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Assessing Collector Bias: A Geometric Morphometric Analysis of a Collection of Isolated Clovis Points from the Midcontinent

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ABSTRACT
Clovis points are found across the contiguous United States as isolated surface finds and as elements of assemblages in surface and subsurface deposits. Despite being scattered over the continent, Clovis points exhibit a remarkable degree of standardization, yet there is still a demonstrable level of variation in their shapes across regions. Including isolated points in regional comparative analyses would significantly increase sample sizes and spatial coverage of these analyses; however, the effects of collector bias—the tendency to collect the most typical and aesthetically pleasing points—are unknown. Here, we examine the shape of a sample of isolated Clovis points from the midcontinent using geometric morphometric techniques. We show that resharpening had little effect on the shape of points and that our sample of isolated points are similar in shape to points from assemblages in the midcontinent. Our findings suggest that isolated points have research potential when collector bias is limited.

KEYWORDS
Clovis points; Missouri; Illinois; Paleoindian; Geometric morphometrics

Introduction
The Clovis culture is unique in its ubiquity, with material remains found across most of unglaciated North America (Anderson 1990; Anderson and Gillam 2000; Barton et al. 2004; Bradley et al. 2010; Buchanan et al. 2012, 2017; Eren and Buchanan 2016; Eren et al. 2015; Haynes 2002; Meltzer 2009; Morrow and Morrow 1999; Sanchez et al. 2014; Smallwood 2012; Smallwood and Jennings 2015; Steele et al. 1998). While Clovis assemblages can include blades, scrapers, and bifaces (Bradley et al. 2010; Eren and Buchanan 2016), the most well-known artifact is the Clovis point. Clovis points are lanceolate bifaces, typically fluted on both sides, with concave bases and parallel to excursive sides (Bradley 1993; Bradley et al. 2010; Wormington 1957). Clovis points have been recovered as isolated surface finds and as elements of assemblages in surface and subsurface deposits. Despite being scattered over the continent, Clovis points exhibit a
remarkable degree of technological standardization (Haynes 2002), yet there is still a demonstrable level of variation in shape across regions (Buchanan et al. 2014; Smith et al. 2015).

Recently, Clovis point shape variation has been assessed using a set of methods known as geometric morphometrics (Buchanan and Collard 2010; Buchanan et al. 2014, 2015; Smith et al. 2015). Geometric morphometric analyses of Clovis point shapes have established differences at the regional and subregional scales (Buchanan et al. 2014, 2015; Smith et al. 2015). In one study, Buchanan et alia (2014) showed that Clovis points in the western half of North America are morphologically different from those in the eastern half of the continent. The eastern points are broader and have deeper basal concavities than the western points. They are also temporally distinct, as the points from the west date earlier than those from the east (Prasciunas and Surovell 2015; Sanchez et al. 2014; Waters and Stafford 2007). This suggests that Clovis groups spread from west to east, and as they moved, they modified their tools. Buchanan et alia (2014) discovered that the most significant shape differences were in the base and reasoned that resharpening would primarily affect the blade and tip; therefore, they discounted resharpening as a major factor in shape variation. In sum, Buchanan and colleagues (2014) suggested that Clovis groups were modifying their points in response to different macroenvironments as the west–east grouping they used for their tests is primarily an environmental division.

In previous studies of Clovis point shape, the focus has been on specimens recovered as parts of assemblages that have been independently dated or contained at least one diagnostic Clovis point (e.g., Buchanan et al. 2014; Smith et al. 2015). A benefit of focusing on assemblages is that it allows researchers to obtain a view of Clovis point variation beyond the most representative typical points. However, intact archaeological sites are relatively rare compared to isolated finds, especially for the early Paleoindian period. Hunter-gatherer populations such as Clovis are presumed to have been highly mobile, tending to stay relatively small in size and track resource patches, rather than settling in one place for a substantial period of time, resulting in a lack of long-term occupations. As a consequence, the Clovis archaeological record is somewhat ephemeral. In addition, Clovis sites date to the late Pleistocene and have been subjected to destructive processes for millennia (Surovell et al. 2009). On the other hand, there are thousands of isolated Clovis points housed in museums and in personal collections of avocational archaeologists (Anderson and Faught 1998; Anderson et al. 2010, 2015). Despite the lack of associated points and tools with many of these isolated points and, in many cases, precise provenience information, these points can be a valuable resource. Isolated finds are useful in demonstrating the spatial range of Clovis people, as well as their patterns of movement and potential relationships with the environment and other groups (Anderson and Gillam 2000; Spiess 1990).
The sample of Clovis points used in this study consists of isolated finds recovered by avocational archaeologists and obtained by Thomas Gilcrease and housed in the Gilcrease Museum in Tulsa, Oklahoma. To have collections of this nature is not uncommon for museums, especially for collections acquired prior to the mid-twentieth century. Two potential drawbacks are associated with collections of isolated points. First, as mentioned above, provenience data are usually limited; in this case, the points we studied have county-level provenience. Second, complete and aesthetically pleasing points are often overrepresented in collectors’ samples, and it is reasonable to assume that this type of collection is more likely to exhibit limited variation relative to assemblages of points recovered from excavated sites. To reiterate, an assemblage, unlike an isolated point, can comprise multiple specimens of the same type, thus demonstrating a de facto level of type variation that might be overlooked or misidentified if specimens in the tails of this distribution are found in isolation. As such, one of the primary goals of this study is to determine how representative our sample of isolated Clovis points in the Gilcrease Museum is compared to documented assemblages of Clovis points from the same region.

Specifically, this study focuses on Clovis points from the midcontinental region of North America because they are well represented in the Gilcrease collection and this region is underrepresented in terms of known excavated Clovis sites (Buchanan et al. 2014). Thus, the analysis of isolated midcontinental Clovis points from the Gilcrease collection has the potential to add to the understanding of regional variation of Clovis points in North America (e.g., Buchanan et al. 2014; Morrow and Morrow 1999; Smith et al. 2015). Accordingly, our analyses for this study focus on three issues. First, we analyze the spatial distribution of the Gilcrease sample of Clovis points to determine how the points are distributed across the midcontinent and if there are any environmental correlates with their distribution. Second, we investigate the potential effects of resharpening as a potential confounding factor in the analysis of point shape. To do this we use geometric morphometrics and analyze the shape variation around landmarks demarcating the blade and base portions of points in our sample and use the same method to examine size-related shape changes in the points. As flintknapping is a reductive process, any modification including resharpening will change the size and possibly the shape of the tool. By comparing the shapes of points of different sizes, we assess whether allometric changes can be attributed to resharpening, such as narrowed blades and blunt tips in smaller points, or if shape changes are unrelated to resharpening. Third, we use geometric morphometrics to compare the shape of the isolated Clovis points in our sample from the midcontinent to the midcontinental sample of points from assemblages analyzed by Buchanan and colleagues (2014). We also compare our sample to those of the other subregions in eastern North America identified by Buchanan and colleagues (2014). Our expectation is that if collector bias has not significantly affected our sample then it should be
indistinguishable from the midcontinental Clovis point assemblages analyzed by Buchanan and colleagues (2014).

**Materials and Methods**

**Materials**

This study examines a collection of points housed at the Gilcrease Museum, which is currently under the management of the University of Tulsa as part of a partnership with the city of Tulsa. Museum collections can sometimes lack contextual information and have limited identifying information, depending on the circumstances of artifact acquisition. In some cases museums acquire artifacts through donations from collectors or, in the past, through the purchase of objects from individuals. Though this ensures the preservation and curation of these artifacts, such items are often isolated finds that rarely have accompanying detailed provenience information. In fact, isolated finds from private collections are often relegated to educational use in museums precisely because there is little else that can be done with them. However, this study focuses on Clovis points in the Gilcrease collection that have associated county-level provenience and, therefore, hold some research potential.

The Gilcrease collection contains approximately 250 complete Clovis points from at least eight different states. We obtained a list of accession numbers, associated provenience information, and photographs of the points from the Gilcrease staff. Out of the 250 Clovis points in the museum, 169 points had county-level provenience (St. Louis, Missouri, is an exception to the county rule as it does not exist within a county but is an independent municipality), from the states of Illinois, Ohio, Missouri, Tennessee, and Kentucky. Due to the uneven distribution of points across the five states represented (for example, there are only two points from Kentucky), we decided to focus on points from the states of Missouri and Illinois, which had the most points—48 and 36, respectively—and also were recovered from conjoining states in the midcontinental region. A majority of the points from Missouri and Illinois were unavailable for direct handling, although most could be observed in exhibit drawers with Plexiglas covers.

Visual inspection indicated that the points in the sample are all made of chert. The cherts are highly variable in color, ranging from white to black and orange to red, some with mottled and banded surfaces. As many of the counties where these points were recovered contain multiple chert sources, we determined that sourcing was not feasible for the present study.

**Spatial Distribution**

We examined the spatial distribution of the recovery locations of the points in this study. However, this examination was necessarily limited by the small
ratio of the analytic scales used: We analyzed the distribution of points with county-level provenience across two states. County-level provenience is more applicable to macroregional or continental-scale analyses (e.g., Anderson and Gillam 2000; Anderson et al. 2010); conversely the spatial analyses of points across two states is more informative for more precisely located artifacts. Nonetheless, we used ArcGIS to examine the distribution of Clovis points in our sample across Missouri and Illinois and correlated the points with geographic data.

Statistical Methods

Clovis Point Descriptive Analyses and Size Grades
We measured the maximum length of points from the tip to the longest basal ear. These data were used for the creation of size grades. In the Paleoindian literature, authors have occasionally referred to points as small or short and large or long. Points referred to as short tend to be in the 3–6 cm range, while long points are considered to be 10 cm or greater (Howard 1990). We used length as the basis for the size grades in the current study (see Buchanan and Collard 2010 for a similar use of size grades). We created three length categories (small, medium, and large) based on terms used in the literature and the distribution of measurements in our sample. We used size grades to assess the potential effects of resharpening by comparing the average shape of points between the size grades.

Point Shape Analyses: Geometric Morphometric Methods
For the point shape analyses, we used geometric morphometric (GM) techniques (for reviews of GM, see Adams et al. 2004, 2013; Bookstein 1991; Bookstein et al. 1985; Dryden and Mardia 2016; Rohlf and Bookstein 1990; Rohlf and Marcus 1993; Slice 2005, 2007; Webster and Sheets 2010; Zelditch et al. 2012). GM has been used extensively in biology for studying specimens of disparate size or orientation (e.g., Jacques and Zhou 2010; Orlofske and Baird 2014). The need for reducing the influence of size on objects and individuals is clear in biology as adults and juveniles of the same species have the same features despite size differences and there is also a need to accommodate malformed, asymmetric, or partial specimens. Archaeologists have borrowed this technique to analyze lithic artifacts in a way that moves beyond descriptive and statistical analyses that do not adequately separate size from shape (Archer and Braun 2010; Buchanan and Collard 2010; Buchanan et al. 2011, 2015; Charlin and González-José 2012; Costa 2010; Eren et al. 2015; Lycett and von Cramon-Taubadel 2013; Lycett et al. 2010; Thulman 2012; Wang et al. 2012).

To carry out GM analyses, we digitized the points in our sample following the procedures outlined in Buchanan and colleagues (2014) to make the results of our study comparable to those of their study. This process begins with taking
digital photographs of the specimens. Photographs of the points used in our study were provided by the Gilcrease Museum and were taken freehand with the points positioned against two standard black-and-white photo scales, one along the base and one along the side of the point. Having the photographs taken freehand was not ideal; in addition, many of the points are on display at the Gilcrease Museum and consequently were not available for photography.

After ensuring that all photographs taken by museum staff matched the accession numbers associated with the points in the sample (accession numbers were written directly on the artifacts and thus visible in photographs), we used the open source software MakeFan ([www.canisius.edu/~sheets/morphsoft.html](http://www.canisius.edu/~sheets/morphsoft.html)) to create equidistant fans (combs) that were superimposed onto each image (Figure 1). We placed primary and semilandmarks at equal distances along the edges of each point using Rohlf’s (2010) tpsDig2 program using the combs. Primary or homologous landmarks are based on specific features identifiable on every specimen, such as the tip or basal ears of a point. Pseudo- or semilandmarks are not placed on identifiable features; rather we placed semilandmarks at equally spaced intervals to approximate the general outline of a point’s edges and base. Thus, with the placement of semilandmarks, it is possible to demarcate important features of an object and to produce a comparable configuration of the entire shape even when faced with minimal homologous features. Using this method, we can then compare the landmarks from multiple specimens without referencing nonshape variables. Following

![Figure 1. Clovis point with superimposed fans and landmarks. Homologous landmarks placed at the tip and at the base are shown as filled black circles.](image)
Buchanan et alia (2014), we placed 23 landmarks around the outline of the points. For each point, we located three homologous landmarks, one at the tip and two at the corners of the base, and placed 20 semilandmarks in the spaces between the tip and basal landmarks. A landmark configuration is shown in Figure 1, with the three homologous landmarks shown in black.

After the landmark configurations were created, we used the *MorphoJ* program (http://www.flywings.org.uk/morphoj_page.htm) to carry out canonical variate and discriminate function analyses (Klingenberg 2011). First, we carried out a preliminary processing analysis in which a Procrustes fit, or Procrustes superimposition (PS), was applied to all the landmark configurations. This procedure scales all the objects to a single size and essentially stacks the landmark configurations. Each configuration (one for each specimen) is centered on principal axes, scaled to the same size, and rotated to achieve an optimal alignment (Klingenberg 2011). This removes size as a variable and leaves a measurement of the difference in actual shape, termed the *Procrustes distance*, or the distance of a given specimen from the average or consensus specimen. We report the variation around the position of each average landmark position and compare the variation for landmarks associated with the blade (landmarks 1, 7–16; see Figure 1) with landmarks associated with the base (landmarks 2–6, 17–23; see Figure 1) for our initial assessment of the effect of resharpening on shape of points in our sample. We assume that for resharpening to have had a significant effect on the shapes of points in our sample the variation around the blade landmarks should be more variable than the basal landmarks.

Following the Procrustes superimposition procedures we carried out canonical variate analysis (CVA) comparing our sample to the samples of Buchanan et alia (2014). CVA examines relationships between groups of variables. CVA is derived from a suite of regression methods that is designed to obtain maximum correlations in linear combinations between the predictor (point shape variables) and criterion canonical variates (size grades and subregions). We also conducted discriminant function analysis (DFA) when we carried out pairwise comparisons. DFA, like CVA, uses linear combinations of variables to determine how well predictor variables discriminate grouped items. DFA tests a group according to input variables and can assess if the group is different enough that a specimen separated from the group would be statistically sorted back into the group based on these independent mathematical analyses. In this case, the shape variables describing the landmark configurations were the variables, and groups were created according to different classifiers (size grades and Buchanan et al.’s subregions). For the CVA and DFA tests, we evaluated statistical differences in Procrustes distances. Procrustes distance describes the total shape change from the consensus landmark configuration.

Our GM analysis was first used to examine the effects of resharpening within our sample. To do this, we created groups of points based on size grades defined by length (as described above). We created three size grades (small, medium,
and large) to test against each other. We used CVA and DFA to determine if these groups were different at a statistically significant level and then examined the average point shape derived from each size grade. Our expectation is that if resharpening has altered the shape of points then the points in the small size grade will be significantly different from the larger points and that these points will have narrower blades and blunter tips relative to medium and large points.

Next, we compared our sample of isolated Clovis points from the midcontinent to a sample of points from midcontinental Clovis assemblages described by Buchanan and colleagues (2014). We also compared our midcontinental sample to the other three subregions (Great Lakes, Northeast, and the Mid-Atlantic) in eastern North America defined by Buchanan and colleagues (2014). In Buchanan and colleagues’ (2014) study, they also found that points from the midcontinent were indistinguishable from points in the Mid-Atlantic and Great Lakes subregions but were statistically different from points in the Northeast. For these comparative analyses, we used DFA and employed the Benjamini and Yekutieli (B-Y) method of adjusting the critical value of test significance for multiple comparisons. The B-Y method is used to reduce the likelihood of a Type I error when carrying out multiple comparisons (Benjamini and Yekutieli 2001; see also Narum 2006).

**Results**

**Spatial Distribution of Clovis Points in the Study**

Our sample of Clovis points from the Gilcrease Museum includes 84 specimens from 33 counties across Missouri and Illinois. Of these, one-fifth came from St. Louis (the municipality), and 44% came from just three counties: St. Louis and Callaway, in Missouri, and Union, in Illinois. Using ArcGIS, we plotted the points in our sample by county on a map of the two states as shown in Figure 2. Superimposing a map of major rivers onto the map of the counties shows that each of the counties with points, with three exceptions, lie along a major river course (Figure 2), with a majority of these clustering along the junc-
tures of three branches of the Mississippi River. During the Pleistocene, the Mississippi River served as the primary channel for water from the melting ice sheets that previously covered the northern half of the continent (Blum et al. 2000). Well-documented Clovis sites in the midcontinent are also located at river junc-
tures (Buchanan et al. 2014), and it has long been understood that access to water is a primary concern of mobile societies. While we do not know where within the county a given point was found, we can say that in this study Clovis points are showing up consistently within a reasonable distance of major waterways. Figure 3 shows the density of points in our sample by county. It is clear from this figure that the concentration of points decreases
with increasing distance from the river. Again, due to the lack of fine-grain provenience, we do not know where within a county a given point was found or if it was associated with a larger site, but at the county level it appears that our sample of points tends to be found near major river ways.

**Clovis Point Size Grades**

Figure 4 shows the maximum length of Clovis points in our sample by state. The two states both have unimodal distributions of length, but Missouri has a wider spread than Illinois (Figure 4). The range of the length of points in our sample is 3–17 cm; this compares well to the range of point lengths from Buchanan et alia’s (2014) midcontinental sample, which span 3 cm to 12 cm.
We used maximum length to divide our sample into three size grades. The distribution of points in our sample by size grade is shown in Table 1. A total of 25 points made up the short group of points, which were 3–6 cm long. The medium group of points consisted of 37 points 7–9 cm in length, and 22 points made up the longest group, measuring 10–17 cm long.

**Geometric Morphometric Analyses of Clovis Point Shape**

After creating the 84 landmark configurations and applying the Procrustes superimposition procedure, we first tested if the levels of landmark variation differed
between the blade and base of the points. Variation in landmark position around the landmarks demarcating the consensus or average configuration is shown in Figure 5A and the variation reported in Table 2. The results of a t-test comparing the landmark variation for the base (mean = 0.0004) and the tip and blade (mean = 0.0002) show that the base has significantly more variation than the tip and blade (t = 2.87, p = 0.009). We carried out the same test focused only on the points in the short size grade (Figure 5B); these are the points most likely affected by resharpening. The results of these tests comparing landmark variation for the base (mean = 0.0003) and the tip and blade (mean = 0.0003) are statistically similar (t = 1.47, p = 0.1566; nonparametric Mann-Whitney U = 44, p = 0.1896). The results of both tests suggest that resharpening had minimal impact on the shape variation of the points in our sample.

Next, we tested if the assigned size grades were statistically different in shape. The DFA pairwise tests indicate that each group is significantly different, with a

**Figure 4.** Histograms of maximum length (cm) for Clovis points in the Gilcrease collection for Missouri and Illinois.

**Table 1.** Distribution of Points by Length and State.

<table>
<thead>
<tr>
<th>Length</th>
<th>Missouri</th>
<th>Illinois</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–6 cm</td>
<td>19</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>7–9 cm</td>
<td>21</td>
<td>16</td>
<td>37</td>
</tr>
<tr>
<td>10–17 cm</td>
<td>8</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
<td><strong>36</strong></td>
<td><strong>84</strong></td>
</tr>
</tbody>
</table>
A

B

Figure 5. Consensus landmark configurations (filled gray circles) with variation around each landmark (open circles) after Procrustes superimposition: (a) consensus for the overall sample of 84 Clovis points and (b) consensus for the short points in the sample.

*p value of <0.0001 (Table 3). Figure 6 shows the difference in the average shape of the large and small points. Large points have narrow blades and bases, whereas small points are wider with deeper basal concavities. The width of the shorter points and the deeper basal concavity are not clearly associated with modifications expected from resharpening; however, the reduction in tip (the position of the tip landmark closer to the base) suggests that resharpening may have concentrated on this location (the tip also is where impact fractures occur most frequently).

Figure 7 shows the canonical variate (CV) scores for the Clovis points in our sample by size grade as a scatter plot. The first two CVs encompass 91.95% of
the overall shape variation in the point sample. It is clear from this graph that along the CV1 axis, representing 86.52% of the overall variation, the size grades are different in shape. Along the CV2 axis, representing 5.44% of the overall variation, the size grades are more similar, with the two extremes of small and large points being nearly similar in their range of variation, while the medium-sized points are more differentiated. Figure 8 is a lollipop graph showing how shape changes along the CV1 axis. This figure compares the average shape differences from the largest points to the smallest points in the sample. Based on this figure, the smaller points in the sample are wider with shallower bases relative to the larger points. Thus, the change from large points to small points coincides with an increase in the width of the points; therefore, the smaller points are unlikely to have been created as a result of resharpening larger points. Taken together, the results of the Procrustes superimposition, DFA, and CVA suggest that the impact of resharpening on the overall shape of the points in our sample is relatively minor and, thus, that comparing our entire sample, regardless of point size, to the sample of Buchanan and colleagues (2014) is justifiable.

### Table 2. Variation ($S^2$) Around Each Landmark for the Gilcrease Museum Clovis Points.

<table>
<thead>
<tr>
<th>Landmark Position</th>
<th>$S^2x$</th>
<th>$S^2y$</th>
<th>$S^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Tip</td>
<td>0.0002152</td>
<td>0.0000138</td>
<td>0.0002290</td>
</tr>
<tr>
<td>2 Base</td>
<td>0.0000608</td>
<td>0.0004637</td>
<td>0.0005245</td>
</tr>
<tr>
<td>3 Base</td>
<td>0.000051</td>
<td>0.000445</td>
<td>0.000496</td>
</tr>
<tr>
<td>4 Base</td>
<td>0.0000394</td>
<td>0.0004284</td>
<td>0.0004678</td>
</tr>
<tr>
<td>5 Base</td>
<td>0.0000200</td>
<td>0.0003749</td>
<td>0.0003949</td>
</tr>
<tr>
<td>6 Base</td>
<td>0.000012</td>
<td>0.0003576</td>
<td>0.000370</td>
</tr>
<tr>
<td>7 Blade</td>
<td>0.000058</td>
<td>0.0003363</td>
<td>0.0003422</td>
</tr>
<tr>
<td>8 Blade</td>
<td>0.000007</td>
<td>0.0002975</td>
<td>0.0003040</td>
</tr>
<tr>
<td>9 Blade</td>
<td>0.0000186</td>
<td>0.0002249</td>
<td>0.0002436</td>
</tr>
<tr>
<td>10 Blade</td>
<td>0.0000464</td>
<td>0.0001354</td>
<td>0.0001818</td>
</tr>
<tr>
<td>11 Blade</td>
<td>0.0001032</td>
<td>0.0000608</td>
<td>0.0001640</td>
</tr>
<tr>
<td>12 Blade</td>
<td>0.0001097</td>
<td>0.0000538</td>
<td>0.0001635</td>
</tr>
<tr>
<td>13 Blade</td>
<td>0.0000530</td>
<td>0.0001310</td>
<td>0.0001840</td>
</tr>
<tr>
<td>14 Blade</td>
<td>0.0000220</td>
<td>0.0002098</td>
<td>0.0002318</td>
</tr>
<tr>
<td>15 Blade</td>
<td>0.0000099</td>
<td>0.0003001</td>
<td>0.0003100</td>
</tr>
<tr>
<td>16 Blade</td>
<td>0.0000086</td>
<td>0.0003474</td>
<td>0.0003560</td>
</tr>
<tr>
<td>17 Base</td>
<td>0.0001038</td>
<td>0.0000367</td>
<td>0.0003807</td>
</tr>
<tr>
<td>18 Base</td>
<td>0.0000259</td>
<td>0.0003624</td>
<td>0.0003883</td>
</tr>
<tr>
<td>19 Base</td>
<td>0.000041</td>
<td>0.0004221</td>
<td>0.0004627</td>
</tr>
<tr>
<td>20 Base</td>
<td>0.0000673</td>
<td>0.0001698</td>
<td>0.0002371</td>
</tr>
<tr>
<td>21 Base</td>
<td>0.0001598</td>
<td>0.0000026</td>
<td>0.0001854</td>
</tr>
<tr>
<td>22 Base</td>
<td>0.0001808</td>
<td>0.0000245</td>
<td>0.0002054</td>
</tr>
<tr>
<td>23 Base</td>
<td>0.0000899</td>
<td>0.0001640</td>
<td>0.0002540</td>
</tr>
</tbody>
</table>

### Table 3. Results of Discriminant Function Pairwise Tests Between Individual Size Grades of Clovis Points. Each Group is Statistically Different from Each Other Group.

<table>
<thead>
<tr>
<th>Size-grade comparison</th>
<th>Procrustes distance</th>
<th>$p$-value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short–Medium</td>
<td>0.0903</td>
<td>&lt;0.0001</td>
<td>Significant</td>
</tr>
<tr>
<td>Short–Long</td>
<td>0.1533</td>
<td>&lt;0.0001</td>
<td>Significant</td>
</tr>
<tr>
<td>Medium–Long</td>
<td>0.0639</td>
<td>&lt;0.0001</td>
<td>Significant</td>
</tr>
</tbody>
</table>
The second GM analysis compares our sample of 84 points to Buchanan and colleagues’ (2014) midcontinental sample. The pairwise DF test shows that our sample is statistically similar to Buchanan and colleagues’ midcontinental sample ($\text{Procrustes distance} = 0.0149; \ p = 0.6270$). Next, we compared our sample to the other three eastern subregions defined by Buchanan and colleagues (2014). To reiterate, Buchanan and colleagues (2014) found that points from the midcontinent were indistinguishable from points from the Mid-Atlantic and Great Lakes subregions but were statistically different from points in the

![Figure 6](image6.png)

**Figure 6.** Lollipop graph on transformation grid showing shape differences defined by the discriminant function. The circles represent the average shape of the small points, and ends of the sticks represent the average shape of the large points.

![Figure 7](image7.png)

**Figure 7.** Scatter plot of the first and second canonical variate scores for the Gilcrease Museum Clovis points from Missouri and Illinois identified by size grade (medium gray = large points, light gray = medium points, black = small points).
Northeast. The results of our comparisons are presented in Table 4. Our findings are similar to the results of Buchanan et alia’s (2014): Our midcontinental sample is statistically similar to Clovis points from assemblages in the Great Lakes and different from those from the Northeast; however, we found that our sample was also different from that from the Mid-Atlantic. The difference found between our sample and the Mid-Atlantic sample of Buchanan et alia (2014) might simply be a consequence of using a much larger sample of points from the midcontinent in our comparison.

Discussion

This study examined a sample of 84 Clovis points from a collection housed at the Gilcrease Museum. This collection is made up of items acquired from private collections that consisted of isolated points recovered by avocational artifact

Table 4. Pairwise Discriminant Function Results Comparing the Gilcrease Museum Sample of Clovis Points from the Midcontinent to Buchanan et alia’s (2014) Subregional Samples.

<table>
<thead>
<tr>
<th></th>
<th>Procrustes Distance</th>
<th>p-value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gilcrease Sample–Midcontinent</td>
<td>0.0149</td>
<td>0.6270</td>
<td>Not Significant</td>
</tr>
<tr>
<td>Gilcrease Sample–Great Lakes</td>
<td>0.0233</td>
<td>0.2860</td>
<td>Not Significant</td>
</tr>
<tr>
<td>Gilcrease Sample–Mid-Atlantic</td>
<td>0.1221</td>
<td>&lt;0.0001*</td>
<td>Significant</td>
</tr>
<tr>
<td>Gilcrease Sample–Northeast</td>
<td>0.0973</td>
<td>&lt;0.0001*</td>
<td>Significant</td>
</tr>
</tbody>
</table>

*B-Y significance level of 0.0184.
collectors. The points have county-level provenience but lack more specific locational information. Our study focused on analyzing points from 33 counties across Missouri and Illinois and investigated if the points from the Gilcrease collections were similar in shape to the variation documented in assemblages of Clovis points.

Prior to our assessment of potential biases in the Gilcrease collection, we examined the degree to which the points may have been modified by resharpening. The results of our analyses of landmark variation showed that the bases rather than the blades of the points were more variable, and since resharpening is thought to have concentrated on the blade, the impact of resharpening appears limited. Next, we split the points into size grades and examined shape differences that are commonly associated with resharpening. We found that the average shapes of the long and short points differed, with shorter points being wider and having deeper basal concavities than the longer points. As neither width nor basal concavity depth is usually associated with resharpening, we concluded that resharpening did not have a significant impact on the shapes of the points in our sample. We want to emphasize that we are not suggesting that resharpening was not practiced at all by Clovis groups in the midcontinent, but rather we are contending that the extent of resharpening appears to have not significantly altered the shapes of the points. Indeed, it appears that variation in the tip landmark might be due to reduction via resharpening, possibly after use episodes that dulled or fractured the tip. However, the overall shape of the points in our sample appears to have been only minimally affected by resharpening.

We can suggest two other factors that might have produced the shape differences we found among the size grades. The first factor is the use of different raw material types or sources for making points of different sizes. This possibility entails some constraints imposed on the flintknappers through the use of particular raw material types, that is, low quality raw material types, which limited the size of finished points. Further analyses directed toward identifying the types of raw materials used to make the points could help researchers determine if a relationship exists between point size and raw material type, although recent studies have shown that raw material quality is not a significant predictor of tool form (Eren et al. 2014). The second factor is that different production modes could have been in use for making points of different sizes. This model suggests that long points were made from bifacial reduction of large nodules, whereas short points were made from flakes when large cores where not available. A recent study by Buchanan and colleagues (2015) of Clovis points from the midcontinental states of Indiana, Ohio, and Kentucky found that increasing distance from raw material source did not correlate with more evidence of resharpening on points. Buchanan et alia (2015) suggested that Clovis points may not be designed to be “long-life” tools, as has been commonly asserted (e.g., Goodyear 1989; Kelly and Todd 1988), where points are resharpened and reduced to the
point of exhaustion and are eventually replaced using transported bifacial pre-
forms that produce much longer points. Instead, they suggested that Clovis
points were replaced when needed, using flakes as raw material. Points made
from flakes are usually smaller than points made from reduced bifaces and
making them is an efficient means of replacing broken or lost points when far
from a lithic source (Eren and Andrews 2013; Kuhn 1994). A similar scenario
can explain our finding that the small points in our sample do not appear to
have resharpened blades. Following Buchanan et alia’s (2015) model, the
shorter points in our sample may have been manufactured from flakes,
whereas the long points may have been made from bifaces. Further research
aimed at identifying flake features on the short points in our sample would be
one way of testing this hypothesis.

In light of the evidence that resharpening had minimal effects on our sample
of Clovis points, we compared our sample to Buchanan et alia’s (2014) sample of
Clovis points from assemblages. We found no difference in the average shape of
points from our sample and the assemblage samples from Buchanan et alia
(2014). This finding suggests that our sample of points collected by different indi-
viduals from isolated contexts is not noticeably biased. Again, collector bias
comes from the way collectors obtain their samples. Because the points in our
study were from isolated contexts, it was possible that they did not represent
the range variation usually found in point assemblages. The results of our com-
parative analyses indicated that there were no such effects of bias on our study
sample. The points from our study and those of Buchanan et alia (2014) were
statistically indistinguishable, suggesting that in this case the sample of isolated
points collected from the surface was not biased.

In sum, this study has shown that isolated points that can be reliably typed
should not necessarily be excluded from comparative analyses as they may
provide additional data about the culture or time period under investigation,
although this needs to be assessed on a case-by-case basis. The Clovis
points in this study were shown to be statistically similar to Clovis points
from archaeological assemblages. The shape analyses presented in this study
are germane to many lines of evidence currently being pursued in Clovis
studies, such as point shape changes related to functional adaptation to
regional environments, technological drift related to fissioning populations,
and use-related modifications such as resharpening. Supporting these types
of models requires large sample sizes, as well as comprehensive testing of con-
 founding variables and possible correlations. Although an archaeological site
can produce adequate sample sizes for analyses, isolated points have the
advantages of being abundant and being found across the landscape. More-
ever, archaeological excavations are not only time and labor intensive but
they are also expensive. In Paleoindian archaeology, sites are rare and often
difficult to locate, access, and excavate. The addition of museum collections
of isolated points with some level of provenience has the potential to
greatly extend and enhance comparative analyses of point forms. As we hope we have shown here, using geometric morphometric techniques to study museum collections has the potential to contribute to research into the causes of variation in Paleoindian point types.

Disclosure Statement

No potential conflict of interest was report by the authors.

Notes on contributors

Kathryn Ragan is an M. A. graduate of the Anthropology Department of the University of Tulsa, where her research focused on geometric morphometric analysis of Clovis points and spatial analysis of the Paleoindian presence in North America.

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References Cited


