Chapter 11
An Assessment of the Impact of Resharpening on Paleoindian Projectile Point Blade Shape Using Geometric Morphometric Techniques

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Abstract Paleoindian archaeologists have long recognized that resharpening has the potential to affect the shape of projectile points. So far, however, the impact of resharpening on the distinctiveness of the blades of Paleoindian projectile points has not been investigated quantitatively. With this in mind, we used geometric morphometric techniques to compare the blades of Clovis, Folsom, and Plainview projectile points from the Southern Plains of North America. We evaluated two hypotheses. The first was that blade shape distinguishes the three types. We found that blade shape distinguished Clovis points from both Folsom and Plainview points, but did not distinguish Folsom points from Plainview points. The second hypothesis we tested was that resharpening eliminates blade shape differences among the types. To test this hypothesis, we used size as a proxy for resharpening. The results of this analysis were similar to those obtained in the first analysis. Thus, our study suggests that, contrary to what is often assumed, resharpening does not automatically undermine the use of blade shape in Paleoindian projectile point typologies.

Introduction

The assignment of projectile points to types is critical for research on the Paleoindian period in North America. Paleoindian specialists rely on projectile point typology to situate assemblages in time when directly dateable material is not recovered. Furthermore, because Paleoindian points are found in such high numbers in mixed or isolated surface contexts, many studies concerning changes in technology and land use have relied on typed specimens (e.g., Anderson and Faught 2000).

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Paleoindian projectile point types are identified in part by characters that describe blade shape (Bamforth 1991; Bradley and Stanford 1987; Morrow and Morrow 1999). However, the use of such characters for classification purposes has been called into question by Flenniken and Raymond (1986). Drawing on the results of a replication study, these authors claim that resharpening has the potential to alter projectile point blade shape in such a way that blade shape no longer distinguishes between types. Clearly, if Flenniken and Raymond (1986) are correct, blade shape should be removed from the list of characteristics used to classify Paleoindian projectile points. This would be particularly problematic because some of the other characters that are considered to be diagnostic for certain Paleoindian projectile point types (e.g., presence/absence of a channel flake) do not occur on all specimens.

Paleoindian archaeologists have long recognized that resharpening has the potential to affect the shape of projectile points (Ellis 2004; Haynes 1980; Hofman 1991, 1992; Shott and Ballenger 2007; Wheat 1976, 1977). So far, however, the impact of resharpening on the distinctiveness of the blades of Paleoindian projectile points has not been investigated quantitatively. With this in mind, we carried out a study in which we used geometric morphometric techniques to evaluate the conventional hypothesis that blade shape distinguishes Paleoindian projectile point types, and also Flenniken and Raymond's (1986) claim that resharpening eliminates blade shape differences among projectile point types. The projectile points we examined are from the Southern Plains of North America and have been assigned to three important Paleoindian types – Clovis, Folsom, and Plainview.

Materials and Methods

Materials

The Southern Plains consists of the Southern High Plains and the Rolling Plains (Fig. 11.1). The Southern High Plains form an almost featureless plateau covering over 130,000 km^2 of western Texas and eastern New Mexico (Holliday 1995). Also known as the Osage Plains, the Rolling Plains are more topographically variable than the Southern High Plains. They lie to the east of the latter, and cover west-central Missouri, southeastern Kansas, and most of central Oklahoma. They also extend into north-central Texas. We focused on points from a single physiographic region in an effort to control for the potentially confounding impact of cultural selection in relation to environmental conditions. We reasoned that such selection is less likely to be a problem when comparing points from one physiographic region than when comparing points from several, since environmental differences are greater between physiographic regions than within them (Cannon 2004; Hunt 1967). We chose the Southern plains because it has a particularly rich archaeological record for the Paleoindian period (Buchanan 2006; Buchanan et al. 2007; Holliday 1997).

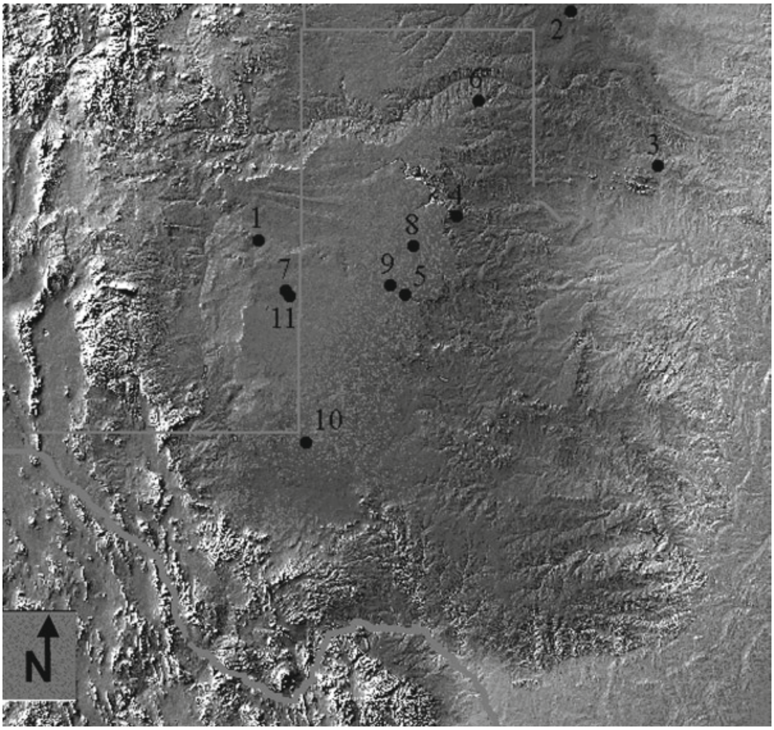

Fig. 11.1 Orthophotograph of the Southern Plains including portions of western Oklahoma, west Texas, and eastern New Mexico showing the locations of assemblages in the analysis. Site names: 1 = Blackwater Draw, 2 = Cooper, 3 = Domebo, 4 = Lake Theo, 5 = Lubbock Lake, 6 = Miami, 7 = Milnesand, 8 = Plainview, 9 = Ryan's, 10 = Shifting Sands, and 11 = Ted Williamson

The sample comprised 28 Clovis points, 47 Folsom points, and 111 Plainview points (Table 11.1). Clovis points are lanceolate in outline with a straight to slightly concave base (Haynes 2002; Hester 1972; Howard 1990). They also usually have a so-called "channel flake" removal. A channel flake is a short (usually less than half the length of the face) flake detached perpendicular to the base. The available evidence suggests that Clovis points were used by populations across North America to hunt large game, including mammoth and bison (Haynes 2002). Folsom points also have lanceolate-shaped blades (Crabtree 1966; Meltzer 2006). They differ from Clovis points in having markedly indented bases and "flutes." The latter are flakes that are removed from the base usually up to two-thirds the length of a point. Folsom points are mostly restricted to the Great Plains and Rocky Mountain regions of western North America, where they appear to have been primarily used to hunt bison. Plainview points are unfluted lanceolate forms. The populations that made Plainview points on the Southern Plains are also thought to have been specialized bison hunters (Sellards et al. 1947). Clovis, Folsom, and Plainview are widely considered to represent a chronological sequence in the Southern Plains (e.g., Holliday 2000;

Table 11.1 The number of projectile points from each assemblage by the type used in the analysis

Site/assemblage	Type	Number of points	References
Blackwater draw	Clovis	22	Boldurian and Cotter (1999); Cotter (1937, 1938); Hester (1972); Howard (1935); Warnica (1966)
Domebo	Clovis	3	Leonhardy (1966)
Miami	Clovis	3	Holliday et al. (1994); Sellards (1938, 1952)
Blackwater Draw-Mitchell Locality	Folsom	2	Boldurian (1990)
Blackwater Draw	Folsom	12	Boldurian and Cotter (1999); Hester (1972)
Cooper	Folsom	10	Bement (1999a, b)
Lake Theo	Folsom	3	Buchanan (2002); Harrison and Killen (1978); Harrison and Smith (1975)
Lubbock Lake	Folsom	6	Johnson (1987)
Shifting Sands	Folsom	14	Amick et al. (1989); Hofman et al. (1990)
Milnesand	Plainview	39	Sellards (1955); Warnica and Williamson (1968)
Plainview	Plainview	10	Holliday (1997); Johnson et al. (1986); Knudson (1983); Sellards et al. (1947); Speer (1983)
Ryan's	Plainview	11	Hartwell (1995)
Ted Williamson	Plainview	51	Buchanan et al. (1996); Johnson et al. (1986); Warnica and Williamson (1968)

Taylor et al. 1996). Clovis is thought to be the oldest of the three types (ca. 13,340–12,830 calendar years ago). According to the conventional chronology, Folsom follows Clovis in time (ca. 12,830–11,900 calendar years ago). The dating of Plainview is uncertain, but generally is thought to overlap with Folsom on the younger end of the latter's time range (Holliday 2000; Holliday et al. 1999).

In order to analyze the full range of variability associated with each point type, only points from assemblages recovered from unmixed contexts were included in the sample. Incorporating isolated points found on the surface would have increased the size of our sample, but it also would have likely biased our results. The reason for this is that isolated points that have been assigned to a type are necessarily distinctive regardless of the amount of resharpening. Thus, including such points would have increased the likelihood of our analyses supporting the conventional hypothesis.

The points come from 13 assemblages recovered from 11 sites. Ten of the assemblages are from the Southern High Plains and three from the Rolling Plains. The Clovis assemblages are associated with mammoth kills (Blackwater Draw, Domebo, and Miami). Some of the Folsom assemblages were recovered from campsites (Blackwater Draw-Mitchell Locality and Shifting Sands). Others were recovered from bison butchering locales (Blackwater Draw, Cooper, Lake Theo, and Lubbock Lake). The Plainview assemblages are from a campsite (Ted Williamson), two bison butchering sites (Milnesand and Plainview), and a cache (Ryan's).

We have used a number of the points in previous studies (Buchanan 2006; Buchanan et al. 2007; Buchanan and Collard 2007). The samples of Folsom and Plainview points used in this study differ from the samples used by Buchanan (2006) and Buchanan et al. (2007). Buchanan (2006) focused on Folsom points from the Southern Plains made only of Edwards chert in order to measure the shape change with distance from source. This restriction was removed in the present study and seven points made of raw materials other than Edwards chert were added to the sample. Seven Folsom points used by Buchanan (2006) were excluded from the study reported here because they were insufficiently complete. Buchanan et al. (2007) also employed a number of incomplete specimens in their analysis of Plainview points. These specimens were also not included in the study reported here. Lastly, we excluded points from three Plainview assemblages that Buchanan et al. (2007) concluded are problematic – Blackwater Draw, Warnica–Wilson, and Lubbock Lake FA5-17. The Blackwater Draw assemblage appears to be from a mixed context. The Warnica–Wilson assemblage comprises material from a campsite combined with a surface collection of points from the surrounding county. The Lubbock Lake FA5-17 assemblage was excluded because the points it contains likely represent a unique type.

Methods

Geometric morphometrics is a suite of methods for acquiring, processing, and analyzing Cartesian coordinate data (Bookstein 1991; Rohlf and Marcus 1993; Slice 2005; Zelditch et al. 2004). The core of geometric morphometrics is the separation of shape from size. This is accomplished by removing differences due to location, scale, and rotational effects. The geometric information that remains after these differences are eliminated is defined as shape.

The steps taken in the acquisition, processing, and extraction of projectile blade shape variables are as follows.

1. *Image acquisition*. Digital images of projectile points were used to capture landmark data. Projectile points were laid flat with their distal ends facing to the right in each photograph (Fig. 11.2). For nearly flat objects, such as projectile points, a two-dimensional approach produces limited information loss (Velhagen and Roth 1997).
2. *Choice and digitization of landmarks*. There are three locations on Paleoindian points that can serve as type II landmarks. A type II landmark is a landmark described by geometric evidence such as the minimum or maximum positions

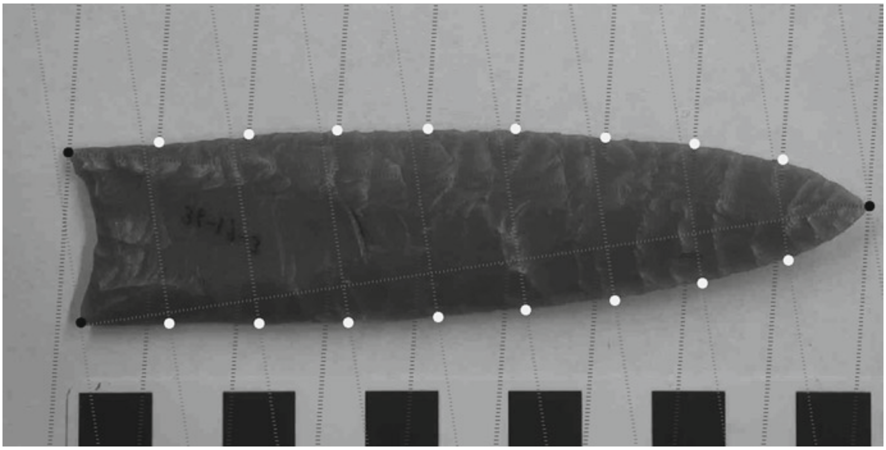

Fig. 11.2 Digital image of a projectile point with the locations of three homologous landmarks (*black circles*) and 16 pseudolandmarks (*white circles*) marked on the projectile point. The lines superimposed on the point image were produced using the MakeFan program

along a curve (Bookstein 1991). Two of the type II landmarks are situated at the base of the point, defined by the junction of the base and edges of the point. The third type II landmark is located at the tip, defined by the junction of the two blade edges. In order to better define the blades, digital "combs" were used to place pseudolandmarks (type III landmarks) along the edges of each blade. Prior to digitizing, two digital combs were superimposed on each image using H.D. Sheet's MakeFan6 shareware program (www.canisius.edu/~sheets/morphsoft.html). Combs are line segments with equally spaced perpendicular lines that are used for placing landmarks at regular intervals on objects without many obvious landmarks. The first comb was placed between the lower basal landmark and the tip landmark. MakeFan was then used to create eight equally spaced perpendicular lines between the two type II landmarks. The same procedure was followed to create a comb for the upper edge of the blade. The pseudolandmarks were placed at the intersections of the lines of the combs and the edges of the blade. In total, 19 landmarks were digitized for each artifact (Fig. 11.2). Landmarks were digitized using tpsDig2 shareware (Rohlf 2002).

3. *Superimposition of landmarks*. The superimposition of landmarks was accomplished using the generalized orthogonal least-squares Procrustes procedure (Rohlf 2003; Rohlf and Slice 1990). Although the digitized artifacts were all photographed using the same procedure and were orientated similarly, the landmark configurations had to be aligned to avoid minor discrepancies arising from the digitizing process. The generalized Procrustes analysis (GPA) uses three steps to align the landmarks associated with each specimen. First, GPA centers the set of landmark coordinates at their origin, or centroid, and scales all the configurations to unit centroid size. Centroid size is a measure of the overall size of a specimen computed as the square root of the sum of the squared distances

from all the landmarks to the centroid. Second, the GPA procedure determines the mean or consensus configuration. Lastly, GPA rotates each landmark configuration so as to minimize the sum-of-squared residuals for the sample. Steps 2 and 3 are repeated iteratively until convergence is achieved.

4. *Specimens in shape space projected to tangent space*. After the GPA has been performed, landmarks associated with each specimen correspond to locations in Kendall's shape space (Slice 2001). Procrustes distances refer to the distances between all pairs of specimens in the shape space (Bookstein 1991). In order to perform traditional statistical analyses on the shape data they must be projected to a tangent Euclidean space (Rohlf 1998). To obtain the smallest amount of shape variation in tangent space, the mean form or consensus configuration is used as the point of tangency. The consensus configuration for the total sample of points derived from the GPA procedure is shown in Fig. 11.3. Using the consensus configuration as the point of tangency, we tested if the amount of shape variation in the point data is small enough to permit statistical analyses to be

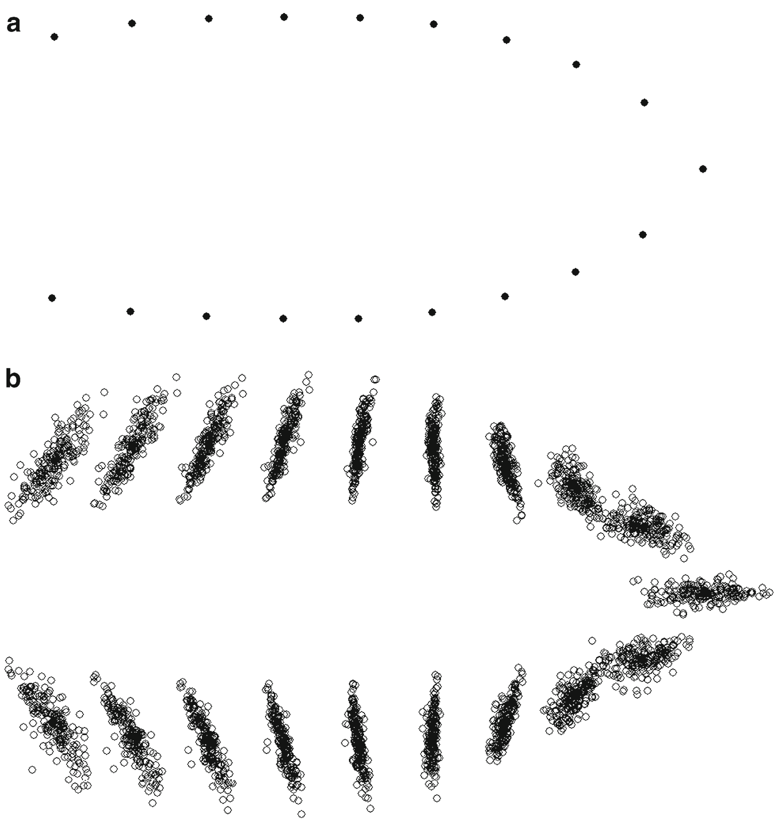

Fig. 11.3 Results of the superimposition method using the generalized orthogonal least-squares Procrustes procedure. (**a**) Consensus configuration of 186 projectile point landmark configurations. (**b**) Variation in projectile point landmark configurations after being translated, scaled, and rotated

performed in the linear tangent space approximate to Kendall's nonlinear shape space. This is accomplished by regressing the distances in the tangent space against the Procrustes distances to determine if the relationship is linear. This test was carried out using the tpsSmall program (Rohlf 2002). The correlation between the two distances was found to be very strong (correlation = 0.9999; root MS error = 0.0001), indicating a good fit between the specimens in shape space and the linear tangent space.

5. *Extraction of partial warps and the uniform component*. Partial warps and the uniform component were computed using the tpsRelw program (Rohlf 2002). A partial warp is an eigenvector of the bending energy matrix that describes local deformation along a coordinate axis. A uniform component expresses global information on deformation. The first uniform component accounts for stretching along the x-axis of a configuration, whereas the second uniform component accounts for variation along the y-axis. Together, the partial warps and the uniform component comprise the weight matrix and represent all information about the shape of specimens. Partial warps and the uniform component can be used in traditional multivariate analyses (Rohlf et al. 1996; Slice 2005).

Having extracted the partial warps and uniform component matrices, we tested the hypothesis that blade shape distinguishes Clovis, Folsom, and Plainview points. We began by subjecting both the partial warps and uniform component matrices to a multivariate analysis of variance (MANOVA). In the first two MANOVAs, we included all specimens and used type as the grouping variable. Since these MANOVAs were significant, we then performed a series of MANOVAs in which the three sets of specimens were compared on a pairwise basis. The goal of these analyses was to determine which types differ significantly. Because MANOVA assumes that group distributions are multivariate-normal with homogeneous covariance matrices, we estimated p-values from a null distribution simulated by random permutation (5,000 iterations). Bonferroni correction was employed in the pairwise analyses. Subsequently, we subjected the partial warps and the uniform component to a discriminant function analysis (DFA) in which point type was used as the grouping variable. The MANOVAs were carried out in MATLAB 6.0 (release 12) using statistical functions written by R.E. Strauss (Strauss 2008). The DFAs were conducted in SPSS 10.0.1.

Subsequently, we carried out two analyses to test the hypothesis that resharpening renders Clovis, Folsom, and Plainview points indistinguishable. In these analyses, we used point area as a proxy for the amount of resharpening on the grounds that smaller points are more likely to have been resharpened than larger points. The point areas were taken from Buchanan (2005, 2006) and Buchanan et al. (2007). We used the point areas rather than the centroid sizes produced by the GPA because they were calculated from more landmarks than used in the present study (36 vs. 19) and included landmarks demarcating the basal portion of points. The base is important to take into account when measuring point size because it ranges from concave to convex in shape both among and within types. In the first analysis, we used the mean point area for each set of points to divide the set in question into a group of large points and a group of small points. We then subjected the shape data to a DFA in which type/size was used as the grouping variable. Next, we tested for differences in the proportions of misclassified points between the large and small groups. The second analysis was identical to the first analysis except three size groups were utilized (small, medium, and large). These analyses were conducted in SPSS 10.0.1.

Results

Table 11.2 summarizes the results of the MANOVA carried out to test the hypothesis that blade shape distinguishes Paleoindian projectile point types. As noted earlier, the MANOVAs in which specimens assigned to all three types were included were significant. This indicates that at least two of the three types have distinctive blade shapes. The MANOVA in which Clovis and Folsom specimens were compared was significant. The MANOVA in which Clovis and Plainview were compared was also significant, albeit less so than the Clovis vs. Folsom one. In contrast, the MANOVA in which Folsom and Plainview were compared was not significant. Thus, the MANOVA analyses partially support the hypothesis that blade shape distinguishes Paleoindian projectile point types. They suggest that blade shape distinguishes Clovis points from Folsom points, and to a lesser extent Clovis points from Plainview points, but does not distinguish Folsom points from Plainview points.

The results of the DFA in which types were used as the grouping variable are shown in Table 11.3. There was no misclassification between Clovis and Folsom points. Twenty-nine percent of Clovis points were misclassified as Plainview points, and 5% of Plainview points were misclassified as Clovis points.

Table 11.2 Results from multivariate analysis of variance tests of shape variables by projectile point type

Types compared	*F*	*p*-value
Clovis, Folsom, Plainview	2.33	0.0002*
Clovis, Folsom	4.13	0.0002*
Clovis, Plainview	2.46	0.0002*
Folsom, Plainview	1.70	0.0218

*Significant at the 0.0125 alpha level in accordance with the Bonferroni correction

Table 11.3 Classification results from a discriminant function analysis of shape variables by projectile point type

	Predicted group membership			
Type	Clovis	Folsom	Plainview	Total
Clovis	20 (71.4)	0	8 (28.6)	28
Folsom	0	27 (57.4)	20 (42.6)	47
Plainview	5 (4.5)	12 (10.8)	94 (84.7)	111

Percentages are shown in parentheses after the number of points in a predicted group

Forty-three percent of Folsom points were misclassified as Plainview points, and 11% of Plainview points were misclassified as Folsom points. Thus, the lowest level of misclassification occurred with Clovis and Folsom, an intermediate level with Clovis and Plainview, and the highest with Folsom and Plainview. As such, the results of the DFA in which types were used as the grouping variable were consistent with the results of the MANOVAs. They also suggest that blade shape distinguishes Clovis points from Folsom points, and to a lesser extent Clovis points from Plainview points, but does not distinguish Folsom points from Plainview points.

The results of the DFA in which each set of points was divided into a small group and a large group are presented in Table 11.4. As in the analyses carried out to test the assumption that blade shape distinguishes Paleoindian point types, there was no misclassification between Clovis and Folsom points, but there was misclassification between Clovis and Plainview points, and between Folsom and Plainview points. Fourteen percent of the large Clovis points were classified as large Plainview points. Twenty-one percent of the small Clovis points were misclassified as small Plainview points, and another 7% were misclassified as large Plainview points. Eight percent of the large Folsom points were misclassified as small Plainview points, and 25% of the large Folsom points were misclassified as large Plainview points. Seventeen percent of the small Folsom points were misclassified as small Plainview points, and the same percentage of the small Folsom points were misclassified as large Plainview points. Two percent of the large Plainview points were misclassified as large Clovis points, and 5% were misclassified as large Folsom points. Six percent of the small Plainview points were misclassified as small Clovis points, 7% were misclassified as large Folsom points, and 11% were misclassified as small Folsom points. None of the differences in misclassification rate between small and large points was significant (Table 11.5). Thus, the DFA in which each set of points was divided into a small group and a large group does not support the hypothesis that resharpening renders Clovis, Folsom, and Plainview points indistinguishable.

The results of the DFA in which each set of points was divided into large, medium, and small groups are shown in Table 11.6. There was no misclassification between Clovis and Folsom points in any of the three size grades. Eleven percent of small Clovis was misclassified as small Plainview. Ten percent of medium Clovis was misclassified as medium Plainview, and the same percentage of medium Clovis was misclassified as large Plainview. Eleven percent of large Clovis was misclassified as medium Plainview. Seven percent of small Folsom was misclassified as small Plainview, 20% of small Folsom was misclassified as medium Plainview, and 7% of small Folsom was misclassified as large Plainview. Thirteen percent of medium Folsom was misclassified as small Plainview, 6% of medium Folsom was misclassified as medium Plainview, and 6% of medium Folsom was misclassified as large Plainview. Six percent of large Folsom was misclassified as small Plainview, 6% of large Folsom was misclassified as medium Plainview, and 25% of large Folsom was misclassified as large Plainview. Eleven percent of small Plainview was misclassified as small Folsom, and the same percentage of small Plainview was misclassified as

Table 11.4 Classification results from a discriminant function analysis of shape variables by two size grades (large and small) within types

	Predicted group membership						
Type	Clovis-small	Clovis-large	Folsom-small	Folsom-large	Plainview-small	Plainview-large	Total
Clovis-small	7 (50)	3 (21.4)	0	0	3 (21.4)	1 (7.1)	14
Clovis-large	1 (7.1)	11 (78.6)	0	0	0	2 (14.3)	14
Folsom-small	0	0	14 (60.9)	1 (4.3)	4 (17.4)	4 (17.4)	23
Folsom-large	0	0	1 (4.2)	15 (62.5)	2 (8.3)	6 (25)	24
Plainview-small	3 (5.5)	0	6 (10.9)	4 (7.3)	33 (60)	9 (16.4)	55
Plainview-large	0	1 (1.8)	0	3 (5.4)	9 (16.1)	43 (76.8)	56

Percentages are shown in parentheses after the number of points in a predicted group

Table 11.5 Misclassification rates from a discriminant function analysis of shape variables by two size grades (large and small) within types

Type	Number misclassified	Percent misclassified	p-Value	Bootstrapped p-value
Clovis-small	7/14	50	0.0984	0.2432
Clovis-large	3/14	21		
Folsom-small	9/23	39	0.9085	1.0000
Folsom-large	9/24	38		
Plainview-small	22/55	40	0.0533	0.0680
Plainview-large	13/56	23		

Results of significance tests for the difference in proportions misclassified between small and large points are given in the last two columns. Bootstrapped p-values are derived from 5,000 iterations

large Folsom. Three percent of medium Plainview was misclassified as small Clovis, and the same percentage of medium Plainview was misclassified as medium Folsom. Three percent of large Plainview was misclassified as large Clovis, and the same percentage of large Plainview was misclassified as large Folsom. The misclassification rate by type/size is shown in Table 11.7. The results of comparisons in the misclassification rates among the three size grades within types are shown in Table 11.8. None of the proportions of misclassified points was significantly different among large, medium, and small groups of points within types. Thus, the DFA in which each set of points was divided into large, medium, and small groups does not support the hypothesis that resharpening renders Clovis, Folsom, and Plainview points indistinguishable.

Discussion

We conducted the study reported here to evaluate two hypotheses. The first was that blade shape distinguishes Clovis, Folsom, and Plainview points. To evaluate this hypothesis we conducted MANOVA and DFA analyses on shape variables. The MANOVA results showed that blade shape is significantly different among the types. However, pairwise MANOVAs found that blade shape distinguishes Clovis points from Folsom points, and to a lesser extent Clovis points from Plainview points, but does not distinguish Folsom points from Plainview points. The DFA was consistent with the MANOVAs. The shape variables correctly discriminated Clovis from Folsom points. Clovis and Plainview points were discriminated less clearly, and Folsom and Plainview points were discriminated at the worst rate. Therefore, our results support the hypothesis that blade shape can be used as a character to distinguish between Clovis and Folsom points. Our results are less clear about the ability of blade shape to distinguish between Clovis and Plainview points. Lastly, the low level of discrimination between Folsom and Plainview points suggests that blade shape cannot be used to discriminate the two types.

Table 11.6 Classification results from a discriminant function analysis of shape variables by three size grades (large, medium, and small) within types

	Predicted group membership									
Type	Clovis-small	Clovis-medium	Clovis-large	Folsom-small	Folsom-medium	Folsom-large	Plainview-small	Plainview-medium	Plainview-large	Total
Clovis-small	7 (77.8)	0	1 (11.1)	0	0	0	1 (11.1)	0	0	9
Clovis-medium	0	7 (70)	1 (10)	0	0	0	0	1 (10)	1 (10)	10
Clovis-large	1 (11.1)	0	7 (77.8)	0	0	0	0	1 (11.1)	0	9
Folsom-small	0	0	0	9 (60)	0	1 (6.7)	1 (6.7)	3 (20)	1 (6.7)	15
Folsom-medium	0	0	0	2 (12.5)	10 (62.5)	0	2 (12.5)	1 (6.3)	1 (6.3)	16
Folsom-large	0	0	0	0	1 (6.3)	9 (56.3)	1 (6.3)	1 (6.3)	4 (25)	16
Plainview-small	0	0	0	4 (10.8)	4 (10.8)	0	21 (56.8)	7 (18.9)	1 (2.7)	37
Plainview-medium	1 (2.7)	0	0	0	1 (2.7)	0	4 (10.8)	26 (70.3)	5 (13.5)	37
Plainview-large	0	0	1 (2.7)	0	0	1 (2.7)	3 (8.1)	3 (8.1)	29 (78.4)	37

Percentages are shown in parentheses after the number of points in a predicted group

Table 11.7 Misclassification rates from a discriminant function analysis of shape variables by three size grades (large, medium, and small) within types

Type	Number misclassified	Percent misclassified
Clovis-small	2/9	22
Clovis-medium	3/10	30
Clovis-large	2/9	22
Folsom-small	6/15	40
Folsom-medium	6/16	38
Folsom-large	7/16	44
Plainview-small	16/37	43
Plainview-medium	11/37	30
Plainview-large	8/37	22

Table 11.8 Results of significance tests for the difference in proportions misclassified between small and medium and small and large points within types

Comparison	*p*-Value	Bootstrapped *p*-value
Clovis-small to Clovis-medium	0.6981	1.0000
Clovis-small to Clovis-large	1.0000	1.0000
Folsom-small to Folsom-medium	0.8864	1.0000
Folsom-small to Folsom-large	0.8323	1.0000
Plainview-small to Plainview-medium	0.2227	0.3378
Plainview-small to Plainview-large	0.0412	0.0784

Bootstrapped *p*-values are derived from 5,000 iterations

The second hypothesis we tested is that resharpening renders Clovis, Folsom, and Plainview points indistinguishable. To evaluate this hypothesis we carried out two size grade analyses. We reasoned that, if the hypothesis is correct, the misclassification rate for small points should be statistically significantly higher than the misclassification rate for larger points, since the former are more likely to have been subject to resharpening than the latter. Tests for differences in the proportion of misclassifications between points of different type/size revealed that none of the proportions were different. Therefore, this part of our study suggests that resharpening does not alter the distinctive blade shapes of points associated with each type. The available evidence suggests that resharpening occurs primarily on the blades of Paleoindian points, probably as a result of rejuvenation work on still-hafted points (Bement 2002; Collins 1999; Cox 1986; Gardner 1983; Gardner and Verrey 1979). Thus, our study indicates that the resharpening hypothesis does not hold for Paleoindian projectile points from the Southern High Plains.

Our finding that resharpening does not result in the convergence of blade shapes among Paleoindian projectile point types is in line with the results of an assessment of the impact of resharpening on point types in the Great Basin conducted by Bettinger et al. (1991) in response to claims made by Flenniken and Wilke (1989). Flenniken and Wilke (1989) analyzed eight assemblages of dart points from the Great Basin and argued that 21 of the 23 types represented in the assemblages are in fact reduction sequence stages rather than types. Bettinger et al. (1991) tested

Flenniken and Wilke's hypothesis by weighing points representing the putative ancestral and derivative types. Their analysis showed that the types that were supposedly created by resharpening were consistently heavier than the ancestral forms, which is inconsistent with Flenniken and Wilke's hypothesis. Together, the results of our study and those obtained by Bettinger et al. (1991) indicate that, contrary to what Flenniken and Raymond contend, resharpening does not automatically led to convergence of projectile point types. Rather, it appears that in some cases that resharpening is carried out in such a way as to maintain a given blade shape.

One implication of our study is that the significant overlap in Folsom and Plainview blade shape is independent of resharpening. One possible explanation for the overlap is that some of the points and/or assemblages have been misclassified. We consider this unlikely given that the assemblages in our sample were identified as belonging to a particular type based on a combination of attributes including diagnostic features on the points themselves, radiocarbon ages, and stratigraphic evidence. There are two other possible explanations for the overlap. One is that Folsom and Plainview descended from a common ancestor and that blade shape is a plesiomorphic character. The other is that Folsom and Plainview points share similar blade shape due to convergent cultural evolution. Folsom and Plainview points were both used for hunting bison and the blade shape of both types may have been honed to an optimal functional efficiency for this task. It should be possible to determine which of these hypotheses is most likely to be correct with cladistic analysis (Buchanan and Collard 2007; Lycett 2007, 2009; O'Brien et al. 2001) and experiments designed to determine performance characteristics (O'Brien et al. 1994).

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