
Author's Response to Peer Reviews

Authors' Response to Peer Reviews of "Population Interaction in the Jōmon Society via 3D Data of Human Crania: Geometric Morphometric Study"

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This is the author's response to peer-review reports for "Population Interaction in the Jōmon Society via 3D Data of Human Crania: Geometric Morphometric Study."

results, and better organization of discussion points to avoid redundancy.

Response: We appreciate the supportive and helpful comments. We describe our modifications here.

Round 1 Review

Reviewer R [1]

General Comments

The study [2] is well-structured, with a clear methodological framework and comprehensive statistical analyses. The Discussion effectively integrates archeological, genetic, and environmental perspectives to interpret morphological variation. However, the manuscript could benefit from more concise writing, clearer interpretation of statistical

Specific Comments

Major Comments

1. The principal component analysis results and statistical tests are well-documented but could be better contextualized. Some P values and effect sizes are presented without adequate interpretation of biological significance.

I'd suggest the authors expand on how the observed morphological differences relate to adaptive or demographic processes.

Response: Thank you for the useful comment. We added an explanation from line 22 of page 5 to line 5 of page 6 as follows:

“Typically, previous research employed a traditional biodistance method (eg, Martin 1928 [3]) and statistical differences between morphological biodistances among different populations have been regarded as genetic differences. For example, as stated below, if geographical clines were found in morphological biodistances, it is commonly argued that populations moved in a certain geographical direction.”

2. *The paper frequently repeats the idea of widespread and continuous interactions among Jōmon populations. While important, this could be streamlined for clarity. I'd suggest the authors consolidate similar points in the Introduction, Discussion, and Conclusion to reduce redundancy.*

Response: Thank you for the helpful comment. We tried to reduce the redundancy.

3. *While the study references past research, it would be helpful to explicitly state how this study differs from previous geometric morphometric studies on Jōmon crania. I'd recommend you include a brief section discussing how the current 3D dataset provides new insights compared to traditional biodistance methods.*

Response: We made a relevant subsection in the Introduction (“Previous Research on the Jōmon Population Interaction”) describing how the present research contributes to the previous research.

4. *The Methods mention mirroring and reconstruction of crania but do not address potential biases this may introduce. I'd suggest the inclusion of a statement on limitations associated with missing data and how they were mitigated.*

Response: Thank you for the important suggestion. We added a statement on limitations and how they were mitigated (lines 5-7 of page 11):

“Since this mirroring should include some subjective biases, mirroring was limited to cases with less distorted crania.”

Minor Comments

5. *The Abstract is informative but a bit lengthy. Consider summarizing key findings in fewer words.*

Response: We followed the editorial comment saying, “Although Reviewer R asked for a more concise abstract, this is not in line with journal requirements or expectations, as the abstract can be up to 450 words and should have sufficient information to understand the study as a whole without needing to refer to the main text.”

6. *Some terms like “prognathism,” “biodistance,” and “geometric morphometrics” could be briefly defined upon first mention for clarity.*

Response: We added a brief explanation of these terms as follows:

- prognathism (protrusion of the jaws) (line 22 of page 12).
- biodistance method using distances between specific measuring points (line 23 of page 5).
- The geometric morphometrics of 3D data, which the present research employed and explores shape variations of targeted objects, typically using coordination of landmarks, has gained traction in various fields, extending to objects such as lithics (lines 15-17 of page 7).

7. *Ensure that all figures and tables are referenced in the text where they are discussed. Some figures appear without clear introduction.*

Response: We ensured the points above were addressed.

8. *Check for uniformity in reference formatting, particularly italics in journal names and capitalization.*

Response: We checked and modified the reference formatting.

9. *Some long sentences could be split for better readability (eg, in the Discussion section).*

Response: We tried to split the sentences, especially in the Discussion section.

10. *The Conclusion could briefly outline potential future studies, such as expanding sample sizes or integrating isotopic dietary data.*

Response: We deleted the Conclusion section following editorial guidelines. We made a subsection in the Discussion and stated the future directions and limitations.

This study is well-executed and provides valuable insights into Jōmon population interactions using 3D geometric morphometrics. Addressing the clarity of statistical interpretation, reducing repetition, and improving Discussion structure would enhance its impact. I'd also recommend a final round of proofreading for grammar and formatting consistency.

Response: Thank you again for the helpful comment. We appreciate it.

Reviewer AE [4]

General Comments

This paper studied 3D data of Jōmon and Yayoi cranial series and analyzed them in terms of temporal and geographical variations. While conventional craniometric studies of Jōmon specimens have been much accumulated, almost no comprehensive ones have analyzed both temporal and regional variation at once. In this sense, the approach of this paper is promising. However, I have major reservations regarding the approaches used to achieve this target; the authors' present approach is not able to clarify the smallness or wideness of the temporal and/or regional variation among Jōmon crania. Another major reservation is the data, as the 3D morphology of the Jōmon crania sustains unavoidable destruction and deformation during burial processes; thus, most of them

were manually repaired. The data used in this study did not mention this bias properly.

Response: We appreciate the highly important comments and suggestions. We followed your suggestion, added a comparative analysis between the Jōmon and Yayoi populations, and mentioned some limitations of the present research. Details of the additional analysis and modifications are described below.

Specific Comments

Major Comments

One major reservation is in the analytical design; the present one seems suitable for the study target, which aims to clarify the temporal (between Jōmon phases) and geographical (between regions in Japan) variations of the Jōmon crania. The authors concluded that there were pronounced morphological variations within individual populations versus smaller variations between different phases and geographical regions (from the Abstract). Unfortunately, this seems unclear to me. Probably a reason for this could be the lack of comparative targets. Figures 5 and 6 present the temporal and regional variations along principal component (PC) 1 and PC2 and indicate only regional variations along PC2 as being significant, but this seems too weak for readers to reconfirm the conclusion of smaller temporal and regional variations. In my idea, as the authors perform the geometric morphometric and principal component analysis procedures for all the Jōmon and Yayoi individuals, all the comparisons can include all the subdivisions of the Jōmon and Yayoi. Afterward, readers can understand the temporal variation among Jōmon crania and also compare the degree of variation compared to those of the Yayoi, and the same is the case for the regional variation.

Response: We added some Yayoi populations (especially from the Aoyakamijichi site in the Late Yayoi period of the Sanin region) and conducted the geometric morphometric and principal component analysis for all the Jōmon populations and Yayoi populations. We could not include the Yayoi population from the Early period and from regions other than the Kyushu and Sanin regions because the excavated Yayoi crania are highly concentrated in the Kyushu region and the Aoyakamijichi site is the only exception with more accurate information and 3D data of more than 5 well-preserved individuals excavated. Moreover, many of the cranial samples from the period are collected in the Kyushu University Museum and Nagasaki University and they do not permit anyone to access the 3D data of the collection. We tried to gather and include as many relatively large and well-preserved samples from the Yayoi population as possible.

The results are summarized in Figure 7 and Multimedia Appendix 3. Figure 7 in particular suggests that variations among the Yayoi population are larger than in the Jōmon populations.

Another aspect that needs to be considered is the power of expression in the PC scores. The present analysis almost confines the results to PC1 and PC2 scores, which explain

only 20% of the total variation (Table 2). When we accept the authors' idea of the advantage of 3D geometric morphometric analysis being inclusion of whole cranial morphology, selection and only a portion of the PCs may lead to disadvantages. I do not have any ideas for tackling this problem; the authors should care about this.

Response: We appreciate this highly useful comment. As the editor also gave us a similar point, we mentioned a limitation of and caution regarding the present results in the Discussion section (from line 22 of page 16 to line 3 of page 17) as follows:

“Second, our discussions have focused on PCs with higher than 5 percentages of contribution rate, which covers less than 40 percentages of total cumulative proportions. Although the results of principal component analysis on 3D data typically tend to be dispersed in more PCs [5-7], we should be careful not to overestimate the present results. The question of how frequently the Jōmon people interacted should be explored from more aspects, including quantitative investigations of relevant archeological remains and mathematical simulations or modeling of the Jōmon population.”

One other reservation is about the Jōmon cranial reconstruction. Most of the fragmentary and heavily reconstructed specimens suffered unavoidable skews and deformation. Because most researchers cannot repair the reconstruction, available options are few, but the authors should mention that they care about this bias. I suggest checking for the position in the plot (eg, outlier position) and the degree of preservation.

Response: Thank you for the important comment. We rechecked and recalculated all the data and modified some of the plots. Also, we added an explanation for the selection of samples in lines 12-15 of page 9 as follows: “Although buried crania from the prehistoric period tend to be distorted due to soil conditions, we chose to measure crania that are regarded as less skewed and well-preserved based on their appearance and excavation information.”

Minor Comments

Page 3, lines 3-5. Subdivision of the Jōmon period is usually capitalized (eg, Incipient or Initial Jōmon phases).

Response: We capitalized the subdivisions.

Page 7, line 1. “Facies symphysialis” can be rephrased as “pubic symphyses.”

Response: We modified the expression.

Page 7, line 12. Cranial morphology should be considered as an outcome being affected by many factors; it should not be simplified as “a human trait.”

Response: We changed “human trait” to “human cranium.”

Page 7, lines 18-21. The purpose of the selection of several Jōmon site data for comparison with the Yayoi site is unclear—do you mean site-to-site comparison?

Response: Sorry for the confusion. As the reviewer said, we meant site-to-site comparison here. We conducted the analysis to explore the degree of variation in the individual Jōmon populations. As the reviewer suggested, we added another comparative analysis with some Yayoi populations to explore the interphase and interregion differences among the Jōmon populations (see also the subsection “Comparisons Between the Jōmon Populations and the Yayoi Population” in the Results section). We added an explanation in the Methods section (lines 13-15 of page 12) as follows: “Such comparisons of the Jōmon populations from different phases and regions with the Yayoi population could reveal the degree of variation in the individual Jōmon populations.”

Page 8, line 15. “We also deform a cranium” is better reworded as “We also show deformation patterns of a cranium...”

Response: We reworded the expression as stated in the comment.

Page 8, line 19. “Statistical tests on PCs...no significant differences” test results (Steel-Dwass test?) should be indicated (probably in a table).

Response: We added a supplementary table (Multimedia Appendix 3: Summary of the statistical tests) summarizing the statistical results.

Page 8, line 21. Significant regional differences were found only along the PC2, is that right?

Response: Fewer significant regional differences were also found along the PC4 and mentioned in the text. We reanalyzed and recalculated all of the data, and regional differences were not found in PC1, PC3, and PC5.

Page 37, Figure 7. The legend of the Kuma-Nishioda site should be in the same color.

Response: We modified the Figure following the comment.

Page 37, Figure 7. The plot of Kuma-Nishioda and Nakazuma seems wrong; many individuals were overlapped at the same points among those from the two sites. It is unusual.

Response: We highly appreciate the important comment. We reanalyzed and recalculated all of the data. Some parts of the results shown in Figure 7 were wrong and were modified. Also, as the statistical differences in the PC2 of the temporal comparisons were missed, we added some explanations as follows (lines 7 to 13 of page 13):

“The PCA results, graphically presented in Figures 5 and 6, suggest that the differences between phases are relatively small, in line with the statistical tests on PCs that indicate statistical differences only in the Early and Final ($Z=3.118$, $P=.022$), Middle and Final ($Z=4.233$, $P<.001$), and Late and Final phase ($Z=4.040$, $P=.001$) in PC2, and the Late and Final phase ($Z=2.946$, $P=.038$) in PC4 (see also Multimedia Appendix 2).”

Page 37, Figure 7 and page 7, lines 23-24. Description of the method of the second comparison is unclear. When and from where do you calculate the PC score data in Figure 7? Did you recalculate them based on the selected pairs? The PC1 and PC2 scores of Kuma-Nishioda sites are different from each case of pairs.

Response: We recalculated the data by each comparison. We added more details in the Methods section as follows (in lines 8-9 of page 12):

“Especially, we selected cranial data from Jōmon sites with relatively larger sample sizes to compare the Kuma-Nishioda site. They were compared via PCA [principal component analysis] by each site.”

Page 10, lines 1-2. “Remarkably small interphase differences.” I think the authors should indicate the evidence of the “smallness.” Please see the major comment.

Response: Thank you for the important comment. As the reviewer suggested, we added data from the Aoyakamijichi site of the Late Yayoi period in the Sanin region and conducted an additional analysis between the Jōmon and the Yayoi populations (from the Aoyakamijichi site and the Kuma-Nishioda site of the Middle Yayoi period in the Kyushu region). The results are summarized in Figure 7 and Multimedia Appendix 3 (Summary of the statistical tests), suggesting that variations between the Jōmon populations were relatively smaller than the Yayoi populations, and that individual populations in the Jōmon period were more various than in the Yayoi period.

Page 10, lines 8-9. “Discrepancy may be due to methodological differences...” The authors’ inference seems to have been made without a reason. Please explain the reasons if you have them. The authors wrote “Geometric morphometrics could examine morphological variation as a whole,...” However, they analyzed only portions (PC1-PC5) of the whole variation. If they insist on the methodological superiority of geometric morphometrics including the whole morphological variation, the authors should use higher-order PC scores.

Response: Sorry for the confusion. We did not intend to claim that geometric morphometrics is superior to the traditional biodistance method in that geometric morphometrics could capture all of the variations. What we would like to say is that the traditional biodistance method focuses on each biodistance between specific measuring points, while geometric morphometrics explores the overall variations between each measuring point. In order to avoid such confusion, we deleted the relevant sentence in the Discussion section and modified the explanations in the Introduction as follows (line 23 of page 7 to line 3 of page 8):

“Furthermore, when analyzing the resulting data, geometric morphometrics is able to track morphological variation among configurations of each measuring point at once, whereas the traditional biodistance method compares each measured distance independently. These differences would provide some new insights.”

Round 2 Review

Reviewer AE [4]

General Comments

I read the Word file as the revised one in this revision, not the PDF file, which seems like an older version. After reading the revised version, I could find some revised points and progressed. However, I still have some reservations about the main conclusions on the wide and continuous interaction among temporal and geographical subpopulations of the Jōmon period.

Response: We appreciate for the reviewer's careful reading and important comments and suggestions. We mentioned all the reviewer's concerns and described our modifications in the below response.

Specific Comments

Major Comments

1. The most serious reservations are the main conclusions of the widespread and continuous population interactions in the Jōmon population. The related results are seemingly found in two portions; one is the cranial variations within the Jōmon population and the other is the comparison of those of the Jōmon and Yayoi populations.

As for the former, the authors hypothesized that "If the populations interacted widely and continuously, there should be less morphological differences among different regions and phases, ie, fewer statistically significant differences between each region and phase are found" (page 8). In this context, however, the results indicated that statistically significant differences are found in PC2. The hypothesis was thus rejected at least in the results along PC2. The authors stressed in the results that "there are no significant differences observed in PC1 and PC3, and the regional differences remain relatively limited" (page 14). There seems to be no reason for this statement. In addition, the authors also mentioned in the Discussion section that "the boxplots of PCs in Figure 6 by region, with the exception of PC2, do not exhibit such clear clinical patterns" (page 15). However, this result seems to me to indicate that a clear morphological cline can be found (at least along PC2) in the Jōmon cranial series, as with those previously proposed by traditional biometric studies. In sum, the conclusion of the small regional differences seems much less confident to be accepted.

2. Concerning the temporal differences, I feel the same kind of ambiguity about it. The principal component analysis results seem to indicate that the interphase differences are small. This is correct, but it is also without any confidence. A couple of interphase comparisons are actually significant. In the Discussion section, the smallness of the interphase difference was contrasted with those previously reported claims (page 15). This is also without any confidence.

Response: Thank you for the important comments. Comment 1 and 2 are related, so we responded to them

together here. As the reviewer pointed out, we admit that PC2 indicated spatiotemporal variations with some statistical differences, which is consistent with some previous research. On the other hand, PC1 and other PCs did not. Since the results were mixed, we argued that even though spatiotemporal differences were found, it is possible that they were relatively small. We have modified the Discussion to clarify our intentions as follows:

"The results of the PCA [principal component analysis] presented above were not straightforward. PC2 showed statistically significant spatiotemporal differences between some regions and phases, which was consistent with previous biometric studies claiming interphase variation [8-10] and geographical clines from north to south [9,11-13], although it is difficult to conclude that their differences are pronounced. This is because PC1 did not show any statistical differences, and a similar study of the Kofun period, examining a larger set of 3D data of human crania by geometric morphometrics, exhibited a geological cline in PC1 [6]. Moreover, as mentioned in the Introduction, given the archeological evidence for the spatiotemporal distinctiveness of the Jōmon material cultures, it would also be expected to find statistically significant differences in PC1. Thus, it is possible that the spatiotemporal differences in the Jōmon period were more nuanced or relatively small."

3. In the case of comparisons of Jōmon and Yayoi specimens, the authors hypothesized that "interregion and interphase variations should be lower than the populations from a different period (Yayoi period)" (page 8). In this context, the result in Figure 7 was described as "interregion and interphase variations should be lower than the populations from a different period" (page 14). This description is also without any confidence. The authors should provide several statistical test results to compare the magnitude of interphase and interregion differences among the Jōmon and Yayoi samples.

Response: We added effect sizes between the Yayoi populations and between the Jōmon populations as follows:

Figure 7 showed that the Jōmon populations substantially overlapped, while the Yayoi populations were more scattered spatiotemporally in PC2 and PC3, which was supported by the fact that the effect sizes of statistical tests between the Yayoi populations ($Z/n=.113$ in spatial and temporal comparisons in PC2) were higher than the ones between the Jōmon populations ($Z/n<.055$ in spatial and $Z/n<.029$ in temporal comparisons in PC2) (see Multimedia Appendix 2).

Minor Comments

4. In the Results section of the Abstract (page 3), "individual populations were more than the Yayoi population" is ambiguous. It seems "more variable than...", but it still contradicts the preceding expression of "the Jōmon populations were spatiotemporally less various than the Yayoi populations." When I seek the corresponding lines in the text, they seem to match the site-to-site comparisons in Figure 8. If this is true, it seems to match the line of "the Jōmon individual populations are more various than the Yayoi

population (page 14-15)." If this is the case, the authors' expressions seem wrong. As Figure 8 presents the site-to-site comparison, each circle represents the individual variation within each site. Thus, the correct expression seems to be "individual variation within a site was more variable in the Jōmon site than that of the Yayoi site."

Response: Thank you for the important suggestion. We modified the description as the reviewer suggested.

5. Page 4, lines 17-19. The following expression is not acceptable: "shift in subsistence patterns and significant technological developments...are conspicuously absent in Jōmon society."

Response: We modified the expression as follows:

"However, features such as the emergence of social hierarchies, shifts in subsistence patterns, and significant technological developments commonly seen in other periods were less radical in Jōmon society."

6. Page 7, lines 3 and 5. "Middle" and "late" phases should be capitalized as Middle and Late.

Response: We capitalized them.

7. Page 14, line 23. Please check the site of "Ebishima," which is correct? Is this indicated to Nakazuma?

Response: We think "Ebishima" is correct, which is shown in the upper left of Figure 8.

8. Page 15, line 1. Please describe how to make Figure 9.

Response: We added explanations as follows:

"Figure 9 shows a visual representation of the configurational changes in landmarks for each comparison. The figure was constructed by the *plotRefToTarget* function in the *geomorph* package of R. Straight bars indicated the degree of variation in each landmark."

9. Page 16, lines 3-5. The suggestion of "the morphological and genetic diversity among the Jōmon populations was not relatively limited, but homogeneous across regions and phases" is not understandable.

Response: Sorry for the vague description. We deleted the latter description to make the description more straightforward as follows:

"It suggests that the morphological and genetic diversity among the Jōmon populations were not relatively limited."

10. Page 16, lines 10-11. The expression is not understandable: "The reason why fewer evidence of such a societal changes were found in the Jōmon period is possibly wide and continuous population interactions."

Response: We have clarified the description as follows:

"The reason why less evidence of societal changes such as the occurrence of warfare and emergence of social hierarchies was found in the Jōmon period is possibly because the Jōmon populations interacted widely and continuously and frequently exchanged knowledge, skills, and resources against environmental disruptions."

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Abbreviations

PC: principal component

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