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A 3-Dimensional Approach to Projectile Point Classification

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A 3-Dimensional Approach to Projectile Point Classification

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Abstract

Typologies have long been used by archaeologists to answer questions about the past, ranging from issues of site chronology to tool function. However, current methods are hampered by subjective misclassifications as well as a loss of the range of variability among different tool forms due to a process that forces them into singular types. This thesis looks to create a simple and reliable technique of projectile point classification. It is also the author's goal to use a classification system that monitors cultural transmission over time. This objective is addressed with an Archaic projectile point sequence from the Albertson site in Ozark region in Northwest Arkansas. A structured-light 3D scanner was used to create complete 3D models of the artifacts that includes several projectile point types. This was done to improve the accuracy and replicability of measurements. Several different quantitative attributes were examined using cluster analysis. The results indicate that current projectile point types applied to the site are suitable for answering questions of site chronology. However, they are inadequate for questions of social interaction.

Acknowledgments

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I would also like to thank my family for their support throughout this process. To my parents, Hayden and Katie Dennis, for their support from the first time I mentioned wanting to be an archaeologist in grade school. To my wife, Haley Dennis, for listening to my ramblings and putting up with my anxieties about this project. Without their support, I would have given up before I began.

Finally, I owe a great debt to the late Dr. Jamie Brandon. His guidance through my undergraduate degree gave me the ability to gain my first job in the field and to be admitted into the graduate program. His class in material culture and the 2017 field school prepared me for work as an archaeologist. His unrelenting optimism inspired me to achieve more than I previously aimed toward. I hope to pass his love for the Archaeology of Arkansas on to future generations.

Dedication

This thesis is dedicated to Dwayne Dennis, who imparted a will to succeed and persevere to his children. This same drive was imparted to me, his grandson, through my own father.

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Chapter 1

Introduction

All archaeological investigation hinges on our knowledge of the artifacts left behind by their creators. To that end, archaeologists use typologies to classify artifacts based on common attributes shared among them, and the contrasting attributes of other types. Typologies have been a cornerstone of archaeology since the culture historical approaches of the early 1900s (Tyler, 1948). A system so vital to the field of archaeology requires precision and replicability. Unfortunately, these variables are not always optimized in current systems of typological classification (Whitaker et al, 1998). In the author's view, classification should sort artifacts in a way that mirrors the cultural forces that created them. It should also allow the same attributes to be measured uniformly by all archaeologists. A 3-Dimensional scanning approach combined with cluster analysis can satisfy both of these requirements in the classification of projectile points.

Projectile point typologies have been an important feature of North American archaeology. One reason for this is the frequency at which projectile points are found at prehistoric archaeological sites on the continent. Another is the depth of time they have in the archaeological record. Projectile points are present in assemblages from the earliest migration to the continent until at least the time of European contact. They are therefore essential for reconstructing site chronologies among pre-colonial settlements. Alternatively, point types have been used as markers of cultural identities that can be mapped across the landscape, whether or not such a connection between identity and point style exists.

The reliability of types as markers of social identities has been debated. Whitaker has demonstrated variation in the consistency with which typological assignments are made by different archaeologists (Whitaker et al, 1998). This can be caused by several factors, including poorly defined types and differences in the experience of the analyst. Another problem with the current classification system for projectile points is that it creates hard boundaries among the attributes used to differentiate types. Natural variation among types often presents a gradient, rather than discrete modes, that is overlooked by forcing a range of morphologies into singular categories. These issues derive from biases and subjectivities introduced by the analyst and therefore runs the danger of misrepresenting cultural behaviors or social identities of the groups that produced the artifacts unless archaeologists develop a way to make point classifications more objective. The unreliability of the current state of projectile-point typologies calls into question the conclusions that are drawn from it.

In an effort to move projectile point classification to a more objective and quantitative method, the author proposes the systematic use of 3-dimensional scanning technology. These scans allow for precise measurements that can be applied uniformly across a sample of points. Higher analytical precision and greater ease of replication can limit the variance caused by individual differences in measuring technique and subjective classification present in the current system. After the measurements are taken, cluster analysis is used to quantify the variation within and between types, which is used to determine whether each type forms a distinct mode or varies over a gradient into other types. Based on the assumption that groups interacting more intensively will share more similarities among their material culture styles, this variation has the potential to answer questions about the cultural identity of ancient people and their relationships across space and over time.

This method is applied to a collection of projectile points from the Albertson site of Northwest Arkansas. The site contained a sequence of Early to Late Archaic points. The points have been typed in the traditional manner by the excavator Don Dickson (Dickson, 1991). The results of the cluster analysis will be compared with the original typologies given to the points. The author predicts that the new analysis will indicate that the older typology suffers from the problems outlined above. The null hypothesis for this project is that the points will cluster into the original typologies proposed by Dickson. If the null is rejected, the relationship among individual points and established types will be explored to arrive at a more nuanced understanding of the variation among points in the region.

Chapter 2

The Use of Typology in Archaeology

Archaeologists subjectively identify attributes that demonstrate the greatest variability among artifacts in a material class to construct typologies. Those types are then used to answer questions about the groups that produced the material. For instance, the attributes of interest could be based on the material used in an artifact's creation, which might answer the question of where the producer obtained them and patterns of mobility on the landscape. Other typologies are based on stages of production. Stage-based typologies are used in lithic studies to situate an artifact's state within a larger reduction trajectory (Shott, 2017). Specific flake types, by-products generated in the production of formal stone tools, can be used to differentiate reduction technologies. While these examples present several uses of typology, none of them deal specifically with the social learning process of sharing technological knowledge across space and over time.

Traditional projectile point typologies are defined by ideational classes (O'Brien and Lyman, 2002:44). For inclusion in a type, the specimen must display the necessary attributes predetermined to represent that type. For projectile point types, the requisite attributes for inclusion usually involve morphological features, typically found on the hafting element, as well as a spatial and temporal variation. It is this shared space and time that makes a type a useful unit of analysis for archaeologists (Sackett, 1977:370). The style and morphology of artifacts are learned through social relationships with peers and over generations. Within reason, archaeologists can examine patterning among those attributes to identify social relationships.

Typologies of Style

Various theories have been put forth about the reliability of modeling cultures based on typological variation (Ford, 1954; Spaulding, 1953). Archaeologists commonly use to the term "style" when describing typological variation (Sackett, 1977; Hegmon, 1992; Wiessner, 1983; Dietler and Herbich, 1998). "Style" is a loaded term that has meant several different things to different researchers over time. Two overarching themes have emerged, those that split style and function as discreet objects for analysis and those that classify style based on function.

Some archaeologists have defined style as the traits of an artifact that are not accounted for by utilitarian performance or technical restraints (e.g., Dietler and Herbich, 1998). If archaeologists are seeking to use style as a means to understand culturally specific traits, this definition becomes a problem. The modern researchers' understanding of utilitarian performance is driven by the current scientific paradigm of the culture in which we live. Archaeologists do use controlled experiments to quantify performance of different artifacts (Pettigrew, 2015; Bronitsky and Hamer, 1986). The size of wounds created by projectile points, for example, has been used as a metric for performance (Friis-Hansen, 1990). Experimentation based on wound size can quantify the advantages of certain projectile point shapes. However, it should not be implied that ancient people were simply progressing through more and more efficient point types. While experimental studies are valuable, they do not necessarily correlate to the ways in which ancient people viewed performance. For example, this definition would view religious artifacts, such as a crucifix, as completely stylistic, which may distort how they are viewed and used by religious practitioners.

Other archaeologists have taken a view of style as having a social function. For Wiessner, the function of style is to transmit information. In the approach proposed by Wiessner, style is divided into separate categories: assertive and emblemic (Wiessner, 1983). Assertive style is "formal variation in material cultural that transmits information about personal and social identity" (Wiessner, 1983:256). Assertive style may reflect one's social standing or position in a larger group. As a result of being an individualized version of style, it is less stable and subject to rapid change in the ways it appears and disappears in the archaeological record. Conversely, emblemic style is "formal variation in material culture that has a distinct referent and transmits a clear message to a defined target population" (Wiessner, 1983:257). Emblemic style is a signal of group identity that defines the in-group versus out-group (Wobst, 1977). As such, isolating emblemic style in material culture assemblages across space would highlight social boundaries.

Sackett (1985) raised a criticism of Wiessner's approach regarding the intentionality of this process. The visual appearance of material culture results from choices made during its production. Those choices, in turn, are culturally informed by the traditional ways in which the group makes a product. Sackett argues that the stylistic traits described by Wiessner exhibit ethnic style but are not intentionally employed as social messages (Sackett, 1990). While Sackett does acknowledge the possibility of social signaling, he points out that the data needed to prove such signaling is often inaccessible to archaeologists. The determining factors contributing to the artifact styles, according to Sackett, is the enculturation process that leads a group of craft producers to make similar choices in the production (Sackett, 1990).

While both concepts of style have merit, they can be difficult to apply in the construction of a typology. The former is too restrictive in terms of what can be considered style, and the later is too difficult to apply to the archaeological record. Ultimately the most basic elements of style are a spatially and temporally specific pattern of doing something (Sackett, 1977:370). Typological classes are usually separated into functional categories. For example, a projectile point is made to impact tissue from a distance and create a wound sufficient that an animal succumbs to hemorrhaging (Friis-Hansen, 1990). The culturally situated choices that the agent makes to accomplish the goal, however, can result in variable point morphologies, appearances, and reduction trajectories within that functional category, all of which can be considered part of the artifact's style (Hegmon, 1992:518). Sackett defined this type of phenomena as isochrestic variation (Sackett, 1977).

Isochrestic, meaning equivalent in use, is the term Sackett uses to show that style is a choice in the service of an end goal (Sackett, 1982). The question remains, do truly functional equivalents really exist? The design of a stone point has to balance the cutting ability and the durability of the tool. A smaller angle on the tip of the point allows for better penetration but it also makes a point weaker and prone to breakage (Friss-Hansen, 1990:497). Some craftsmen may choose a more durable point. Others may decide to value sharpness over durability. It is impossible to determine which point is functionally better as it relates to the specific preferences of the craftsman. Regardless, Sackett maintains that archaeologists rarely have enough information to make a judgement on true equivalence (Sackett, 1977:374). Since ancient people probably did not have the same cultural understanding of utilitarian function as modern archeologists, this is likely a moot point. It may be more accurate to think of style as variation among artifacts with equivalent goals.

Using Sackett's isochrestic variation as the basis for a concept of style, it is possible to create a classification system that sees artifacts as the result of choices made by agents. How does a series of choices become common among a group of people so that their artifacts can be said to belong to a similar type? What does such a typology represent? The choices used in the creation of these artifacts are situated within the cultural norms and traditions, a particular way of making them that may differ from producers situated within other groups. Cultural transmission theory seeks to explain the avenues that make passing these rules between members possible.

Cultural Transmission

Cultural transmission theory (CT) recognizes culture as a process in which inheritance plays a key role (Eerkens and Lipo, 2007:242). Information on ways to produce projectile points is passed along primarily via social learning and observation. While CT is based on a model of common decent similar to that of biological evolution, there are key differences. Like biological evolution, the transmission of information can happen vertically from parent to offspring or master to student. Unlike biological evolution, it can also be shared horizontally from peer to peer (Cavalli-Sforza and Feldman, 1981). Genetic transmission is limited to a single event in which genes are passed to the next generation. CT by contrast can include multiple episodes of transmission with varying amounts of information (Eerkens and Lipo, 2007). Multiple paths of transmission coupled with the lack of limits to the structure of the information transmitted allow for quicker modification of traits than is possible with genetic inheritance (Boyd and Richerson, 1985).

Eerkens and Lipo break the CT process into three dimensions which are content, context, and mode (Eerkens and Lipo, 2007). Content is the information that is being transmitted corresponding roughly to a gene in genetic transmission. Content changes over time largely as a result of either innovation or drift (Neiman, 1995). Innovations that lead to greater overall fitness are replicated and passed on to others. Drift occurs when the information being transmitted is altered unintentionally. For instance, the rules of production are miscommunicated, or the student lacks the ability to execute the rules properly. Context is seen as the physical and social setting of the information exchange (Eerkens and Lipo, 2007:249). The particular setting could amplify or reduce the amount of drift in the content, such that groups that are in continuous contact may show greater coherence in point styles over time than groups that are more isolated, assuming that those closely interacting groups are not motivated to intentionally differentiate their material culture styles. Mode references the cognitive rules by which people acquire information. It is not completely understood wether mode is a function of culture or it is structured biologically (Eerkens and Lipo, 2007:250). When creating typologies, archaeologists deal specifically with content. The artifact is the material embodiment of the information that was transmitted.

Constructing Typologies

Projectile point typologies traditionally employed in archaeology are created with descriptions of key morphological attributes (Justice, 1987; Ray, 2016). These attributes are sorted through a series of selected categories. For instance, projectile points are often sorted into side-notched, corner-notched, and basal-notched categories based on the shape of the lower half of the point (the hafting element). Select attributes are used to create bins that isolate projectile points into discreet types, even if variation between them forms a gradient of morphologies that trend into each other. When untyped specimens are found, they are compared to a type collection or illustrations in region-specific type guides. While this process has certain benefits, namely the quick relative dates it gives archaeologists in the field, it also has some disadvantages. One problem is the subjectivity involved in comparing a projectile point to published photographs and drawings, which can add variability in classification that is not culturally significant. A second problem is that forcing untyped specimens into an established typology averages over variation within and between types that could be of cultural importance.

A classification system that seeks to investigate social interaction would embrace variation as a part of cultural transmission or stylistic drift resulting from a relative lack of interaction among groups. Variation results from any factor that causes deviation from the styles traditionally used by a culture group, which can include innovation, errors in copying, relative isolation among groups, or external influences. Instead of limiting the analysis to a few categories per morphological attribute, archaeologists should examine the range of variation itself as an important component of culture change. Acknowledging the range would allow archaeologists to hypothesize about social learning and interaction among groups through space and over time. A set of standardized measurements and classification system of similarity would eliminate the subjectivity of type guides. Standardization would also alleviate concerns about the validity of proposed types.

By defining style as a choice, and situating those choices in a cultural context, the entire use-life of a projectile point can be seen as a product of style. Projectile pointes are constantly changing as a result of cycles of use and maintenance (Ray, 2016; Ahler and Geib, 2000). These cycles are often depicted as chains or trees with separate branches (Bleed, 2001). The branches spring out from nodes that represent different choices that could be made at a particular stage. Such an analogy works well with the concepts of style and CT deployed in this study. The maintenance of projectile points clearly involves choosing from a range of potential options. Maintenance can then be considered as further stylistic input on the form of projectile points.

Two types of classification are possible when taking stylistic input over the use-life of the projectile point into consideration. Projectile points could be classified in the context of their cycle of maintenance. That is to say projectile points in the same temporal context archaeologically, but in different stages of their use-life, could be classified. A second type of classification could be done with points that are in a similar stage of maintenance. The later of these two is the goal of this paper. The classification system employed here will look at the variations in projectile point morphology at the end of their use life. The purpose of this type of classification is identifying transmission over the temporal context of a site.

Chapter 3

The Archaic in the Ozarks

While the Archaic period spans about 9000 years in the archaeological record of the Eastern Woodlands of the United States, it accounts for less than 20 percent of radiocarbon dates (McElrath, Fortier, and Emerson, 2009:4). The cause of this discrepancy can be debated, but the result has been an increased reliance on projectile point typologies to date archaeological sites. A database used by Nolan and Fishel to examine the chronological assessment of over 4,000 sites indicates that 99 percent were assigned dates based on diagnostic projectile point types (Nolan and Fishel, 2009). It is fair to say that the chronology of the Archaic in its current state is defined by projectile point seriations. Since the Archaic represents a pre-ceramic period of the North American archaeological record, those seriations are indispensable for understanding cultural processes.

In the Ozark region, the Archaic period ushered in a greater diversity of projectile point types compared to the earlier Paleoindian period (Sabo and Early, 1990:45). Several different cultural complexes are defined for this period, including Tom's Brook, Caudill, and White River. These complexes are identified by associated tool assemblages that include one or more point types (Sabo and Early, 1990:51-52).

Investigations at the Big Eddy site in the Missouri Ozarks suggest that identifying complexes based on point types has merit (Ray, Lopinot, and Hajie, 2009:157). The Big Eddy site contains well stratified deposits with relatively discreet point types found in each stratum. It was rare for multiple point types to occur within a single stratum. When a stratum did produce multiple types, the authors believed them to represent overlapping territories of different cultural groups interacting at that location (Ray, Lopinot, and Hajie, 2009:178). In the specific case of

Smith and Etley points, the similarities between the two were attributed to horizontal transmission between similar small groups with overlapping territories. Other instances of multiple types with shared attributes have been identified. During the excavation of Rodgers Shelter, Kay noted the presence of both Smith and Afton points in contexts together (Kay, 1983:63). It is unclear wether these findings represent one group using similar techniques to create separate tools, transmission between groups resulting in similar techniques, or sequential occupation of the shelter by different groups that could not be distinguished within the broad chronological phases that archaeologists are often reduced to working with.

Several changes took place during the Archaic that may have contributed to projectile point type diversification. Populations were becoming less mobile and less specialized in their subsistence pursuits and more entrained to exploiting diverse resources within their territories. During the Early and Middle Archaic, populations were likely organized into small bands traveling over the landscape, exploiting seasonal abundance of food sources (Sabo and Early, 1990:57). There was continued hunting of large mammals such as deer, but faunal remains indicate an increase in hunting small game like rabbit and squirrel (Sabo and Early, 1990:54). Evidence of nut mast processing also exists (Kay, 1983:63).

In the Late Archaic, settlement patterns continued to shift to increasingly localized territories with the addition of semi-sedentary base camps (Sabo and Early, 1990:63). Base camps were inhabited for increasingly larger durations over the year. The shift to more permanent camps was made possible by the cultivation of native seeds like goosefoot and may-grass that provide another food source that thrived in disturbed anthropogenic areas. Cultivation of several plant species in the Late Archaic is confirmed by Kay in the investigation of Philips Spring and Rodgers Shelter (Kay, 1983:61).

The changes in settlement patterns and foodways could account for projectile point variation in two ways. First, the change in population structure toward more localized home ranges likely altered the context and geographic extent of transmission. The communities themselves would have become more localized, and the restricted geographic range of interaction limited influences from groups situated farther away. Second, the diversification of foodways likely had an impact on the content of transmission. The morphologies of projectile points would have been altered to accommodate new dietary trends.

Table 1. Stratigraphy of the Albertson site with date ranges and time periods

STRATA	LEVELS	PHASE/PERIOD	DATE	C-14:
Stratum 1	1a-2b	Neosho Phase	A.D. 1500-1650	UGA-3942 1395-1605 A.D.
Stratum 2	3a-3b	Late Caddoan	A.D. 1450-1500	None
Stratum 3	4a-12b	Late Caddoan- Terminal Archaic	900 B.C.- 1450 A.D	UGA-3941 775-925 A.D.
Stratum 4	13a-15b	Terminal Archaic-Middle Archaic	5000 B.C.-900 B.C.	UGA-3940 780-1020 B.C.
Stratum 5	16a-24b	Middle Archaic-Early Archaic	8500 B.C.-5000 B.C.	UGA-3939 6215-6705 B.C.

The Albertson Site

The Albertson Site is a bluff-shelter in Benton County, Arkansas. The Shelter runs parallel to Spavinaw Creek with a length of 59 feet and a maximum width of 17 feet. The site was excavated by Don Dickson during the summers of 1967-1969. Don Dickson was a local resident and a vocational archaeologist who worked in coordination with the Arkansas Archeological Survey. Dickson established procedures that would standardize excavation across the site. Excavation was done carefully with a trowel so that artifacts could be recovered in situ. This allowed him to piece-plot artifacts of significance. Excavation was done in arbitrary six-inch levels (Dickson, 1991:1). The soil matrix was screened through quarter-inch mesh (Dickson, 1991:5).

The site was exceptionally well stratified and contained cultural remains form Early Archaic through historic times (Figure 1). Dickson strategically took four carbon-14 samples to help confirm his site chronology (Dickson, 1991:24). Features with diagnostic artifacts or those at the transition of two strata with different cultural phases were selected. He recognized five different soil strata (Dickson, 1991:25)(Table 1). Stratum 1 contained a Neosho phase component and was given a date range of 1500-1650 AD. Stratum 2 was made up of a late Caddoan phase that was dated to 1450-1500 AD. Stratum 3 began in 900 BC in Terminal Archaic and ended in the Late Caddoan around 1450 AD. Stratum 4 was dated between 5,000 BC and 900 BC running from Middle Archaic to Terminal Archaic. Stratum 5 contained an Early to Middle Archaic component dating 8,500 B.C. to 5,000 B.C.

Dickson interpreted the Early Archaic period at the site as a time when small groups of hunters used the site as a temporary camp. He drew this conclusion based on interspersed small hearths with limited tool kits associated with them (Dickson, 1991:264). Throughout, the Middle and Late Archaic, the site was maintained as a seasonal camp. Deer and small mammal bones were found across all the Archaic period strata (Dickson, 1991:266). However, plant processing tools began to appear in the Middle Archaic (Dickson, 1991:266-270).

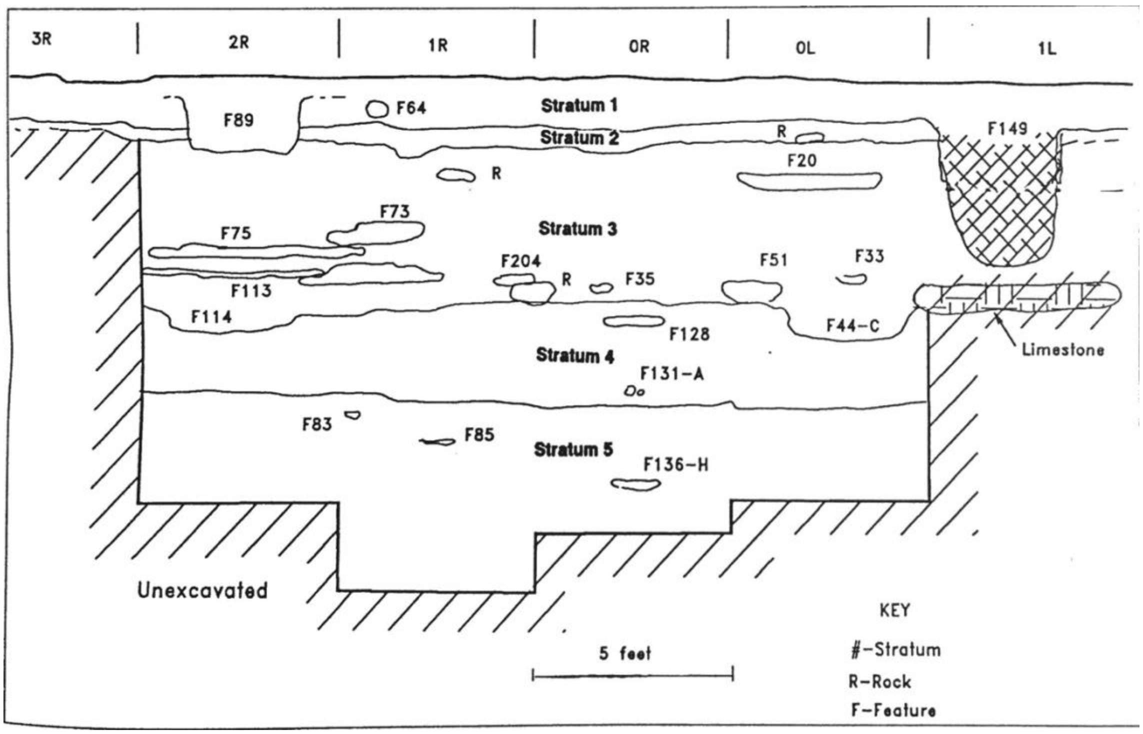

Figure 1. Excavation profile from Albertson site (Dickson, 1991:23)

There is a wide diversity of projectile point types present at the site. Many of the points show signs of intensive use and resharpening. This indicates that the maintenance of weapons systems was carried out there. The damaged and exhausted points were left at the shelter and replaced.

The fact that the points showed signs of intensive use and maintenance and were ultimately discarded at the end of their use-lives make them directly comparable in this analysis. The size and shape of projectile points changes throughout their production and use life. A newly finished point might be significantly different morphologically from a point at the end of its use life (Ray, 2016; Ahler and Geib, 2000). If projectiles in various stages of maintenance were used than multiple types could be created that in fact are different stages of the same style. All of the points in this collection had reached a critical phase in which the cost of maintenance was greater than the performance returned (Bleed, 1986). It can then be concluded that all the points in this sample are at a similar stage of use. As such, they represent specific styles of production and maintenance, and not the spectrum of an individual style through several stages. For this project, thirty-nine Archaic projectile points with intact proximal ends were chosen for 3-Dimensional scanning.

Chapter 4

A 3D-Scanning Approach to Classification

When collecting data that would be useful in understanding the transmission of cultural traits it is important to capture the spectrum of variation within the sample. In order to capture such variation, measurements of the projectile points need to be as accurate as possible. With help form the Arkansas Archeological Survey, a 3D scanner was used to capture the data for project. Making measurements directly on 3D models of the points enhances replicability of the data as others can perform the measurements on the same models, which can be shared electronically, using a variety of open-sourced software.

The scanner used for this project was a Artec Space Spider. This type of scanner uses structured light to make 3D models of objects. The Space Spider uses blue spectrum light, which results in higher levels of accuracy when used in a setting with ambient light. This gives the Space Spider an advantage over other scanners that are often distorted by external light sources. When creating a model, the scanner projects a pattern of light onto the object. Multiple cameras set at different angles then triangulate points on the object based on the shadow distortions from the light source.

The Space Spider produces models with resolution of up to 100 microns. Also, producing 3D models allowed for measurements to be taken rapidly. All of the measurements for this sample were taken in less then two hours. It was also easy to measure angles on the projectile points using the software Blender. While 3D scans made measuring more accurate and faster, they also make it possible for the scans to be used again in future analyses either undertaken by the author or shared with other researchers.

Scanning projectile points involved a two-step process. First, the points were put on a turntable with the distal end stuck in modeling clay so that the proximal end stood vertically for scanning. The point was then scanned from all sides. Next, the point was flipped so that the proximal end was stuck in the clay and the remaining parts of the distal end were scanned. This process created two unique scans that had to be joined in order to render the full point. When the scans were joined, the modeling clay could be edited out giving a clear view of the entire artifact. The merger of the scans created a watertight mesh, a model with one closed surface, that could be exported to other software. The models were exported into the program Blender. Blender allows measurements to be taken between any two points of a model. It also allows users to measure various angles.

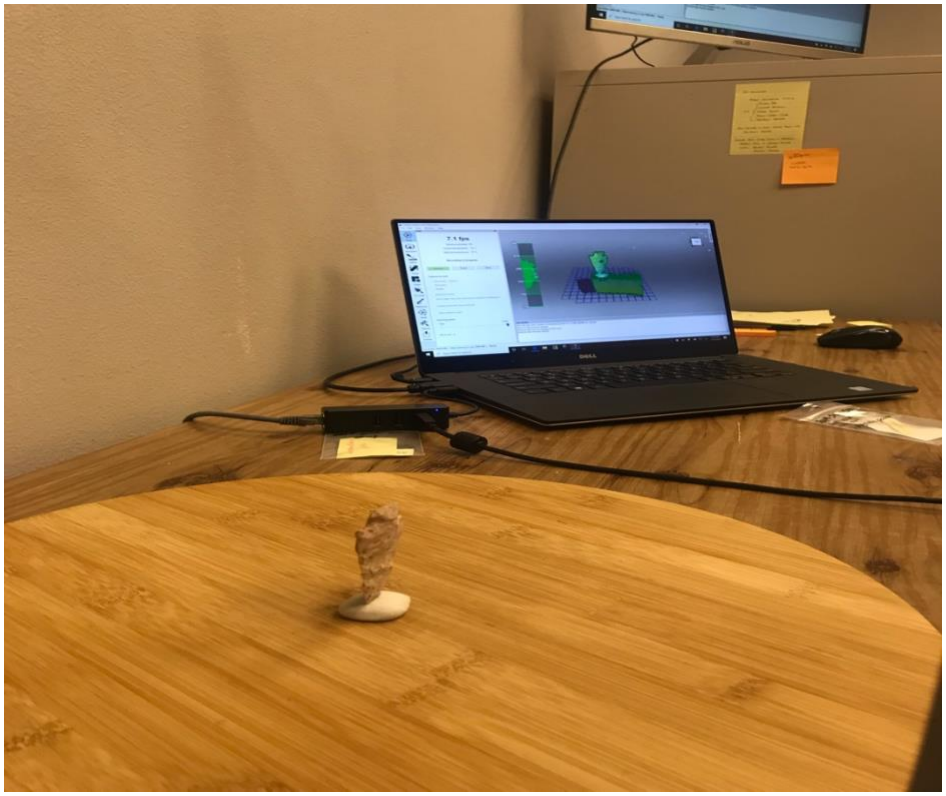

Figure 2. Example of the scanning procedure

The Sample

The measurements used in this project required an intact proximal end for all specimens. As such, only points with an intact and undamaged base were selected. While the site contained projectile points from the Early Archaic to the Late Caddo periods, only Archaic points were selected. This period offered the greatest number of preserved points. Also, limiting the analysis to the Archaic was a means to select a subsample that could be scanned within the time constraints of the project.

The thirty-nine points scanned were broken into seventeen types by Dickson (Dickson, 1991). Dickson constructed his own typology for the points at the site that was then compared to other regionally defined types. When deemed similar enough to types named in published literature, his provisional types were attributed to the established regional typology. There are eight established types that have been identified among the sample: Smith, Table Rock, Stone Corner Notched, Kings Corner Notched, Jakie, and Rice. While Dickson notes similarities between the other site-specific types he created and broader regional typologies, he opted to keep the provisional type names that he originally ascribed. The types named from the site typology are LA-7, LA-2, LA-3, LA-9, LA-1, CS-1, LA-6, LA-5, MA-3, MA-2, and RS-1.

Two types and a total of three points are dated to the Early Archaic. The Early Archaic points consist of one Jackie point and two Rice points. Three types and ten points are dated to the Middle Archaic. Middle Archaic points consist of seven RS-1, two MA-2, and one MA-3. Twelve types with a total of twenty-six points are dated to the Late Archaic. Of the Late Archaic points, there are two Smith, two LA-7, four LA-2, three Table Rock, two LA-3, four LA-9, two LA-1, one Stone Corner Notched, two Kings Corner Notched, two CS-1, one LA-6, and one LA-5. Other details including artifact number, level, and stem morphology are presented in Table 2.

Table 2 Projectile Points used in analysis with type names and Stratigraphic level

Artifact	Dickson	Haft	Stratum	Level
1351b	Smith	Stemmed	4	11
1348b	LA-7	Corner Notched	4	11
1341b	LA-2	Corner Notched	4	11
1372b	LA-2	Corner Notched	4	11
1400b	LA-2	Corner Notched	4	11
1363b	LA-2	Corner Notched	4	11
1340b	Table Rock	Stemmed	4	11
1349b-1	LA-3	Corner Notched	4	11
1349b-2	LA-3	Corner Notched	4	11
1339b	Table Rock	Stemmed	4	11
1342b-1	LA-9	Basal Notched	4	12
1342b-2	LA-9	Corner Notched	4	12
1342b-3	LA-9	Basal Notched	4	12
1352b	LA-1	Corner Notched	4	12
1354b	LA-1	Corner Notched	4	12
1397b-1	Smith	Stemmed	4	13
1397b-2	Smith	Stemmed	4	13
1423b	Stone CN	Corner Notched	4	13
1358b	Kings CN	Corner Notched	4	13
1395b	Kings CN	Corner Notched	4	13
1386b-1	CS-1	Stemmed	4	14
1386b-2	CS-1	Stemmed	4	14
1389b	LA-7	Corner Notched	4	14
1424b	LA-6	Side Notched	4	14
1353b	LA-5	Stemmed	4	14
1374b	Table Rock	Stemmed	4	14
1588b	MA-3	Stemmed	4	16
1359b	RS-1	Stemmed	4	16

Table 2 Projectile points used in analysis with type names and stratigraphic level Cont.

Artifact	Dickson	Haft	Stratum	Level
1357b	RS-1	Stemmed	4	16
1378b	MA-2	Stemmed	4	16
1379-1	RS-1	Stemmed	4	16
1379b-2	RS-1	Stemmed	4	16
1391b	RS-1	Stemmed	4	16
1404b	MA-2	Stemmed	4	16
1377b	RS-1	Stemmed	4	16
1414b	RS-1	Stemmed	4	16
1616b	Jakie	Crescent	4	17
1618b	Rice	Lobed	4	17
1590b	Rice	Lobed	4	17

Measurements

When constructing typologies of projectile points, archaeologists generally concentrate on the hafting element (Ray, 2017; Justice, 1987; De Azevedo, 2014). The function of the projectile point somewhat constrains the morphology of the blade. By contrast, there are many more options for hafting techniques, which results in greater morphological variability observed in the hafting element. Generally, types are created by sorting points into hafting styles. An example of this would be stemmed or notched points. After this initial division stemmed points might be divided into contracting or expanding stem. Likewise, notched points might be divided into corner or side notched. The measurements used in this project allow the comparison of the specific degree of contraction or the precise angle of the notches. This added variability can help illuminate the relatedness of certain types. Nine measurements were taken for each point: maximum blade width, maximum base width, neck width, neck width height, maximum thickness, neck thickness, lower notch angle left, lower notch angle right, upper notch angle left, upper notch angle right. To ensure that differences in shape, rather than size, were being compared, measurements were turned into ratios for final analysis. The decision to use ratios was made after considering the changes projectile points undergo though their use life (Ray, 2016). Cycles of use and maintenance generally have an effect on the size of the points (Ahler and Geib, 2000). While the context and morphology of these points indicates they are all at a similar stage in their life cycle, differences in size could still be attributed largely to small differences in use intensity.

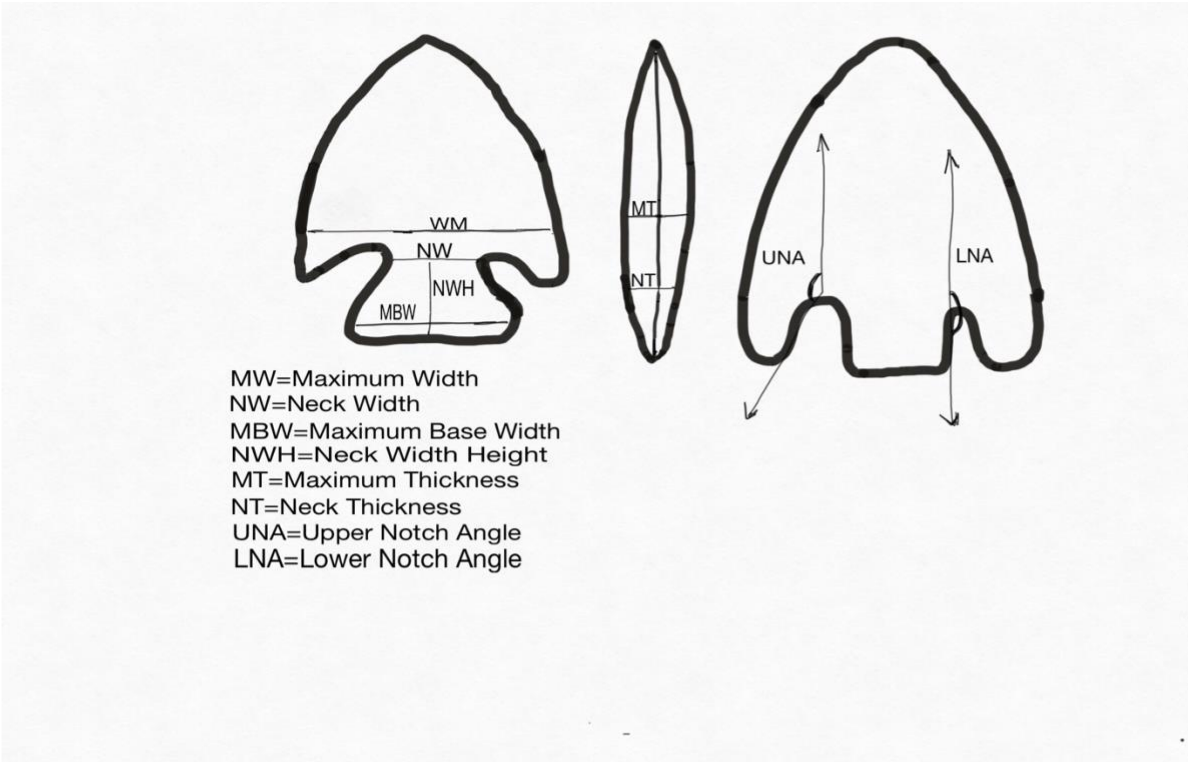

Figure 3 Placement of measurements taken with Blender

Ratios defined for quantitative analysis are neck width/neck width height, maximum blade width/neck width, maximum thickness/neck thickness, lower notch angle ratio, and upper notch angle ratio. The angle ratios were calculated by taking the average of the right or left measurements and dividing it by 360. The ratios were intended to measure elements that are often visually estimated by an archaeologist. The neck width/neck width height ratio monitors the general length of the haft element. The maximum blade width/neck width monitors the constriction of the point from the widest to the shortest. The maximum base width/neck width is a calculation of the categories generally defined as straight, contacting, or expanding stem. The thickness ratio measures the general tapering of the point toward the stem. The angle ratios relate to the common classifications of side notched, corner notched, or basal notched. Using these measurements should help eliminate the subjectivity of categorical classification.

Statistical Analysis

For the statistical analysis, the ratios were uploaded to the software package Past (Hammer et al, 2001). Past offers a range of tools for data analysis, this includes principal components analysis, cluster analysis, and morphometrics. Cluster analysis was selected for this data set because of its clear visualization of similarity or difference among the specimens. Specifically, the Neighbor Joining (NJ) method was used for the current data set (Saitou and Nei, 1987). The NJ method has one key advantage over other clustering methods. This advantage lays in NJ ability to account for stratigraphy.

Accounting for stratigraphy in the analysis is extremely important. As stated previously, types are bounded spatially and temporally. While all the specimens are from the same location, the strata represent sequential periods of time that might separate the people who occupied the shelter by hundreds or thousands of years. If the temporal differences are not actively incorporated into the analysis, it could mislead the analyst to make faulty conclusions. For example, if two points are very similar in morphology but there is a time gap of several thousand years between them, placing them in the same cluster provides little interpretive value for understanding social learning process. The NJ method allows the dendrogram to be rooted at a specific location. In this case, the dendrogram was rooted at the projectile point from the deepest stratigraphic deposit. The branches formed off this original node are not required to be the same length (Saitou and Nei, 1987). Individual branches of the dendrogram can then be compared with the site's stratigraphy. Thus, the clusters present a visual representation of changing variability in the projectile points sequence though time.

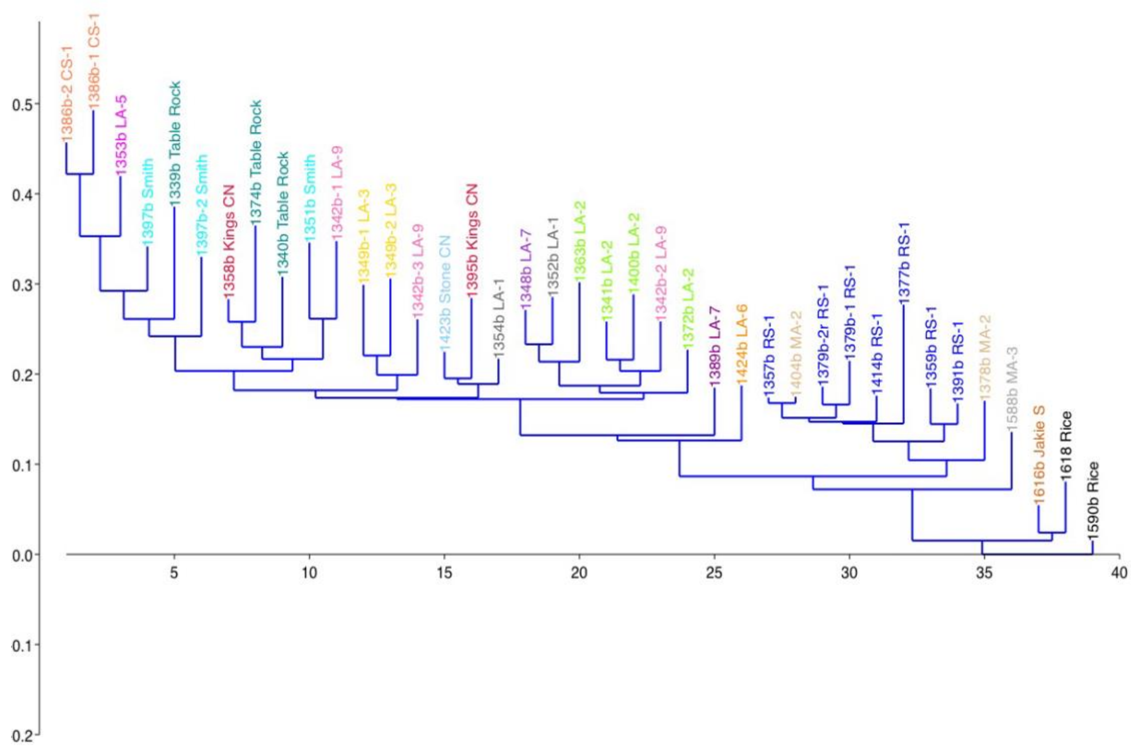

Figure 4. Stratigraphic dendrogram of projectile points. Each color represents a point type used by Don Dickson

Adding stratigraphic data for the analysis meant that there would be a mixed set of ordinal and continuous data. To measure similarity among projectile points using different types of data the Gower Similarity Index was used. Gower is a popular index for measuring similarity among mixed data sets (Hummel, Edelman, and Kopp-Schneider, 2017). Gower describes how it is possible to use mixed data sets when addressing similarity (Gower, 1971:859). The Gower index normalizes the range of variation in each variable making them comparable to each other (Gower, 1971). If the traditional euclidean equation had been used, the ordinal scale of the stratigraphic data would have weighed too heavily on the cluster results. Instead, Gower takes all the measurements for a particular attribute and measures the distances between them on a normalized scale. The distance between the attribute value of each specimen is scaled between 0 and 1. The scaling process is done for each attribute individually. The scaled data is used to find the cluster solution.

To examine the effects of incorporating normalized stratigraphic position on the cluster solutions, a second cluster solution was run without stratigraphic data. The second dendrogram used the same NJ method as the first and was also rooted at the same point. With the only difference being the presence or absence of stratigraphic data, the dendrograms are directly comparable and the influence of using stratigraphic data as a variable in the clustering solution can be addressed.

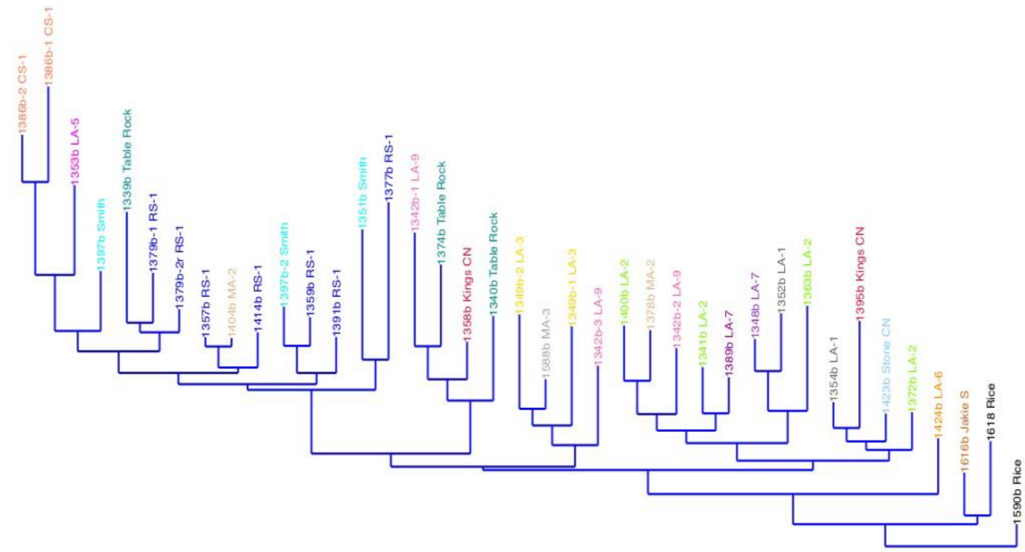

Figure 5. Non-stratigraphic dendrogram of projectile points. Each color represents a point type used by Don Dickson

Results

The stratigraphic dendrogram calls into question some of the types proposed by Dickson. Of the thirty-nine points in the sample, only ten were directly paired with a point given the same type designation. Two of these pairs, 1386b-2CS-1/1386b-CS-1 and 1349b-1LA-3/1349-2LA-3, represent matches between the only points of their respective types. Two pairs consist of points classified as RS-1 by Dickson. In the dendrogram, all of the RS-1 specimen are tightly clustered. The final pair consisted of points 1341b LA-2 and 1400B LA-2. The LA-2 type contained a total of four points. While the two other LA-2 points are relatively close to the pair they are not the closest in similarity according to the dendrogram. These five pairs represent four types defined by Dickson that were to some extant reliable. Five other types consisted of a single specimen each. The seven other point types are more similar to another specimen than to each other.

The dendrogram was rooted at point 1590b Rice. This point was recovered from the deepest level in the sample. Branching directly out from this node are the other two Early Archaic points in the sample. The cluster of Early Archaic points is then directly followed by a cluster of the ten Middle Archaic points. Following the Middle Archaic branch, the final large cluster contains all twenty-six Late Archaic points. The three large time segments of the Archaic are perfectly represented in the dendrogram. However, within these larger clusters the placement of points does not correspond to their exact stratigraphic location. For example, both CS-1 points were located near the bottom of the Late Archaic sequence, but they appear on the very top of the dendrogram. Similarly, Point 1374b was found in the deepest Late Archaic level, but it appears closer to other points typed Table Rock near the top of the dendrogram. This indicates that while points are held in a loose chronological order they are still able to cluster with points that share a similar morphology.

Looking at the dendrogram in terms of morphology, the way that the general hafting categories clustered together becomes apparent. The three Early Archaic points are not stemmed or notched. These points have crescent shape indentions on the side that give the base a lobed appearance. This is a unique hafting technique within the sample and thus these points are shown as separated by a large distance from all others. In contrast all of the points from the Middle Archaic would be classified as stemmed and form a tight cluster. The Late Archaic sequence contains the most points and the most diversity. Examining this cluster from left to right they are broadly organized as side notched, followed by corner notched, then basal notched, and finally stemmed. While the broad categories that are generally used in projectile point typologies are present, there is still noticeable variation within them. For instance, points1341b LA-2 and point 13491 LA-3 are both considered corner notched they are part of smaller clusters in the dendrogram. Likewise, points like 1358b and 1395b are both typed as Kings Corner Notched but they occupy different smaller clusters. The cluster analysis allows more variation to be considered than the standard categories approach.

Figure 5 presents the dendrogram created without the use of stratigraphic data. The greatest difference between the two dendrograms is the placement of the Middle Archaic points. The RS-1 points clustered with the Smith and Table Rock points. This cluster represents all of the stemmed points in the sample. One MA-2 and one MA-3 point moved into clusters of notched points. These clusters are only marginally altered by the new additions. While the clusters of Late Archaic points have minor alterations in their order the larger clusters present in the stratigraphic dendrogram are intact.

Using only morphometric data in the analysis, without linking to stratigraphy, did not show the types used by Dickson to be consistent. The dendrogram without stratigraphic data clustered fewer points of the same type than the dendrogram that did include stratigraphy. Only six points total were clustered together with another point given the same type by Dickson. Two of these points are CS-1 and are the only two points of their type in the analysis. The other four points are all typed as RS-1. Morphologically the dendrogram starts on the right with lobed than moving left to corner notched followed by basal notched and finally stemmed. Apart from the Early Archaic points on the far right the points do not cluster in any way that is indicative of their temporal affiliation.

Chapter 5

Conclusions

This analysis has shown that standard projectile point typologies can be unreliable. A large portion of the projectile point types proposed by Dickson did not cluster together. Less than half of the points with a possible type match were paired in the stratigraphic dendrogram. The clustering coherence of the original types was even worse in the analysis excluding stratigraphy as an input variable. There are two possible explanations for this shortcoming. One possibility is that the projectile point types are not defined well enough to be of interpretive value. In this scenario the points are typed correctly, but the type itself is so general that it overlaps with other more refined types. Some types may be so broad that they are difficult to apply to a real data set. Another explanation is that the methods used by Dickson to classify the data set were not replicable. In this case the types themselves are well defined but the methods of classification are faulty.

In either case the three-dimensional scanning approach used in this study offers solutions. When dealing with the problem of poorly defined types, this method completely circumvents the issue. Instead of defining a type and then looking to match a specimen to those parameters, the method of making standardized measurements on 3D models introduces less bias as it clusters points based on objective similarities or differences. Clusters can than be investigated individually or compared against one another. The 3D scans themselves allow for very accurate measurements to be taken in a repeatable fashion. This ability allows the method to be replicable among different archaeologists. Beyond this, the 3D approach allows for increased versatility for the data captured. The scans can be easily distributed to other archaeologists. Furthermore, a large range of measurements can be taken at the discretion of the researcher.

The 3D scanning approach provides a method for comparing the relatedness of all projectile points. Such comparisons are not easily accomplished with traditional types. While it is possible to compare the individual points to each other, the types themselves are, in essence, a mode of variation for the group. This means that types are difficult to compare because the process of creating them requires isolating them from one another. Cluster analysis looks at the full range of variation and makes it easy to quantify the similarities and differences of all points. Using a clustering method also eliminates the problem of untyped specimens. When a point has attributes of more than one type, it can often be a judgement call of the archaeologist to place it into a category. This problem is eliminated in the clustering method as it will be placed according to its similarity with other specimens.

What does the final analysis reveal about cultural transmission at the Albertson site? First, it should be pointed out that the sample size is relatively small and heavily skewed toward the Late Archaic. However, the stratigraphic dendrogram shows that the three large time units included in the sample are easily separated. It is not surprising for this separation to occur as the great difference in projectile point technology is one of the primary means by which the time periods were established by archeologists. The high degree of variation is not necessarily the result of the people creating the projectiles in the Late Archaic being of different ancestry than those in the Middle and Early Archaic. The data collected in this study only indicates that a restructuring of transmission patterns has taken place. However, Population replacement can not be completely ruled out with this data set.

Clearly the content being transmitted is radically different from the Early Archaic through the Late Archaic. Cultural transmission theory offers an explanation for the divergence in style. The variation between the Early Archaic and the other time periods is much greater than what would be expected from continuous vertical transmission with only subtle or slow paced drift (Eerkens and Lipo, 2005). According to simulated models of transmission, variation caused by drift should take place in relatively small increments and compound over time (Eerkens and Lipo, 2005). Drift should not cause dramatic shifts in style like the ones seen between the Archaic periods. Shifts such as these are indicative of innovation. Innovation is often the result of a reorganization of information or techniques rather than an invention from whole cloth (Eerkens and Lipo, 2006). Reorganization can result in drastically different styles because of the compounding effect of technical choices (Schiffer and Skibo, 1987). The choices made in the initial creation of the point have a direct impact on the possible choices for successive steps. Large-scale shifts in style can happen quickly because of the divergent paths that early choices create.

Dickson proposed that the Smith points of the Late Archaic might be related to the RS-1 points of the Middle Archaic (Dickson, 1991). However, the typology he employed did not quantify the relationship between these points. Based on the stratigraphic dendrogram, Smith and RS-1 points are the result of separate patterns of transmission. The dendrogram without stratigraphy does not show this separation. This indicates a gap in the collection of points at the site. It is likely that during the time period between these two point types the site was not occupied by groups responsible for the transmission of this style. If a larger sample was taken from the surrounding area this hypothesis could be tested. If the separation between these points is filled in by adding new collections this would indicate that the site has a temporal gap for this particular style. This example shows the benefit of using stratigraphic data. It allows archaeologists to make predictions about potential holes in a data set.

When examining solely the Late Archaic in the first dendrogram, examples of drift are apparent. There are some tight clusters that exhibit a level of variation consistent with drift. For instance, there are seven corner notched points clustered together which Dickson separated into four types. The cluster includes all four of type LA-2 as well as one LA-7, one LA-1, and one LA-9. Instead of four separate types, this cluster likely represents drift in a single projectile point style. In contrast, The CS-1 type shows a level of morphological divergence from all other points that cannot be attributed to drift. CS-1 points are a distinct style that shows little relation to the other points. These two points could represent a separate group at the site, a large shift in style from innovation, or a separate point tradition within the same group.

Outside of the previously mentioned cluster of seven points no tight cluster in the Late Archaic is larger than three specimens. The smaller clusters are closely joined to each other unlike the gap between the CS-1 cluster and all others. The author believes this to be an indication of limited transmission among groups of people who likely only interacted periodically throughout the year. The population dynamics of the Late Archaic represent periods of concentration around seasonal resources alternating with dispersal as those resources were exhausted. Changing social structures present the opportunity for transmission patterns to be reorganized into minor innovations. The variation from innovation would be kept low because of the periodic population consolidation that would stabilize the existing style (Okumura and Araujo, 2014). Population size was continually rising throughout the Archaic (Sabo and Early, 1990). Larger numbers of individuals equate to more transmission events and more possibilities for copying error (Eerkens and Lipo, 2005). The combination of these two factors explain the series of small clusters that are all closely linked. While the possibilities are intriguing there simply are not enough data points to confirm these suspicions. A larger data set that includes a wider spatial area is required. However, this study has shown the potential to interpret variation in projectile points using the framework of cultural transmission.

The framework of CT is only possible when stratigraphic data is used in the analysis. CT is a temporal phenomenon. Clustering without temporal data can be a useful tool for examining morphometric variability. Non-stratigraphic analysis can show researchers where possible holes in their collection may be. However, understanding the process of CT can only be accomplished with temporal data. Applying the concepts of drift and innovation requires a time scale. To understand the social process of transmission artifacts most be linked spatially and temporally for the event of transmission to take place.

Future Directions

Since the approach described in this paper has shown the potential to understand the social process of transmission it can be applied to large data sets. In the future this would include a data set with spatial data as well. Projectile points from across multiple sites in the Ozark region could be compared. If the analysis was limited to a small temporal range than it could be possible to identify transmission between interacting groups. There are likely overlapping communities in the region of the Albertson site that were influencing each other. Looking at similarity across the Ozarks would allow this hypothesis to be tested. If the clusters that form are clearly isolated from each other it would indicate highly distinct communities with little transmission between them. By contrast, if the clusters show overlap it would indicate shared knowledge between communities.

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