

Haruhiro Fujita, Toru Miyao, Hironori Imai, Hiroyuki Sasaki, Yew Kwang Hooi and Simon Kaner (2025) Analysis of Sensory Impression Factor Structures of Jomon Potteries through a Semantic Differential Method Viewing 3D Models on MR equipment. Zenodo, ver.3 peer-reviewed and recommended by PCI Archaeology <https://doi.org/10.5281/zenodo.14788676>

E. Bruner (2023). Cognitive Archaeology, Body Cognition, and the Evolution of Visuospatial Perception. Elsevier Science & Technology, San Diego, United States

Charles E. Osgood, George J. Succi and Percy H. Tannenbaum (1957). The measurement of meaning, Urbana, vol. IL, University of Illinois Press.

Reviews

Evaluation round #3

Reviewed by [Lizzie Scholtus](#) , 03 February 2025

This third version of the manuscript is much more effective. The introduction is well constructed, defining what Jomon ceramics are, why they are interesting for research into perception in archaeology and in what contexts the SDM method has already been applied. The section on the research question provides a clear understanding of what is at stake in this article. In addition, the conclusion has been rewritten to leave more room for a description of the results, what they contribute to research into perception and how they might be used, as well as the method, in the future.

The addition of illustrations of the different pots used in the experiment enables the reader to understand and follow the participants' responses. The presence of the data and analysis files also means that the methodology can be followed with precision.

In conclusion, the article is coherent from beginning to end, clear and precise thanks to the addition of numerous references and I think this paper can now be accepted (I just noticed a few minor typos like double spaces).

Evaluation round #2

DOI or URL of the preprint: <https://doi.org/10.5281/zenodo.13846760>

Version of the preprint: 2

Authors' reply, 02 February 2025

Dear recommenders,

Upon the comprehensive recommendations and instructions to revise the first version of manuscript, I made major revisions on

- 1 clear conclusion
- 2 discussions
- 3 references

Thank you for your all supports provided

Decision by [Mathias Bellat](#) , posted 28 October 2024, validated 28 October 2024

As said before, this preprint shows an innovative concept and possible future application, and I would strongly recommend it.

Most of the problems highlighted during the first revision were taken into account, which improved the quality of the preprint.

- If the methodological part or its general structure is now clearer, some sentences and words need to be rewritten for clarity. More broadly, the pre-print could be greatly improved with the help of a native English speaker writer.
- The conclusion lacks a clear focus on "What are the major findings of this research?".
- Both reviewers highlighted an interest in having the experiment results in supplementary material.
- Some references are lacking and have to be added as suggested by the reviewers.
- In general, care has to be taken regarding the figure's legend and position during the final layout rendering.

Overall, the second version of the pre-print shows major improvement and is almost suitable for recommendation.

Before being accepted, we ask for a minor revision of the preprint.

Reviewed by [Lizzie Scholtus](#) , 24 October 2024

The authors have addressed most of the issues raised in the previous review. The introduction now recontextualises the project in the context of archaeological research and provides a better understanding of the aims of this paper. The new section on the issues also provides a clearer understanding of the aims of the study. I also appreciate the improvement in the presentation of the experimental protocol.

Some parts of the paper are still a bit blurry. The part Future Studies is written as if all the different analysis that it presents are already done and I don't really understand why they are then "future" studies. I also think it's a problem that this section is more developed than the discussion section. The entire article would also benefit from proofreading by a native English speaker. There are some problems with the position of the figures but I am sure that this will be fixed on a later stage.

There were no supplements with this new submission, I would really like to have a display of the different pots with their names to be able to understand the results and clearly see which ones are the Okinohara and Umataka potteries.

In conclusion, with the explanation of a research question, the project described here is even more interesting. Once again I think that the methodology developed to allow a group of participants to interact with an archaeological object and then record their impression are really innovative and could contribute a lot to the study of perception and cognitive archaeology. The minor suggestions described above would help to make it clearer for everyone.

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Reviewed by [Alphaeus Lien-Talks](#) , 15 October 2024

Summary: The manuscript presents an innovative study on how museum visitors perceive Jomon pottery using modern technological methods, such as Mixed Reality (MR) with Microsoft HoloLens and the Semantic Differential (SD) technique. The authors investigate sensory impressions of pottery, applying factor analysis to group adjectives and uncover key impression factors like "vigor," "attractiveness," and "surface smoothness." The study is a valuable contribution to the field of museum studies and cognitive archaeology, exploring new

ways of interpreting historical artifacts through modern sensory and cognitive science techniques. Title and Abstract Does the title clearly reflect the content of the article? Yes

Does the abstract present the main findings of the study? Yes Introduction Are the research questions/hypotheses/predictions clearly presented? Yes

Does the introduction build on relevant research in the field? Yes Materials and Methods Are the methods and analyses sufficiently detailed to allow replication by other researchers? Yes

Are the methods and statistical analyses appropriate and well described? Yes Results In the case of negative results, is there a statistical power analysis (or an adequate Bayesian analysis or equivalence testing)? N/A

Are the results described and interpreted correctly? Yes Discussion Have the authors appropriately emphasized the strengths and limitations of their study/theory/methods/argument? Yes

Are the conclusions adequately supported by the results (without overstating the implications of the findings)? No (please explain) Strengths:

Innovative Approach: The integration of MR technology (Microsoft HoloLens) for viewing 3D models of pottery is novel and valuable, offering new insights into visitor engagement with ancient artifacts. This approach allows for a more immersive and interactive experience compared to traditional museum exhibits.

Methodological Rigour: The application of the Semantic Differential Method (SD) and factor analysis is sound. The use of a quantitative approach to extract sensory impressions from museum visitors is robust and clearly explained, providing reliable data for analysis.

Clear Results: The factor analysis clearly identifies key factors such as "vigor," "attractiveness," and "surface smoothness," and the variations among the pottery types are presented effectively. These findings offer significant insights into how modern audiences perceive ancient pottery styles.

Interdisciplinary Relevance: The manuscript bridges archaeology, cognitive science, and museum studies, making it relevant across several fields. The use of technology to understand the sensory impressions of museum visitors is a timely contribution, especially as more museums adopt digital tools to enhance visitor experiences. Areas for Improvement: Conclusion:

Issue: The manuscript lacks a dedicated conclusion. This is a critical omission, as the conclusion should tie together the key findings and underscore the implications of the research.

Recommendation: The authors should include a conclusion that summarizes the major findings (e.g., the prominence of "vigor" and "attractiveness" in pottery impressions), reflects on the broader significance of using MR in museum contexts, and highlights the contribution of this study to our understanding of sensory impressions in archaeological and cultural artifacts. Future Research Directions:

Issue: The manuscript touches briefly on future studies but lacks depth in outlining specific research directions.

Recommendation: The authors could expand the section on future research by: Elaborating on how deep learning models could be used to further explore sensory and cognitive responses to pottery, as mentioned in section a of the future studies.

Exploring how gaze-tracking technologies like Apple Vision Pro could provide additional insights into visitor engagement and object perception.

Suggesting broader applications of these methodologies to other types of artifacts or museum collections, thereby expanding the study's relevance beyond Jomon pottery. References:

Issue: The current reference list is strong but could be broadened to include more recent studies on MR technologies in museums and psychological research on art and sensory perception.

Recommendation: Incorporating recent literature on the integration of digital technologies in museums, visitor behavior, and modern sensory studies would strengthen the theoretical foundation of the manuscript and connect it more firmly with current debates in the field. Linking Results to Broader Discussions:

Issue: The results are well-presented, but the manuscript could do more to situate these findings within broader theoretical discussions, such as human cognitive evolution, cultural transmission, and the role of artifacts in social memory.

Recommendation: Expanding the discussion to link the sensory impressions of modern visitors with ancient cognitive processes and spatial cognition, as introduced by Kobayashi and others, would deepen the impact of the paper. Drawing connections between the Jomon people's use of pottery and how their cognitive structures might be understood through sensory impressions would provide a richer cultural and anthropological context. Minor Revisions:

Clarification of Terms: Some technical terms, such as "Semantic Differential Method" and "factor analysis," could be explained more clearly for readers who may not be familiar with these methodologies.

Figure Labels: Ensure that all figures (e.g., scree plots and factor score variations) are clearly labeled and referenced in the text, enhancing the reader's ability to follow the analysis. Conclusion: Overall, this manuscript makes a significant contribution to the study of sensory impressions in museum contexts and the use of modern digital technologies to understand historical artifacts. It is methodologically sound, with a novel approach and clear results. However, the lack of a conclusion and the need for more detail in the discussion of future research leave room for improvement. Expanding on these aspects will elevate the paper's impact and relevance. I recommend the manuscript for publication after these revisions.

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Evaluation round #1

DOI or URL of the preprint: <https://doi.org/10.5281/zenodo.12660533>

Version of the preprint: 1

Authors' reply, 27 September 2024

This is the second version of the manuscript, with major revisions.

I dropped all parts on the Microsoft HoloLens technical parts as well as digital museology. I added "future studies" looking "cognitive mind" by deep mind models.

I made all efforts to respond the reviewers comments, but due to the time limit, I would like to submit the latest version to catch up the deadline of recommendation for CAA2024 proceedings.

Thank you for your all support and comments provided

Best regards

Decision by [Mathias Bellat](#) , posted 19 September 2024, validated 19 September 2024

Because this preprint shows an innovative concept and possible future application, I would strongly recommend it.

However, we do not think that this preprint is suitable for scientific publication yet. Both reviewers highlighted two main issues within the preprint.

1. The methodological background is not well explained and needs substantial improvement. Indeed, the final objective of the paper is not well described. Is it a study case of a *HoloLens* or a test of human perception? In the case of the second option, a better presentation of the results from the interviews and perception of people is needed.
2. A small lack of clarity on the methodology part. References can be mixed up, and it is not a very "reader/user-friendly" methodology. As innovative, the approach needs to be well explained in plain words for everybody to understand it.

Before being accepted, we ask for a major revision of the preprint.

The paper presents a new type of analysis based on viewing 3D models and sensory response, which is very interesting and could contribute a lot to the study of perception and cognitive response to material culture. The methodology developed to allow a group of participants to interact with an archaeological object is very interesting. The idea of asking them about their feelings and emotions during these interactions is completely innovative.

However, it lacks a clear focus and a closer link to current archaeological research. While the methodology section goes into detail about the operation and technical aspects of the equipment used to display the 3D models, it is very light on the experimental protocol itself and the statistical analyses carried out.

Finally, the discussion tries to relate the experiment to the cultural heritage context, but doesn't clearly express what the results mean for the museums that seem to be the target of the experiment. This lack of questioning makes it difficult to fully evaluate the results.

The focus of the paper needs to be better defined. Is it an archaeological study of the perception of material culture or a test for Microsoft HoloLens?

• **Title and abstract**

Does the title clearly reflect the content of the article? [X] Yes, [] No (please explain), [] I don't know

Does the abstract present the main findings of the study? [X] Yes, [] No (please explain), [] I don't know

• **Introduction**

Are the research questions/hypotheses/predictions clearly presented? [] Yes, [X] No (please explain), [] I don't know

The research question is not clearly defined in the introduction. Only the last sentence of the introduction could be seen as a research question, but it only states that it is of interest to study "the sensory impressions of modern individuals". What is the aim of the project? What are the research hypotheses? What is the archaeological significance of this study? What is the subject of the work? Some elements of the answer are present in the conclusion, such as the link with museum display, but this needs to be developed in the introduction.

Does the introduction build on relevant research in the field? [] Yes, [X] No (please explain), [] I don't know

The Jomon pottery is nicely recontextualised in the first two paragraphs of the introduction, but its use is not defined until the conclusion. I would also have liked to see some good quality images of them. There are only some poor quality 3D models in the appendix.

The theoretical background is quickly established with the notion of spatial cognition, which could be described a bit more and linked to the project research. It might be interesting to link the paper to some of the previous research in archaeology on perception, cognition and material culture, such as (but it depends on the research question):

• Bruner, E., 2023. *Cognitive Archaeology, Body Cognition, and the Evolution of Visuospatial Perception*. Elsevier Science & Technology, San Diego, UNITED STATES.

• Knappett, C., Malafouris, L. (Eds.), 2008. *Material Agency: Towards a Non-Anthropocentric Approach*. Springer, New York.

• Constant, A., Tschantz, A.D.D., Millidge, B., Criado-Boado, F., Martinez, L.M., Müller, J., Clark, A., 2021. The Acquisition of Culturally Patterned Attention Styles Under Active Inference. *Front Neurobot* 15, 729665. <https://doi.org/10.3389/fnbot.2021.729665>

• **Materials and methods**

Are the methods and analyses sufficiently detailed to allow replication by other researchers? [] Yes, [X] No (please explain), [] I don't know

It is not possible to replicate the analysis. The authors have only provided the data with no explanatory metadata (what do the numbers mean?) and in a format that is difficult to analyse statistically (there seems

to be too much different information per column). Furthermore, there is no script or steps to reproduce the calculations. All we know is that factor analysis was used.

Are the methods and statistical analyses appropriate and well described? Yes, No (please explain), I don't know

The authors spend a lot of time describing the equipment used and all its features, although it doesn't seem to be the most important part of the analysis. If I understand correctly, this HoloLens was used to allow the participant to see the ceramics in the environment, but the main focus of the analysis is their answers to a series of questions described as "The Semantic Differential Method". The explanation of this method is really light and the paper could benefit from more details about it and how the reader can understand the data submitted in relation to this survey. I don't think it is necessary to describe all the sensors on the equipment unless they are part of the results, which they don't seem to be.

The description of the experimental protocol is also limited. How were the participants selected? What is their background? How long were they able to interact with the objects? How were colour blind or visually impaired people treated?

• Results

In the case of negative results, is there a statistical power analysis (or an adequate Bayesian analysis or equivalence testing)? Yes, No (please explain), I don't know

Are the results described and interpreted correctly? Yes, No (please explain), I don't know

The results are well described and illustrated, but there may be a lack of explanation. How are Tables 2 and 3 to be understood? What is a load score?

• Discussion

Have the authors appropriately emphasized the strengths and limitations of their study/theory/methods/argument? Yes, No (please explain), I don't know

These elements are not really part of the discussion. It focuses more on the use of digital objects in the cultural heritage environment than on a real interpretation of the results. This is mainly due to a lack of questions. As the purpose of the study is not defined, it is not possible to argue or conclude on a question.

This section also lacks references. In fact, there are only 7 in the whole article, two of which are links to the Microsoft website and one of which doesn't work.

Are the conclusions adequately supported by the results (without overstating the implications of the findings)? Yes, No (please explain), I don't know

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Reviewed by [Alphaeus Lien-Talks](#) , 15 August 2024

Review of paper title: Analysis of Sensory Impression Factor Structures of Jomon Potteries through a Semantic Differential Method Experiment Utilizing 3D Models on Microsoft HoloLens

Summary: The paper presents a study on the sensory impressions of Jomon pottery, particularly flame-like pots, using a Semantic Differential Method experiment with 3D models viewed through Microsoft HoloLens. The research investigates how modern viewers perceive these ancient artefacts, considering factors like "vigor," "attractiveness," "surface smoothness," and "weight." The study is thorough in its approach, involving a sample of 73 participants who provided feedback on 16 sensory adjectives. The use of mixed reality (MR) technology in this context is innovative and adds a unique dimension to the study of cultural heritage.

Strengths:

Innovative Methodology: The use of Microsoft HoloLens to create 3D holograms of Jomon pottery and assess sensory impressions is an innovative application of MR technology. This approach provides a new way of engaging with ancient artefacts, making the study highly relevant in the context of digital heritage and museum studies.

Comprehensive Analysis: The paper employs a robust statistical approach, using factor analysis and analysis of variance to extract and interpret the sensory impression factors. The identification of distinct factors like

"vigor," "attractiveness," and "surface smoothness" offers a clear understanding of how participants perceive different pottery types.

Cultural and Historical Relevance: The paper successfully ties the sensory impressions of the pottery to their cultural and historical significance, particularly in the context of the Jomon period. This adds depth to the study and makes it relevant to both archaeologists and those interested in cultural heritage.

Technological Integration: The detailed explanation of the HoloLens hardware and its application in the experiment adds a valuable technical dimension to the paper. It demonstrates the potential of MR technology in museum settings, offering practical insights for future applications.

Areas for Improvement:

Clarity in Methodology: While the methodology is innovative, the description of the Semantic Differential Method could be more detailed for readers unfamiliar with this approach. A clearer explanation of how the adjectives were selected and how they relate to the sensory impressions of the pottery would enhance the paper's accessibility.

Discussion on Limitations: The paper would benefit from a more explicit discussion of the limitations of the study. For example, the sample size and the demographic composition of the participants could impact the generalizability of the findings. Addressing these aspects would strengthen the validity of the conclusions drawn.

Investigating the Role of Visual and Aesthetic Characteristics: Future studies should explore how the visual and aesthetic characteristics of MR experiences influence visitor enjoyment and emotional responses in museums. Does the beauty of the MR experience enhance the overall visit, or is its ability to evoke emotions typically associated with physical objects more significant? Additionally, comparing these findings with visitors' reactions to seeing the physical objects themselves would provide insights into the unique contributions of MR to art appreciation.

Specific elements for improvement: see the commented version of the paper.

Overall Evaluation:

The paper is a significant contribution to the field of digital heritage and the study of Jomon pottery. It introduces a novel application of MR technology, offering valuable insights into how modern viewers perceive ancient artifacts. With some improvements in clarity and depth, particularly in the discussion of benefits of the technology, limitations and future directions, the paper could have a substantial impact on both academic research and practical applications in museums.

Recommendation: Accept with minor revisions.

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