Peer Community In Archaeology

2D Geometric Morphometrics of Projectile Points from the Southwestern United States

Adrian L. Burke *based on peer reviews by* ***James Conolly*** *and 1 anonymous reviewer*

Robert J. Bischoff (2023) Geometric Morphometric Analysis of Projectile Points from the Southwest United States. SocArxiv, ver. 8, peer-reviewed and recommended by Peer Community in Archaeology. https://doi.org/10.31235/osf.io/a6wjc

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Burke, A. (2023) 2D Geometric Morphometrics of Projectile Points from the Southwestern United States. *Peer Community in Archaeology*, 100315. 10.24072/pci.archaeo.100315

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Bischoff (2023) is a significant contribution to the growing field of geometric morphometric analysis in stone tool analysis. The subject is projectile points from the southwestern United States. Projectile point typologies or systematics remain an important part of North American archaeology, and in fact these typologies continue to be used primarily as cultural-historical markers. This article looks at projectile point types using a 2D image geometric morphometric analysis as a way of both improving on projectile point types but also testing if these types are in fact based in measurable reality. A total of 164 point outlines are analyzed using Elliptical Fourier, semilandmark and landmark analyses. The author also uses a network analysis to look at possible relationships between projectile point morphologies in space. This is a clever way of working around the predefined distributions of projectile point types, some of which are over 100 years old. Because of the dynamic nature of stone tools in terms of their use, reworking and reuse, this article can also provide solutions for studying the dynamic nature of stone tools. This article therefore also has a wide applicability to other stone tool analyses.

References:

Bischoff, R. J. (2023) Geometric Morphometric Analysis of Projectile Points from the Southwest United States, SocArXiv, a6wjc, ver. 8 peer-reviewed and recommended by Peer Community in Archaeology. https://doi.org/10.31235/osf.io/a6wjc

Reviews

Evaluation round #2

DOI or URL of the preprint: https://doi.org/10.31235/osf.io/a6wjc
Version of the preprint: 7

Authors' reply, 21 August 2023

My sincere apologies for the delay. I have added the PCI logo, corrected all the citations, added clarification to the figures and removed the mean of means (good catch).

Decision by Adrian L. Burke, posted 01 June 2023, validated 01 June 2023

There are a couple of minor/final revisions to be made, primarily to clarify some figures. Almost there!

The suggestions for final revisions will be sent directly to the author.

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.31235/osf.io/a6wjc
Version of the preprint: 5

Authors' reply, 19 May 2023

Dear Dr. Burke,

Thank you for your efforts. I appreciate the comments by the reviewers and have done my best to accommodate their feedback and many of their suggestions. Individual points are addressed below where I felt additional clarification was needed.

Sincerely,
Robert Bischoff

Reviewer 1

Figure 3 – the figure has been fixed to show all points and the caption and discussion have been updated to be clearer

Lines 171-174 The formula discussion has been clarified

Lines 230-231 The reviewer is referring to archaic points that are still much larger than the points I am referring to

Lines 233-247 Clarified wording

Lines 260-268 Clarified wording

Figure 13 – clarified figure caption and added more discussion in paper

Figures 14/15 added discussion of distance

Reviewer 2

Modified tone to be more impersonal

Added methods and results headings

Clarified language throughout.

Lines 31-32 and more – clarified projectile point from point

Lines 37-48 added references

Line 67 moved statement to methods

Lines 69-70 clarified wording

Background – Made several adjustments – although some repetition is used to make it easier on the reader to follow along

Line 103 – Clarified that the number stated was the number used

Line 110/125/126 clarified wording

Line 180 changed wording to reflect this correction

Line 183 Removed unnecessary statement

Line 194 clarified meaning

Lines 207-208 – updated to reflect correction and included additional reference

Line 324 – reorganized paragraph

Tables – explained in the text what mean columns were

Figure 10 Explained morphospace

Lines 281-282 adopted suggestion

Figure 12 – R function prevents moving the legend but it doesn't cover anything important

Lines 312-316 – clarified wording

Lines 346 – the PCA plot adds nothing important to the paper

Figure 13 is referenced – added additional discussion

Conclusion – Added additional language to summarize aims of paper and better summarize results.

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Decision by Adrian L. Burke, posted 24 April 2023, validated 24 April 2023

New methodological approach to studying projectile points using geometric morphometric analysis

A very useful contribution to the growing field of geometric morphometric analysis in stone tool analysis. The reviewers liked this manuscript and feel it should be published. The reviewers made several recommendations for improvements which while they are minor (mostly clarifications on wording and methodology), added up they represent some additional work for the author. The reviewers' suggestions are detailed enough to allow for a quick turnaround and we feel that this manuscript should definitely be published once these adjustments are made.

Reviewed by James Conolly, 14 April 2023

I like these sorts of studies that explore the limitations of particular methods. To the extent that EFA is a popular approach for projectile geomorphometrics, the results shown here clearly show that more traditional landmark (and to a lesser extent) semilandmark approaches may outperform EFA based GM. Overall, it's an interesting and worthy study. However, there are a few places needing some work to improve clarity. I understand GM (and especially PCA based data reduction) and I had a hard time following what was happening in places — meaning I suspect that its not me, but the presentation of the methods that needs some reconsideration, as follows:

Throughout, make sure hyphens are converted to em-dashes when used as clausal separators.

I don't understand figure 3 – there are only 15 sample points, and one illustration and one scan; where does the "20 randome projectile points" fit in (there are 30 illustrated). What is this showing? This needs a much cleared caption and/or more information about what it is supposed to show.

Line 135 – Why are Archaic points found at later sites? Should this be earlier?

Line 171 to Line 174 – this formulate doesn't do what it is claimed (which is to provide the number of harmonics needed). E.g. substituting the values of the four coefficients obtained from the EFA for harmonic 1, as provided in table 2 of Caple et al., 2017, i.e., −330.422, 99.73088, −192.586, and −296.596), into equation

between 172 and 174, provides a Harmonic Power of 122091.6708. Clearly this isn't right and so something here is not be explained correctly.

Line 234 "Only what I term, the corner…" awkward phasing. Try "In the second configuration, what I term the corner…"

Page 230 to 231: "While it is possible to modify the base of the point and 230 even convert a side-notched point into a corner-notched point and vice-versa, it is unlikely that this happened regularly with the small arrowpoints used in this study (Loendorf, Rogers, et al., 2019)." However, this happens with smallish points in the NE (e.g. the Brewerton Corner to Brewerton Eared – described in Justice).

Page 233 to 247 — this gets confusing because I think the author is using semi-landmark and landmark interchangeably. It looks to me like (Figure 8) that these are all semi-landmarks (i.e., points along an outline rather than at definable spots). If I'm correct, then changing landmark to semilandmark when meaning the latter would remove the ambiguity. If I'm wrong, then a table is needed describing how the landmarks were defined.

Line 260 to 268. I can't work out what the author is doing here. The results show poor discrimination of points because the EFA can't discriminate between side and corner notched, so as an alternative these types of pre-sort on this variable. Then what? Is that what Table 4 shows? If so, shouldn't this be perfect across the board, as you've pre-sorted exactly on this variable? I don't understand what is happening here, so this needs a much cleared description of what is happening.

Figure 13 needs further explanation — the boxes and codes are meaningless without some knowledge of what the numbers refer to. Could the boxes be replaced with an image of the point as in fig 14? That would communicate the idea better.

Figure 14/25: what are the distance units? The units of the PC space?

Individually these are relatively simple to fix, but combined these make for substantial change but I think will improve the ms.

Reviewed by anonymous reviewer 1, 27 February 2023

The manuscript presents a geometric morphometric analysis of projectile points from the Southwest of the United States. The paper's primary goal is to analyze the unclassified projectile points from Tonto Basin, Arizona. To select the most suitable method for analyzing projectile points from Tonto Basin, the author compared various geometric morphometric approaches on previously classified late prehistoric projectile points from the Southwest of the United States. More precisely, the author compares Elliptical Fourier Analysis (EFA) to landmarks and semilandmarks approaches based on Generalized Procrustes Analysis (GPA). Results showed that the semilandmarks and EFA do not adequately distinguish between projectile points' shapes, especially at identifying notches. However, the landmark approach provided promising results and thus was selected as the primary method to analyze the projectile points from the Tonto Basin sites.

The analysis of projectile points through GM is a relatively novel approach in archaeology. Therefore, one of the main contributions of this paper is the comparison between EFA, semilandmarks and landmarks-based methods in the analysis of projectile points. While the EFA necessitates complete projectile points to extract the shape of the projectile points, the landmark and semilandmark approaches allow the analysis of fragmented or broken projectile points. The methodological approach is innovative, and the study makes a valuable contribution to the knowledge base in the archaeology of the Southwest of the United States (e.g., line 49). The research is replicable. The availability of the R script used to achieve these analyses shows the study's repeatability and the author's best practices.

I recommend the publication of this manuscript; however, the following suggestions need to be considered.

General comments:

- It is recommended to avoid using statements in the first person to maintain an objective, impersonal tone in academic writing. For instance, in **line 119**, talking about the Momocs package, you mention, "… but I have found the tpsDig's utility to be more superior." This sentence must be reformulated with data or proof

supporting your statement. Also, **line 94**, "In my experience, this can be a frustrating way to spend your time".
- The structure of the paper needs to be modified. For instance, in **line 154** Geometric Morphometrics section should be preceded by another section entitled methods. These changes will enable the readers to find the section where you discuss the methodology easily. Additionally, the section comparisons (**line 248**) should be named "results" as it presents the results of your analysis. Please follow the specific format used in scientific writing: introduction, materials, methods, results, and discussion (and/or conclusion).
- Be more precise in your statements. For instance, in **line 57**, you talk about "the code" and that it will be available. Please distinct that you're referring to your R script used for analysis. As you do not mention before this line that you are using R language programming for your study, it is essential to be concise because not all readers are familiar with the terminology. Also, in **line 64**, you say, "...those approaches..." please be precise about which approach you are referring to (GM).
- Distinguish between points when it refers to landmarks and points when it refers to projectile points. For example, in **lines 31-32 and 178**, "points" refer to the landmarks used in the analysis and in **lines 37, 223-225, and 28**7, however, "points" refer to projectile points. Please be cautious about the terminology and precise, as not all readers are familiar with GM. This needs to be standardized throughout the manuscript.
- For all PCA graphs, all the axes need to be scaled.

Introduction (line 23)

- **Lines 37 to 41**: lack of references.
- **Line 67**: to be more precise, the statement referring to the code and data availability should be mentioned in the materials and/or methods sections (e.g., line 114), not in the introduction.
- **Lines 69 to 70**: aside from the abstract, it is not previously mentioned that the corner-used landmark analysis is the most successful. Additionally, you are presenting the results of your analysis in the introduction. Be careful not to mix up the study's aims with the study's results; the latter should only be discussed in the results section (in your case, "comparisons")—same remarks for **line 71**.

Background (line 72)

- This section relates to the materials used; it seems more appropriate to include it within the "data collection" section as you discuss the selected dataset and the reasons for doing so (**lines 73-76**).
- The "background" section needs to be re-evaluated as it starts with the presentation of the sites and materials used in this study (**lines 73 to 84**), then is followed by the lack of documentation (**lines 85 to 89**). It is concluded by the limitations of the method used and the aims of the current study (**lines 90 to 99**). There are a lot of elements presented in this section that need to be reassigned to the appropriate section of the article to avoid repetition.

Data collection (line 100)

- This subsection should be a section on its own (usually referred to as materials, although data collection is also acceptable) that includes "projectile points of the Southwest" and "Tonto Basin Projectile" as subsections.
- **Line 103**: it is mentioned that "Many of Justice's types could not be included..." based on that statement, and out of the 74 illustrations, how many projectile points were used in this study? The sample needs to be mentioned explicitly.
- **Line 11**0: you refer to figure 3 in the text. Figure 3 is a representation of results based on a PCA. The figure needs to be described (briefly) in the text. It is essential to explain to the reader why there should be no hesitation in using illustrations for 2D morphometric analysis based on the results of figure 3.
- **Line 125**: the following sentence needs clarification: "... the authors identify correlates of the types".
- **Line 126**: please state clearly and explicitly the period you are interested in exploring.

Geometric morphometrics (line 154)

- This subsection should be a section on its own; usually, it is referred to as methods.

- **Line 180**: semilandmarks are not necessarily an alternative approach to landmarks; they can be used in addition to landmarks.
- **Line 183**: what kind or type of error are you referring to here?
- **Line 183**: spelling consistency of semilandmarks (or semi-landmarks).
- **Line 194**: the following sentence needs clarifications: "… using the samples coordinates as landmarks".
- **Line 199**: precision is needed here – "the principal disadvantage to using landmarks in projectile points analysis". In addition, reproducibility depends on the objects of study and the accuracy of landmarks' descriptions.
- **Lines 207 and 208**: automating landmarks registration through templates is possible.
- **Line 234**: to avoid any confusion between the outline used in EFA and the "outline" used here to refer to a landmark configuration, you should add the number of landmarks used (between 30 and 42, as mentioned in line 245). This information should be presented earlier in the paragraph.

Comparisons (line 248)
- This section should be renamed results, as it presents the results of all the analyses.
- **Line 254**: elaborate more on the following statement: "… results were unsatisfactory…".
- **Tables 2, 3 and 4**: LDA results – what do the values located at the mean/mean cell stand for?
- **Line 264**: this information can also be added in the paragraph between lines 233 and 247 as it is part of the methods used and helps the reader understand why you used different protocols (figures 8 and 9).
- **Figure 10**: what is a morphospace? The term needs to be defined for the reader; not all are familiar with GM terminology. "Morphospace" should be defined in the text before using it in a plot's title. In addition, the legend needs to be adjusted; it covers part of the plot (top right quadrant).
- **Line 273**: PCA aims "… to reduce the dimensionality andidentify patterns in the dataset."
- **Lines 281-282**: for Pueblo Alto Side Notched results, you can add the value 0.86 in the text so that it is easier for the reader to find the information, just as you did in **line 325** (Ldk in tables 2-4).
- **Line 282**: when you say, "The results are better…". In what sense? What do you mean by better? As compared to EFA? How did you come to that conclusion?
- **Line 287**: "Figure 11 shows the mean shapes for the selected projectile point types" it is essential to be precise that these are results of the EFA (just as you mention in the title of figure 11, page 18).
- **Lines 301, 302 and 304**: "points" as previously suggested, it is important to distinguish between points as in coordinates or as in projectile.
- **Lines 305-307**: in selecting the number of landmarks to use, you went through an analysis and presented the results between lines 305 and 307. It would be interesting to summarize these results in a table. And when you mention "higher numbers of points…", how many points? And higher compared to what number?
- **Line 308**: can you elaborate on "similar dimensions of variation"?
- **Figure 12 (page 19)**: projectile points in the plot are cropped out (right). Additionally, the legend covers part of the plot.
- **Lines 312 to 316**: the description needs to be more specific. You present a lot of information, some of which seem contradictory. For example, you end your paragraph by saying that the side-notches are still problematic. However, in the previous sentence, you say it is somewhat better for side-notched points. In addition, please mention that you are comparing EFA and semilandmarks approaches here.
- **Line 321**: are you referring to figure 3? As previously commented in the introduction, you need to discuss the preliminary analysis results that helped you determine which GM approach to apply on the Tonto Basin sample.
- **Lines 328**: "… this analysis struggled more so." – What do you mean by "struggled"? Based on what results/or analysis?
- **Line 329**: be more precise in your statements; "they were previously the worst performing type when using EFA and semilandmarks approaches."
- **Line 330**: How do you know that these two types are entangled? Based on what analysis?

- **Line 332**: "the final analysis" – which analysis? LDA? Be more precise.
- **Lines 335-336**: what do you mean by consistent? And more consistent and accurate, compared to what?
- **Line 336**: what type of enhancement? What do you propose to enhance results?
- **Line 337**: be more precise in your statement, for example, "… higher accuracy compared to EFA and semilandmarks".
- **Line 340**: "my purposes". It would be essential to remind the readers about your study objectives and be explicit.
- **Line 345**: precision – "projectile points proved the most effective when tested on the justice sample".
- **Line 346**: you mention the PCA analysis here but do not display the plot; why not display the PCA results?
- **Line 350**: you mention that the purpose of the study is not to explore the patterns; however, since you are the first to apply GM and PCA analysis to this collection, it would be pertinent to explore the patterns further.
- **Line 357**: what do you mean by "flatten multidimensional space"? Remember that not all readers are familiar with multivariate statistics and GM analysis.
- **Lines 359-360**: "the results are messier". What do you mean? Please explain this statement.
- **Lines 363-364**: need of references for the following statement "The side-notched points have a particularly large cluster of typical Hohokam side-notched points."
- **Line 367**: "GM analysis better captures…" – better compared to what?
- **Figure 13 (page 21)**: the figure needs to be referenced and discussed in the text. Describing all the figures/results used in the paper is crucial.
- **Figures 14 and 15**: it is important to add the information related to the sites of origin (information could be mentioned under each projectile point); otherwise, it limits the results' interpretation.
- The results of the Tonto Basin projectile points analysis can be interpreted further. For example, what were the results of the PCA? Were you able to notice any patterns? Although according to figures 13 and 14, both network graphs based on morphometric distances show some type of clustering, it would have been interesting to see the PCA results. I think you should discuss the results of the PCA further in this section as they seem interesting and innovative for the field. Furthermore, it would be interesting to compare your results to the initial five clusters in the original report(line 142).

Conclusion (line 375)
- **Lines 377 to 379**: need to be clarified.
- **Line 381**: "… the most useful method". Please mention the GM approach. Using which GM approach? EFA, landmarks or semilandmarks?
- **Lines 376 to 386**: this first paragraph summarizes all the methodological approaches you used (comparing three GM approaches) on the justice sample and a summary of the results. It seems like the paragraph is missing some critical information; for instance, you do not mention the semilandmarks approach. Please be more concise. Also, it does not remind the readers of your objectives and aims.
- **Lines 389-390**: the first part of the sentence mentions that classification was not possible due to sample size, but the second part states that it is possible to classify with these methods. This sentence needs clarification.
- **Line 391**: "… this chapter…"; is this paper part of a book?
- The whole section does not mention any references. Your findings must be contextualized, discussed and compared to other studies.

Download the review