out. This answer offers an opportunity to think that the vocalised amplified tone A$^\#_3$ was not included in the ritual by chance, but was chosen because of the resonance, under its influence. This may have happened instinctively and unconsciously. Moreover, the resonance may have influenced the altered states of consciousness sought in the cave. In a published experiment, exposure to resonance was reported to cause the sensation of a tone ringing in the listener’s head (Watson & Keating, 1999, p. 330). Interestingly, a very similar kind of tone, humming, buzzing, or “ringing in the ears” is a typical hallucination experienced during the altered states (Blom, 2010, pp. 70–71, 678–679, 681; see also Lewis-Williams, 1995). If the resonant tone was associated with this hallucination and possibly even induced it, it is no wonder that Pirunkirkko was regarded as an effective place for reaching the shamanic consciousness.

6 Conclusion

Although the Pirunkirkko cave in Koli is a relatively recent site, it can provide new information or insights for archaeologists, who work on natural and built spaces dated to much more distant times. First, our study of Pirunkirkko brings out a previously less studied acoustic phenomenon, particularly associated with cracks, crevices, ravines, and corridors, and introduces a set of rigorous archaeoacoustic methods for studying such places. Second, the versatile archival and interview materials of the study provide an example of the sensory experiences, beliefs, and practices that may have been associated with these places, as well as the interaction between the cultural phenomena and the acoustic properties of the spaces. These examples can be used for
ethnoarchaeological comparisons and interpretations, especially in connection with the study sites, where the researcher’s only direct sources are the physical space and its material remains.

Our audio analysis indicates that the Pirunkirkko cave, a traditional meeting place for sages, has a distinct acoustic characteristic. The less than 1 m wide inner corridor houses a pronounced resonance phenomenon, in which a standing wave between two parallel rock walls generates a ringing tone at 219–232 Hz. This tone stays audible after loud instantaneous broadband noises, such as balloon pops, hand claps, and drumbeats. Alternatively, the ringing tone can be excited by singing at the same frequency or one of its integer multiples. This resonance phenomenon must have been present in the historical rituals performed in the cave, because the ethnographic record shows that they were full of loud impulse-like noises. The sages shouted, jumped, trampled, shot with a gun, and struck the rock with various objects. In the case of the contemporary shamanic ritual, the field recording proves that the resonance is involved in the practitioner’s drumming and singing. The cave responds to one of the three sung tones – the one matching the resonant frequency – by amplifying it throughout the singing. The seasons do not seem to have an effect on the phenomenon, as it is repeated in recordings made in March, July, and September.

Such a distinctive resonance is perhaps one of the reasons why Pirunkirkko has become important to the historical sages and contemporary practitioners as well as all those who have used the place over time. In such acoustics, people do not perform their rituals alone, but in interaction and cooperation with the physical space and natural environment. The resonance provides a means of deep connection and transaction with some kind of other-than-human participant or agent, signalling their presence and existence. One of the most intriguing aspects of this study is that the local folklore or the interviewed practitioner does not mention the resonant tone at all. Instead, they speak about the “spirit of the cave,” “special energy,” and “new horizons” opened up by drumming. These expressions might be considered as alternative cross-sensory characterisations for the inexplicable acoustics phenomenon, or the discreet elusive effects that resonance adds to a sonic performance or ritual. Thus, the study of acoustics gives new tools for examining and understanding the religious beliefs and experiences reported in Pirunkirkko and similar places. In addition, the study illustrates how cultural frameworks of thought guide our sensory perceptions leading to different experiences and interpretations.

Abbreviations

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Informed consent: Informed consent has been obtained from all individuals included in this study.

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