Cultural Transmission in the Paleoindian of Eastern North America

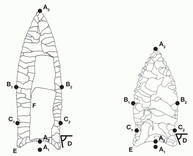
Incorporating Outline-Based Geometric Morphometrics with Cladistic Reconstructions

Matthew T. Boulanger
Department of Anthropology
Southern Methodist University

Abstract

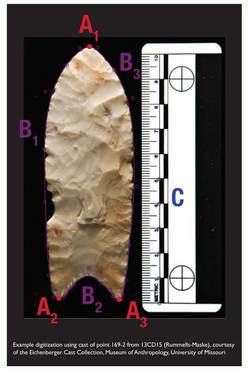
The Paleoindian record of eastern North America has long been characterized as exhibiting a remarkable variety of fluted- and non-fluted projectile-point forms. The temporal, spatial, and cultural significance of this variety remains poorly understood owing to a sparse radiocarbon record as well as to inconsistencies in nomenclature and traits used to define point forms. Building on previous studies, paradigmatic classification is used to define and explore the replicable fluted-point classes from a large database of eastern finds. Outline-based geometric morphometrics is used to define and explore the morphospace of these classes, and character- and morphological-based phylogenetics are used to propose historical and spatial relationships.

For more than 20 years, research has been ongoing into the use of cladistic reconstructions to pose testable hypotheses concerning the heritable continuity of eastern Paleoindian projectile points (see O'Brien et al. 2016). Much of this research has employed paradigmatic classification as a means of establishing analytical units (taxa) and as a way of establishing discrete traits on which parsimony analyses are performed. However, over this same time period, significant advancements have been made in both computing software and hardware, and it is increasingly possible to avoid the once-necessary step of converting continuous morphometric data (measurements) into discrete variables (character states).



Measurements and qualitative traits used to measure Paleoindian projectile points (from Boulanger 2015). This system was first used by O'Brien, Darwent, and Lyman (2001).

Here, I use outline-based geometric morphometrics to capture overall point form. Additional qualitative characters used in previous analyses (e.g., number of sides fluted, number of flutes) are also incorporated. Three landmarks were designated on each point: point tip (A_1), left-tang center (A_2), and right-tang center (A_3). Bezier curves were then used to capture the left (B1) and right (B_3) blade edges as well as the point base (B_2). All measurements are converted from pixels to mm (C). Digitization was performed using StereoMorph (Olsen and Westneat 2015).

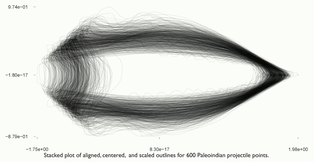


Example digitization using cast of point 169.2 from 13CD15 (Rummells-Maske), courtesy of the Eichenberger Cast Collection, Museum of Anthropology, University of Missouri

Stacked plot of aligned, centered, and scaled outlines for 600 Paleoindian projectile points.

Blade and base outlines were digitized for a toal of 600 Early-, Middle-, and Late-Paleoindian projectile points. 567 of these points are from contexts within the Eastern Woodlands. 33 comparative Western Clovis points are also included. These derive from Dent (Colorado), Simon (Idaho), Domebo (Oklahoma), Naco and Lehner (Arizona), Blackwater Draw (New Mexico), and Miami (Texas). One fluted "fish-tailed" point from ZF200-B (Macapale Island) in Panama is also included (see Faught 2006).

Outline coordinates and landmark positions for each projectile point were extracted using Momocs (Bonhomme et al. 2014) within R. 3.4 (R Core Development Team 2018). Point outlines were normalized for rotation, position, and size through alignment based on landmark positions and centroid size.



Stacked plot of aligned, centered, and scaled outlines for 600 Paleoindian projectile points.

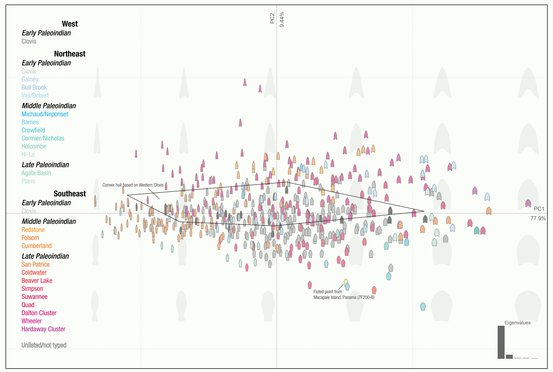
Elliptical Fourier Transforms were calculated for each point specimen. 21 harmonics were retained, accounting for more than 99.% of the total harmonic power.

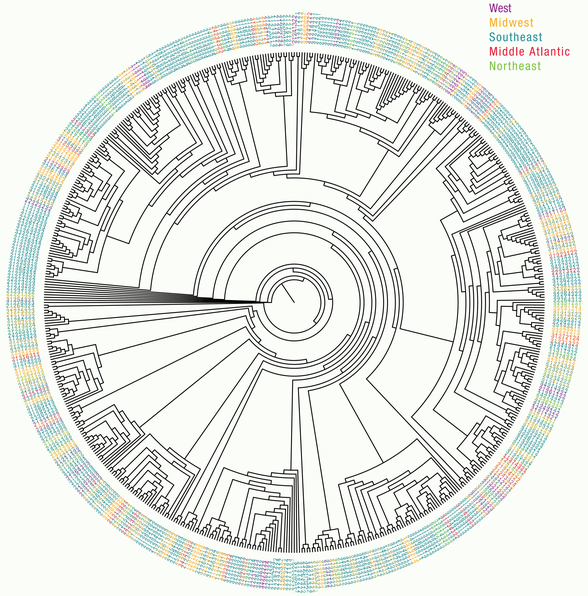
Principal component analysis (PCA) was used to reduce the dimensionality of the morphometric data.

Results of the PCA indicate that five components describe more than 95% of the cumulative shape variation. To understand how the PCA captures shape variability, the origin (0) and three standard deviations on either side of the origin were used to model the morphospace of projectile points.

A majority (nearly 78%) of the variance in shape can be explained by PC1, which appears to relate to length:width ratio and basal concavity depth. The second PC describes basal concavity depth as well as the degree of flaring vs. fish-tailing of the base. PC3 describes the degree to which the lower (proximal) blade edges are concave (positive) or convex (negative); whereas the fourth PC describes straight proximal-half blades versus contracting proximal-half blades.

A plot of the first two PCs displays 87% of the cumulative shape variance in the morphometric data, and allows visualization of the positions of individual point specimens within the overall morphospace. Here, points are color-coded according to the typological designation given to them by the reporting author(s). Clovis points from western contexts are shown in black, and a convex hull indicates the bounds of shape variation within them. Note that eastern points show greater variation along both axes, with limited patterning regarding their assigned type.





The PC-transformed shapes were used to generate 80 equally-spaced sets of XY coordinates approximating the outline of each point specimen. These landmark data were merged with the matrix of discrete character data for each specimen used in early studies, and the entire supermatrix was processed using TNT (Goloboff and Catalano 2016). An estimated consensus tree based on the examination of over 1.5 billion tree arrangements is shown here, with each point specimen represented by it paradigmatic class, color coded to reflect the region within which it was found.

References

Bonhomme, V. et al. 2014. Momocs: outline analysis using R. *Journal of Statistical Software* 56(13).

Boulanger, M.T. 2015. Phylogenetic and Morphometric Analyses of Eastern Fluted-Point Forms. Ph.D. dissertation, Department of Anthropology, University of Missouri.

Faught, M.K. 2006. Paleoindian archaeology in Florida and Panama. In *Paleoindian Archaeology: A Hemispheric Perspective*, Morrow, J.E. and Gnecco, C. (eds.), pp. 164-183. Gainesville, University Press of Florida.

Goloboff, P.A. and Catalano, S.A. 2016. TNT version 1.5, including a full implementation of phylogenetic morphometrics. *Cladistics* 32:221-238.

O'Brien, M.J. et al. 2001. Cladistics is useful for reconstructing archaeological phylogenies: Paleoindian points from the southeastern United States. *Journal of Archaeological Science* 28:1115-1136.

O'Brien, M.J. et al. 2016. Design space and cultural transmission: case studies from Paleoindian eastern North America. *Journal of Archaeological Method and Theory* 23(2):692-740.

Olsen, A. and Westneat, M.W. 2015. StereoMorph: an R package for the collection of 3D landmarks and curves using a stereo camera set-up. *Methods in Ecoogy and Evolution* 6:351-356.

R Core Development Team. 2018. R: A language and Environment for Statistical Computing. Vienna, R Foundation for Statistical Computing.