

Peer Review Information

Journal: Nature Ecology & Evolution

Manuscript Title: A 51,000 year old engraved bone reveals Neanderthals' capacity for symbolic behavior

Corresponding author name(s): Thomas Terberger, Dirk Leder

Editorial Notes:

Reviewer Comments & Decisions:

Decision Letter, initial version:
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2nd December 2020

*Please ensure you delete the link to your author homepage in this e-mail if you wish to forward it to your co-authors.

Dear Dirk,

Your manuscript entitled "A decorated bone from Einhornhöhle (Germany) shows Neanderthals' capacity for modern human behaviour" has now been seen by three reviewers, whose comments are attached. The reviewers have raised a number of concerns which will need to be addressed before we can offer publication in Nature Ecology & Evolution. We will therefore need to see your responses to the criticisms raised and to some editorial concerns, along with a revised manuscript, before we can reach a final decision regarding publication.

In particular, additional microscopic imaging as recommended by reviewer 2 would be welcome if possible.

We therefore invite you to revise your manuscript taking into account all reviewer and editor comments. Please highlight all changes in the manuscript text file [OPTIONAL: in Microsoft Word format].

We are committed to providing a fair and constructive peer-review process. Do not hesitate to contact us if there are specific requests from the reviewers that you believe are technically impossible or unlikely to yield a meaningful outcome.

When revising your manuscript:

* Include a "Response to reviewers" document detailing, point-by-point, how you addressed each reviewer comment. If no action was taken to address a point, you must provide a compelling argument. This response will be sent back to the reviewers along with the revised manuscript.

* If you have not done so already please begin to revise your manuscript so that it conforms to our Article format instructions at <http://www.nature.com/natecolevol/info/final-submission>. Refer also to any guidelines provided in this letter.

* Include a revised version of any required reporting checklist. It will be available to referees (and, potentially, statisticians) to aid in their evaluation if the manuscript goes back for peer review. A revised checklist is essential for re-review of the paper.

Please use the link below to submit your revised manuscript and related files:

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Note: This URL links to your confidential home page and associated information about manuscripts you may have submitted, or that you are reviewing for us. If you wish to forward this email to co-authors, please delete the link to your homepage.

We hope to receive your revised manuscript within four to eight weeks. If you cannot send it within this time, please let us know. We will be happy to consider your revision so long as nothing similar has been accepted for publication at Nature Ecology & Evolution or published elsewhere.

Nature Ecology & Evolution is committed to improving transparency in authorship. As part of our efforts in this direction, we are now requesting that all authors identified as 'corresponding author' on published papers create and link their Open Researcher and Contributor Identifier (ORCID) with their account on the Manuscript Tracking System (MTS), prior to acceptance. ORCID helps the scientific community achieve unambiguous attribution of all scholarly contributions. You can create and link your ORCID from the home page of the MTS by clicking on 'Modify my Springer Nature account'. For more information please visit www.springernature.com/orcid.

Please do not hesitate to contact me if you have any questions or would like to discuss these revisions further.

We look forward to seeing the revised manuscript and thank you for the opportunity to review your work.

[REDACTED]

Reviewer expertise:

Reviewer #1: Neanderthal archaeology

Reviewer #2: bone artefacts and cut mark analysis

Reviewer #3: radiocarbon dating

Reviewers' comments:

Reviewer #1 (Remarks to the Author):

REVIEW

A decorated bone from Einhornhöhle (Germany) shows Neanderthals' capacity for modern human behaviour

Summary

This paper presents original research in the form of data from an excavation outside a cave in Germany, including new radiocarbon measurements and in particular a modified bone artefact older than any known Homo sapiens occupation.

On that basis it is proposed to be of Neanderthal authorship, and additionally is claimed to be an intentionally decorated object intended for visual display.

The authors give limited background on the history of the cave, which has previously seen informal digging, excavation several decades ago, and renewed research in the past six years. They also contextualise evidence for Neanderthal non-functional or aesthetic objects.

The majority of the article is focused on the archaeological context, dating and description of a Megaloceros phalange which shows anthropic modifications. There is also a section detailing experiments undertaken marking cow bones of varying condition using lithic tools, to assess similarity to the archaeological artefact and the possible time taken for production.

The article concludes with a quite lengthy discussion on the symbolic context in Late Pleistocene Europe, consideration of evidence proposed to support a decorative intention for the markings on the modified bone. There is also discussion of a theory that particularly unusual conditions in NW Europe stimulated the development of various technological innovations as well as the claimed symbolic purpose of the bone.

Specific comments (please see marked PDF also)

I congratulate the authors on their fieldwork and research, and the following lengthy critical comments are made with the intention to help the paper stand more robustly both in terms of data presented, but in particular the proposed interpretations.

The artefact is clearly quite unique for the Middle Palaeolithic, whatever the origin of the modifications, but as the authors are aware, claiming symbolic or aesthetic elements in Neanderthal material culture is complicated and open to justifiable scepticism. I think in this case it is better to simply present the object and its context (with the improvements I suggest in terms of giving as much detail as possible) and avoid discussing decoration, symbolism or other loaded terms explicitly. The object is not in an ideal archaeological context, but it is directly dated and clearly has been modified in a way which does not resemble 'traditional' butchery traces. Therefore the key discussion should be on the nature of the marks themselves, and attempting to show that a functional situation would be unlikely to create them. At present I think this aspect needs further work.

The discussion on possible special significance of NW Europe I think is not useful for this paper, which should be primarily descriptive, and therefore if this material was removed and left to a later paper,

there would be more room for the suggestions I make below.

Taphonomy and context

The taphonomic context of the bone is not especially clear. How far did the roof-fall cover the modern excavated zone?

More detail on the history of casual digging at the site is required, in terms of ensuring that the cave entrance area where the object comes from was in-situ. Did casual excavation happen in that area, or largely inside the cave? How much sediment is believed to have been removed, and how? Was it mostly overlying deposits, or was there disturbance into the layers containing technologically-Middle Palaeolithic lithics? Additionally, since the cited references for the 1980s are in German, it would be useful to have a more detailed description of the works undertaken and findings.

Page 3, line 98 states that the cave mouth layer 4.5 probably correlates to an excavated layer inside the cave; it would be useful to have sedimentological support for this, if available.

The claim that the modified bone is probably from a relatively undisturbed context is difficult to see support for, since the inclination data in SI Figure 7 appears to show that this is a pocket of more horizontal objects, while when viewed in plan, directly adjacent to the bone objects are oriented quite differently. Some clarification of this would be beneficial; were textural differences visible in sediment during excavation? How does all this affect where the modified or other bones come from, in relation to a possible Neanderthal occupation of the cave? Are they being argued as in-situ from an exterior occupation in the cave mouth, or are they derived?

Page 4, line 100 onwards: some more details on the contents of layer 4.5 are necessary. How many bones, what density, what condition, what percentage butchered, any refits? The same for the lithics, and in particular some images of these should be included, even if they are undiagnostic (rather than those from inside the cave). What does the taphonomy of the bone and lithic assemblage indicate about the formation of layer 4.5?

Page 5, line 111 onwards: The association of the deer bones, cave bear bones and the incised bone are not entirely clear from the photographs including SI Figure 8; if there are any photographs of the bone in situ that would be beneficial to see. SI Figure 4 has a photograph and the caption refers to the "projected location" of the bone, does this mean it was not recovered in-situ?

When examined in detail the "projected location" also appears to place it well above the other bones, and potentially in a different, greyer layer with more stony inclusions. This might be an artefact of the red circle's placement on the photograph, but given the scale it is not easy to see, and a more detailed context would be good to see photographically. Ideally also a more detailed drawn plan, which presumably is available from the excavation records.

While the details of radiocarbon dating are out of my area of expertise, it is unusual to have so many different laboratories involved for such a small number of dates. An explanation of why this is the case would be useful, as while it can potentially provide validation, this is only the case if samples from the same object are dated by different laboratories. Otherwise, the possibility of different dating processes may be an issue. This should be clarified, with the reason for the different laboratories explained.

Bone markings

While the presence of anthropic incisions on the phalange is clearly demonstrated, asserting that they are a coherent decorative design is not clearly supported.

The word "motif" (first use page 1, line 11) is quite loaded as it presupposes a design that links to a

wider graphic tradition or context. Similarly “decoration” (first use page 1, line 12) in this context is problematic. “Modified” or “incised” are more neutral.

The ordering of the markings in Figure 3 is not obviously supported; there appears to be overlap/overmarking which it would be beneficial to explore further. For instance, based on the available images the line currently numbered “3” appears to potentially cut over “5” but perhaps not “4”, while the termination of line “2” also appears to cut into “4”. The incisions “3” and “6” additionally appear significantly different, removing more material and more like thinning/shaving than a linear engraved.

More detail on the proposed different tools/gestures involved in producing the flat vs. stepped edges of the cuts would be beneficial. Is it possible for example to quantify the sequence, the number of tool changes, this is indeed created by different tools? Other cases where this kind of analysis has been attempted includes the incised hyaena bone from Les Pradelles (cited in the paper). Related to this, before I read the text I looked at the images, my impression of the marks is not that they were engraved, but chopped at an angle. Would this potentially explain the apparent difference in texture between the surfaces parallel to the bone surface, and the vertical edges described as ‘stepped’?

Page 5, line 140 onwards: more data on the rest of the surface of the bone would be useful, relating to SI Figure 9 (which perhaps should be in the main article, not the Supporting Information). It is stated that there is no usewear/polish, however SI Fig 9 shows “old surface abrasion”- some clarification of what that means and macro images would be useful, since it apparently overlies two of the cut areas. Additionally, more details on the postdepositional alterations and modern damage marked in SI Fig 9 are necessary: what are the proposed processes for the ancient alterations? How did the modern damage occur? How do they impact on the anthropic markings?

Experiments

Experimental work is a positive addition, however in this case the impression is that they start out by assuming the marks were engraved as decoration and attempting to replicate them, rather than attempting to disprove they are unintentional modifications with a practical explanation. This is a key aspect to consider when dealing with controversial objects, and in particular material attributed to Neanderthals.

Further experiments should be undertaken to explore if there is any way to produce the marks by using a phalange as an anvil, a processing surface to chop other materials etc.

The experiments show that when carving bone, softening is beneficial. But to demonstrate that artefact itself was prepared prior to markings being made, it is also necessary to examine the state of the bone itself: is it possible to see a general consistency difference from being boiled on the surface or broken interior, for example? Is there any usewear showing other alteration, similar to scraping preparation done for Middle Palaeolithic bone retouchers.

The relevance of the data on blade usewear used for carving (SI Table 4) is unclear, since there are no archaeological lithics being compared with.

Intepretation

More explanation of why this object cannot be regarded as having any practical explanation would be

worthwhile. For example, is it possible that the phalange was used as a small anvil for chopping another substance?

Additionally, I am not sure that the basal lines in themselves support the interpretation that the phalange was intended to be stood up on the base.

What is the evidence for the phalange being from a butchered carcass? Are there other cut-marks from this?

Page 9, line 236 onwards: In particular the discussion of a potential anthropomorphic interpretation of the markings does not add anything to the text (since it is not supported by analysis and then rejected) and should be removed.

Page 10, line 251-2 and subsequent discussion to line 264, plus Figure 4; I do not think the claim of a "unique cluster" of archaeological features in this region is really supported, since the record from many regions contains 'unique' aspects simply because of the sparsity of the record. Similarly, I do not think a claim that there is something special about this region based on it being particularly challenging makes sense either, given the time span of the references and objects cited, plus the existence of "cultural novelties" elsewhere in Europe from the same wide time period (including birch tar actually being demonstrably older in Italy). This argument does not add to the substance of the paper or the significance of the object and I think it should be removed.

General

Page 1, line 7: It's perhaps better to avoid "modern humans" as the term is rather loaded and non-specific, and state at the outset something like early Homo sapiens.

SI Figure 7: clarify the Y axis scale on the profile image; is this half metres? Also a scale on the lower plan image would be useful; are the squares 1m?

SI Table 7 : perhaps better not to suggest "jewellery" as the category since many of the publications involved don't make such an explicit claim. Also, it might be worth distinguishing between Châtelperronian contexts and those that are Middle Palaeolithic.

CONCLUSION

This paper is worthy of publication *with the suggested significant modifications*, which I hope will make the presentation of the object and its significance stronger and clearer.

Review signed by Rebecca Wragg Sykes in support of open peer review.

Reviewer #2 (Remarks to the Author):

This is a very interesting paper, which could have repercussions for our understanding of the behavioural capability of the last Neanderthals. Because of its importance, the date of the specimen is the crucial factor in this paper. I am not expert in radiocarbon dating and, as such, I can't enter too much into the merits of the validity of the dates suggested by the authors. I'm sure another reviewer may be more suitable in considering this issue. To my knowledge, the detection limit for radiocarbon dating is ~ 47,000BP. This would imply that the specimens dated beyond 47,000 years old, are 'at least' 47,000 years old. However, for the decorated giant deer phalanx the authors give a 'precise' radiocarbon age of 47.8 +2.8/ -2.1 ka BP. Little discussion is present in the supplementary

information files to understand how reliable these dates are, and yet this is paramount in the interpretation of the engraving. I think more details are needed, including a discussion of the reliability of these results.

The engraved specimen

I can however offer some specific comments concerning the engraving of the specimen itself. The engraved specimen is described well and clearly, and I agree with the authors' conclusion. There are no doubts the engraving is genuine and in consideration of its shape, form and location, it can only be attributed to an artistic representation. However, I think the paper could be improved by presenting some further results:

- There are no SEM images of the engraving, or 3D Focus Variation microscope images. These would have given a better understanding of the way the engravings were performed as well as the tools used during the process. Direct comparisons with the numerous cut marks present on bones at the site would also highlight the differences between butchery marks and engravings. Both cut marks and engraved grooves would benefit from better micro-images (notably SEM) to show these differences. These are all lacking from the paper, including the supplementary information, where only CT renders and CT scans of the engraved specimen are presented.

- The authors conclude that 'The use of a giant deer phalanx – a very impressive herbivore – as raw material underlines the special character of the item making symbolic meaning very likely'. What is the frequency of giant deer compared to other animals at the site? Were giant deer uncommon? This would strengthen the hypothesis of the selection of a 'special' animal as well as strengthen the artistic and symbolic meaning of the engraved specimen. If other giant deer phalanges are present at the site, it would also be useful to present comparisons of CT scans of an unmodified specimen next to the engraved one. This would allow to better understand how much of the cortical surface of the engraved bone has been modified or removed during engraving.

- Finally, concerning the engraving itself, I'm also not convinced that all engravings were produced in one single incidence and as a continuous action. Is it not possible that each groove was engraved at different times? I suggest this is given further consideration, as very little discussion is presented in this regard.

Experiments and comparison with fossil specimen.

I found it very useful that the authors added to the fossil description a detailed experimental work to better understand how the grooves were made, and what state of preservation the bone was in when it was engraved.

These are some suggestions to further improve this part:

- The conclusions presented by the authors about the feasibility of cutting a dry/fresh/partially fleshed bone in different conditions are interesting, but slightly limited. Not many studies have been dedicated to the analysis of cut/engraved bone in different states of 'freshness', but some literature could be of interest and should possibly be mentioned and used to extend the conclusions already presented by the authors:

Kooi, R.J., Fairgrieve, S.I., 2013. SEM and stereomicroscopic analysis of cut marks in fresh and burned bone. *J. Forensic Sci.* 58 (2), 452–458.

Wallduck R. and Bello S.M. 2018. Cut mark micro-morphometrics associated with the stage of carcass decay: a pilot study using three-dimensional microscopy. *Journal of Archaeological Science: Reports* 18: 174-185.

- The authors state: 'A test of soaking bone in water to soften the cortical surface thus enabling an easier carving process was unsuccessful - after the bone was submerged for six weeks under water, the cortical surface was just as hard as in the beginning'. How was hardness determined? Were incisions made before and after soaking the bone? There are no details of this component of the experiment anywhere else in the manuscript. More information could be useful to demonstrate what were the conditions of the bone when it was engraved.

Method.

The authors refer to 'microscopic inspections other than CT scan'. I don't know what these refer to, as I could only notice the presence of macro-photos, but not SEM or the use of other micro-imaging techniques of analyses (which, as I suggest above, should be added to the paper). There is no explanation of how measurements of the grooves (e.g. depth, length) were obtained. Overall, more details of the techniques of analyses used should be added to the supplementary information, as these are very limited in this section.

Minor comments:

- Although well written, in places the English needs some improvement and editing. For example, at page 4 line 195 'the engraved second giant deer phalanx' should be 'the engraved giant deer second phalanx'.
- Page 6 line 154: '(2) what are the best conditions to carve these grooves (time,..)'. I assume the authors mean 'time after the death of the deer'? Whatever 'time' refers to, this should be clarified.
- There are some minor inconsistencies in the format of the references that need to be addressed.
- SI figure 4: To make it clearer I would suggest the authors add arrows or letters/numbers corresponding to 'the partially articulated red deer bones and horizontal calccrete slabs in layer 6 (mid-left) and the almost horizontal bovid bone in layer 4.5 (foreground right)'. I would also recommend to add the names/numbers of the layers on the photo.

Reviewer #3 (Remarks to the Author):

This is an important paper describing the discovery of a very interesting decorated bone from a site in Germany called Einhornhöhle. The authors have described the material very well and undertaken a careful analysis. Despite an experimental section that isn't at all strongly based around experimental protocols such as hypothesis or blind testing the overall paper is convincing enough and I suggest that the paper is accepted with minor revisions.

The chronological support for the piece being around 51,000 years old is convincing. I would suggest, however, that there is a strong likelihood that the age is actually beyond 50,000 cal BP, because the direct date, despite being finite, is clearly at or very near the radiocarbon limit. We must remember that 1 in 20 dates of material that is beyond radiocarbon background will generate a finite age. The totality of the dating evidence suggests it is very likely to be greater than 50 ka BP. In line 13 where

the authors say "The find is directly dated to ~51,000 years before present and the age is confirmed by further radiocarbon dates." I would suggest that it should say "The find is directly dated and, along with the other radiocarbon dates that are beyond the radiocarbon limit, suggests strongly that the artefacts dates to at least 51,000 years ago".

Line 74: This sentence containing "...is situated along the northern boundary of the Neanderthal habitat", I felt needed some additional context. What do the authors mean by 'habitat' here? Is it an ecological term, describing a specific environmental niche, or does it refer to the distribution that is known at the time, or times? Some clarification is needed.

I am confused as to the method regarding how the samples were calibrated in the Supplementary. The authors say "Minimum ages (e.g >45 ka BP) have been calibrated applying 1 ka standard deviation". Could they be more specific?

Line 82: Please use 'period' as in Tertiary Period.

Line 176-7:

"Nine samples from layer 4.5 and layer 6, mostly obtained from humanly modified bones including the decorated item and charcoals, were submitted for radiocarbon dating". Can the authors be more specific here and say how many were humanly modified? As it is one has to check in Supp. Table 6 for this information.

Page 11 in the Supplementary, note the spelling:

The bone was sampled for aDNA analyses.

*****END*****

Author Rebuttal to Initial comments

Responses to reviewers 1-3

We would like to thank the reviewers for their detailed and helpful comments on our manuscript. Please find our responses to the problems addressed in the following.

Reviewer #1 (Remarks to the Author)

Specific comments

The artefact is clearly quite unique for the Middle Palaeolithic, whatever the origin of the modifications, but as the authors are aware, claiming symbolic or aesthetic elements in Neanderthal material culture is complicated and open to justifiable scepticism. I think in this case it is better to simply present the object and its context (with the improvements I suggest in terms of giving as much detail as possible) and avoid discussing decoration, symbolism or other loaded terms explicitly.

Response/ action taken: While such terms represent commonly used vocabulary in archaeology, we are aware that some authors/readers have reservations towards such 'loaded terms'. Therefore, we have largely replaced them with more neutral terminology throughout the text. On the other hand, we would like to avoid complete neutralisation of explicit terms in order to sustain a meaningful context particularly for non-archaeologists who will be less aware of 'loaded' terms specific to the discipline. As we demonstrate the regular spaced and similar incisions are carved and have no accidental origin.

The object is not in an ideal archaeological context, but it is directly dated and clearly has been modified in a way which does not resemble 'traditional' butchery traces. Therefore the key discussion should be on the nature of the marks themselves, and attempting to show that a functional situation would be unlikely to create them. At present I think this aspect needs further work.

Response/ action taken: we improved the text (see manuscript, Line 167 onwards, and Figures 3 and 4). In addition, our experiments have shown that creating the observed incisions necessitates time-intensive cutting and scraping actions, thus applying different techniques and gestures (see manuscript, Line 224 onwards). The observed incisions are remarkably different to the impacts potentially experienced by chopping or hammering motions (Supplementary information - METHODS – Experiment - Rational).

The discussion on possible special significance of NW Europe I think is not useful for this paper, which should be primarily descriptive, and therefore if this material was removed and left to a later paper, there would be more room for the suggestions I make below.

Response/ action taken

Reviewed and changed. We reviewed and moved this part to the Supplement Information to provide regional context (Supplementary information - RESULTS – Regional context).

Taphonomy and context

The taphonomic context of the bone is not especially clear. How far did the roof-fall cover the modern excavated zone?

Response/ action taken: we improved the text on this point (Manuscript, line 96 onwards, and line 99 in particular)

More detail on the history of casual digging at the site is required, in terms of ensuring that the cave entrance area where the object comes from was in-situ. Did casual excavation happen in that area, or largely inside the cave? How much sediment is believed to have been removed, and how?

Response/ action taken: the former cave entrance was not affected by earlier diggings.

Previous excavations occurred inside the cave. We improved the text accordingly (Manuscript, line 96 onwards, and Supplementary Text – RESULTS – Site Information).

Was it mostly overlying deposits, or was there disturbance into the layers containing technologically-Middle Palaeolithic lithics? Additionally, since the cited references for the 1980s are in German, it would be useful to have a more detailed description of the works undertaken and findings.

Response/ action taken: We followed your advice and improved the text ((Manuscript, line 96 onwards, and Supplementary Text – RESULTS – Site Information).

Page 3, line 98 states that the cave mouth layer 4.5 probably correlates to an excavated layer inside the cave; it would be useful to have sedimentological support for this, if available.

Response/ action taken: The correlation of Layer 4.5 at the former cave entrance and layer B inside the Jacob-Friesen Gallery is supported by similar sedimentary characteristics (grain-size distribution, pH, and mineral content). We improved the text (Manuscript, line 106 onwards) and the SI (Supplementary Text – RESULTS – Sediment analyses, last paragraph).

The claim that the modified bone is probably from a relatively undisturbed context is difficult to see support for, since the inclination data in SI Figure 7 appears to show that this is a pocket of more horizontal objects, while when viewed in plan, directly adjacent to the bone objects are oriented quite differently. Some clarification of this would be beneficial; were textural differences visible in sediment during excavation? How does all this affect where the modified or other bones come from, in relation to a possible Neanderthal occupation of the cave? Are they being argued as in-situ from an exterior occupation in the cave mouth, or are they derived?

Response/ action taken: We added more detailed information on the find situation and the context (manuscript, line 127 onwards; Supplementary Text – RESULTS – Site information, last paragraph; Supplementary Text – RESULTS – Inclination and orientation; Supplementary Figure 8).

Page 4, line 100 onwards: some more details on the contents of layer 4.5 are necessary. How many bones, what density, what condition, what percentage butchered, any refits? The same for the lithics, and in particular some images of these should be included, even if they are undiagnostic (rather than those from inside the cave). What does the taphonomy of the bone and lithic assemblage indicate about the formation of layer 4.5?

Response/ action taken: More detailed information on the finds / faunal remains from the layers 6 and 4.5 the human impact have been added (manuscript, line 109 onwards; SI Figures 2, 6, 7, and 9; SI tables 1 and 2; SI Methods and SI Results on faunal remains).

Page 5, line 111 onwards: The association of the deer bones, cave bear bones and the incised bone are not entirely clear from the photographs including SI Figure 8; if there are any photographs of the bone in situ that would be beneficial to see. SI Figure 4 has a photograph and the caption refers to the "projected location" of the bone, does this mean it was not recovered in-situ?

Response/ action taken: We have now indicated the position of the engraved bone in SI Fig 9 and added the total station coordinates in SI Methods – Inclination and Orientation.

Comment: As these photos were taken in an oblique angle right under the cave roof (see FIG 2; SI Fig 4), the position remains approximate. The incised bone was deposited "near the western section" that is pictured in Figure 2, about 10 cm east of it. Therefore, the find can only be "projected" onto the profile in accordance with the acquired total station data. All single finds and samples were 3D-recorded by total station as a standard procedure (SI Methods – Inclination and Orientation), but not every bone was photographed during excavation. The incisions on the engraved bone were discovered during post-excavation cleaning as we have pointed out (see text old version, line 141).

When examined in detail the “projected location” also appears to place it well above the other bones, and potentially in a different, greyer layer with more stony inclusions. This might be an artefact of the red circle’s placement on the photograph, but given the scale it is not easy to see, and a more detailed context would be good to see photographically. Ideally also a more detailed drawn plan, which presumably is available from the excavation records.

Response/ action taken: It is unclear what is meant by “the other bones” as bones were found above and below the engraved item (Figs. 2; SI Figs. 4 and 8). More contextual information is now provided (manuscript, line 128 onwards, also see Figure 2) and the total station coordinates added in SI Methods – Inclination and Orientation.

While the details of radiocarbon dating are out of my area of expertise, it is unusual to have so many different laboratories involved for such a small number of dates. An explanation of why this is the case would be useful, as while it can potentially provide validation, this is only the case if samples from the same object are dated by different laboratories. Otherwise, the possibility of different dating processes may be an issue. This should be clarified, with the reason for the different laboratories explained.

Response/ action taken: In our opinion, the involvement of different laboratories improves the reliability of the obtained results. Charcoal dates were produced in Poznan, that was selected due to previous experience with that lab. Poznan laboratory is well-established and is reliably working for many years now. Bones were generally dated at the CIO (Groningen) for the same reason and the long standing experience in the pre-treatment of bone samples. The same can be said for CEZA Mannheim. The incised item was dated at the Leibniz lab Kiel by one of us (MH) and the samples were taken together with one of the responsible archaeologist and corresponding authors (TT). The sampling was performed in the lab and the pre-treatment, as well as, the dating was conducted by MH as a senior researcher with a long standing experience in sample/ bone pre-treatment and radiocarbon dating (Huels et al. 2017).

Bone markings

While the presence of anthropic incisions on the phalange is clearly demonstrated, asserting that they are a coherent decorative design is not clearly supported.

Response/ action taken: Here we would respectfully like to disagree, and refer to the arguments outlined in our manuscript, some improved. There are three regularly spaced incisions on each side (Figure 2), the incisions meet at similar angles of 90-100° (line 148 onwards), they differ significantly from well-known cut-marks (line 167 onwards), and we find no support for a practical use (line 174 onwards). The regular spacing of the incisions of two

interlinked line sets (line 187), the two techniques necessary to create such markings (experiment, micro-traces SI text), as well as, the pre-treatment likely necessary to handle these bones (experiment, SI text) and the time likely spent to create each incision (about 11 mins, experiment) are further arguments. Some of the arguments were summarized in the discussion (manuscript, line 283 onwards).

The word “motif” (first use page 1, line 11) is quite loaded as it presupposes a design that links to a wider graphic tradition or context. Similarly “decoration” (first use page 1, line 12) in this context is problematic. “Modified” or “incised” are more neutral.

Response/ action taken: The term “motif” is now replaced by “pattern”; “decoration” is now largely replaced by incised, engraved, modified, and the like. But we see good arguments to interpret the complex incisions of the *Megaloceros* phalange as a decoration (see comment above).

The ordering of the markings in Figure 3 is not obviously supported; there appears to be overlap/overmarking which it would be beneficial to explore further. For instance, based on the available images the line currently numbered “3” appears to potentially cut over “5” but perhaps not “4”, while the termination of line “2” also appears to cut into “4”.

Response/ action taken: We improved the text on this point and provide information on the order of the incisions (manuscript, line 151 onwards).

The incisions “3” and “6” additionally appear significantly different, removing more material and more like thinning/shaving than a linear engraved.

Response/ action taken: We previously addressed the limitations of lines 3 and 6 in the manuscript (old version, line 128) and provided supportive imagery (SI Figure 3). However, we now added a figure in the text (new text version, Figure 4) and a more detailed Supplementary Figure (SI Figure 12) to provide further illustration. While line 6 is too incomplete to permit any inferences as to the applied carving techniques, the observed horizontal surface compares well with horizontal surfaces achieved during the experiment (line 244 onwards). The same is true regarding the vertical edge of line 3 while the horizontal plain appears quite distort (line 243 onwards, Figures 4 and 5, SI Figure 12). The observed ripples of this horizontal plane have not been replicated during our experiment and thus might indicate a different technique or tool responsible for the deep incision (line 243 onwards).

More detail on the proposed different tools/gestures involved in producing the flat vs. stepped edges of the cuts would be beneficial. Is it possible for example to quantify the sequence, the

number of tool changes, this is indeed created by different tools? Other cases where this kind of analysis has been attempted includes the incised hyaena bone from Les Pradelles (cited in the paper).

Response/ action taken: We added line 206 onwards, line 232 onwards and Figure 5 to the manuscript that explain and visualise the cutting and scraping gestures, micro-traces and some information on tool changes (SI Table 6). Also see SI Figure 13, showing experimental setup and illustrating gestures. Further information are given in the SI-Results-Experiment-Blades section.

Comment: The mentioned hyena bone from Les Pradelles comprises shallow, short (c. 3 mm max. length) incisions that are thought to have been made with a single flint blade due to their similarities in section and shape. Importantly, the marks are small enough that a single blade could have made them all before becoming blunt. The markings on the Einhornhöhle bone, however, are significantly larger and deeper. Indirect evidence that multiple blades would have to have been used comes from our experiment: the replica blades wore down so quickly that it would have been impossible to make all incision without changing/retouching the blade. The other possible identifier mentioned in that paper (or rather the supplementary material) are internal striation patterns within the incision that we also see in three incisions of the Eihornhöhle item (Figure 5 and SI Figure 14, line 232 onwards)

Related to this, before I read the text I looked at the images, my impression of the marks is not that they were engraved, but chopped at an angle. Would this potentially explain the apparent difference in texture between the surfaces parallel to the bone surface, and the vertical edges described as 'stepped'?

Response/ action taken:

This was our first guess too, however, chopping as a high-energy-impact technique can be expected to cause compaction of bone tissue that would have been visible at least at the base of each mark. No such compaction has been observed, neither during stereo-microscopy, nor micro-CT scan analysis, nor 3D digital microscopy.

Given the small size of the incisions (15-30 mm in length, 2-5 mm deep) a very small, but heavy tool would have to be used. It is highly unlikely, that such regular spaced incisions of similar type are created by chopping on a phalanx c. 6 cm long. By applying controlled experiments we were able to replicate the observed surface modifications only by the techniques described in the text (see Supplementary Figure 11).

We improved the text and provide additional information (SI Methods- Experiment-Rational).

Page 5, line 140 onwards: more data on the rest of the surface of the bone would be useful, relating to SI Figure 9 (which perhaps should be in the main article, not the Supporting Information). It is stated that there is no usewear/polish, however SI Fig 9 shows “old surface abrasion”- some clarification of what that means and macro images would be useful, since it apparently overlies two of the cut areas. Additionally, more details on the postdepositional alterations and modern damage marked in SI Fig 9 are necessary: what are the proposed processes for the ancient alterations? How did the modern damage occur? How do they impact on the anthropic markings?

Response/ action taken: We have now added 3D microscopy images (Figure 4) and improved SI Figure 10. We improved the SI text accordingly and provide detailed information on post-depositional alterations and carnivore bite marks (SI-Results-The incised giant deer second phalanx-Postdepositional alterations). The only modern damage observed on the modified bone is a linear scratch likely caused by an excavation tool. While post-depositional alterations thus left different localised traces on the item, the overall patterning of the incisions remains clear and the corpus of surfaces, profiles, and work traces forming these lines, particularly those of lines 1-2 and lines 4-5, are well visible. The modified bone's state of preservation is comparable to other bones from the same layer (layer 4.5; SI-Table 2). Human agency may account for some of the observed surface rounding and micro chipping in the case the item had been carried around or worn for an extensive period, before it was deposited. Alternatively, rounding and chipping might have been caused by weathering, sediment pressure and/or trampling (manuscript lines 184 onwards and 246 onwards).

Experiments

Experimental work is a positive addition, however in this case the impression is that they start out by assuming the marks were engraved as decoration and attempting to replicate them, rather than attempting to disprove they are unintentional modifications with a practical explanation. This is a key aspect to consider when dealing with controversial objects, and in particular material attributed to Neanderthals.

Response/ action taken: We carefully checked the possibility of an origin by unintentional modifications (manuscript, line 167 onwards). The observed incisions significantly differ from well-known unintentional modifications. Cut-marks created with flint tools usually create incision depths well under <100 µm while the incisions of the modified giant deer second phalanx are by a 10 to 50-fold magnitude deeper (Figure 4). Furthermore, typical cut marks lack a horizontal plane adjacent to the vertical cut that is however a standard feature of all incisions on the modified item (Figure 3). We improved the text to make this point more clear (manuscript, line 167 onwards).

We also provided imagery of some typical cut-marks on bones from the former cave entrance (Supplementary Figure 7), showing their apparent different character. For these reasons, we decided to refrain from additional experiments to “disprove” that the marks were not created in that fashion. Also, see previous remarks on the potential use as chopping surface.

Our experiment was not designed to confirm or disprove a hypothesis, but rather to gather empirical data and experiences from which we can draw conclusions about how the incisions could have been made. That our interpretations may be correct is supported by a) the feasibility of our proposed methods and b) the morphological similarities between the original and replica marks (especially the stepped flanks; SI Figure 14). In theory we could design further experiments to get more precise data on (for example) how long exactly a single flint blade would last or if different lithic blades have faster/slower carving times. At this stage and for our purpose, i.e. to show approximately how these markings could have been made and how long it could have taken, our experiments should suffice.

Further experiments should be undertaken to explore if there is any way to produce the marks by using a phalange as an anvil, a processing surface to chop other materials etc.
Response/ action taken: Further experiments will always be beneficial, yet see our argument above. The specifically mentioned uses as an “anvil” or a “processing surface to chop other materials”, however, seem extremely unlikely as we have pointed out above in the manuscript (line 174; see Domínguez-Rodrigo & Barba 2006, Alunni et al. 2005, Lewis 2008 for chopping/hacking marks with different tools).

The experiments show that when carving bone, softening is beneficial. But to demonstrate that artefact itself was prepared prior to markings being made, it is also necessary to examine the state of the bone itself: is it possible to see a general consistency difference from being boiled on the surface or broken interior, for example? Is there any usewear showing other alteration, similar to scraping preparation done for Middle Palaeolithic bone retouchers.

Response/ action taken: A small number of studies that aimed to differentiate between boiled and unboiled bones have been conducted to date showing that this is all but trivial (e.g. Solari et al. 2015, Pijoan et al. 2007; Munro et al. 2007; Roberts et al. 2002). Particularly, in regards to bones that were exposed to temperatures $\leq 100^{\circ}\text{C}$ (boiled) for a relatively short time period (≤ 9 hrs), an array of physiochemical analyses is needed to acquire any results. Therefore, we decided to refrain from such analyses until comparative data is more robust and less invasive methods become available.

The relevance of the data on blade usewear used for carving (SI Table 4) is unclear, since there are no archaeological lithics being compared with.

Response/ action taken: (now SI Table 6) The table provides information on the blades we used for the experiment, which is necessary in order to make the experiment replicable.

Basic information on the created wear marks is provided for future experiments and comparisons. Flint is a commonly used raw material in Palaeolithic Europe, so our experimental data will allow for easy comparisons by future works. Some more info on the lithics from the cave and cave entrance is now added (manuscript, line 100 onwards; SI Results-Site Information; SI Methods-Experiment; and SI Fig 2; see above).

Interpretation

More explanation of why this object cannot be regarded as having any practical explanation would be worthwhile. For example, is it possible that the phalange was used as a small anvil for chopping another substance?

Response/ action taken: This point was raised earlier and has been addressed now in the text (manuscript, line 174 onwards) and in further comments/additions above.

Additionally, I am not sure that the basal lines in themselves support the interpretation that the phalange was intended to be stood up on the base.

Response/ action taken: This will ultimately depend on the perception of the individual observer and thus should remain open to debate. There is little doubt that this part of the bone is altered by the regular lines and this is a further argument for an intentional design of the modifications of the bone.

What is the evidence for the phalange being from a butchered carcass? Are there other cut-marks from this?

Response/ action taken: We improved the text and provided additional imagery from a nearby unmodified second phalanx (manuscript, line 183; SI-Results- The incised giant deer second phalanx-*Chaine opératoire*; SI Results – Fauna and taphonomy; SI Figure 6 and SI Table 1). We cannot exclude that either phalanx might have been collected. Recent studies have shown, however, that putrefying liquids on decaying bones limit the efficacy of cutting (Wallduck & Bello 2018). Further faunal remains of *Megaloceros* found in the same layer argue for a hunted individual, but both actions collecting raw material and hunting involve behavioural premeditation.

Page 9, line 236 onwards: In particular the discussion of a potential anthropomorphic interpretation of the markings does not add anything to the text (since it is not supported by analysis and then rejected) and should be removed.

Response/ action taken: We reviewed this part and decided to remove it from the text.

Page 10, line 251-2 and subsequent discussion to line 264, plus Figure 4; I do not think the claim of a “unique cluster” of archaeological features in this region is really supported, since the record from many regions contains ‘unique’ aspects simply because of the sparsity of the record. Similarly, I do not think a claim that there is something special about this region based on it being particularly challenging makes sense either, given the time span of the references and objects cited, plus the existence of “cultural novelties” elsewhere in Europe from the same wide time period (including birch tar actually being demonstrably older in Italy). This argument does not add to the substance of the paper or the significance of the object and I think it should be removed.

Response/ action taken: Reviewed and changed. We reviewed and moved this part to the Supplement Information to provide regional context (Supplementary information - RESULTS – Regional context).

General

Page 1, line 7: It's perhaps better to avoid “modern humans” as the term is rather loaded and non-specific, and state at the outset something like early *Homo sapiens*.

Response/ action taken: "modern humans" has been replaced by *Homo sapiens* in the text.

SI Figure 7: clarify the Y axis scale on the profile image; is this half metres? Also a scale on the lower plan image would be useful; are the squares 1m?

Response/ action taken: "m ü NN" is now replaced by "m asl", so that the scale should be clear. Additionally, the figure caption now specifies the plan grid represents 1 m² squares.

SI Table 7: perhaps better not to suggest “jewellery” as the category since many of the publications involved don't make such an explicit claim.

Response/ action taken: replaced with "personal ornaments"

SI Table 7: Also, it might be worth distinguishing between Châtelperronian contexts and those that are Middle Palaeolithic.

Response/ action taken: changes have been made.

Reviewer #2 (Remarks to the Author)Radiocarbon dating

To my knowledge, the detection limit for radiocarbon dating is ~ 47,000BP. This would imply that the specimens dated beyond 47,000 years old, are 'at least' 47,000 years old. However, for the decorated giant deer phalanx the authors give a 'precise' radiocarbon age of 47.8 +2.8/ -2.1 ka BP. Little discussion is present in the supplementary information files to understand how reliable these dates are, and yet this is paramount in the interpretation of the engraving. I think more details are needed, including a discussion of the reliability of these results.

Response/ action taken: We added further information in the SI-Methods-Radiocarbon samples-Leibniz Labor Kiel.

As a common procedure results were corrected for isotope fractionation and for process blanks. The final sample ^{14}C concentration is related to the hypothetical atmospheric value in 1950. On average, normal carbon-sized bone background samples give apparent ^{14}C concentrations around 0.2 ± 0.07 pMC (percent Modern Carbon), equivalent to 49,800 ^{14}C years BP. After blank correction, sample KIA 55192 gave a radiocarbon concentration of 0.26 ± 0.08 pMC, equivalent to a finite radiocarbon age of 47800 +2800/-2100 BP. The Leibniz Labor Kiel delivers age estimates that well-compares to other established laboratories, namely CIO (Groningen) and ORAU (Oxford University), which underscores the reliability of the obtained finite radiocarbon age for the incised bone (Huels 2017).

The engraved specimen

However, I think the paper could be improved by presenting some further results: There are no SEM images of the engraving, or 3D Focus Variation microscope images. These would have given a better understanding of the way the engravings were performed as well as the tools used during the process.

Response/ action taken: We have performed additional 3D digital microscopy and added images in Figures 4-5 and SI Figure 12. Additional information on micro-traces are presented and potential tool/gestures discussed (manuscript, line 232 onwards).

Direct comparisons with the numerous cut marks present on bones at the site would also highlight the differences between butchery marks and engravings. Both cut marks and engraved grooves would benefit from better micro-images (notably SEM) to show these differences. These are all lacking from the paper, including the supplementary information, where only CT renders and CT scans of the engraved specimen are presented.

Response/ action taken: We previously provided macro-images of typical cut marks on bones from Einhornhöhle's cave entrance (SI Figure 7) and have now added 3D digital microscopy images (Figures 4-5, SI Figure 12) and added information (manuscript, line 167), highlight significant differences between the observed incisions and well-known unintentional modifications (e.g. butchering marks, trampling marks; e.g. Boschin & Crezzini 2011; Courtnya et al. 2020; Domínguez Rodrigo et al. 2012). Incisions of the modified giant deer second phalanx are by a magnitude of 10x to 50x deeper than cut-marks created with lithic tools (Figure 4, SI Figure 12). Furthermore, typical cut marks lack the horizontal plane adjacent to the vertical cut that is a distinctive feature of the incisions on the modified item. As the characteristics of cut and trampling marks are rather well-established by experimental studies and they significantly differ from those observed on the modified item, we decided not to go into depth about the cut-marks of Einhornhöhle's fauna.

The authors conclude that 'The use of a giant deer phalanx – a very impressive herbivore – as raw material underlines the special character of the item making symbolic meaning very likely'. What is the frequency of giant deer compared to other animals at the site? Were giant deer uncommon? This would strengthen the hypothesis of the selection of a 'special' animal as well as strengthen the artistic and symbolic meaning of the engraved specimen.

Response/ action taken: We added further information on the frequency of species in layer 6 and 4.5 (manuscript, line 113 onwards; SI Table 6; SI Table 1). Giant deer (*Megaloceros giganteus*) is represented by two phalanges and ten teeth, which is not surprising given the small size of the excavated volume in layer 4.5 (c. 1 m³). We mention and reference in the text (manuscript, line 183), that the special character of the modified item is underlined by the paucity of giant deer north of the Alps around 55-35,000 BP (Lister & Stuart 2019).

If other giant deer phalanges are present at the site, it would also be useful to present comparisons of CT scans of an unmodified specimen next to the engraved one. This would allow to better understand how much of the cortical surface of the engraved bone has been modified or removed during engraving.

Response/ action taken: Another giant deer second phalanx was retrieved during last year's excavation and was recently made available after conservation (SI Results – Fauna and taphonomy). Both specimens are now presented in a single image (SI Figure 6) permitting direct comparison.

Finally, concerning the engraving itself, I'm also not convinced that all engravings were produced in one single incidence and as a continuous action. Is it not possible that each

groove was engraved at different times? I suggest this is given further consideration, as very little discussion is presented in this regard.

Response/ action taken: We improved the text on this point (SI-Results-The incised giant deer second phalanx-Chaine opératoire) and took a longer time span into consideration. Both options are possible, however the regular character of the incision in our view favours a short time span and/ or the performance by a single person.

Experiments and comparison with fossil specimen

The conclusions presented by the authors about the feasibility of cutting a dry/fresh/partially fleshed bone in different conditions are interesting, but slightly limited. Not many studies have been dedicated to the analysis of cut/engraved bone in different states of 'freshness', but some literature could be of interest and should possibly be mentioned and used to extend the conclusions already presented by the authors:

Kooi, R.J., Fairgrieve, S.I., 2013. SEM and stereomicroscopic analysis of cut marks in fresh and burned bone. *J. Forensic Sci.* 58 (2), 452–458.

Wallduck R. and Bello S.M. 2018. Cut mark micro-morphometrics associated with the stage of carcass decay: a pilot study using three-dimensional microscopy. *Journal of Archaeological Science: Reports* 18: 174-185.

Response/ action taken: We thank the reviewer for the comment and references. We added information on previous experiments in the manuscript and SI (manuscript, line 221 onwards; SI-Results-The incised giant deer second phalanx-Chaine opératoire; SI-Results-Experiments, last paragraph). The paper by Kooi and Fairgrieve is less relevant to our study as it deals with burning bones after incisions were made. We further agree with the reviewer that comparable studies are sparse and we believe that our study will add useful data to the topic.

The authors state: 'A test of soaking bone in water to soften the cortical surface thus enabling an easier carving process was unsuccessful - after the bone was submerged for six weeks under water, the cortical surface was just as hard as in the beginning'. How was hardness determined? Were incisions made before and after soaking the bone? There are no details of this component of the experiment anywhere else in the manuscript. More information could be useful to demonstrate what were the conditions of the bone when it was engraved.

Response/ action taken: We expanded the text in the SI (SI Methods – Experiment-Rational). All in all no difference in hardness could be detected. Other experiments have shown that water submersion only works to soften thin or fragmented bone pieces, up to a maximum

thickness of 2.5 mm (e.g. Osipowicz 2007; Newcomer 1976), whereas the engraved item is up to 39.9 mm thick.

Method

The authors refer to 'microscopic inspections other than CT scan'. I don't know what these refer to, as I could only notice the presence of macro-photos, but not SEM or the use of other micro-imaging techniques of analyses (which, as I suggest above, should be added to the paper). There is no explanation of how measurements of the grooves (e.g. depth, length) were obtained. Overall, more details of the techniques of analyses used should be added to the supplementary information, as these are very limited in this section.

Response/ action taken: Stereomicroscopy was performed using a ZEISS Stemi 305 Greenough stereo microscope (SI Methods-fauna and taphonomy). We have now performed 3D digital microscopy and added text and images (manuscript, line 232; Figures 4-5 and Supplementary Figure 10). The chapter on methods and the technologies applied has been considerably improved (manuscript, line 317 onwards; SI Methods-3D digital microscopy).

Minor comments

Although well written, in places the English needs some improvement and editing. For example, at page 4 line 195 'the engraved second giant deer phalanx' should be 'the engraved giant deer second phalanx'.

Response/ action taken: we corrected the text accordingly.

Page 6 line 154: '(2) what are the best conditions to carve these grooves (time,...)'. I assume the authors mean 'time after the death of the deer'? Whatever 'time' refers to, this should be clarified.

Response/ action taken: i.e. carving time, the time spent to create the incisions. We improved the text (manuscript, line 197; SI-Methods-Experiment; SI Table 5).

There are some minor inconsistencies in the format of the references that need to be addressed.

Response/ action taken: We checked the references and made changes where necessary.

SI figure 4: To make it clearer I would suggest the authors add arrows or letters/numbers corresponding to 'the partially articulated red deer bones and horizontal calcrete slabs in layer 6 (mid-left) and the almost horizontal bovid bone in layer 4.5 (foreground right)'. I would also recommend to add the names/numbers of the layers on the photo.

Response/ action taken: This was done now, and info was added in the caption of SI figure 4.

Reviewer #3 (Remarks to the Author):

The chronological support for the piece being around 51,000 years old is convincing. I would suggest, however, that there is a strong likelihood that the age is actually beyond 50,000 cal BP, because the direct date, despite being finite, is clearly at or very near the radiocarbon limit. We must remember that 1 in 20 dates of material that is beyond radiocarbon background will generate a finite age. The totality of the dating evidence suggests it is very likely to be greater than 50 ka BP. In line 13 where the authors say "The find is directly dated to ~51,000 years before present and the age is confirmed by further radiocarbon dates." I would suggest that it should say "The find is directly dated and, along with the other radiocarbon dates that are beyond the radiocarbon limit, suggests strongly that the artefacts dates to at least 51,000 years ago".

Response/ action taken: We improved the text accordingly (manuscript, line 13, line 30, line 257 onwards, and in line 279).

Line 74: This sentence containing "...is situated along the northern boundary of the Neanderthal habitat", I felt needed some additional context. What do the authors mean by 'habitat' here? Is it an ecological term, describing a specific environmental niche, or does it refer to the distribution that is known at the time, or times? Some clarification is needed.

Response/ action taken: We improved the text (manuscript, line 21, 77, SI-Results-Regional context).

I am confused as to the method regarding how the samples were calibrated in the Supplementary. The authors say "Minimum ages (e.g >45 ka BP) have been calibrated applying 1 ka standard deviation". Could they be more specific?

Response/ action taken: We improved the text on the calibration in the Methods (manuscript, 356 onwards). We calibrated infinite ages for comparative reasons. To provide minimum age estimates of infinite dates, a theoretical standard deviation of 1,000 radiocarbon years was computed for every infinite date in OxCal. For graphic illustrations the calibrated age ranges were consequently cut off at the minimum-age-boundary, e.g. at 47,000 cal BP for a radiocarbon date >45,000 BP (Supplementary Figure 15).

Line 82: Please use 'period' as in Tertiary Period.

Response/ action taken: changed to 'Tertiary Period'.

Line 176-7: "Nine samples from layer 4.5 and layer 6, mostly obtained from humanly modified bones including the decorated item and charcoals, were submitted for radiocarbon

dating". Can the authors be more specific here and say how many were humanly modified?
As it is one has to check in Supp. Table 6 for this information.

Response/ action taken: We improved the text (manuscript, line 251 onwards): "Nine samples from layer 4.5 and layer 6 were submitted for radiocarbon dating consisting of three charcoal samples, two non-modified bones, three cut-marked bones, and the engraved giant deer phalanx ..."

Page 11 in the Supplementary, note the spelling: The bone was sampled for aDNA analyses.

Response/ action taken: corrected.

Decision Letter, first revision:

8th March 2021

Dear Dirk,

Thank you for submitting your revised manuscript "A decorated bone from Einhornhöhle (Germany) shows Neanderthals' capacity for modern human behaviour" (NATECOLEVOL-201011972A). It has now been seen again by the original reviewers and their comments are below. The reviewers find that the paper has improved in revision, and therefore we'll be happy in principle to publish it in Nature Ecology & Evolution, pending minor revisions to satisfy the reviewers' final requests and to comply with our editorial and formatting guidelines.

We are now performing detailed checks on your paper and will send you a checklist detailing our editorial and formatting requirements in about a week. Please do not upload the final materials and make any revisions until you receive this additional information from us. I just want to mention now the question about terminology raised by reviewer 1--i.e. "decorated" versus other options, e.g. "modified". I wonder if you would consider "engraved" as a compromise since it has more functional connotations while still clearly linked to art and symbolic behaviour. I would also recommend removing "modern human behaviour" from the title as this feels a bit dated, especially because your work is directly demonstrating that symbolic behaviour is not the preserve of "modern humans". We can discuss this some more, but I would suggest a title change to something like "A 51,000 year old engraved bone reveals Neanderthals' capacity for symbolic behavior"

Thank you again for your interest in Nature Ecology & Evolution. Please do not hesitate to contact me if you have any questions.

[REDACTED]

Reviewer #1 (Remarks to the Author):

I thank the authors for addressing the vast majority of my suggestions for improving the manuscript. My only remaining request, which I do think is important, is to change the title of the paper from "decorated" to "modified", for the reasons I discussed in my previous review.

"Decorated" implies an intention to embellish the surface for a primarily visual, 'beautifying' or other aesthetic effect, and this is not demonstrated. The alterations could equally be instead relating to some kind of information content, or possible with an unknown ergonomic function. Therefore I think "modified" or other terms describing the technique of modification are more appropriate, such as "engraved"/"carved".

Reviewer #2 (Remarks to the Author):

The authors has followed the reviewers comments, and I think the paer is now much improved and ready for publication.

Reviewer #3 (Remarks to the Author):

I am satisfied with the authors responses to my comments and questions. I have read the revised manuscript and it is much improved and clear. I think that it makes a really important contribution and I am happy to recommend publication in its current state.

Our ref: NATECOLEVOL-201011972A

11th March 2021

Dear Dr. Leder,

Thank you for your patience as we've prepared the guidelines for final submission of your Nature Ecology & Evolution manuscript, "A decorated bone from Einhornhöhle (Germany) shows Neanderthals' capacity for modern human behaviour" (NATECOLEVOL-201011972A). Please carefully follow the step-by-step instructions provided in the personalised checklist attached, to ensure that your revised manuscript can be swiftly handed over to our production team.

Please get in contact with us immediately if you anticipate it taking more than two weeks to submit these revised files.

When you upload your final materials, please include a point-by-point response to any remaining reviewer comments.

If you have not done so already, please alert us to any related manuscripts from your group that are under consideration or in press at other journals, or are being written up for submission to other journals (see: <https://www.nature.com/nature-research/editorial-policies/plagiarism#policy-on-duplicate-publication> for details).

In recognition of the time and expertise our reviewers provide to Nature Ecology & Evolution's editorial process, we would like to formally acknowledge their contribution to the external peer review of your manuscript entitled "A decorated bone from Einhornhöhle (Germany) shows Neanderthals' capacity for modern human behaviour". For those reviewers who give their assent, we will be publishing their names alongside the published article.

Nature Ecology & Evolution offers a Transparent Peer Review option for new original research manuscripts submitted after December 1st, 2019. As part of this initiative, we encourage our authors

to support increased transparency into the peer review process by agreeing to have the reviewer comments, author rebuttal letters, and editorial decision letters published as a Supplementary item. When you submit your final files please clearly state in your cover letter whether or not you would like to participate in this initiative. Please note that failure to state your preference will result in delays in accepting your manuscript for publication.

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Reviewer #2:

Remarks to the Author:

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Reviewer #3:

Remarks to the Author:

I am satisfied with the authors responses to my comments and questions. I have read the revised manuscript and it is much improved and clear. I think that it makes a really important contribution and I am happy to recommend publication in its current state.

Manuscript: NATECOLEVOL-201011972A
Author: Thomas Terberger, Dirk Leder
Article type: Article

The Title proposed below has been edited to comply with our formatting requirements and improve the accessibility of your work. Titles should not exceed characters (including spaces) or contain punctuation. Please update the Title in your manuscript files accordingly. Note that further minor changes may be made during the production process, and you will be able to check these in the proofs.

Title:

A 51,000 year old engraved bone reveals Neanderthals' capacity for symbolic behavior

Abstract:

The Early Upper Palaeolithic of Europe is well-known for its remarkable symbolic expressions which demonstrate the capacity of early Homo sapiens for abstract thinking, storytelling, and communication by symbols and adornment. By contrast, the capacity for advanced technology and modern cultural behaviour in (late) Neanderthals is commonly perceived as limited despite recently accumulating evidence to the contrary. Here we report on the discovery of an incised bone item from recent excavations at Elnhörnöhle in the Harz Mountains (northern Germany) that is engraved with stacked-offset chevrons. The find is directly dated to at least 51,000 years before present and the age is confirmed by further contextual radiocarbon dates. These early dates assign the bone item to late Neanderthals and predate any known Homo sapiens presence in Central Europe. Experimental studies suggest that the bone was probably treated before carving. The small excavation area produced cut-marked bones while diagnostic Middle Palaeolithic stone artefacts are present within a few meters distance inside the cave. For the first time, we successfully directly dated a carved item of Middle Palaeolithic origin and our findings show that expressions of symbolic behaviour were part of Neanderthals' behavioural repertoire before early Homo sapiens arrived in Central Europe. While located at the northern boundary of the world inhabited by Neanderthals, northern Central Europe has produced exceptional finds such as wooden weapons, bone tools, adhesives, and now evidence for Neanderthal symbolic behaviour, demonstrating elaborate skills and cognitive abilities in pre-Homo sapiens hominins.

Your paper will be accompanied by the editor's summary below. Please let us know if there are any inaccuracies.

Editor's Summary:

The authors report an incised giant deer phalanx (toe bone), directly radiocarbon dated to at least 51,000 years old. The age and context of the object suggests that it was engraved by Neanderthals.

Additional Abstract Requests:

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The following changes to the author list have been made since the initial version of manuscript was submitted:

Added: **Andrea Tröller Reimer, Tim Koddenberg**

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Final Decision Letter:

7th May 2021

Dear Dirk,

We are pleased to inform you that your Article entitled "A 51,000 year old engraved bone reveals Neanderthals' capacity for symbolic behavior", has now been accepted for publication in Nature Ecology & Evolution.

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