

Review

The Neanderthal Musical Instrument from Divje Babe I Cave (Slovenia): A Critical Review of the Discussion

Matija Turk ^{1,2,*}, Ivan Turk ³ and Marcel Otte ⁴

¹ ZRC SAZU Institute of Archaeology, Novi trg 2, 1000 Ljubljana, Slovenia

² National Museum of Slovenia, Prešernova 20, 1000 Ljubljana, Slovenia

³ Lunačkova 4, 1000 Ljubljana, Slovenia; ivan.turk.46@gmail.com

⁴ Université de Liège, 7, Place du XX Août, Bât. A1, 4000 Liège, Belgium; marcel.otte@ulg.ac.be

* Correspondence: matija.turk@zrc-sazu.si

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Abstract: The paper is a critical review of different evidence for the interpretation of an extremely important archaeological find, which is marked by some doubt. The unique find, a multiple perforated cave bear femur diaphysis, from the Divje babe I cave (Slovenia), divided the opinions of experts, between those who advocate the explanation that the find is a musical instrument made by a Neanderthal, and those who deny it. Ever since the discovery, a debate has been running on the basis of this division, which could only be closed by similar new finds with comparable context, and defined relative and absolute chronology.

Keywords: Palaeolithic; Mousterian; Neanderthals; musical instrument; Divje babe I

1. Introduction

Discoveries that shed light, directly or indirectly, on the spiritual life of Neanderthals always attract great attention from the professional and lay public. One such find was unearthed in 1995 in Mousterian level D-1 (layer 8a), as a result of long-lasting (1979–1999) excavations in the Palaeolithic cave site of Divje babe I (DB) in western Slovenia, conducted by the ZRC SAZU Institute of Archaeology from Ljubljana. It was a left femur diaphysis, belonging to a one to two-year-old cave bear cub with holes (inventory no. 652), which resembled a bone flute (Figure 1). The object was found cemented into the breccia in the immediate vicinity of Neanderthal hearth, placed into a pit [1,2].

The excavation leader, I. Turk, proposed two possible explanations soon after its discovery: An artefact or a pseudo-artefact in the form of a gnawed and teeth-pierced femur diaphysis [1]. According to the first explanation, this find would be the oldest musical instrument [2–10]. The main surprise was not the great age of the find (at first 45,000 years, later 50,000–60,000 years), determined with ¹⁴C AMS, U/Th, and ESR on accompanying finds of charcoal, cave bear bones and teeth [8,9,11], but its undeniable attribution to Mousterian culture, i.e., Neanderthals. As such, it would represent significant evidence for existence of musical behaviour, long before the spread of anatomically modern humans across Europe that occurred roughly 40,000 years ago. In the last two decades, our view of Neanderthals has changed radically, but at the time of discovery, the idea of the existence of music in Neanderthal culture still seemed revolutionary.

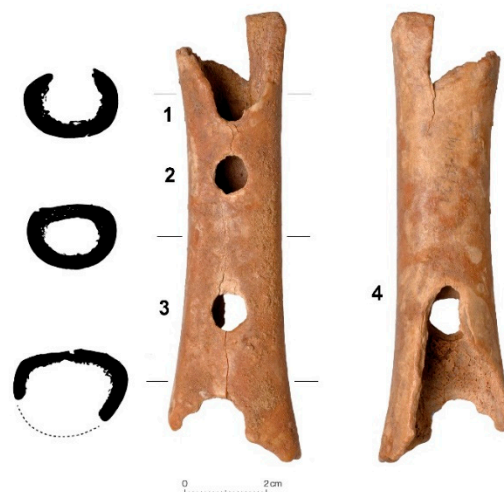


Figure 1. The perforated femur diaphysis no. 652 from Divje babe I with two complete (nos. 2 and 3) and two partially preserved holes (nos. 1 and 4). Soon after discovery, the question arose whether it was a Neanderthal musical instrument or simply a bone pierced and gnawed by a carnivore (photo Tomaž Lauko, NMS).

2. Contestable Explanation of the Carnivore Origin of the Holes

The explanation of the find as a pseudo-artefact was immediately unilaterally taken over by F. d'Errico and colleagues [12], G. Albrecht and colleagues [13], P. G. Chase with A. Nowell [14], and later some others [15,16]. Thus, they negated the potential multilateral significance the find could have had for archaeology and other sciences. Advocates of the carnivore origin of the holes have not rested in the years since the discovery of specimen no. 652. They published a series of articles on the same topic. Among them, d'Errico was the only one who micro-scoped the find and explained the findings of the microscopy in accordance with his previous estimate [12], published in *Antiquity* in 1998 [17–19]. I. Turk with colleagues [10,20–25] (see also [26]) continuously argumentatively claimed that some of their statements, regarding their explanations about the origin of the holes and damages on the perforated bone, are incorrect [13,14,16,27–29]. To obtain more accurate explanation of the find, I. Turk and colleagues performed and published a series of experiments on perforating fresh brown bear femur diaphyses, using models of wolf, hyena, and bear dentitions (Figure 2), as well as replicas of Palaeolithic tools that were present in various Mousterian levels in DB [20,21,30,31]. Various musical tests of the find were also performed, which was reconstructed several times for this purpose [7,32–37].

After I. Turk and colleagues contested the arguments for the carnivore origin of the holes in numerous publications and offered arguments for their anthropic origin, it was up to advocates of the carnivore origin to refute their findings argumentatively, which they have not done so far. Their discussion of the find is distinctly one-sided and, with one sole exception [13], included no experiments. They presented certain erroneous claims to support their explanation, e.g., about the number of holes [14,19,27], contra [20,22,23], how the holes cannot be made in any other way than by drilling [13,28], contra [10,21,30], the placement of holes on the thinnest parts of the cortical bone [13,14,16], contra [22–24], actual possibilities of teeth grip in connection to holes and gnawing marks [13,14,16,18,19], contra [20,24,25], the sound capabilities of the musical instrument, if that is what the find actually is [19,27], contra [7,36–38], the inappropriateness of a cave bear femur as a support for a musical instrument in comparison to the supports from bird bones [29], contra [7,36–38], and about the frequency of gnawing marks [18] (Figure 9 from Reference [18]), Ref. [19], which in certain cases can also be explained as corrosion formations [10,39]. Corrosion was found to be especially strong in the layer containing the find [10,40].

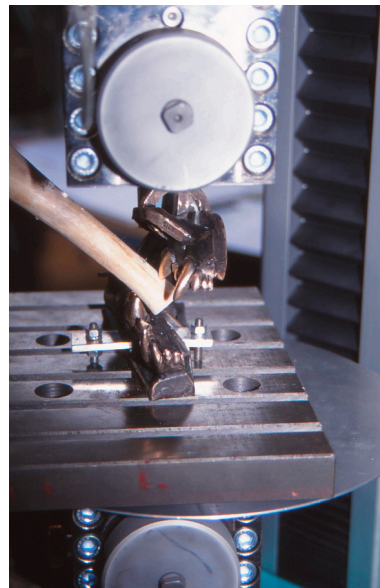


Figure 2. Experimental piercing of a fresh femur of a young brown bear using a bronze model of hyena's dentition and the ZWICK/Z 050 machine for measuring compressive force (photo Ivan Turk, ZRC SAZU).

Supporters of the anthropic origin of the holes were also mistaken; e.g., about the original number of holes [4] and the original length of the musical instrument [35]. The first reconstructions of the find intended to research its musical capabilities, which places the mouthpiece into the large notch on the distal metaphysis, and which consequentially did not consider the opposite hole (at the time supposed to be a thumb hole because of its proximity to the mouthpiece), were also erroneous [31,32,34]. Due to the wrong orientation, the capability of the find as a musical instrument was reduced, and a remnant of the straight edge sharpened from both sides on the proximal part of the diaphysis, which functions on the musical instrument as the cutting edge of the mouthpiece, was overlooked [10,37] (Figure 9 from Reference [10]). It should be noted that we are dealing here with the first example of a bevelled mouthpiece edge. A bevelled mouthpiece edge, which enables better musical performance of the instrument is not known in later Upper Palaeolithic wind instruments, which are made of mammal limb bones. At already thin bone cortex of bird bones, the additional sharpening of the mouthpiece edge is not necessary to achieve better sonority.

When defining the holes on the femur diaphysis no. 652, which are the key component of all wind instruments, we have to start from certain findings of research of all cave bear finds, acquired with wet sieving of all sediments during the excavations of I. Turk, as well as from the findings of his fresh bone piercing experiments. In DB, the main damage to the bones was, in addition to humans, made by wolves (all remains belong to 30 individuals at the most) and not cave hyenas (zero specimens and no indirect proof, such as coprolites and digested bones) [25], contra [16]. The complete and partial holes on the femur diaphysis are undoubtedly of mechanical origin. Namely, both have a funnel-shaped inner edge, which occurs during piercing with a tooth or a pointed tool. Experiments show that the compression of the diaphysis with sharp (unworn) teeth or striking it with a pointed tool result in the longitudinal cracking of the compact bone [20]. Longitudinal cracks are present on some of the fossil bones that were undoubtedly pierced by carnivores [16] (Figures 5 and 6 from Reference [16]). Thus, the femur or some other tubular bone, with removed meta- and epiphyses, usually breaks in half longitudinally during piercing and widening of the hole(s) [16] (Figure 6 from Reference [16]). This is, however, not true for compression and piercing with strongly worn teeth and blunt pointed tools. A crack on the posterior side of the femur diaphysis no. 652 (Figure 1), which zigzags longitudinally from one end to the other is only superficial, and occurs during weathering in the course of fossilization.

It is significantly different from the continuous, rectilinear in-depth crack that occurred on fresh bones during experimental piercing with metal models of carnivore dentition. Since the femur diaphysis no. 652 is not cracked in this way, solely worn teeth or blunt pointed tools can be considered to have produced the holes.

Both partial holes, which advocates of the carnivore origin of the holes considered to be evidence of bites, can be explained differently. V-shaped fractures start on both ends of the diaphysis in the partial hole, meaning that the holes came first and both fractures followed (Figure 1). If the fractures had been made simultaneously with the holes, three cracks would certainly have occurred: Two connected to the fracture and the third one on the diaphysis, with its starting point in the remains of the hole [13] (Figure 10.3 and p. 8, point 4 from Reference [13]). There is no third crack on either of the partial holes. Among 550 cave bear femur diaphyses without epiphyses, similar in size to specimen no. 652 from various layers in DB, only two are pierced and none with the V-fracture and a partial hole.

Judging from the shape and size of the holes, we agree with F. d'Errico [12,18] that they could have been pierced primarily with canines (Figure 3). C. Diedrich [16] believes that all holes in the bones of cave bear from different sites were made exclusively by premolars and molars. According to the first explanation, primarily an adult cave bear is possible, while, according to the second, it would have to be an adult cave hyena which was, like all hyenas, specialised for crushing bones. Frequent *in vivo* damage on the canine teeth of adult cave bears indicates their rough use. Measured forces from our experiments with models of various carnivore dentitions reveal that piercing with canine teeth takes one-time greater force than piercing with molars and two-times greater force if the tip of canine tooth is blunt [20]. Such forces are on the verge of the capability of the largest carnivores [41,42]. The oval shape of one of the holes and possible antagonist canine impression on the opposite, anterior side connected to it are not in line with the grip and occlusion of canine teeth [10,24], *contra* [18]. Congruity with the occlusion can be achieved only if the diaphysis is placed lengthwise to the teeth line in the sagittal direction. Such a bite would be highly unlikely, if possible at all. Due to the different shape of teeth tips and shape of the holes (Figure 3) and the unusual longitudinal femur grip considering the only possible dent (pitting after d'Errico [18] (Figure 9 from Reference [18]) of the antagonist tooth [25], cave hyena and the grip with so-called crushing teeth, which is referred to by C. Diedrich [16], is not an option. As stated above, there is also no direct and indirect evidence of the presence of hyena at DB. The same as for the bite of a hyena is true for the bite of a wolf, which is the second best represented carnivore at the site, next to cave bear. The latter is represented with several thousand individuals. It is also not possible to make a partial hole and a complete hole one beneath the other and simultaneously an emphasised depression right by hole no. 3 (Figure 3f, Figure 5) with just any tooth [24], *contra* [16,18].

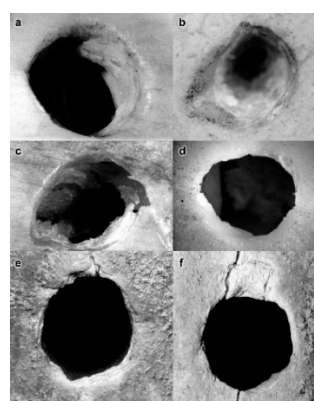


Figure 3. Experimental holes on juvenile femur diaphysis of brown bear made by: (a) a bear's canine tooth, hole size 8.2×8.2 mm; (b) a hyena's lower canine tooth, hole size 6.5×8.3 mm; (c) a hyena's 3rd upper premolar, hole size 6.5×9.0 mm; (d) a hole made by a pointed stone tool and bone punch, size 6.0×7.4 mm (e,f) complete holes no. 2 (size 8.2×9.7 mm) and 3 (size 8.7×9.0 mm) on the femur from DB no. 652 (ZRC SAZU, Archive of Institute of Archaeology).

Many juvenile femur diaphyses, and other tubular bones of extremities in DB and elsewhere have a bigger distal or proximal semi-circular notch, which is typical carnivore damage. Such a notch also occurs on the distal metaphysis of femur no. 652 from DB (Figure 1). Considering the circumstances, it can be attributed to a wolf, with which P.G. Chase and A. Nowel also agree [14]. Undisputable traces of gnawing on both ends of the diaphysis cannot be linked with certainty to the occurrence of both complete holes and at least one partial hole [10,24], contra [18]. Since it was possible for carnivores to damage Palaeolithic osseous artefacts and leave traces of teeth on them, which is proven by some of the gnawed osseous points [20] (Figure 20 from Reference [20]), ([43] p. 257, Photo 1), this could have happened to femur diaphysis no. 652 at some later time. Most probably, it was at that time that both V-fractures with the starting point in the hole, from which only a partial hole could have remained both times, could have been made.

3. Anthropic Origin of the Holes

Due to the shortcomings the explanation of F. d'Errico and his colleagues regarding the carnivore origin of the holes and damage on femur diaphysis no. 652, more attention is warranted to the alternative explanation of the find and findings connected to it, which are based on the results of appropriate experiments and on indirect evidence from archaeological finds in Mousterian levels of DB.

When piercing bones Neanderthals could imitate carnivores and use pointed tools and the dynamic force of strikes, instead of the compression force of teeth. Holes can be carved into the diaphysis with pointed stone tools [30] found in the Mousterian levels of DB [44]. The bone does not crack during this procedure. The edge of such holes is irregular and serrated, just as with holes on the specimen no. 652, while the edge of holes made by a tooth is generally smooth, depending on the thickness of the cortical bone (Figure 3). Clearly recognisable tool marks are not always present as was attested by F. d'Errico. Namely, six experimentally carved holes were put under microscopic examination. Tool marks were detected on only half of them [19]. However, characteristic damage, such as a broken tip and other fractures, does occur on the tools. Such damage is also present on some of the Mousterian tools from DB [10,20,31] (Figure 4). Holes can also be made with a blunt ad hoc bone punch, struck with a wooden hammer, if a dent has previously been carved into the cortical bone. The holes produced by this technique are morphologically identical to the holes on the specimen no. 652 and completely lack the conventional manufacture marks [21].



Figure 4. Tools suitable for perforating cortical bone: Pointed stone tools (the first on the right has a broken tip) and bone punches from the Mousterian layers of Divje babe I (photo Tomaž Lauko, NMS).

Whether the bone will crack depends on the shape of the punch point (blunt or sharp). In Mousterian levels of DB, beside rare undisputable fragments of bone and antler points, some ad hoc punches with rounded tips were found [23,45] (Figure 4).

At first glance, such artificially made holes on the diaphysis resemble holes made with teeth. The latter are almost always in the vicinity of the epiphyses and only exceptionally on juvenile diaphyses of the approximately same size, such as specimen no. 652 [16]. This is conditioned with the ability of large carnivores, i.e., physical restriction regarding the grip and muscle strength, and with the thinner cortical bone near epiphyses. Unlike animals, man was able to pierce holes along the entire femur diaphysis, regardless of the thickness of the cortical bone. While puncturing bones, people could choose among significantly more methods than animals, which instinctively always do exactly the same. Therefore, in the case of the artefact, it is easier to substantiate the problematic damage, including the above-mentioned depression near hole no. 3 on the posterior side of the diaphysis. Namely, in its vicinity, there are two parallel micro-scores on the abraded surface of the cortical bone (Figure 5), which could be interpreted as cut marks made by stone tools. These micro-scores are never mentioned by advocates of the carnivore origin of the holes. The possibility that people used a femur, the distal end of which was previously damaged by carnivores, is not ruled out. Regarding the absence of other microscopic traces related to manufacture, they could have been erased due to extremely strong corrosion in the layer comprising the find. Only the more distinct scores were preserved, as well as the dent(s) (pitting after F. d’Errico [18]) made by teeth, which, considering their position, cannot be connected with certainty to the production of holes by compression and piercing with teeth. Due to their orientation and shape, all scores and dents, recognized by d’Errico and colleagues, cannot be attributed to carnivores. Carnivores make scores with their teeth that are perpendicular or slightly oblique to the axis of the diaphysis. They are not able to make a score subparallel to the axis of the diaphysis with their bites [10] (Figure 9 from Reference [10]). Some of the dents must have been made by corrosion, which was not considered by d’Errico and colleagues [39]. At least one longitudinal score could be a tool mark.

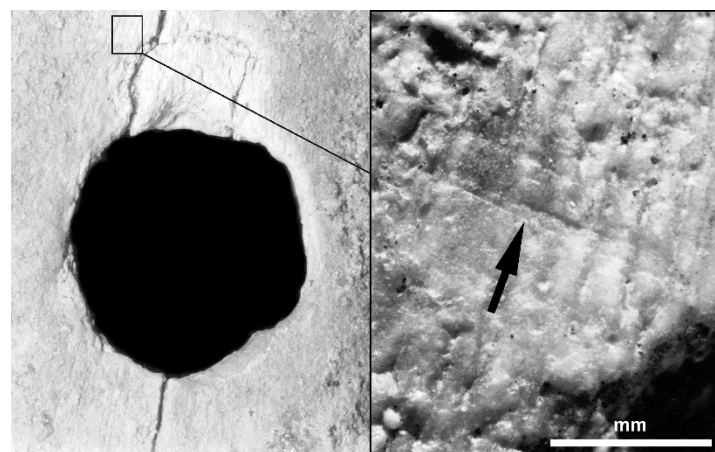


Figure 5. Depression near hole no. 3 on the posterior side of the diaphysis and location of two parallel micro-scores on the abraded surface of cortical bone (marked with an arrow) (ZRC SAZU, Archive of Institute of Archaeology).

The strongest argument for the thesis that, the DB perforated femur is indeed a deliberately crafted musical instrument, comes from experimental musical research on a reconstructed find. It was determined that the artificially transformed juvenile diaphysis is ideal in shape and length for the performance of music using a special playing technique [36,37]. Following the directions of I. Turk [22], in 2010, the missing parts, and both partial holes of the original, were reconstructed on the left cave bear juvenile femur of the size of the original (Figure 6). Due to practical reasons, the mouthpiece of

the reconstructed musical instrument was made on the straight edge of the widened part of medullary cavity. This edge fits lips better than the edge of the narrowed part. Later, professional musician L. Dimkaroski established that on the original, the remnant of the straight part of this edge is bevelled on both sides of the cortical bone and could as such function as the perfected cutting edge of the mouthpiece [37]. Considering the position of the edge of the mouthpiece and torsion of the diaphysis, the diaphysis of the left femur is also handier for a right-handed musician, while a right femur diaphysis would be more suitable for a left-handed player. All contemporary music genres can be played on the thus reconstructed musical instrument. The comparative acoustic analysis and tests revealed its great musical capability. With a musical capability of $3\frac{1}{2}$ octaves [37] (a CD in the appendix), the reconstructed musical instrument from Divje babe I surpasses the musical capability of reconstructed Aurignacian osseous wind instruments, made from the bones of large birds [38,46,47].



Figure 6. Reconstruction of the Neanderthal musical instrument from Divje babe I. The reconstructed parts are in white plaster. The position of the bevelled cutting edge of the mouthpiece is marked by an arrow (photo Tomaž Lauko, NMS).

4. Conclusions

If the holes on femur no. 652 are not equated with the obvious and frequent impressions of teeth, i.e., punctures with the impressed cortical bone [16] (Figure 4: 9b–11b; Figure 7: 2b from Reference [16]) – on meta- and epi-physes from cave bear sites, as is done by d’Errico and some of his adherents, the find does not have a suitable comparison in collections of pierced limb bones of cave bear [16,48]. The exception is the diaphysis of a juvenile femur with three holes from the Aurignacian cave site Istállóskő in Hungary [6,49], which is currently not considered to be a potential musical instrument, due to numerous more convincing new finds of Aurignacian wind instruments in cave sites of the Swabian Jura [50] and the French Pyrenees [51].

Currently, this unique find fulfils all conditions on the basis that it can be defined as the oldest known musical instrument. These are: clear archaeological and stratigraphic context [44], dating [8,9,11], explanation of manufacturing [21], musical verification [36,37], ([47] (p. 458), contra [19] p. 55), and good comparisons in later periods [52]. In a preserved state, the find is not suitable for playing music. Playing was enabled by the reconstruction based on concrete data and the well-founded assumption that the reconstructed parts were removed by a wolf, prior to cementation. Similarly damaged is the Upper Palaeolithic musical instrument from the loess layer in the open-air site Grubgraben (Austria) [52]

(Figures 2 and 3 form the Reference [52]). Due to the fine texture of the loess, the damage on the Grubgraben flute could have occurred exclusively prior to its inclusion into the sediment. Presumably, it was damaged by a wolf occasionally feeding on the remains of the prey of Palaeolithic hunters.

The find of the Mousterian musical instrument from DB has certain advantages in relation to other, declaratively the oldest similar instruments from the sites in the Swabian Jura, in regards to context, stratigraphy, reconstruction, and morphometric characteristics. The context and stratigraphy, supported by indirect ^{14}C AMS, U/TH, and ESR dates [8,9,11], are indisputable because the find, firmly cemented into the breccia, could not move within the sediment or be mixed with older finds due to detected gaps in sedimentation. One of them occurred above the cemented part of layer 8, where the musical instrument was found [53]. The leading Aurignacian artefact – the point with the split base – found in the youngest Pleistocene combined layer 2–3, two metres higher, enables the cultural paralleling of Aurignacian level with sites of the Swabian Jura and simultaneously indisputably proves the greater relative age of specimen no. 652, in comparison to the finds of musical instruments in the Swabian Jura and elsewhere [50].

The reconstruction of the DB musical instrument is more reliable than the reconstructions of Swabian finds, in which either the length or the mouthpiece are not preserved [46,47,50,54]. The morphometric characteristics of the DB musical instrument are such that, even on the basis of physical laws, despite the smaller length, they enable a greater musical capability in comparison to Swabian finds. Excuses of everything being dependent on the interpreter are only partly valid. This has also been confirmed by the unpublished musical experiments of professional musician L. Dimkaroski (personal communication) with the replica of Swabian wind instrument GK 1 and comparative acoustic calculations of F. Z. Horusitzky [38] for Swabian instruments GK 1 and GK 3.

The musical instrument from Divje babe I, which predates 50 ka, firmly supported with a Mousterian (Neanderthal) context and chronology, remains the strongest material evidence so far for Neanderthal musical behaviour. According to the present knowledge and archaeological context of the find, there are no obstacles for the find to be interpreted as a Neanderthal musical instrument.

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