ANALYZING THE BIOLOGICAL RELATEDNESS OF INDIVIDUALS

FROM A MID- TO LATE-1800s MISSOURI CEMETERY

by

Cassie E. Skipper, B.S.

A thesis submitted to the Graduate College Council of
Texas State University in partial fulfillment
of the requirements for the degree of
Master of Arts
with a Major in Anthropology
December 2015

Committee Members:

Daniel J. Wescott, Chair

M. Katherine Spradley

Michelle D. Hamilton

ACKNOWLEDGEMENTS

I would first like to thank my committee chair, Dr. Daniel Wescott, for his support throughout this process. You have always been willing to help in any way possible, and you constantly provide an amusing and stimulating learning environment. For a man whose immediate response to a question is usually "I don't know," you definitely have an impressive store of knowledge, which you are always willing to share. You have challenged me to think differently and have helped me to become a better researcher. I would also like to thank my committee members. Dr. Kate Spradley has been an incredible source of knowledge during my time in the M.A. program. You have challenged my mind consistently throughout the time I have known you, and I am happy to say that you sparked my interest in statistics. I am lucky to have been taught and mentored by you, and I truly appreciate you. Dr. Michelle Hamilton has a critical mind and sharp eye. Thank you for questioning my words and challenging me to exceed. Dr. Deborah Cunningham, although you were not on my thesis committee, you have been a great source of support. I apologize for telling your secret in print, but everyone should know how amazing you are. I and the other Texas State students are lucky to have the opportunity to learn from and study with the incredible faculty at Texas State University.

I am also grateful to Drs. Richard Jantz and Joseph Hefner for kindly sharing their data as comparative samples in my thesis research. Your assistance is very much appreciated.

To my friends in my Anthropology cohort, including the year before and after me, you have been such amazing supporters. The master's program has been an intense adventure, and I am so glad that I got to share it with you fine people. I have made friends and family for life here at Texas State. Many thanks to my family, especially my parents and my younger sister, who have been so understanding and great listeners throughout the past 2 years. To my sister, Amy, you brighten my life. I appreciate my family for instilling strong values in me and raising me to speak my mind and never settle for less than I can possibly achieve.

I am a reflection of the influences these people have had on me. I am grateful for the impact that each of these individuals has had on my life.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

ABSTRACT

Biodistance studies are valuable tools in biological anthropology because they help address questions about population structure and demographics. In this study, metric and nonmetric data are used to examine the biological relatedness of 11 American Black individuals whose graves were exposed in the abandoned 19th century Shiloh Methodist Cemetery during flooding of the Missouri River in 1993. All associated Shiloh Methodist Church records and documents were destroyed in the flood, leaving the identity of these individuals unknown. The purpose of the study is to examine the biological distance between the Shiloh individuals and West African, American Black, and American White populations and the within group variation the Shiloh individuals to determine if there is phenotypic homogeneity among the Shiloh individuals.

Analyses of the metric and nonmetric indicate the individuals align most closely with American Blacks from the era than African populations. Mahalanobis distances between each pair of crania (D=2.79) are less than expected (D=3.61) for an American Black population and indicate that the Shiloh individuals examined were likely members of the same biological and cultural community. The results of this study do not support that the Shiloh individuals were recent migrants from Africa or members of a single family unit. The contrast between the funerary adornment of Shiloh Feature 13 and the other 10 individuals combined with their morphological similarities imply there were likely multiple social levels in the American Black community. Future research will include DNA analyses of the Shiloh sample to define their biological relationships, which

will be compared with the current results to evaluate the relationship between metric and nonmetric data and their level(s) of genetic influence.

I. INTRODUCTION

Research Problem and Purpose

The 1993 flood of the Missouri River in Callaway County, Missouri exposed the skeletal remains of approximately 18 individuals buried in the late 1800s at the Shiloh Methodist Church Cemetery near Jefferson City and destroyed Church documents about the cemetery. All associated Shiloh Methodist Church records were destroyed in the flood. Of the exposed skeletons, 11 young individuals of presumed American Black ancestry were excavated from three rows for analysis. Since little information is known about the demographic makeup of the American Blacks that lived in the area and attended the Shiloh Church, the purpose of this research is to conduct a biological distance analysis of the 11 available individuals from the Shiloh Cemetery to determine within group variation and determine if they are phenotypically more closely related to African or American Black populations. The present research is important because understanding the relationship between individuals in the cemetery is necessary to provide context for future studies assessing the health of the 11 individuals and understanding the spatial relationships within the Shiloh Methodist Cemetery and whether these potential spatial relationships have any cultural and/or biological significance. Biological distance analyses of these individuals also contribute to our understanding of the broader social and biological history of 19th Century Central Missouri, especially the life and death of American Blacks living in the region.

Research Questions

Historical records indicate that both Black and White members of the Shiloh Church were buried in cemetery. Furthermore, historical archaeologists studying central Missouri argue that the Shiloh Blacks were probably not slaves although census data indicate that the majority of American Blacks in the region were slaves until the end of the Civil War. Therefore, the primary questions addressed in this thesis are 1) are the 11 individuals of African ancestry?, 2) do they align more closely with African or American Black populations?, and 3) can craniometric and cranial and dental nonmetric data be used to discern whether the individuals represent a biological community or a group of unrelated persons? In this study, metric (cranial) and nonmetric (cranial and dental) data were used to assess the ancestry of the individuals from the Shiloh Methodist Cemetery (Question 1), whether they are recent immigrants from Africa (Question 2) and their biological relatedness (Question 3). This multi-method approach was employed to maximize information from the data available. This multi-method approach is appropriate for bioarchaeological analyses and will elaborate on existing literature as well as knowledge about the Shiloh group.

Because the Shiloh Methodist Cemetery was originally used as an interracial cemetery the presumption of American Black ancestry for these individuals was first tested using Howells (1973) and Ousley and McKeown (2001) cranial measurements, which were input into FORDISC 3.0 (Jantz and Ousley 2005b) and DISPOP (Jantz 2000). Craniometric information from the Shiloh Cemetery skeletal remains were then compared to existing data sets from African and American Black general populations to examine the question of recent migration. The assumption is that the individuals will be more morphologically similar to African populations than American Blacks if they are recent migrants. The term ‘recent’ is used here to describe those individuals that either migrated from Africa in their lifetime or whose parents had migrated to the U.S. as a result of the African Diaspora. Nonmetric data from the Shiloh Cemetery individuals was also compared among the Shiloh individuals and to available data on Africans and American Blacks. Again the assumption is that the Shiloh individuals will be more morphologically similar to African populations than American Blacks if they are recent migrants. Finally, variation in metric data was examined by comparing Mahalanobis distances between each pair of crania. The assumption is that if the individuals are related or represent a biological community they will exhibit less variation than expected based on a random sample.

Background

Shiloh Church and Cemetery

In the late 1800s, the Shiloh Methodist Church Cemetery was located in Callaway County across the Missouri River from Jefferson City. The Shiloh Methodist interracial congregation began in 1809, but the church was not built at that location until 1851. The earliest recorded burial at the Shiloh Cemetery site was in 1838, but most of the individuals in the cemetery were buried between 1851 and 1876. In 1876, the church was dismantled and moved to Cedar City, thereby changing its name to the Cedar City Methodist Church, which was subsequently destroyed by the same flood in 1993 that unearthed the Shiloh burials (Gaarde 1993).

Flooding of the Missouri River in 1993 uncovered the forgotten Shiloh Methodist Cemetery. Unfortunately, church records associated with the original cemetery were also destroyed in the 1993 flood. Flood waters eroded away 1.5 meters of topsoil exposing the cemetery site (23CY593), which was surveyed by the Missouri Archaeological Society (Figures 1.1-3). According to archaeological records, 18 burials were discovered, 15 of which were excavated. Four of the recovered burial represent infants and were not used in this study.

The recorded graves were primarily arranged in three rows at the site (Figures 1.1. – 1.3). One row extending southeast to northwest contained 11 individuals that were buried with their head facing southwest. The other two rows were parallel and extended southwest to northeast with the head of the pointed northwest (Gaarde 1993). According to Gaarde (1993), all of the burials discovered had remnants of wooden coffins as well as square nails, and the individuals were laid in an supine extended position. All of the individuals, except the burial identified as Feature 13 (F13), appear to be interred in simple wooden coffins. The coffin containing the skeleton of F13 was 1.5 meters deeper than the others and adorned with silver knobs and an oval glass viewing window (Figure 1.4). In addition, the soil outline of F13's coffin indicates that it had a six-sided silhouette with a faceted construction with a glass viewing plate near the head. This construction is much finer than the other features' simple wooden coffins. F13 also contained hard rubber buttons which carry the 1951 Goodrich patent for rubber hardening. These buttons were manufactured by the Novelty Rubber Company from 1855 to 1886 (Sutton and Arkush 2002). Therefore, this individual was most likely buried between 1855 and 1876. The mean date of viewing window glass manufacture for this coffin, based on equations from Moir (1987), is 1858, which is consistent with the estimated burial dates of 1855 and 1876.

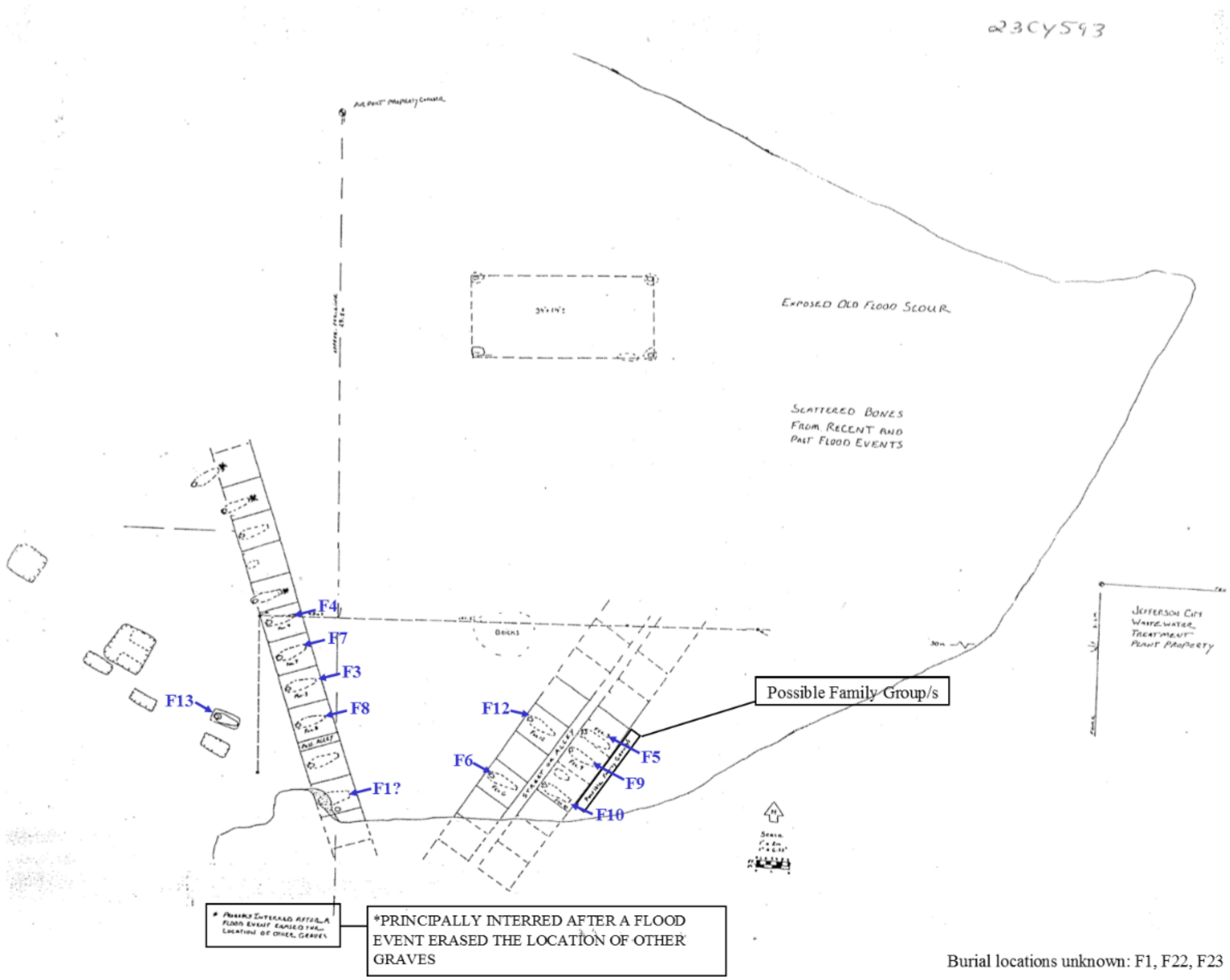

Figure 1.1. Site map of 23CY593 with burials used in this study labeled (Gaarde 1993).

Figure 1.2. Aerial view of 23CY593 showing a single row of burials oriented in a southwest to northeast direction (Gaarde 1993).

Figure 1.3. Aerial view of 23CY593 showing two parallel rows of burials oriented in a northwest to southeast direction (Gaarde 1993).

Figure 1.4. Overview of Feature 13 showing the skeleton and remnants of the coffin's glass viewing window (Gaarde 1993).

Limited information is known about the other individuals uncovered from the Shiloh Methodist Cemetery, and the identities of these people remain unknown. However, dental cementum increment analysis indicate that most of the individuals died in the Spring or Summer (Wedel and Wescott 2011). Because cemeteries are often spatially arranged based on kinship (Stojanowski and Schillaci 2006) the Shiloh group is an excellent candidate for a biodistance study.

Shiloh Community

Callaway County, Missouri was first organized in November 1820 and had an established population of 1,797 people by 1821 (Burch 1955). According to the State Historical Society of Missouri, the population in Callaway County had risen to 9,920 by 1850, where 3,907 of those individuals were enslaved Africans. According to the State Historical Society of Missouri (2012), census records from 1860 note a population increase to 12,926 with a corresponding increase in the slave population to 4,523. There were very few free Blacks in the mid-1800s throughout the state of Missouri. Only 2.9% of the American Black population in 1850 were free with a small increase to 3.0% in 1860 (Bellamy 1973). The total Black and White populations of Missouri were 682,044 and 1,181,992 in 1850 and 1860, respectively.

The life of a Black person in mid-1800 Missouri was no different from other slave states (Bellamy 1973). Free Blacks were tolerated but subjected to harsh white racism. The members of this small free portion of the population were considered as a threat to slave property by white people, who harbored great prejudice against them. The main mechanisms by which blacks were freed was through the court suits, self-purchase, and manumission. If an individual were freed via manumission, then their master granted their freedom. Many offspring of masters' slave mistresses were freed in this manner. This practice was often frowned upon but became more prominent as politics changed in the 1850s (Bellamy 1973).

Because the Shiloh Methodist Cemetery was in operation for 14 years (1851 to 1865) prior to the abolition of slavery it is possible that at least some of the Shiloh individuals could have been enslaved. This study has the potential to shed light on whether the Shiloh individuals were free Blacks or slaves. If they were slaves, it is more likely that they would not be as closely related and therefore have a within group variation similar to the general American Black population. On the other hand, if they were freed Blacks and represent a biological community, the crania are likely to exhibit less within group variation than the general American Black population. The phrase 'closely related' is used here to describe immediately or close extended family members. The current research compared Shiloh cranial measurements and dental morphoscopic traits to African and American Black reference populations. Metric and nonmetric variables have often been used to investigate both ancestry and familial relationships because they have a certain level of heritability (Berry and Berry 1967; Carson 2006; Delgado-Burbano 2007; Edgar 2002; Hauser and De Stefano 1989; Hefner 2009). One would expect that a family unit would have a limited range of variation for the metric and nonmetric variables compared to the wide range of variation exhibited by a reference population.

Biodistance Studies

Biodistance analyses are commonly used in bioarchaeological studies because they allow researchers to examine issues related to evolutionary history and population structure (e.g., kinship relationships, postmarital residence patterns, social groups) (Carson 2006; Stojanowski and Schillaci 2006). This information provides context for assessing population health, history, movement, and boundaries. Biodistance analysis is the study of phenotypic data, which have been affected by genetic drift and gene flow over a short period of time (Stojanowski and Schillaci 2006). By studying the biological distance of interred individuals, researchers can begin to understand many aspects of the social group, including the social structure, mating rules, migration patterns, post marriage residence patterns, and population size (Stojanowski and Schillaci 2006).

The fundamental idea of examining biological relatedness using metric and nonmetric methods are similar. The expectation is that a certain amount of heritability is attached to trait expression (Stojanowski and Schillaci 2006). However, metric and nonmetric methods have often been viewed as divergent and incomparable. Tyrrell (2000) explains that arguments have been made to the effect that nonmetric cranial traits are difficult to assess and result in ambiguity, but he does see potential for these methods in the future. Wheat (2009) investigated this debate further by testing researchers with a variety of educational levels and levels of experience based on their incorrect or correct assessment of ancestry when provided with a number of human skull casts and a list of nonmetric cranial traits. She found there was no significant difference in the levels of experience versus education between individuals who accurately or inaccurately placed the casts in their correct ancestral group. These results indicate the straightforward benefits of using nonmetric methodology. Furthermore, Herrmann's dissertation research utilized nonmetric cranial traits in a biological distance analysis of Green River archaic sites (Herrmann 2002). Mahalanobis' D^2 values were pooled together for the separate sites in his study, and both individual site vectors and pooled values were imported into R for analysis. Age and sex were taken into account, and full heritability of the traits was assumed. These methods allowed Herrmann to evaluate within and between group biological affinities. Herrmann's research discovered both geographical and temporal influences on the biological distance structure based on the variation of morphological cranial traits. Using these methods, Herrmann was able to make inferences about the Green River mating network and residence patterns.

Many researchers have argued for the use of nonmetric trait analysis in ancestry estimation. Although Rhine (1990) utilized what are now antiquated nonmetric trait methods, his explanation that nonmetric methods are useful because they do not require special equipment and can be used when the cranium is damaged remains valid. These advantages have led to the inclusion of nonmetric morphological analysis in the evaluation of ancestry and kinship (Gill 1998; Hefner 2009; Hefner and Ousley 2014). Gill (1998) studied craniofacial traits as a means of identifying geographic races, including White, East Asian, American Indian, Polynesian, and Black. While the term 'race' has nearly been eradicated from the biological anthropology field, ancestry estimation shares many of the fundamental ideas as the craniofacial traits included in Gill's study. More specifically, the use of morphological traits to estimate ancestry is based on the transmission of traits among kin. Because kinship groups are often geographically clustered and cultures generally practice assortative mating biologically linked groups form that allow individuals to be accurately classified into ancestral groups (Brace 1995; Kennedy 1995; Ousley *et al.* 2009; Relethford 2009; Sauer 1992). This is exemplified in Hefner's (2009) study in which he tested 11 macromorphoscopic nonmetric cranial traits on 747 individuals from four ancestral groups (i.e., African, European, Asian and Native American) and found a statistically significant correlation between trait frequencies and ancestry for 10 of the traits. Loosely defined, macromorphoscopic traits are nonmetric traits viewable on a physically larger scale than many small scale nonmetric traits and may have a more direct link to heritability than many nonmetric traits. Although macromorphoscopic traits are useful for estimating ancestry, Hefner (2009) warned against attempting to base any ancestry estimation on trait expression without the inclusion of a statistical evaluation of these traits.

Craniometric methods have also often been used to study trait heritability. Spradley (2006) studied genetic admixture and secular changes in craniofacial morphology using data on craniometric variation. From her research, Spradley found that the Americans Black individuals exhibited single nucleotide polymorphisms (SNPs) and craniometric measurements intermediate between American Whites and the first few generations of American Blacks. These results revealed that craniometric morphology is more influenced by genetic factors than plasticity. If the reverse were true, the sampled individuals would have shown a much greater change in cranial shape over a shorter amount of time. More specifically, because the environment in which these individuals lived changed quickly during their shift from Africa to North America it would be expected that cranial morphology would change rapidly as a response to this environmental change if morphology was, indeed, driven primarily by plasticity. However, Spradley's (2006) research showed more subtle morphological changes during this shift and intermediate results, which supports genetics as a primary determining factor over plasticity. Similarly, Wescott and Jantz (2005) addressed the question of secular change in American Blacks and Whites over the past 150 years. To do this, the authors used a sample of 644 crania of Black and White males and females and took 2-D Cartesian coordinates of each and classified these by birth year (i.e., mean birth year [MBY] and range [BYR]). The known antemortem demographics of each individual used in the study were compared against the resulting data, and they found there was a relative downward and backward movement of opisthion and basion compared to an upward movement of lambda. Better and improving health conditions and nutrition allowed a steady increase in infant growth over time, which was determined to be the ultimate cause of the secular change in American Black and White crania. The secular change exhibited by both groups followed a parallel path. American Whites and Blacks retained morphological differences despite exposure to a similar environment over the past 150 years (Wescott and Jantz 2005).

Additionally, craniometrics have been used to investigate biological relatedness in archaeological settings (Carson 2006; Russell 2006; Schillaci and Stojanowski 2005; Spradley 2006). Carson (2006), for example, utilized cranial morphology and maximum likelihood variance components analysis on 298 pedigreed individuals from Hallstatt, Austria born 1707-1888 to determine heritability of cranial metric traits. The crania of these individuals were exhumed, decorated usually with date of death, and placed in an ossuary located behind the Catholic Church in Hallstatt as part of cultural mortuary practices. Using a combination of cranial identity (i.e., cranial decoration), age, and church records, the author was able to determine the identity of these individuals. Variance components heritability values of these individuals supported low to moderate heritability of the craniometric traits under study. More specifically, cranial length and neurocranial measurements had higher heritabilities than cranial breadth measurements, which seemed to be under more environmental control. Because the heritability values in the Carson (2006) study are population-specific they cannot be applied to other populations or samples. However, the current study does support the use of craniometrics in biodistance analysis.

Nonmetric dental traits have also been used to evaluate the role of genetics in morphological trait expression and variation. The Arizona State University Dental Anthropology System (ASUDAS) and Turner *et al.* (1991a) are often used as the foundation for dental trait investigation among individuals that are potentially biologically related. Delgado-Burbano (2007) utilized Turner *et al.* (1991a) and the ASUDAS and concluded that groups of different ancestral lines display dissimilar frequencies of marked dental nonmetric traits. Irish (1997) applied 36 nonmetric dental traits to evaluate potential biological differences between African groups. Using Smith's Mean Measure of Divergence (MMD), Irish's results showed a clear phenotypic division between North African and Sub-Saharan African groups. The Multidimensional Scaling of the MMD results depicted two tight clusters of North African and Sub-Saharan African groups, which indicates more homogeneous phenotypic relationships within rather than between these respective samples. This points to a lack of significant genetic drift or genetic divergence between these populations. Irish proposed a Sub-Saharan African dental complex, which is based on a compiled list of dental nonmetric traits with frequencies specific to geographic Sub-Saharan African groups and their descendants. Irish's dental complex allows researchers to compare unknown samples to Sub-Saharan African groups apart from other world populations. Results of Irish's (1997) dental nonmetric study were in alignment with other research performed on North African and Sub-Saharan African groups that were compared within Irish's study, including skeletal, genetic, anthropometric, and linguistic studies of these groups (Coppa *et al.* 2002; Curtin 1969; Edgar 2007) . This cross-comparison of methodologies supports the use of dental morphoscopic traits in biological distance analyses.

Because craniometrics and nonmetric (cranial and dental) data have been tied to heritability these data types were included in the present research. Furthermore, multiple data types were used in order to cross-validate the results and to compare the different methodologies. The inclusion of multiple methodologies helped to answer the proposed research questions.

Craniometrics are now accepted as a valid method of estimating ancestry and biodistance. Though not the primary aim of this research, comparing the results of this data type to the results when using nonmetric data may help to better define the link between nonmetric traits and their heritability. Metric data are likely more often used to identify ancestry and biological relationships because they are more quantifiable than nonmetric data. There are many issues involved with using nonmetric methods, including trait description ambiguity, which traits to use, how many traits to use, which traits yield the most accurate results, etc. It is the hope of the current author that this research may aid in solving one or more of these issues.

Thesis Outline

The subsequent chapters detail the analyses and findings of the present biodistance research. Chapter 2 describes the sample groups and methods used in this study as well as the statistical procedures used to assess significance. Chapter 3 details the findings of the present metric and nonmetric data analysis. Chapter 4 discusses the results and potential implications for the use of the methods employed here in similar research. Chapter 5 provides concluding remarks, including summary findings and possible future research avenues for biodistance studies in bioarchaeological samples.

II. MATERIALS AND METHODS

Shiloh Sample

The skeletal remains of 11 individuals exposed during the 1993 flood and subsequently excavated from the Shiloh Methodist Cemetery were used in this study. Table 2.1 provides the age and sex distribution of the Shiloh individuals.

Table 2.1. Age and sex estimations for the Shiloh Cemetery individuals.

Burial	Age Category	Age (years)	Sex
1	Adolescent	15-16	Probable Male
3	Early Adult	18-23	Male
4	Late Adolescent	17-18	Probable Male
6	Adolescent	15-16	Probable Female
7	Adolescent	11-13	Probable Female
8	Adult	45-55	Male
9	Adolescent	16-17	Female
12	Adult	25-30	Female
13	Late Childhood	9-10	Probable Female
22	Adolescent	13-15	Female
23	Adolescent	13-16	Female

Sex was estimated by the current author using standard nonmetric traits of the skeleton (Bass 2005; Buikstra and Ubelaker 1994; Klales *et al.* 2012; Phenice 1969; Walker 2005). Age was estimated by the current author and forensic odontologist Dr. James P. Fancher using growth and development standards of the skeleton and dentition for juveniles and adolescents (AlQahanti *et al.* 2010; Arany *et al.* 2004; Blankenship *et al.* 2007; Cameriere *et al.* 2007; Demirjian *et al.* 1973; Kasper *et al.* 2009; Lewis and Senn 2013; Mincer *et al.* 1993; Moorrees *et al.* 1963), and age-related changes of the pubic symphysis and auricular surface for adults (Boldsen *et al.* 2002; Boldsen *et al.* 2014; Milner and Boldsen 2011).

Craniometric and nonmetric cranial and dental traits were used to compare the heterogeneity of the Shiloh individuals to appropriate and available reference population standards. If the Shiloh individuals are biologically related, then they share very similar genetic information. By contrast a population would have a larger variety of genes. Theoretically, if the Shiloh individuals are biologically related, they will exhibit significantly less variation than the reference samples to which they are compared.

Utilizing both metric and nonmetric analyses will 1) increase the accuracy of the Shiloh individuals' ancestry estimations, 2) allow for the observation of similarities and differences in the results produced by both method types, and 3) provide a more holistic approach to the current biodistance analysis, resulting in a better overall understanding of the Shiloh sample.

Craniometrics

A Microscribe 3D digitizer was used to collect craniometric measurements for this study. Landmark data were used to calculate 22 linear craniometric measurements defined by Howells (1973) (Appendix A, Table 1). Only 7 individuals from the Shiloh Cemetery could be measured because those younger than 15 years of age or those who had damage to the cranium that did not permit measurement were not utilizes in this study. A minimum age of 15 was chosen for inclusion in this study because the FORDISC Help File indicated that individuals around 15 years of age or older classify as expected (Jantz and Ousley 2005a).

The Shiloh individuals were excavated from a 19th Century interracial cemetery around the end of slavery. Therefore, it was prudent to investigate the ancestry of these individuals and the possibility that one or more of these individuals could have been recent slaves. Two rounds of craniometric analyses were included. Each round of analysis included different groups of references samples. Stage one included reference samples that were used to estimate the ancestry of the Shiloh sample, including American Whites, American Blacks (Forensic Anthropology Data Bank Blacks, Terry Blacks, and Todd Blacks), and African (Bushman, Zulu, and West African) groups. Once the ancestry of the Shiloh individuals was estimated, the list of reference samples for stage two was narrowed appropriately. The second stage included reference samples that were used to estimate the range of variation among the Shiloh group to estimate whether they could have been biologically related. This stage included American Black reference data from the Forensic Anthropology Data Bank (FDB) and Terry and Todd collections.

Ancestry was estimated using both FORDISC and DISPOP because the latter includes African samples while the former does not. This also provided cross-validation of the results, which was helpful as several of the digitized Shiloh individuals were subadults. This additional step provided verification of the results for these individuals because subadult ancestry estimation can be difficult.

Several statistical procedures were conducted on the data using the following software: FORDISC 3.1, DISPOP, NTSYS, and R programming language. Craniometric data were input to FORDISC 3.1 (Jantz and Ousley 2005b) from ThreeSkull (Ousley 2014) to estimate the ancestry of the Shiloh individuals using appropriate sex groups. That is, the sex of the individual was estimated using pelvic features; therefore, only

Blacks and Whites of that sex were used in the analysis. The program conducts a discriminant function analysis and outputs the resulting Mahalanobis distances, posterior probabilities, and typicality probabilities. Group membership is assigned for the unknown specimen by measuring the relative distance of the unknown from the centroid of the reference groups used for comparison. Posterior probabilities provide an estimate of membership of an unknown specimen to each reference group (Jantz and Ousley 2005b). The sum of the posterior probabilities must equal one. Typicality probabilities assess whether an unknown skull is typical of a specific group based on how similar its measurements are to those most common in the reference group. This is done by finding the average variability of the groups being used in the study. Unlike posterior probabilities, typicality probabilities do not have to sum to 1.0. Therefore, typicality probabilities can yield more insight into whether the assigned group membership is appropriate.

The craniometric data were also analyzed in DISPOP, a multivariate computer program created by Jantz (2000), for three purposes. First to estimate ancestry. Second to evaluate the variation among the Shiloh Methodist Cemetery skeletal sample. Finally, to conduct canonical variate analysis on the Shiloh group, American Black groups, and African groups. The 'African' reference sample includes Bushman, Zulu, and West African groups collectively unless otherwise specified. The 'American Black' reference sample includes data from the historic Terry and Todd Collections (Hunt and Albanese 2005; Quigley 2001) and the modern Forensic Anthropology Data Bank (FDB) collection. The Terry and Todd Blacks represent 19th Century American Blacks from St. Louis, MO and Cleveland, OH, respectively. The FDB sample primarily represents 20th

Century forensic cases submitted to the University of Tennessee (Jantz and Ousley 2005a).

Because missing data is not allowed in DISPOP analyses, two rounds of statistical procedures were performed using DISPOP on the craniometric measurements in order to maximize the data. While reasonably well preserved, the Shiloh crania were each fragmented to some extent, which limited the number of craniometric measurements that could be collected via digitizing. By performing two rounds of analyses in DISPOP, the author was able to maximize the data collected from these fragmented remains by including more variables in the second DISPOP analysis with the exclusion of F9, the most fragmented cranium. The first round included seven Shiloh individuals (F1, F3, F4, F6, F8, F9, and F12) and is referred to as DISPOP ANALYSIS 1: all Shiloh individuals. The second round included Shiloh individuals F1, F3, F4, F6, F8, and F12 and is referred to as DISPOP ANALYSIS 2: Shiloh individuals excluding F9.

The canonical variate analyses provided Mahalanobis distance (D^2) values for both the individuals and groups. DISPOP utilized the Defrise-Gussenhoven (1967) method to estimate the amount of variation within the Shiloh group and between this group and the American Black reference groups. The Defrise-Gussenhoven method tests whether the distance (D^2) between pairs of individual crania is greater than would be expected if they were from the same population (Jantz and Owsley 2001). More specifically, the D^2 values between pairs of individual skulls drawn at random are compared to the value determined based on random expectation if drawn from a single population (Jantz and Owsley 2001). The expected distance (D) is calculated by randomly selecting pairs of skulls from a single population that has the same covariance matrix as the pooled within group matrix of reference populations. The distance is considered significant if it is greater than the expect distance (D) (Jantz and Owsley 2001). Essentially, if the Shiloh individuals have a larger average distance than expected, then there are outliers (i.e., completely unrelated) individuals within this group. A canonical variates plot and a principal coordinates plot was used to visual the Mahalanobis distance values produced in DISPOP.

Dental Nonmetrics

Fifty-six morphological dental traits were visually assessed for each of the individuals from the Shiloh Methodist Cemetery. The dental traits utilized in this research (Appendix A, Table 2) were based on the Arizona State University Dental Anthropology System (ASUDAS) (Turner *et al.* 1991b). The ASUDAS comparative 3D reference plaques were used to assess the nonmetric dental trait stages and/or presence/absence. The use of the casts increases accuracy and precision and reduces intra- and inter-observer error. The trait stages were then assigned a score of 0 (absent) or 1 (present) based on Turner's or Edgar's breakpoints (Edgar 2013; Scott and Turner 1997). Breakpoints reassign trait scores that are based on degrees of trait expression to a present/absent scale for simplicity. For example, Carabelli's trait can be scored 0 to 7, where 0 is smooth/absent, 4 indicates a large Y-shaped depression is present, and 7 is a present large free cusp (Turner *et al.* 1991b). The breakpoint system for this trait reassigns scores 0-4 as absent and 5-7 as present. Breakpoints are used to more efficiently compare and analyze data. The dental trait breakpoints used in this study are included in Appendix A, Table 3.

As there are a number of juveniles in the Shiloh Cemetery sample, only available permanent dentition was scored using the ASUDAS to estimate ancestry. The nonmetric dental trait frequencies for the Shiloh individuals were compared to African group frequencies published in (Irish 1993) and American Black group frequencies published in Edgar (2002, 2007) in the dental nonmetric analysis. Tables 2.2 and 2.3 show the groups used in this research as comparative samples. The trait frequencies for the Shiloh group and Irish and Edgar samples were statistically analyzed in R (R Development Core Team 2010) using Mean Measure of Divergence and plotted using Multidimensional Scaling. If the Shiloh individuals had recently come from Africa, they would likely display dental morphologies similar to those found in West and West-Central Africans since these groups were the most affected by the African Diaspora and slave trade (Curtin 1972; McMillin 2012).

Table 2.2. African groups from Irish (1993) used in the nonmetric dental analysis.

Sample	Region of Africa	Total
Congo	West-central	30
Gabon	West-central	39
Ghana	West	47
Kenya	East	114
Khoikhoi	South	37
Nigeria/Cameroon	West	57
Pygmy	West-central	22
South Africa	South	22
San	South	99
Senegambia	West	42
Sotho	South	178
Tanzania	East	43
Togo/Benin	West	25
Tukulor	West	39
Algeria	North	26
Bedouin	North	49
Canary Islands	Northwest	163
Carthage	Northwest	28
Chad	North-central	29
Christian	Northeast	18
El Hesa	Northeast	72
Kabyle	Northwest	32
Kharga	Northeast	26
Lisht	Northeast	61
Meroitic	Northeast	91
Mesolithic	Northeast	57
Soleb	Northeast	32
X-Group	North	39

Table 2.3. American Black groups from Edgar (2002, 2007) used in the nonmetric dental analysis.

Sample	Time Period	Total
All periods American Blacks	1650-1960	613
Early period American Blacks	1650-1850	34
Middle period American Blacks	1825-1910	414
Late period American Blacks	1920-1960	165

The dental nonmetric data was analyzed using Mean Measure of Divergence (MMD), a statistical method devised by C.A.B. Smith and first used by Grewal (1962). The procedure for measuring divergence between two populations is described in Berry and Berry (1967). In the current research, MMD was performed on the nonmetric dental trait frequencies in R (R Development Core Team 2010), a free programming language, and was used to estimate ancestry of the Shiloh sample using African and American Black reference samples. MMD is a dissimilarity measure, where smaller values represent similarity and larger values represent greater phenetic distance between the samples compared (Irish 2010). The MMD values were visually represented in a Multidimensional Scaling plot.

Cranial Nonmetrics

Twenty paired and twenty unpaired nonmetric cranial traits described in Buikstra and Ubelaker (1994) and Hefner (2009) were collected for each individual from the Shiloh Methodist Cemetery (Appendix A, Table 4). The traits were scored as absent or present, and if present, degree of trait expression as appropriate. These traits were primarily based on Berry and Berry (1967) and Hauser and De Stefano (1989) and capture morphological epigenetic variation between and among populations. The operating assumption is that a high frequency of the same traits among several of the Shiloh Cemetery individuals represents a biological connection between them. While a biological relationship can be observed using nonmetric cranial traits, a specific relationship cannot be determined using this method.

The frequency of traits present among multiple individuals were used to assess the potential for biological relatedness using Mean Measure of Divergence (MMD) and plotted using Multidimensional Scaling (MDS). Multidimensional Scaling provides a visual interpretation of similarity of individuals or groups compared by the researcher (Kruskal and Wish 1978).

Two groups of comparative morphoscopic cranial data were used in the current research. African and American Black reference groups were used to investigate the level of morphological similarities between the Shiloh individuals. If they were first or second generation American Black individuals, they would likely share more similarities with African groups than American Black groups as these individuals are more likely to have recently come from Africa. The first dataset (Table 2.4) was provided by Dr. Richard Jantz from the Forensic Anthropology Data Bank (Jantz and Ousley 2005a), and the second dataset (Table 2.5) was provided by Dr. Joseph Hefner from Osteoware (Hefner 2009; Osteoware 2011). The comparative analyses performed with the Forensic Anthropology Data Bank and Osteoware datasets will be referred to throughout this text as CRANIAL NONMETRIC ANALYSIS 1 and CRANIAL NONMETRIC ANALYSIS 2, respectively.

Table 2.4. Sample groups from the Forensic Anthropology Data Bank (FDB) used in CRANIAL NONMETRIC ANALYSIS 1.

Curator	Population	Total
Louisiana State University	American Black	9
University of New Mexico	American Black	1
University of Tennessee, Knoxville	American Black	18
University of South Carolina Aiken	American Black	2
National Museum of Natural History	American Black	24
Regional Forensic Center Nashville	American Black	2
Regional Forensic Center Memphis	American Black	2
Arizona State University	American Black	2
Hamilton County Medical Examiner	American Black	2

Table 2.5. Sample groups from Osteoware used in CRANIAL NONMETRIC ANALYSIS 2.

Curator	Population	Total
National Museum of Natural History	African	30
National Museum of Natural History	American Black	101
University of Tennessee, Knoxville	American Black	27

Multidimensional Scaling was performed on the nonmetric trait data to determine statistical significance between the individuals of the Shiloh Cemetery sample based on nonmetric cranial and dental trait frequencies. The MDS output was used to assess the similarity/dissimilarity of the individuals' nonmetric traits. Multidimensional Scaling was used to evaluate the nonmetric cranial data instead of Mean Measure of Divergence (MMD) for the following reasons: 1) smaller differences are preserved in MDS as this analysis functions to maximize variances between objects, 2) MMD is not Euclidean so distances are not always significant, and 3) MMD results sometimes include distortions (Ousley 2015 personal communication). The trait frequencies for both the nonmetric cranial and dental data were entered into NTSYSpc 2.2 (Applied Biostatistics 2008), a multivariate program and numerical taxonomic system. The MDS output shows more similar groups or objects as being closer in proximity in the plot, while those that are more dissimilar are shown as being farther apart.

Intraobserver Reliability

In order to ensure scoring accuracy intraobserver reliability studies for the morphological traits used in this research were conducted prior to collecting data. This was done by scoring the traits on the Texas State University Donated Skeletal Collection housed at the Texas State Grady Early Forensic Anthropology Research Laboratory (GEFARL) and on unidentified Operation Identification skeletal collection housed at the Texas State University Osteology Research and Processing Laboratory (ORPL).

Seventeen individuals from the Texas State University Donated Skeletal Collection were evaluated for nonmetric cranial trait intraobserver reliability using Cohen's Kappa. Twenty paired and twenty unpaired cranial nonmetric traits were used in the current research. Sixteen paired and nineteen unpaired traits were scored for intraobserver error. Five traits were not included in the intraobserver error study as these traits were later included in the research, including mastoid foramen, mastoid foramen exsutural, accessory palatine foramen, frontal foramen, and pharyngeal fossa. These traits were thoroughly researched and discussed with Dr. Daniel J. Wescott to ensure the author properly understood the trait description and scoring system prior to collecting data on the Shiloh sample. Three rounds were scored for each of the 35 traits in the intraobserver study. Therefore, three Cohen's Kappa k values were available per trait. More specifically, Round 1 was compared to Round 2, Round 2 was compared to Round

3, and Round 3 was compared to Round 1. Intraobserver results for the cranial nonmetric traits are included in Appendix B, Table 1.

Eight individuals from the Texas State University Donated Skeletal Collection and Operation Identification Collection were evaluated for nonmetric dental trait intraobserver reliability using Cohen's Kappa. Intraobserver results for the dental nonmetrics are included in Appendix B, Table 2.

III. RESULTS

<u>Intraobserver Reliability</u>

Cranial Nonmetrics

Overall, there is a high level of intraobserver agreement (Appendix B, Table 1). Traits that yielded low k values or poor agreement were removed from the study, such as Auditory Exostosis. Some traits showed an improvement in intraobserver reliability. For example, Inferior Nasal Morphology increased from fair agreement to good agreement during the three rounds. Traits that do not have Cohen's Kappa k values or assigned levels of agreement and displayed as a dash (-) indicate that one of the scoring rounds was considered to be a constant by the statistical procedure; therefore, a comparison could not be made. Cohen's Kappa considers a variable (i.e., a column of scores) to be a constant when all scores within at least one column in the comparison are exactly the same, such as all zeros. This makes Cohen's Kappa indeterminate. For these situations, the author manually assessed each round comparison in the raw data. If the scores were, indeed, identical in the comparison, a 'perfect agreement' classification was assigned.

Dental Nonmetrics

Intraobserver reliability results for the nonmetric dental traits are available in Appendix B, Table 2. Problems similar to those described when comparing the nonmetric cranial intraobserver data occurred when comparing the dental traits. These issues were handled in the same manner described in the cranial nonmetrics intraobserver section.

Ancestry

Craniometrics: FORDISC ANALYSES

With the exception of F9, the Shiloh individuals digitized and analyzed in FORDISC were estimated to be of Black ancestry when Black and White reference groups were used (Table 3.1). F9 was classified as being most similar to the White Female reference group, but was typical of a White Female (Typ F=0.503) and a Black Female (Typ F=0.450); therefore, both classifications were included in Table 3.1. Only F1 had a different sex classification based on craniometrics and postcrania.

Table 3.1. FORDISC results for the Shiloh Cemetery individuals using groups American Black Males and Females and American White Males and Females.

Individual	Number of measurements	Groups compared to	Classified into	Posterior probability	Typ F[1]
F1	20	BM, WM	BM	0.981	0.161
F3	21	BM, WM	BM	1.000	0.270
F4	11	BM, WM	BM	0.733	0.127
F6	21	BF, WF	BF	1.000	0.625
F8	11	BM, WM	BM	0.990	0.386
F9	11	BF, WF	WF	0.796	0.503
F12	14	BF, WF	BF	0.671	0.936

[1]Typicality Probability

Craniometrics: DISPOP ANALYSES

In order to maximize the results due to missing data, two runs were performed using craniometric data in DISPOP, which are referred to as DISPOP ANALYSIS 1 and 2. DISPOP ANALYSIS 1 included all digitized Shiloh individuals (F1, F3, F4, F6, F8, F9, and F12) against American Black and African groups. The 'African' reference sample includes Bushman, Zulu, and West African groups collectively unless otherwise specified. The 'American Black' reference sample includes data from the historic Terry and Todd Collections (Hunt and Albanese 2005; Quigley 2001) and the modern Forensic Anthropology Data Bank (FDB) collection. Figure 3.1 depicts the DISPOP ANALYSIS 1 output using seven craniometric measurements.

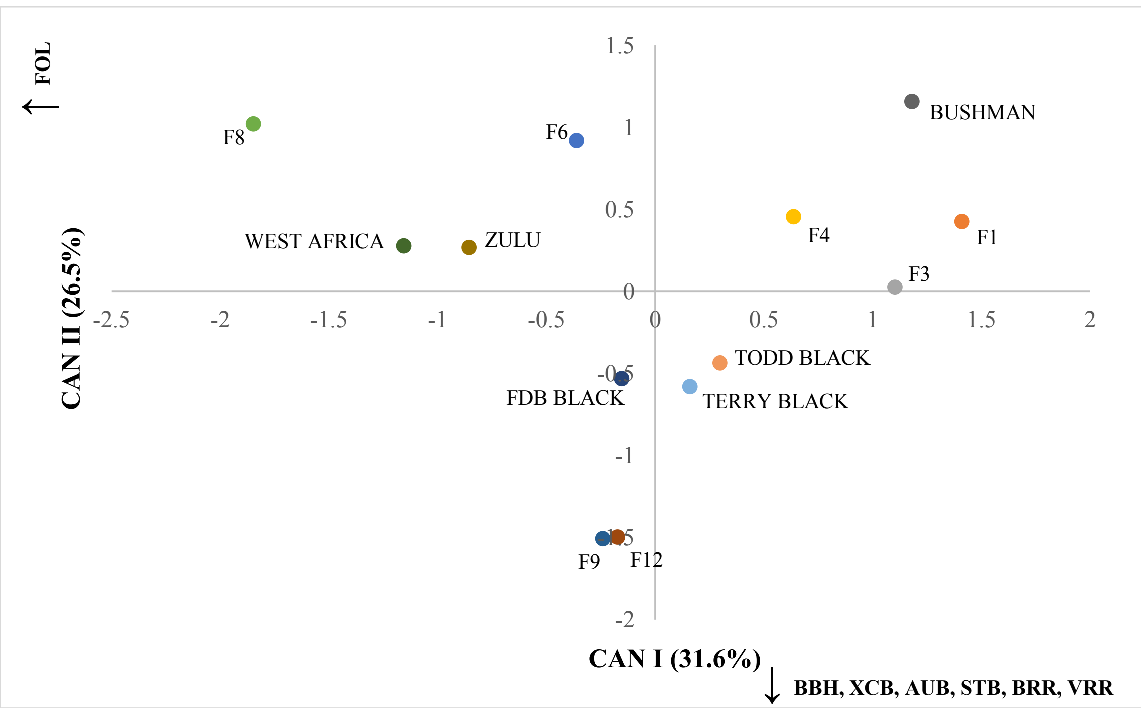

Figure 3.1. Canonical variates plot for DISPOP ANLYSIS 1: all Shiloh individuals[1].
[1]The measurement abbreviations on the axis indicate the highest loading variables.

Canonical variate 1 (CAN 1) separates groups primarily by cranial heights and vertex radii (Table 3.2), with F6, F8, F9, F12, Zulu, West Africa, and FDB Black on the left and F1, F3, F4, Bushman, Terry Black, and Todd Black on the right of the plot. CAN 2 separates groups mainly due to biauricular breadth (AUB), maximum cranial breadth (XCB) and foramen magnum length (FOL), with American Blacks, F9, and F12 in the lower portion and Africans and other Shiloh individuals in the upper portion (Table 3.2). The American Black groups are clustered together in the center.

Table 3.2. Among canonical structure coefficients for DISPOP ANALYSIS 1: all Shiloh individuals.

Variable	CAN 1	CAN 2
Basion-Bregman Height (BBH)	-0.759	-0.446
Maximum Cranial Breadth (XCB)	0.256	-0.717
Biauricular Breadth (AUB)	-0.308	-0.758
Bistephanic breadth (STB)	-0.096	-0.581
Foramen Magnum Length (FOL)	-0.505	0.680
Bregma Radius (BRR)	-0.502	-0.476
Vertex Radius (VRR)	-0.675	-0.432

The Mahalanobis squared distances (Table 3.3) and posterior probabilities (Table 3.4) show that all of the Shiloh individuals classify as American Black except F6 and F8. Both of these individuals classify as West African.

Table 3.3. Mahalanobis distances for DISPOP ANLYSIS 1: all Shiloh individuals[1].

	AFRICAN			AMERICAN BLACK		
SHILOH	BUSHMAN	ZULU	WEST AFRICA	FDB BLACK	TERRY BLACK	TODD BLACK
F1	5.139	7.722	7.751	4.411	3.456	**3.45**
F3	6.275	7.363	7.076	3.171	2.351	**2.194**
F4	7.696	8.199	7.376	6.852	5.434	**4.655**
F6	3.802	1.943	**1.744**	2.708	3.36	3.064
F8	13.803	5.033	**2.442**	6.037	7.07	7.506
F9	11.48	5.548	5.995	3.643	3.04	**2.541**
F12	11.653	5.996	5.365	**2.098**	2.637	3.62

[1]Bolded values indicate group classification.

Table 3.4. Posterior probabilities for DISPOP ANLYSIS 1: all Shiloh individuals[1].

	AFRICAN			AMERICAN BLACK		
SHILOH	BUSHMAN	ZULU	WEST AFRICA	FDB BLACK	TERRY BLACK	TODD BLACK
F1	0.13105	0.03601	0.0355	0.18861	0.30395	**0.30488**
F3	0.04592	0.02665	0.03076	0.21677	0.32658	**0.35333**
F4	0.08230	0.06402	0.09661	0.12552	0.25507	**0.37648**
F6	0.09299	0.23559	**0.26021**	0.16068	0.11600	0.13453
F8	0.00210	0.16887	**0.61681**	0.10221	0.06097	0.04904
F9	0.00414	0.08034	0.06426	0.20822	0.28162	**0.36143**
F12	0.00327	0.05527	0.07577	**0.38805**	0.29633	0.18131

[1]Bolded values indicate group classification.

DISPOP ANLYSIS 2 included the digitized Shiloh individuals, excluding F9 due to missing data, against American Black and African groups. Figure 3.2 depicts the output for DISPOP ANLYSIS 2 using 22 craniometric measurements.

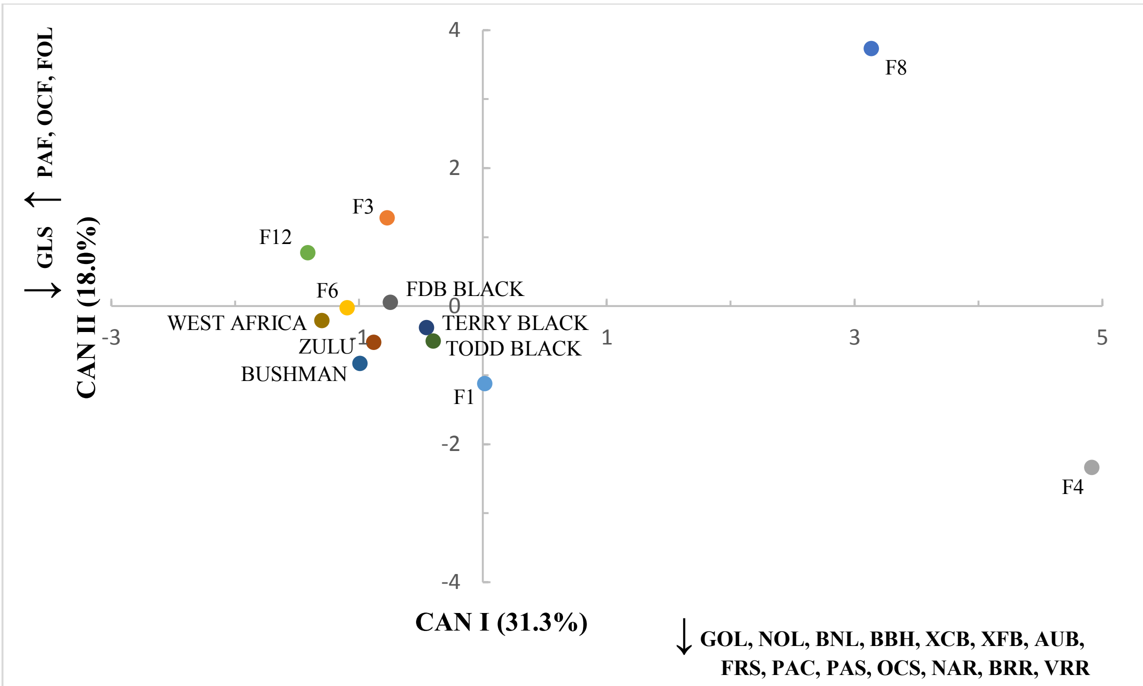

Figure 3.2. Canonical variates plot for DISPOP ANLYSIS 2: Shiloh individuals excluding F9[1].

[1]The measurement abbreviations on the axis indicate the highest loading variables.

Shiloh individuals F4 and F8 are the most isolated along CAN 1 with large glabella projections (GLS), long foramen magnums (FOL), and large parietal subtenses (PAF). On CAN 2, F8 is separated due to a large frontal fraction (FRF), frontal chord (FRC), nasion radius (NAR), and vertex radius (VRR).

Table 3.5. Among canonical structure coefficients for DISPOP ANALYSIS 2: Shiloh individuals excluding F9.

Variable	CAN 1	CAN 2
Maximum Cranial Length (GOL)	0.557	0.458
Nasio-Occipital Length (NOL)	0.549	0.350
Basion-Nasion Length (BNL)	0.045	0.507
Basion-Bregma Height (BBH)	-0.293	0.549
Maximum Cranial Breadth (XCB)	0.200	-0.376
Maximum Frontal Breadth (XFB)	0.373	0.431
Biauricular Breadth (AUB)	0.340	-0.032
Glabella Projection (GLS)	0.922	0.313
Bistephanic Breadth (STB)	0.277	-0.352
Frontal Chord (FRC)	-0.012	0.789
Frontal Subtense (FRS)	-0.374	0.096
Frontal Fraction (FRF)	-0.214	0.912
Parietal Chord (PAC)	0.498	0.197
Parietal Subtense (PAS)	0.680	0.303
Parietal Fraction (PAF)	0.365	-0.110
Occipital Chord (OCC)	-0.582	0.090
Occipital Subtense (OCS)	-0.110	-0.236
Occipital Fraction (OCF)	-0.237	0.239
Foramen Magnum Length (FOL)	0.744	0.174
Nasion Radius (NAR)	0.096	0.707
Bregma Radius (BRR)	-0.173	0.592
Vertex Radius (VRR)	0.028	0.630

The Mahalanobis squared distance results (Table 3.6) classify all of the Shiloh individuals as American Black. The posterior probabilities in Table 3.7 further support the classifications in Table 3.6.

Table 3.6. Mahalanobis distances for DISPOP ANALYSIS 2: Shiloh individuals excluding F9[1].

	AFRICAN			AMERICAN BLACK		
SHILOH	BUSHMAN	ZULU	WEST AFRICA	FDB BLACK	TERRY BLACK	TODD BLACK
F1	21.345	24.623	26.694	21.963	21.407	**20.824**
F3	25.976	24.51	25.66	16.071	**13.964**	16.339
F4	50.477	43.484	49.766	40.359	35.77	**34.69**
F6	23.495	16.858	18.06	**14.062**	15.802	14.667
F8	43.798	37.273	40.675	**32.138**	34.899	34.785
F12	23.719	15.589	13.37	**8.092**	9.85	11.381

[1]Bolded values indicate group classification.

Table 3.7. Posterior probabilities for DISPOP ANALYSIS 2: Shiloh individuals excluding F9[1].

	AFRICAN			AMERICAN BLACK		
SHILOH	BUSHMAN	ZULU	WEST AFRICA	FDB BLACK	TERRY BLACK	TODD BLACK
F1	0.23447	0.04554	0.01616	0.17215	0.2273	**0.30437**
F3	0.00148	0.00308	0.00173	0.20950	**0.60099**	0.18322
F4	0.00023	0.00744	0.00032	0.03551	0.35215	**0.60435**
F6	0.00351	0.09690	0.05313	**0.39220**	0.16435	0.28991
F8	0.00182	0.04762	0.00869	**0.62065**	0.15604	0.16518
F12	0.00024	0.01382	0.04193	**0.58694**	0.24375	0.11333

[1]Bolded values indicate the highest posterior probabilities.

Dental Nonmetrics

Multidimensional Scaling plots of the nonmetric dental Mean Measure of Divergence (MMD) values are shown below in Figure 3.3. The Shiloh sample containing 11 individuals was compared to Irish's African groups and Edgar's American Black groups. The Shiloh group (SHILOH) is isolated from the other groups in the analysis in the top right area of the plot (Figure 3.3). The Shiloh sample is closest to the following Congo group (MMD value=0.022); this is also the only group from which the Shiloh sample is not statistically significantly different. The Shiloh group is most divergent from Irish's South Africa group (MMD value=4.896). Further, the Shiloh sample is significantly divergent from Edgar's All (AAB), Early (EAB), Middle (MAB), and Late (LAB) American Black groups with MMD values of 3.428, 3.032, 3.155, and 0.684, respectively. The Shiloh group retained certain dental morphologies from the West and West-Central reference groups while diverging significantly from the West African groups to which they would be expected to be most similar. Ultimately, the Mean Measure of Divergence values do not align the ancestry of the Shiloh sample with any of the African or American Black reference groups.

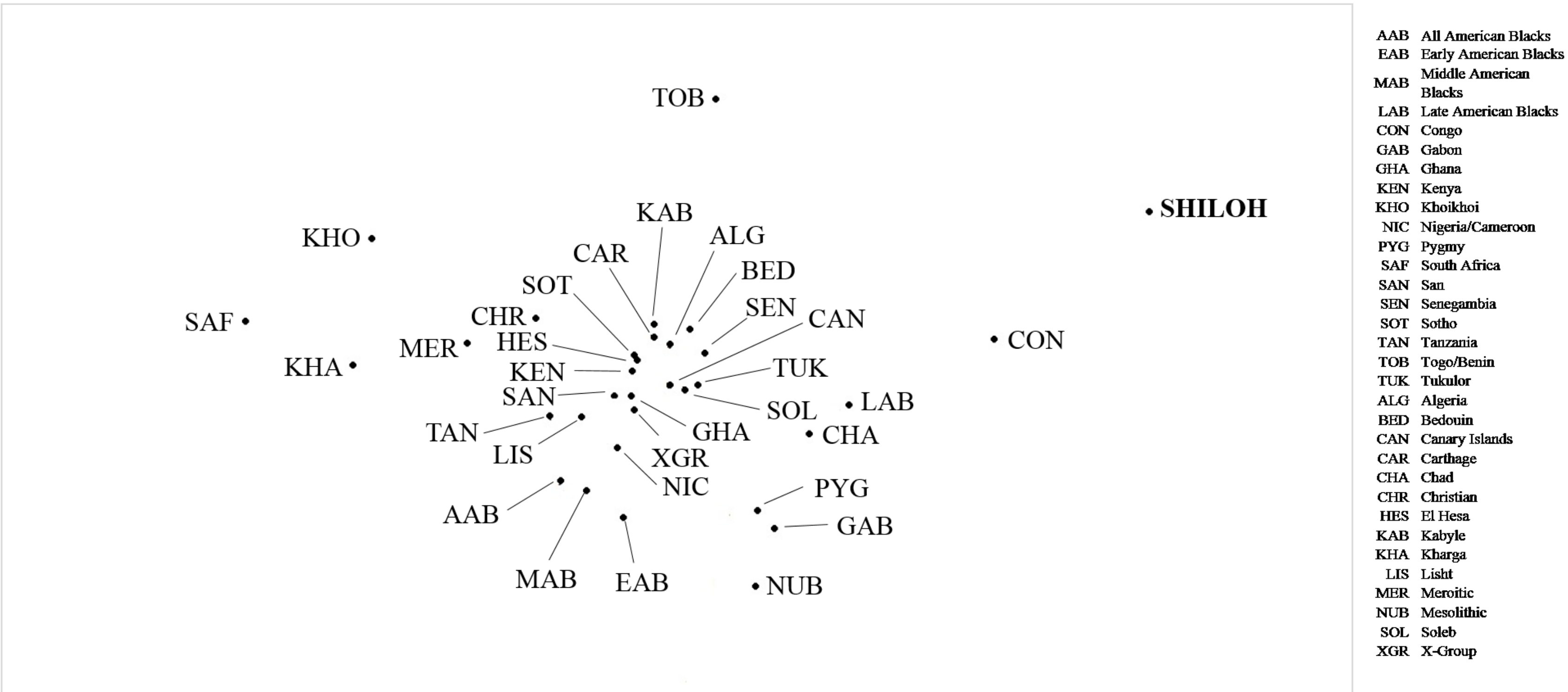

Figure 3.3. Multidimensional Scaling plot of the dental nonmetric Mean Measure of Divergence values.

The 18 morphoscopic dental traits used in the nonmetric dental analysis are provided in Table 3.8 with their respective measures of divergence. Traits with a dash (-) in the measure of divergence column were not retained for analysis by the R programming MMD code. Of the 18 dental nonmetric variables used in this analysis, only two were retrained, including hypocone UM2 and congenital absence UM3. These traits had large measure of divergence values and were highly influential in the MMD analysis. UM2HC frequencies decreased significantly between the Middle American Blacks and Late American Blacks.

Table 3.8. Dental nonmetric trait measure of divergence values.

	Dental trait code	Name	Measure of divergence
1	WING	Winging UI1	-
2	UI1LC	Labial curve UI1	-
3	UI1SS	Shoveling UI1	-
4	UI2IG	Interruption Groove UI2	-
5	UI2TD	Tuberculum dentale UI2	-
6	UCMR	Mesial ridge UC	-
7	UCDR	Distal accessory ridge UC	-
8	UM2HC	Hypocone UM2	290.222
9	UM1C5	Cusp 5 UM1	-
10	UM1CB	Carabelli's trait UM1	-
11	UM3PR	Parastyle UM3	-
12	UI2PS	Peg-shaped UI2	-
13	UM3CA	Congenital absence UM3	442.207
14	LM1AF	Anterior fovea LM1	-
15	LM1DW	Deflecting wrinkle LM1	-
16	LM1MT	Mid trigonal crest LM1	-
17	LM1PS	Protostylid LM1	-
18	LM1C7	Cusp 7 LM1	-

Kinship

Previous results support the classification of the Shiloh individuals as American Black. The potential kinship of these individuals was then investigated using 19th Century American Black reference groups from the FDB, Terry, and Todd collections.

Craniometrics

Mahalanobis distances for the seven Shiloh crania are shown in Table 3.9. DISPOP was used to generate an expected distance between skulls when selected at random from the Shiloh sample using the same covariance matrix as the pooled within matrix of the references samples included in the analysis. The distances below were generated based on American Black reference population data. The closest cranial pair was F1 and F3, while the most dissimilar pair was F8 and F9.

Table 3.9. Mahalanobis distances (D) among unknowns.

	F1	F3	F4	F6	F8	F9	F12
F1	0	0.972	2.745	2.169	3.445	3.324	2.737
F3		0	2.850	2.089	3.204	2.834	2.593
F4			0	2.964	3.336	2.764	3.642
F6				0	2.010	2.971	2.616
F8					0	3.463	3.459
F9						0	2.441
F12							0
Expected distance (D)	3.60555						
Mean distance	2.79171					SD	0.627118

The expected distance for the Shiloh individuals based on American Black population data would be 3.60555. The mean distance between the Shiloh individuals was calculated as 2.79171. According to the DISPOP results for this group, distances greater than 5.566555, or 1.65 standard deviations above the expected distance, can be considered significant by a one-tailed test (Jantz and Owsley 2001). Therefore, there are no outliers in the Shiloh sample.

Cranial Nonmetrics

The Shiloh sample was compared to two sets of reference data. The first comparison will be referred to as CRANIAL NONMETRIC ANALYSIS 1 and included cranial nonmetric data provided by Dr. Richard Jantz from the Forensic Anthropology Data Bank (FDB). The second comparison will be referred to as CRANIAL NONMETRIC ANALYSIS 2 and included macromorphoscopic data provided by Dr. Joseph Hefner from Osteoware.

Multidimensional Scaling of CRANIAL NONMETRIC ANALYSIS 1: traditional cranial nonmetric traits is shown in Figure 3.4. The MDS plot depicts similarities and dissimilarities between the Shiloh individuals and Forensic Anthropology Data Bank 20th Century Blacks based on 29 traditional morphoscopic cranial traits, including paired traits. All of the Shiloh individuals are located on the left side of the plot. While they are not closely clustered, they are also not widely spread. The Shiloh individuals overlap with the FDB individuals in Dimension II (D II) but do not show the wide range of variation exhibited by the FDB individuals in Dimension I (D I).

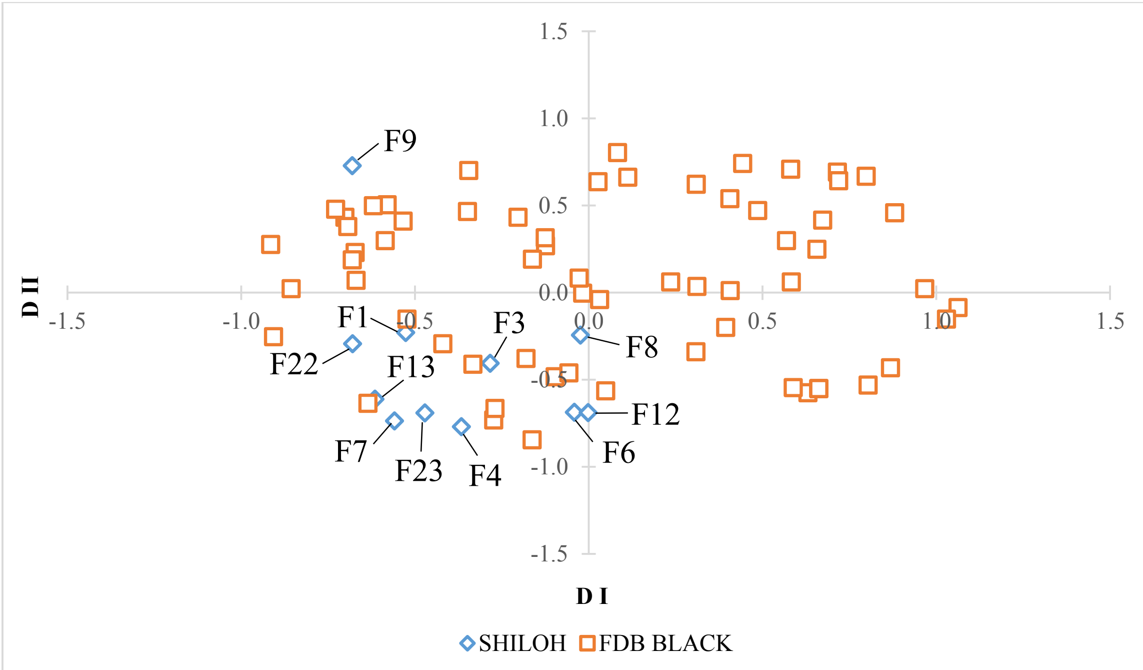

Figure 3.4. Multidimensional Scaling plot for CRANIAL NONMETRIC ANALYSIS 1: traditional cranial nonmetric traits.

Multidimensional Scaling of CRANIAL NONMETRIC ANALYSIS 2: Hefner's new macromorphoscopic traits is shown in Figure 3.5. The MDS plot depicts the Shiloh individuals and Hefner's 20th Century Terry Blacks, Africans, and American Blacks based on 11 macromorphoscopic cranial traits. Most of the Shiloh individuals fall in the lower right quadrant. The Shiloh individuals are spread across both dimensions and overlap with Terry Black and American Black, while the African individuals are mostly clustered in the lower left quadrant. The overlap of Shiloh with both of the American Black groups align them with this ancestry.

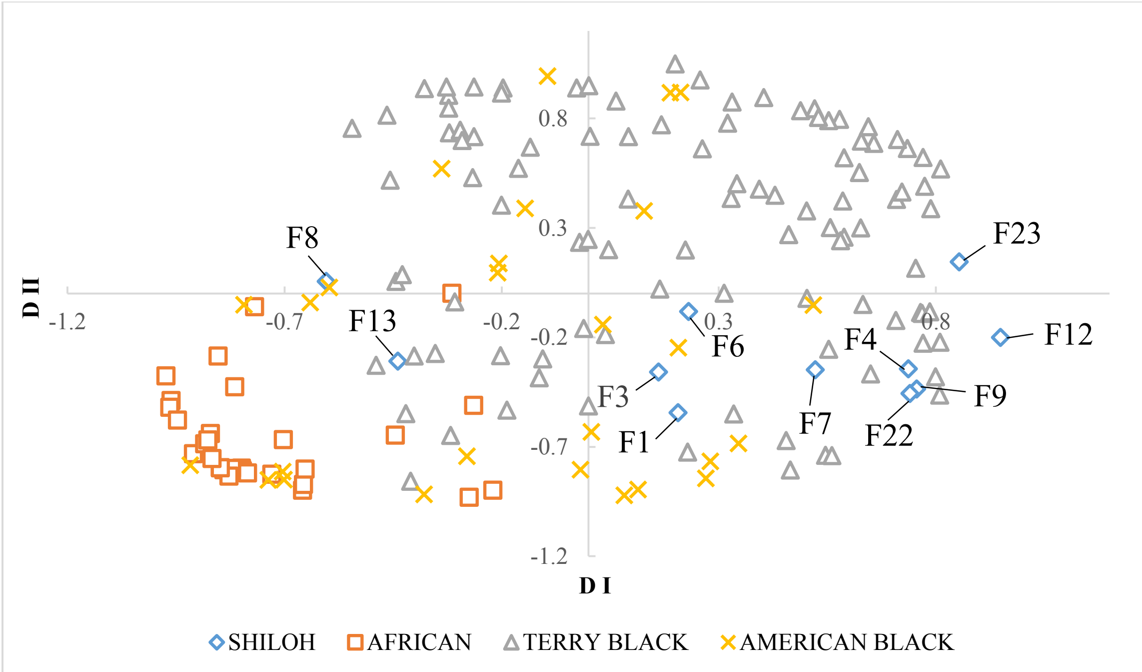

Figure 3.5. Multidimensional Scaling plot for CRANIAL NONMETRIC ANALYSIS 2: Hefner's new macromorphoscopic cranial traits.

IV. DISCUSSION AND CONCLUSION

The current analyses include 11 individuals recovered from a mid- to late-1800s Missouri Cemetery. Because the Shiloh Methodist Church records were destroyed in a flood in 1993 there is no recorded information about these individuals' identities or the biological relationships, if any, between them. Cranial measurements as well as dental and cranial morphological traits were used to estimate the ancestry and identify the biological relationship among these individuals. Utilizing both metric and nonmetric analyses enabled the author to 1) independently verify the Shiloh individuals' ancestry estimations, 2) observe similarities and differences in the results produced by both method types, and 3) execute a more holistic approach to the current biodistance analysis, which resulted in a better overall understanding of the Shiloh sample. These points and their implications will be discussed throughout this chapter.

Intraobserver Reliability

Seventeen individuals from the Texas State University Donated Skeletal Collection were evaluated for nonmetric cranial trait intraobserver reliability using Cohen's Kappa (Appendix B, Table 1). Overall, there was a high level of intraobserver agreement. Traits that yielded low k values or poor agreement were removed from the study. These were removed because poor agreement indicates that the scorer was not able to identify the trait or its stages. Potential reasons for this include scorer error and ambiguity in the trait description. For some traits, the intraobserver reliability improved throughout the pilot study. For example, when scoring inferior nasal morphology, the author's agreement between scoring rounds increased from fair agreement to good agreement during the three rounds. This suggests that the scorer became more proficient at identifying and scoring this trait with practice over time.

Eight individuals from the Texas State University Donated Skeletal Collection and Operation Identification Collection were evaluated for nonmetric dental trait intraobserver reliability using Cohen's Kappa (Appendix B, Table 2). Problems similar to those described when comparing the nonmetric cranial intraobserver data occurred when comparing the dental traits. These issues were handled in the same manner described in the nonmetric cranial traits intraobserver section above.

There are many potential issues users may encounter when using the ASU Dental Anthropology System method. Generally, some of the trait descriptions are ambiguous. Further, many of the ASUDAS traits do not have breakpoints available, which renders data for those traits unusable as they cannot be easily quantified or statistically analyzed. For those traits that do have breakpoints available, the issue evolves as there are multiple breakpoints available from different sources. This leads to confusion and ultimately high interobserver error. The breakpoints function to change the ordinal data scored as trait stages to nominal presence/absence data. While this makes statistically analyzing the data easier, it seems to render the very act of scoring the traits in stages obsolete. Dental nonmetric analyses undoubtedly have their merits, but there needs to be more standardization for trait descriptions and breakpoint cut-offs in order to increase the utility of this methodology.

Ancestry

The ancestry of the 11 Shiloh individuals were estimated by the author (Table 3.1, Tables 3.3-4, and Tables 3.6-7) prior to performing the kinship analysis because records for the Shiloh Method Cemetery were destroyed in 1993. This information provided the basis for choosing the appropriate reference data for the craniometric and cranial nonmetric analyses included in the kinship portion of this research.

Craniometrics

All but one of the seven individuals included in the craniometric ancestry analysis were classified as American Black in FORDISC 3.1 (Jantz and Ousley 2005b) (Table 3.1). The one individual's measurements that yielded different results was F9. What must be taken into account is how the program classifies unknowns. FORDISC (Jantz and Ousley 2005b) classifications are limited to the population groups selected for analysis. Therefore, an unknown individual analyzed in FORDISC will be ultimately classified into one of the selected reference groups. When compared to Black and White male and female reference data, FORDISC indicated that F9's cranial measurements are typical of both a White female and a Black female with typicality probabilities of 0.503 and 0.450, respectively. However, the program classified this individual as a White female with a posterior probability of 0.796. This means there is a 79.6% chance F9 is a White female when Black and White female reference groups are selected. Due to the approximately 150 year postmortem interval and fragility of the remains, many of the Shiloh individuals' crania were fragmented to some degree. F9's splanchnocranium was missing. Had these skeletal elements been present, they could have altered the results if those measurements were included in the analysis. In addition, the age-at-death of F9 was estimated at approximately 16 to 17 years. It is possible that the cranium of this individual had not completed development, possibly affecting the ancestry classification. Finally, there was probably some gene flow between the Shiloh White and Black groups.

The Shiloh individuals' craniometric measurements were also analyzed for ancestry in DISPOP (Jantz 2000) because FORDISC does not have African reference data. The fragmentary state of the remains could account for the isolation of both F4 and F8 in DISPOP ANALYSIS 2: Shiloh individuals excluding F9 (Figure 3.2, Tables 3.5-7). In addition, the young age of F4 (17-18 years old) could have influenced his isolation in the canonical variate analysis in Figure 3.2. Utilizing two different craniometrics analysis (FORDISC and DISPOP) helped to increase the accuracy of the ancestry estimation for the Shiloh individuals. Interestingly, while F9 classified as a WF in FORDISC, the same individual was classified as American Black in DISPOP. This could be explained by the difference in reference groups used in each of the software packages. Further investigation into these reference groups may provide more insight into this peculiarity.

F6 and F8 also presented intriguing classification results. F6 and F8 were classified as American Black DISPOP ANALYSIS 2: Shiloh individuals excluding F9 (Figure 3.2, Tables 3.5-7) in which 22 craniometric variables were included in the analysis. By contrast, this same individuals classified as African in DISPOP ANALYSIS 1: all Shiloh individuals (Figure 3.1, Tables 3.2-4) in which only seven craniometrics variables were included in the analysis. There are multiple possible explanations for these classification differences: 1) the first analysis included far fewer variables, which directly impacted the classifications, 2) the fragmentary state of the remains impacted these classifications, and 3) the ages of these two individuals influenced these results. F6 was one of the youngest individuals (15-16 years old) digitized in this sample, which could heavily influence the contrasting classifications. By comparison, F8 was the oldest individual digitized (45-55 years old). F8's results present an interesting hypothesis: as the oldest it is possible that he had more African genetic information than the younger individuals in the Shiloh group. mtDNA analysis may provide more insight into this hypothesis. Ultimately, it was beneficial to use multiple methods to estimate the ancestry of the Shiloh individuals.

Dental Nonmetrics

The dental nonmetric analysis did not yield conclusive results with respect to estimating the ancestry of the Shiloh sample. African and American Black reference data were chosen for this comparison as these were the most likely groups into which the Shiloh would classify based on the craniometrics analyses. The fact that Shiloh's dental morphologies are significantly different from all of the African groups except one indicates that these individuals were unlikely to be recent African immigrants (Figure 3.3). However, this does not provide enough information to evaluate the enslaved status of the Shiloh individuals, themselves. It would be inappropriate to state the enslaved status of the Shiloh individuals based solely on these results because the exact burial dates for this group are unknown. The following information is known: the Shiloh Methodist Cemetery operated from 1851 to 1876, and the abolition of slavery occurred in 1865. While the coffin glass thickness approximated the burial date of Feature 13 (F13) to 1858, this date may not be accurate for the other burials. In addition, the grandeur of F13's coffin is a stark contrast to the other Shiloh individuals' simple coffins. This may suggest that F13 experienced an elevated status and was not a slave. However, this has no impact on the remaining 10 burials without more detailed context and information. Finally, the fact that the Shiloh individuals were probably not recent African immigrants, which was indicated by their divergence from the African reference data, has no bearing on their enslaved versus free status. Even if these individuals were next of kin to first generation American Blacks or first generation American Blacks themselves, they could have been freed before or enslaved until their deaths. Further analyses using dichotomous nonmetric dental data would be needed to glean more information.

The dental morphology of the Shiloh group was significantly different from all American Black groups in the analysis. Shiloh was most similar to the Late American Blacks (born 1920-1960) and more dissimilar to the Early (born 1650-1850) and Middle American Blacks (born 1825-1910). This was unexpected as these individuals were buried in a cemetery that operated from 1851-1876. This could indicate a certain level of isolation of the Shiloh community from other U.S. communities. Given the results and implications from this analysis, the Shiloh individuals shared some dental morphologies with their contemporary American Blacks, but they likely conformed more to a regional or community morphological mosaic. Only four of the individuals used in Edgar's American Black samples were from the Terry collection, a Missouri reference collection, due to poor preservation and/or advanced dental wear that prevented trait scoring. Further research using regional data from Missouri and surrounding states would be needed in order to properly investigate the hypothesis that the Shiloh individuals' dental traits conformed to a community pattern. Ultimately, the nonmetric dental results did not yield as much information as was originally expected.

Kinship

Once the ancestry of the Shiloh sample had been estimated, kinship analyses were performed to identify the biological relationship among the group. This portion of the research served to analyze the Shiloh community structure.

Craniometrics

Mahalanobis distances for the Shiloh individuals (F1, F3, F4, F6, F8, F9, and F12) were produced in DISPOP using the Defrise-Gussenhoven (1967) method (Table 3.9). The mean distance between the Shiloh individuals was D=2.7971, which is below both the random expected distance (D=3.60555) and the significance threshold of D=5.566555 based on the American Black reference population. This means that there were no outliers in the Shiloh crania and that they exhibit less variation than expected based on a random sample of the American Black population. This has two possible implications: 1) these individuals were biologically related and/or 2) they were members of the same or neighboring communities. DNA analysis would be needed to further identify the relationship between them, which has been planned as part of future research on this sample group.

Cranial Nonmetrics

Nonmetric cranial traits were also employed to analyze the biological relatedness of the Shiloh sample. CRANIAL NONMETRIC ANALYSIS 1: traditional cranial nonmetric traits (Berry and Berry 1967; Buikstra and Ubelaker 1994; Hauser and De Stefano 1989) compared the Shiloh individuals to the American Black population in the Forensic Anthropology Data Bank (Figure 3.4), while CRANIAL NONMETRIC ANALYSIS 2: Hefner's new macromorphoscopic traits (Hefner 2009) compared the Shiloh individuals to African and American Black groups from Osteoware (Figure 3.5). Two difference sets of nonmetric traits were used to cross-validate the results and investigate the difference in the two methods. The Shiloh individuals varied less than the reference groups in both analyses, meaning they clustered more than the reference populations. However, the Shiloh cluster was slightly tighter when compared to FDB Black using traditional cranial nonmetric traits (Figure 3.4). Because the Shiloh group aligned well with the American Black reference groups in both analyses the tighter grouping in Figure 3.4 is likely explained by the different trait sets used in the two analyses. In a broad sense, the fact that both trait sets showed the Shiloh group aligning with American Black populations implicates genetic influence on and retention of these traits. However, the difference in the size of the clusters in these analyses could mean that the traditional epigenetic traits are better at parsing out genetic relatedness in unknown individuals, and the macromorphosopic traits may be better utilized in ancestry estimation. More research on traditional nonmetric (Berry and Berry 1967; Buikstra and Ubelaker 1994; Hauser and De Stefano 1989) versus Hefner's newly revised macromorphoscopic traits (Hefner 2009) is needed to explain their different heritability patterns.

While F9 is the most isolated from the Shiloh group in Figure 3.4 using the traditional nonmetric traits, this cranium clusters closely with F1, F4, F7, and F12 in Figure 3.5, which used Hefner's new macromorphoscopic traits. This is also the most heavily fragmented skeleton. The different sets of morphological traits used in the analyses could explain some of the interesting variation in F9. Notably, F9 and F22 overlap each other in Figure 3.5, which could indicate a possible familial relationship. In addition, the two analyses produced noteworthy results for F13, the individual who received a more impressive and geographically separated burial than the others. The use of traditional nonmetric traits in CRANIAL NONMETRIC ANALYSIS 1 (Figure 3.4) showed F13 aligning well with her fellow Shiloh Cemetery members, but she was separated from them in CRANIAL NONMETRIC ANALYSIS 2 (Figure 3.5), which used Hefner's macromorphoscopic traits to observe the Shiloh variation. A potential future research project could include investigating social hierarchy and heritability using Hefner's traits. In addition, collecting both the traditional nonmetric traits as well as Hefner's new macromorphoscopic traits for all of the individuals in these reference populations (i.e., FDB Blacks and the Terry Blacks and American Blacks used in Osteoware) and rerunning these analyses would provide a direct comparison of these traits and a clearer view of how they can best be utilized in future research.

Unfortunately, there were no obvious correlations between the cemetery structure and the kinship results aside from F13. More importantly, the smaller range of variation between the Shiloh individuals compared to the range seen in the reference populations used in the analyses have significant implications when investigating the biological relatedness of these 11 individuals. Both cranial nonmetric analyses (Figures 3.4-5) analyses showed the Shiloh individuals clustered more tightly than the reference populations to which they were compared. While these crania were not always strongly aligned with each other, they also did not vary to the extent or beyond that of the reference data. This indicates that the Shiloh individuals were likely members of a biological community that shared the same gene pool. This would explain why the Shiloh crania exhibited similar morphoscopic traits. However, the lack of a tight Shiloh cluster suggests that these individuals were unlikely to be a single or extended family unit. Again, DNA analysis is necessary to further explain the biological relationship of the Shiloh crania.

Shiloh Community

The 11 individuals from the Shiloh Methodist Cemetery studied here produced a range of information about 19th Century life in Central Missouri. All Shiloh individuals aligned most closely as American Black based on craniometric and dental nonmetric analyses. Ten of the 11 individuals were buried in simple wooden coffins devoid of indicators of higher social status, while the final Shiloh individual in Feature 13 was buried in a grand manner with grave goods that indicated a higher status than her fellow group members. This implies that the Shiloh community consisted of multiple social levels among its Black members. However, the results presented here did not render enough information to definitively evaluate the slave status of the Shiloh individuals. The cranial metric and nonmetric similarities among these 11 people suggest a communal level of biological relatedness. The elevated status of F13 compared to her fellow group members could imply a potential for upward movement in the community's social hierarchy.

Based on this information, it seems that the members of the Shiloh sample lived in an established 19th Century community that either did not have a high difference in the population's number of slaves and free Blacks or these two groups were buried separately. If there was a continual influx of genes due to the introduction of slaves from various African groups, the expected range of variation exhibited by the cranial metric and nonmetric results would likely be much larger. The similarities exhibited by the Shiloh sample suggest a low influx of new genetic material into the community. More detailed analyses are needed to further investigate the social status and biological relationship of the Shiloh sample.

Future Analyses

A premolar from each of the 11 Shiloh individuals was submitted to the University of Texas at Austin for DNA analyses. The results of these tests were not completed in time for inclusion in this thesis. The following analyses were performed: 1) sex determination for the 8 subadults (F1, F3, F6, F7, F9, F13, F22, and F23), 2) matrilineal relatedness for all 11 individuals, and 3) patrilineal relatedness for the 2 adult males (F3 and F8), which will determine the amount of paternal genetic contribution. The question of biological relatedness among these individuals will be answered upon receipt of these results.

This definitive data will have a profound impact on the results presented in the current study. The population structure of the Shiloh community will become clearer, and questions about the relationship between metric and nonmetric traits may be better addressed with this new information.

Conclusion

The current research presents a biodistance study of 11 unknown individuals from a mid- to late-1800s Missouri cemetery using cranial metric and dental and cranial nonmetric analysis. Using canonical variate analysis on cranial measurements in conjunction with Mean Measure of Divergence on dental morphoscopic traits the Shiloh were estimated to align most closely with Black population data. In order to investigate the potential biological relatedness of the Shiloh crania, craniometric and nonmetric cranial data were employed. Mahalanobis distances and the Defrise-Gussenhoven (1967) method as well as Multidimensional Scaling of the Mean Measure of Divergence values were used to examine the range of variation exhibited by the Shiloh individuals in comparison to range of African and American Black reference populations. Results indicated that while the Shiloh crania did not cluster tightly enough to be considered a family unit, they were clustered more tightly than individuals from the reference data. Therefore, it is likely that these crania represent members of a community.

The estimated Black ancestry of all 11 individuals in the Shiloh Cemetery sample has provided more insight into the population structure and demographics of this mid-1800s Callaway County community. The Shiloh Methodist Church congregation at the time of the Shiloh burials was likely young American Blacks with a mix of social classes. The congregation was likely composed of a younger demographic as this age group was represented by the individuals buried in the Shiloh Methodist Church Cemetery. The kinship results indicated that these individuals were related as community members. From this one can infer that the Shiloh community members and families had created a homestead in Central Missouri.

Several lines of research into this sample group have yet to be investigated. Appropriate dental nonmetric reference data should be included in the future to research the whether the results would 1) align with the current results and 2) further analyze the community structure of this group and their contemporaries. In addition, ongoing research includes DNA analysis of these 11 individuals, which will be presented in a future publication to identify the detailed biological similarities and dissimilarities between them. DNA results will also serve to explain the genetic influence on metric and nonmetric trait expression.

APPENDIX SECTION

A: DEFINITIONS OF CRANIOMETRIC TRAITS AND NONMETRIC TRAITS USED

B: NONMETRIC INTRAOBSERVER RESULTS

APPENDIX A: DEFINITIONS OF CRANIOMETRIC TRAITS AND NONMETRIC TRAITS USED

Table 1. Definitions of craniometric measurements used from Howells (1973).

	Craniometric measurement code	Name	Description of measurement	Reference
1	GOL	Glabello-occipital length	Greatest length, from the glabellar region, in the median sagittal plane.	H[1]: 170
2	NOL	Nasio-occipital length	Greatest cranial length in the median sagittal plane, measured from nasion.	H[1]: 171
3	BNL	Basion-nasion length	Direct length between nasion and basion.	H[1]: 171
4	BBH	Basion-bregma height	Distance from bregma to basion, as defined.	H[1]: 172
5	XCB	Maximum cranial breadth	The maximum cranial breadth perpendicular to the median sagittal plane (above supramastoid crests).	H: 172
6	XFB	Maximum frontal breadth	The maximum breadth at the coronal suture, perpendicular to the median plane.	H[1]: 172
7	AUB	Biauricular breadth	The least exterior breadth across the roots of the zygomatic processes, wherever found.	H[1]: 173
8	GLS	Glabella projection	The maximum projection of the midline profile between nasion and supraglabellare (or the point at which the convex profile of the frontal bone changes to join the prominence of the glabellar region), measure as a subtense.	H[1]: 181
9	STB	Bistephanic breadth	Breadth between the intersections, on either side, of the coronal suture and the inferior temporal line marking the origin of the temporal muscle (the stephanion points).	H[1]: 173
10	FRC	Frontal chord	The frontal chord, or direct distance from nasion to bregma, taken in the midplane and at the external surface.	H[1]: 181
11	FRS	Frontal subtense	The maximum subtense, at the highest point on the convexity of the frontal bone in the midplane, to the nasion-bregma chord.	H[1]: 181
12	FRF	Frontal fraction	The distance along the nasion-bregma chord, recorded from nasion, at which the nasion-bregma, or frontal, subtense falls.	H[1]: 181-182
13	PAC	Parietal chord	The external chord, or direct distance from bregma to lambda taken in the midplane and at the external surface.	H[1]: 182

14	PAS	Parietal subtense	The maximum subtense, at the highest point on the convexity of the parietal bones in the midplane, to the bregma-lambda chord.	H[1]: 182
15	PAF	Parietal fraction	The distance along the bregma-lambda chord, recorded from bregma, at which the bregma-lambda, or parietal, subtense falls.	H[1]: 182
16	OCC	Occipital chord	The external occipital chord, or direct distance from lambda to opisthion taken in the midplane and at the external surface.	H[1]: 182
17	OCS	Occipital subtense	The maximum subtense, at the most prominent point on the basic contour of the occipital bone in the midplane.	H[1]: 182-183
18	OCF	Occipital fraction	The distance along the lambda-opisthion chord, recorded from lambda, at which the lambda-opisthion, or occipital, subtense falls.	H[1]: 183
19	FOL	Foramen magnum length	The length from basion to opisthion, as defined.	H[1]: 181
20	NAR	Nasion radius	The perpendicular to the transmeatal axis from nasion.	H[1]: 183
21	BRR	Bregma radius	The perpendicular to the transmeatal axis from bregma. See Howells radius definitions for more information.	K[2]: 140
22	VRR	Vertex radius	The perpendicular to the transmeatal axis from the most distant point on the parietals (including bregma or lambda), wherever found.	H[1]: 183

[1]Howells (1973)
[2]Key (1983)

Table 2. Definitions of dental nonmetric traits used.

	Dental trait code	Name	Description of trait[1]
1	WING	Winging UI1	Rotation of the upper central incisors.
2	UI1LC	Labial curve UI1	The labial surface of the upper incisors, when viewed from the occlusal aspect, can range from being essentially flat to showing a marked degree of convexity.
3	UI1SS	Shoveling UI1	The presence of lingual marginal ridges.
4	UI2IG	Interruption groove UI2	Grooves which cross the cingulum, and often continue down the root, are occasionally seen on the upper incisors (more frequently on the lateral incisor than on the central).
5	UI2TD	Tuberculum dentale UI2	This feature occurs in the cingular region of the lingual surface of the upper incisors and canine. This feature can take the form of ridges on the lingual surface (referred to as mediolingual ridges) or various degrees of expression of a cusp (known on the canine as the canine tubercle).
6	UCMR	Mesial ridge UC	Normally, the mesiolingual marginal ridge of the upper canine is similar in size to the distolingual marginal ridge. Occasionally, the mesial ridge is larger than the distal, and, in pronounced cases, it possesses a distal deflection approximately two-thirds of the way down from the occlusal surface due to its attachment to the tuberculum dentale.
7	UCDR	Distal accessory ridge UC	Occurs in the distolingual fossa between the tooth apex and the distolingual marginal ridge.
8	UM2HC	Hypocone UM2	The distolingual cusp or cusp 4. Absence and severely reduced forms of this cusp are more common on M1 and (especially) M2 than the same forms of the metacone.

9	UM1C5	Cusp 5 UM1	A fifth cusp, the metaconule, may occasionally be present in the distal fovea of the upper molars between the metacone and hypocone.
10	UM1CB	Carabelli's trait UM1	Occurs on the lingual surface of the mesiolingual cusp (the protocone or cusp 1) of the upper molars.
11	UM3PR	Parastyle UM3	It is most common on the buccal surface of the mesiobuccal cusp (the paracone or cusp 2) of the third molar.
12	UI2PS	Peg-shaped UI2	Defined by various workers as a tooth which is very reduced in size and lacking the normal crown morphology, being instead peg-shaped.
13	UM3CA	Congenital absence UM3	
14	LM1AF	Anterior fovea LM1	Located on the anterior occlusal surface, this feature, termed precuspidal fossa, was considered to be taxonomically significant by Hrdlicka (1924).
15	LM1DW	Deflecting wrinkle LM1	The form of variation of the medial ridge on cusp 2.
16	LM1MT	Mid trigonal crest LM1	A ridge or loph that bridges cusps 1 and 2.
17	LM1PS	Protostylid LM1	A paramolar cusp found on the buccal surface of cusp 1. It is normally associated with the buccal groove separating cusps 1 and 3.
18	LM1C7	Cusp 7 LM1	Cusp 7, the metaconulid or tuberculum intermedium, occurs in the lingual groove between cusps 2 and 4 of the lower molars, most commonly on the first molar.

[1]All trait definitions are from Turner *et al.* (1991).

Table 3. Dental nonmetric traits with breakpoints.

	Dental trait code	Trait (Grades)	Breakpoints[1] (Absent/Present)
1	WING	Winging UI1 (0-4)	0/1-4
2	UI1LC	Labial curve UI1 (0-4)	0-1/2-4
3	UI1SS	Shoveling UI1 (0-6)	0-2/3-6
4	UI2IG	Interruption groove UI2 (0-4)	0/1-4
5	UI2TD	Tuberculum dentale UI2 (0-6)	0/1-6
6	UCMR	Mesial ridge UC (0-3)	0/1-3
7	UCDR	Distal accessory ridge UC (0-5)	N/A
8	UM2HC	Hypocone UM2 (0-5)	0-1/2-5
9	UM1C5	Cusp 5 UM1 (0-5)	N/A
10	UM1CB	Carabelli's trait UM1 (0-7)	0-4/5-7
11	UM3PR	Parastyle UM3 (0-6)	0/1-6
12	UI2PS	Peg-shaped UI2 (0-2)	0/1-2
13	UM3CA	Congenital absence UM3 (0-3)	0/1
14	LM1AF	Anterior fovea LM1 (0-4)	N/A
15	LM1DW	Deflecting wrinkle LM1 (0-3)	0/1-3
16	LM1MT	Mid trigonal crest LM1 (0-1)	0/1
17	LM1PS	Protostylid LM1 (0-7)	0/1-7
18	LM1C7	Cusp 7 LM1 (0-4)	0/1-4

[1]All trait breakpoints are from Turner *et al.* (1991).

Table 4. Definitions of cranial nonmetric traits used.

	Name	Description of trait	Reference
1	Lambdoid ossicle - medial[5]	Ossicle located within the medial portion of the lambdoid suture.	1,2,3
2	Lambdoid ossicle - lateral[5]	Ossicle located within the lateral portion of the lambdoid suture.	1,2,3
3	Parietal foramen[5]	Located on the parietal bone, within or near the suture at obelion. Foramen should lead into the canal extending to and perforating the internal table.	1,2,3
4	Mastoid foramen[5]	The mastoid foramen corresponds to the external aperture of the mastoid canal and may vary with respect to size, number, and position.	1,2,3
5	Mastoid foramen exsutural[5]	The anterior ethmoid foramen pierces the medial wall of the orbit. It normally lies on the suture between the medial edge of the orbital plates of the frontal and ethmoid bones, but it occasionally emerges above the suture.	1,2
6	Coronal ossicle[5]	Ossicle located within the coronal suture.	1,2,3
7	Epiteric bone[5]	Ossicle located at the junction of the frontal, parietal, temporal, and sphenoid bones.	1,2,3
8	Fronto-temporal articulation[5]	Normally the frontal bone is separated from the squamous part of the temporal bone by the greater wing of the sphenoid and the anterior inferior angle of the parietal bone. Occasionally the frontal and temporal bones are in direct contact, forming a fronto-temporal articulation.	1
9	Parietal notch bone[5]	Ossicle located within the parietal notch, between the squamous portion of the temporal and parietal.	1,2,3
10	Ossicle at asterion[5]	Ossicle located at the junction of the occipital, parietal, and temporal bones.	1,2,3
11	Ossicle in mastoid suture[5]	Ossicle located in the suture between the temporal and occipital bones.	1,2,3

12	Foramen of Huschke/Tympanic dihescence[5]	Incomplete closure of the tympanic plate of the temporal bone. The defect occurs on the anterior aspect, posterior to the mandibular fossa.	1,2,3
13	Anterior condylar canal double/Divided hypoglossal canal[5]	The hypoglossal canal is located superior to the occipital condyle, normally at an angle perpendicular to the main axis of the condyle. The hypoglossal canal can be divided by spines located within the canal or on the internal aspect adjacent of the foramen magnum.	1
14	Accessory palatine foramen[5]	The lesser palatine foramina lie on both sides of the posterior border of the hard palate immediately posterior to the greater palatine foramen, and transmit the lesser palatine nerves. When more than one (there may be three or four) foramen is present, it has been scored as accessory.	1
15	Supraorbital foramen complete[5]	The supraorbital foramen transmits the supraorbital vessels and nerve. It is frequently incomplete (or open). In this case it is often described as a 'supraorbital notch.'	1,2,3
16	Frontal foramen[5]	A well-defined secondary foramen in the vicinity of (usually lateral to) the supraorbital foramen has been scored as a frontal foramen. Frequency a cluster of tiny foramina are present, but these have been ignored.	1,2
17	Sutures into infraobital foramen[5]	Located on the orbital and facial surfaces, though presence on the facial surface only will be scored. A complete suture extends from the orbital margin to the infraorbital foramen.	1,2,3
18	Accessory infraorbital foramen[5]	A second foramen may lie immediately adjacent to the infraorbital foramen.	1,2,3
19	Mylohyoid bridge[5]	Bony bridge over the mylohyoid canal of the mandible, either in the region of the mandibular foramen or approximately in the center of the groove.	1,2,3
20	Accessory mental foramen[5]	Foramina located on the external aspect of the mandibular corpus inferior to P3. The most frequent variant is double foramina.	1,2,3

21	Ossicle at lambda/Apical bone	Ossicle located at lambda, within the posterior fontanelle.	1,2,3
22	Inca bone	Failure of fusion of the primary ossification centers of the squamous portion of the occipital bone. Most commonly a transverse suture (sutura Mendoza) divides the squamous portion at the point of the highest nuchal line. It is important to distinguish the Inca bone from the presence of an ossicle at lambda, which is smaller and center in the posterior fontanelle.	1,2,3
23	Sagittal ossicle	Ossicle located within the sagittal suture.	1,2,3
24	Bregmatic bone	Ossicle located at the junction of the paired parietals and frontal, formed within the anterior fontanelle.	1,2,3
25	Palatine torus	Rarely, a bone ridge runs longitudinally down the midline of the hard palate. This is the palatine torus.	1,2
26	Mandibular torus	Bony ridge or series of nodules that develop on the lingual aspect of the lower jaw near the premolars and canines.	1,2
27	Metopism	The metopic suture is located on the midline of the frontal bone, from bregma to nasion. Suture may be completely retained or may only extend a short distance from nasion.	1,2,3
28	Pharyngeal fossa	A rather indistinct depression of the enclosed triangular bone surface from the pharyngeal tubercle to the insertion of the posterior margin of the vomer.	1,2
29	Superior sagittal sinus turns left	The superior sagittal sulcus most commonly flexes right. Variations include left flexure and bifurcation.	1,2,3
30	Anterior nasal spine (ANS)	The anterior nasal spine is scored progressively as slight, intermediate, and marked.	4
31	Inferior nasal aperture morphology (INA)	The most inferior portion of the nasal aperture, which, when combined with the lateral alae, constitutes the transition from nasal floor to the vertical portion of the maxillae, superior to the anterior dentition.	4

32	Interorbital breadth (IOB)	Interorbital breadth is assessed as narrow, intermediate, and broad. This assessment is made relative to the facial skeleton.	4
33	Malar tubercle (MT)	The malar tubercle is a caudally protruding tubercle located on the inferior margin of the maxilla and zygomatic bone in the region of the zyomaticomaxillary suture.	4
34	Nasal aperture width (NAW)	The width of the nasal aperture width is assessed relative to the facial skeleton. It is scored as narrow, medium, or broad.	4
35	Nasal bone shape (NBS)	Nasal bone shape is assessed from the anterior view with the cranium positioned in approximate anatomical position. An assessment is made of the lateral contours of the nasal bones.	4
36	Nasal overgrowth (NO)	Nasal overgrowth is an inferior projection of the lateral border of the nasal bones beyond the maxillae at nasale inferious.	4
37	Postbregmatic depression (PBD)	Postbregmatic depression is a slight to broad depression along the sagittal suture, posterior to bregma that is not the result of pathology.	4
38	Posterior zygomatic tubercle (PZT)	The posterior zygomatic tubercle, or the marginal process, is a posterior projection of the zygomatic bone at approximately midorbit as viewed in the lateral plane.	4
39	Supranasal suture (SPS)	The supranasal suture is the fusion of the nasal portion of a frontal suture that appears as a complex of interlocking bone spicules at glabella.	4
40	Zygomaticomaxillary suture (ZS)	Assessment of the zygomaticomaxillary suture is based primarily on the approximate location of greatest lateral projection of the suture, and also on the number of major angles present.	4

[1]Berry and Berry (1967); [2]Hauser and De Stefano (1989); [3]Buikstra and Ubelaker (1994); [4]Hefner (2009); [5]Paired trait

APPENDIX B: NONMETRIC INTRAOBSERVER RESULTS

Table 1. Results of Cohen's Kappa intraobserver reliability for cranial morphoscopic traits.

Trait	Intraobserver Error, Cohen's Kappa k	p-value	Interpretation of Cohen's Kappa
Anterior Nasal Spine 1 * Anterior Nasal Spine 2	0.721	0.000	Good agreement
Anterior Nasal Spine 1 * Anterior Nasal Spine 3	0.391	0.011	Fair agreement
Anterior Nasal Spine 2 * Anterior Nasal Spine 3	0.642	0.000	Good agreement
Apical Bone 1 * Apical Bone 2	1.000	0.046	Very good agreement
Apical Bone 1 * Apical Bone 3	1.000	0.046	Very good agreement
Apical Bone 2 * Apical Bone 3	1.000	0.025	Very good agreement
Asterionic Bone 1 * Asterionic Bone 2			-
Asterionic Bone 1 * Asterionic Bone 3	-0.111	0.725	Poor agreement
Asterionic Bone 2 * Asterionic Bone 3			-
Auditory Exostosis 1 * Auditory Exostosis 2	-0.118	0.511	Poor agreement
Auditory Exostosis 1 * Auditory Exostosis 3	-0.118	0.511	Poor agreement
Auditory Exostosis 2 * Auditory Exostosis 3	0.190	0.432	Poor agreement
Bregmatic Bone 1 * Bregmatic Bone 2			-
Bregmatic Bone 1 * Bregmatic Bone 3			-
Bregmatic Bone 2 * Bregmatic Bone 3			-
Condylar Canal 1 * Condylar Canal 2	0.648	0.007	Good agreement
Condylar Canal 1 * Condylar Canal 3	0.643	0.008	Good agreement
Condylar Canal 2 * Condylar Canal 3	0.767	0.001	Good agreement
Coronal Ossicle 1 * Coronal Ossicle 2			-
Coronal Ossicle 1 * Coronal Ossicle 3			-
Coronal Ossicle 2 * Coronal Ossicle 3			-
Divided Hypoglossal Canal 1 * Divided Hypoglossal Canal 2	0.862	0.000	Very good agreement

Divided Hypoglossal Canal 1 * Divided Hypoglossal Canal 3	0.545	0.003	Moderate agreement
Divided Hypoglossal Canal 2 * Divided Hypoglossal Canal 3	0.726	0.000	Good agreement
Epipteric Bone 1 * Epipteric Bone 2	1.000	0.005	Very good agreement
Epipteric Bone 1 * Epipteric Bone 3			-
Epipteric Bone 2 * Epipteric Bone 3			-
Flexure of Superior Sagittal Sulcus 1 * Flexure of Superior Sagittal Sulcus 2	0.890	0.000	Very good agreement
Flexure of Superior Sagittal Sulcus 1 * Flexure of Superior Sagittal Sulcus 3	0.776	0.000	Good agreement
Flexure of Superior Sagittal Sulcus 2 * Flexure of Superior Sagittal Sulcus 3	0.878	0.000	Very good agreement
Foramen Ovale Incomplete 1 * Foramen Ovale Incomplete 2			-
Foramen Ovale Incomplete 1 * Foramen Ovale Incomplete 3			-
Foramen Ovale Incomplete 2 * Foramen Ovale Incomplete 3			-
Foramen Spinosum Incomplete 1 * Foramen Spinosum Incomplete 2			-
Foramen Spinosum Incomplete 1 * Foramen Spinosum Incomplete 3			-
Foramen Spinosum Incomplete 2 * Foramen Spinosum Incomplete 3	1.000	0.000	Very good agreement
Inca Bone 1 * Inca Bone 2			-

Inca Bone 1 * Inca Bone 3			-
Inca Bone 2 * Inca Bone 3			-
Inferior Nasal Morphology 1 * Inferior Nasal Morphology 2	0.243	0.105	Fair agreement
Inferior Nasal Morphology 1 * Inferior Nasal Morphology 3	0.327	0.029	Fair agreement
Inferior Nasal Morphology 2 * Inferior Nasal Morphology 3	0.749	0.000	Good agreement
Interorbital Breadth 1 * Interorbital Breadth 2	0.370	0.025	Fair agreement
Interorbital Breadth 1 * Interorbital Breadth 3	0.387	0.010	Fair agreement
Interorbital Breadth 2 * Interorbital Breadth 3	0.562	0.001	Moderate agreement
Infraorbital Suture 1 * Infraorbital Suture 2	0.590	0.001	Moderate agreement
Infraorbital Suture 1 * Infraorbital Suture 3	0.500	0.006	Moderate agreement
Infraorbital Suture 2 * Infraorbital Suture 3	0.904	0.000	Very good agreement
Lambdoid Ossicle 1 * Lambdoid Ossicle 2	0.571	0.121	Moderate agreement
Lambdoid Ossicle 1 * Lambdoid Ossicle 3	1.000	0.014	Very good agreement
Lambdoid Ossicle 2 * Lambdoid Ossicle 3	0.571	0.121	Moderate agreement
Malar Tubercle 1 * Malar Tubercle 2	0.071	0.636	Poor agreement
Malar Tubercle 1 * Malar Tubercle 3	0.046	0.760	Poor agreement
Malar Tubercle 2 * Malar Tubercle 3	0.243	0.077	Fair agreement
Metopic Suture 1 * Metopic Suture 2	-0.049	0.567	Poor agreement
Metopic Suture 1 * Metopic Suture 3	-0.049	0.567	Poor agreement
Metopic Suture 2 * Metopic Suture 3	1.000	0.000	Very good agreement
Multiple Infraorbital Foramina 1 * Multiple Infraorbital Foramina 2	0.765	0.002	Good agreement

Multiple Infraorbital Foramina 1 * Multiple Infraorbital Foramina 3	0.765	0.002	Good agreement
Multiple Infraorbital Foramina 2 * Multiple Infraorbital Foramina 3	1.000	0.000	Very good agreement
Nasal Aperture Shape 1 * Nasal Aperture Shape 2	0.600	0.000	Good agreement
Nasal Aperture Shape 1 * Nasal Aperture Shape 3	0.718	0.000	Very good agreement
Nasal Aperture Shape 2 * Nasal Aperture Shape 3	0.683	0.000	Very good agreement
Nasal Aperture Width 1 * Nasal Aperture Width 2	0.414	0.025	Fair agreement
Nasal Aperture Width 1 * Nasal Aperture Width 3	0.436	0.013	Fair agreement
Nasal Aperture Width 2 * Nasal Aperture Width 3	0.808	0.000	Very good agreement
Nasal Bone Contour 1 * Nasal Bone Contour 2			-
Nasal Bone Contour 1 * Nasal Bone Contour 3			-
Nasal Bone Contour 2 * Nasal Bone Contour 3	0.360	0.027	Fair agreement
Nasal Bone Shape 1 * Nasal Bone Shape 2	0.346	0.026	Fair agreement
Nasal Bone Shape 1 * Nasal Bone Shape 3	0.311	0.043	Fair agreement
Nasal Bone Shape 2 * Nasal Bone Shape 3	0.164	0.380	Poor agreement
Nasal Overgrowth 1 * Nasal Overgrowth 2	0.883	0.000	Very good agreement
Nasal Overgrowth 1 * Nasal Overgrowth 3	0.638	0.005	Good agreement
Nasal Overgrowth 2* Nasal Overgrowth 3	0.541	0.012	Moderate agreement
Nasofrontal Suture 1 * Nasofrontal Suture 2	0.626	0.000	Good agreement
Nasofrontal Suture 1 * Nasofrontal Suture 3	0.626	0.000	Good agreement
Nasofrontal Suture 2 * Nasofrontal Suture 3	0.720	0.000	Good agreement

Orbital Shape 1 * Orbital Shape 2	0.564	0.009	Moderate agreement
Orbital Shape 1 * Orbital Shape 3	0.338	0.063	Fair agreement
Orbital Shape 2 * Orbital Shape 3	0.269	0.074	Fair agreement
Ossicle in Occipito-Mastoid Suture 1 * Ossicle in Occipito-Mastoid Suture 2			-
Ossicle in Occipito-Mastoid Suture 1 * Ossicle in Occipito-Mastoid Suture 3			-
Ossicle in Occipito-Mastoid Suture 2 * Ossicle in Occipito-Mastoid Suture 3			-
Parietal Foramen 1 * Parietal Foramen 2	0.846	0.001	Very good agreement
Parietal Foramen 1 * Parietal Foramen 3	0.846	0.001	Very good agreement
Parietal Foramen 2 * Parietal Foramen 3	1.000	0.000	Very good agreement
Parietal Notch Bone 1 * Parietal Notch Bone 2			-
Parietal Notch Bone 1 * Parietal Notch Bone 3			-
Parietal Notch Bone 2 * Parietal Notch Bone 3			-
Postbregmatic Depression 1 * Postbregmatic Depression 2	0.380	0.115	Fair agreement
Postbregmatic Depression 1 * Postbregmatic Depression 3	0.876	0.000	Very good agreement
Postbregmatic Depression 2 * Postbregmatic Depression 3	0.485	0.046	Moderate agreement
Posterior Zygomatic Tubercle 1 * Posterior Zygomatic Tubercle 2	0.280	0.080	Fair agreement
Posterior Zygomatic Tubercle 1 * Posterior Zygomatic Tubercle 3	0.557	0.000	Moderate agreement

Posterior Zygomatic Tubercle 2 * Posterior Zygomatic Tubercle 3	0.550	0.001	Moderate agreement
Pterygo-alar Bridge 1 * Pterygo-alar Bridge 2	0.614	0.001	Good agreement
Pterygo-alar Bridge 1 * Pterygo-alar Bridge 3	1.000	0.000	Very good agreement
Pterygo-alar Bridge 2 * Pterygo-alar Bridge 3	0.614	0.001	Good agreement
Ptergyo-spinous Bridge 1 * Ptergyo-spinous Bridge 2	-0.150	0.140	Poor agreement
Ptergyo-spinous Bridge 1 * Ptergyo-spinous Bridge 3	-0.037	0.756	Poor agreement
Ptergyo-spinous Bridge 2 * Ptergyo-spinous Bridge 3	0.370	0.074	Fair agreement
Sagittal Ossicle 1 * Sagittal Ossicle 2			-
Sagittal Ossicle 1 * Sagittal Ossicle 3			-
Sagittal Ossicle 2 * Sagittal Ossicle 3			-
Supranasal Suture 1 * Supranasal Suture 2	0.206	0.096	Fair agreement
Supranasal Suture 1 * Supranasal Suture 3	0.234	0.038	Fair agreement
Supranasal Suture 2 * Supranasal Suture 3	0.901	0.000	Very good agreement
Supraorbital Foramen 1 * Supraorbital Foramen 2	0.57	0.006	Moderate agreement
Supraorbital Foramen 1 * Supraorbital Foramen 3	0.891	0.000	Very good agreement
Supraorbital Foramen 2 * Supraorbital Foramen 3	0.673	0.001	Good agreement
Supraorbital Notch 1 * Supraorbital Notch 2	0.779	0.000	Good agreement
Supraorbital Notch 1 * Supraorbital Notch 3	0.651	0.002	Good agreement
Supraorbital Notch 2 * Supraorbital Notch 3	0.821	0.000	Very good agreement

Transverse Palatine Suture 1 * Transverse Palatine Suture 2	0.702	0.000	Good agreement
Transverse Palatine Suture 1 * Transverse Palatine Suture 3	0.350	0.013	Fair agreement
Transverse Palatine Suture 2 * Transverse Palatine Suture 3	0.630	0.000	Good agreement
Tympanic Dihiscence 1 * Tympanic Dihiscence 2			-
Tympanic Dihiscence 1 * Tympanic Dihiscence 3			-
Tympanic Dihiscence 2 * Tympanic Dihiscence 3			-
Zygomatico-facial Foramina 1 * Zygomatico-facial Foramina 2	0.729	0.000	Good agreement
Zygomatico-facial Foramina 1 * Zygomatico-facial Foramina 3	0.616	0.003	Good agreement
Zygomatico-facial Foramina 2 * Zygomatico-facial Foramina 3	0.872	0.000	Very good agreement
Zygomaticomaxillary Suture 1 * Zygomaticomaxillary Suture 2	0.337	0.000	Fair agreement
Zygomaticomaxillary Suture 1 * Zygomaticomaxillary Suture 3	0.171	0.075	Poor agreement
Zygomaticomaxisllary Suture 2 * Zygomaticomaxillary Suture 3	0.605	0.001	Good agreement

Table 2. Results of Cohen's Kappa intraobserver reliability for dental morphoscopic traits.

Trait	Intraobserver Error, Cohen's Kappa k	p-value	Interpretation of Cohen's Kappa
Anterior fovea 1 * Anterior fovea 2			-
Anterior fovea 1 * Anterior fovea 3			-
Anterior fovea 2 * Anterior fovea 3	1.000	0.083	Very good agreement
C distal accessory ridge 1 * C distal accessory ridge 2	1.000	0.014	Very good agreement
C distal accessory ridge 1 * C distal accessory ridge 3	1.000	0.014	Very good agreement
C distal accessory ridge 2 * C distal accessory ridge 3	1.000	0.014	Very good agreement
C mesial ridge 1 * C mesial ridge 2			Very good agreement
C mesial ridge 1 * C mesial ridge 3			Very good agreement
C mesial ridge 2 * C mesial ridge 3			Very good agreement
C2 parastyle 1 * C2 parastyle 2			Very good agreement
C2 parastyle 1 * C2 parastyle 3			Very good agreement
C2 parastyle 2 * C2 parastyle 3			Very good agreement
Carabelli cusp 1 * 2	0.760	0.000	Good agreement
Carabelli cusp 1 * 3	0.760	0.000	Good agreement
Carabelli cusp 2 * 3	1.000	0.000	Very good agreement
Congenital absence 1 * Congenital absence 2			-
Congenital absence 1 * Congenital absence 3			-
Congenital absence 2 * Congenital absence 3			Very good agreement
Cusp5 1 * Cusp5 2			Very good agreement
Cusp5 1 * Cusp5 3			Very good agreement
Cusp5 2 * Cusp5 3			Very good agreement

Cusp6 1 * Cusp6 2			Very good agreement
Cusp6 1 * Cusp6 3			-
Cusp6 2 * Cusp6 3			-
Cusp7 1 * Cusp7 2			Very good agreement
Cusp7 1 * Cusp7 3			-
Cusp7 2 * Cusp7 3			-
Deflecting wrinkle 1 * Deflecting wrinkle 2			Very good agreement
Deflecting wrinkle 1 * Deflecting wrinkle 3			Very good agreement
Deflecting wrinkle 2 * Deflecting wrinkle 3			Very good agreement
Double shoveling 1 * Double shoveling 2			Very good agreement
Double shoveling 1 * Double shoveling 3			Very good agreement
Double shoveling 2 * Double shoveling 3			Very good agreement
Enamel extension 1 * Enamel extension 2			Very good agreement
Enamel extension 1 * Enamel extension 3			Very good agreement
Enamel extension 2 * Enamel extension 3			Very good agreement
Groove pattern 1 * Groove pattern 2			-
Groove pattern 1 * Groove pattern 3			-
Groove pattern 2 * Groove pattern 3			-
Hypocone 1 * Hypocone 2	0.400	0.221	Moderate agreement
Hypocone 1 * Hypocone 3	0.571	0.121	Moderate agreement
Hypocone 2 * Hypocone 3	0.182	0.439	Poor agreement
Interrupted groove 1 * Interrupted groove 2			Very good agreement
Interrupted groove 1 * Interrupted groove 3			Very good agreement
Interrupted groove 2 * Interrupted groove 3			Very good agreement
Labial curve 1 * Labial curve 2	-0.091	0.728	Poor agreement
Labial curve 1 * Labial curve 3	-0.500	0.134	Poor agreement
Labial curve 2 * Labial curve 3	0.500	0.134	Moderate agreement
Mesial and distal cusps 1 * Mesial and distal cusps 2			Very good agreement

Mesial and distal cusps 1 * Mesial and distal cusps 3			Very good agreement
Mesial and distal cusps 2 * Mesial and distal cusps 3			Very good agreement
Metacone 1 * Metacone 2	0.143	0.649	Poor agreement
Metacone 1 * Metacone 3	0.333	0.414	Fair agreement
Metacone 2 * Metacone 3	0.143	0.649	Poor agreement
Mid trigonal crest 1 * Mid trigonal crest 2			-
Mid trigonal crest 1 * Mid trigonal crest 3			Very good agreement
Mid trigonal crest 2 * Mid trigonal crest 3			-
Molar cusp number 1* Molar cusp number 2			-
Molar cusp number 1 * Molar cusp number 3			-
Molar cusp number 2 * Molar cusp number 3			Very good agreement
MXPAR distal 1 * MXPAR distal 2			-
MXPAR distal 1 * MXPAR distal 3			-
MXPAR distal 2 * MXPAR distal 3			Very good agreement
MXPAR mesial 1 * MXPAR mesial 2			Very good agreement
MXPAR mesial 1 * MXPAR mesial 3			Very good agreement
MXPAR mesial 2 * MXPAR mesial 3			Very good agreement
Odontome 1 * Odontome 2			Very good agreement
Odontome 1 * Odontome 3			Very good agreement
Odontome 2 * Odontome 3			Very good agreement
P lingual cusps 1 * P lingual cusps 2	0.319	0.027	Fair agreement
P lingual cusps 1 * P lingual cusps 3	0.273	0.064	Fair agreement
P lingual cusps 2 * P lingual cusps 3	0.750	0.001	Good agreement
Peg reduce 1 * Peg reduce 2			Very good agreement
Peg reduce 1 * Peg reduce 3			Very good agreement
Peg reduce 2 * Peg reduce 3			Very good agreement
Protostylid 1 * Protostylid 2			-
Protostylid 1 * Protostylid 3			Very good agreement

Protostylid 2 * Protostylid 3			-
Root number 1 * Root number 2			Very good agreement
Root number 1 * Root number 3			Very good agreement
Root number 2 * Root number 3			Very good agreement
Shoveling 1 * Shoveling 2			Very good agreement
Shoveling 1 * Shoveling 3			Very good agreement
Shoveling 2 * Shoveling 3			Very good agreement
Status/Wear 1 * Status/Wear 2	1.000	0.000	Very good agreement
Status/Wear 1 * Status/Wear 3	0.800	0.001	Good agreement
Status/Wear 2 * Status/Wear 3	0.800	0.001	Good agreement
Tomes root 1 * Tomes root 2	-0.500	0.386	Poor agreement
Tomes root 1 * Tomes root 3	0.400	0.386	Moderate agreement
Tomes root 2 * Tomes root 3	0.000	1.000	Poor agreement
Tuberculum dentale 1 * Tuberculum dentale 2			Very good agreement
Tuberculum dentale 1 * Tuberculum dentale 3			Very good agreement
Tuberculum dentale 2 * Tuberculum dentale 3			Very good agreement
Uto-Aztecan 1 * Uto-Aztecan 2			Very good agreement
Uto-Aztecan 1 * Uto-Aztecan 3			Very good agreement
Uto-Aztecan 2 * Uto-Aztecan 3			Very good agreement
Winging 1 * Winging 2	1.000	0.025	Very good agreement
Winging 1 * Winging 3	1.000	0.025	Very good agreement
Winging 2 * Winging 3	1.000	0.014	Very good agreement

REFERENCES CITED

AlQahanti SJ, Hector MP, and Liersidge HM. 2010. Brief communication: The London atlas of human tooth development and eruption. American Journal of Physical Anthropology 142(3):481-490.

Applied Biostatistics I. 2008. NTSYSpc - Multivariate data analysis system. 2.2 ed: Exeter Software.

Arany S, Iino M, and Yoshioka N. 2004. Radiographic survey of third molar development in relation to chronological age among Japanese juveniles. Journal of Forensic Sciences 49(3):534-538.

Bass WM. 2005. Human osteology: A laboratory and field manual. Springfield, MO: Missouri Archaeological Society.

Bellamy DD. 1973. Free blacks in Antebellum Missour 1820-1860. Missouri Historical Review 67(2):198-226.

Berry AC, and Berry RJ. 1967. Epigenetic variation in the human cranium. Journal of Anatomy 101(2):361-379.

Blankenship JA, Mincer HH, Anderson KM, Woods MA, and Burton EL. 2007. Third molar development in the estimation of chronological age in American Blacks as compared with Whites. Journal of Forensic Sciences 52(2):428-433.

Boldsen JL, Milner GR, Konigsberg LW, and Wood JW. 2002. Transition analysis: A new method for estimating age from skeletons. In: Hoppa RD, and Vaupel JW, editors. Paleodemography: Age distributions from skeletal samples. Cambridge: Cambridge University Press. p 73-106.

Boldsen JL, Milner GR, and Ousley SD. 2014. ADBOU 2.1.041. Erie: Mercyhurst University.

Brace CL. 1995. Region does not mean "race"—Reality versus convention in forensic anthropology. Journal of Anatomy 101(2):361-379.

Buikstra JE, and Ubelaker DH. 1994. Standards for data collection from human skeletal remains: Proceedings of a seminar at the field museum of natural history, organized by Jonathan Haas. Fayetteville: Arkansas Archaeological Survey.

Burch C. 1955. Historic Callaway County, 1818 to 1838. Callaway County, Missouri: Daniel Boone Regional Library.

Cameriere R, Ferrante L, Belcastro M, Bonfiglioli B, E. R, and Cingolani M. 2007. Age estimation by pulp/tooth ratio in canines by mesial and vestibular peri-apical x-rays. Journal of Forensic Sciences 52(5):1151-1155.

Carson EA. 2006. Maximum likelihood estimation of human craniometric heritabilities. American Journal of Physical Anthropology 131(2):169-180.

Coppa A, Cucina A, Lucci M, Pellegrini A, and Vargiu R. 2002. The populations of circum-Caribbean from the 4th millennium B.C. to the conquest: The biological relationships according to possible migration patterns. American Journal of Physical Anthropology Supplemental 33:57.

Curtin PD. 1969. The dimensions of the Atlantic Slave Trade. Madison, Wisconsin: University of Wisconsin.

Curtin PD. 1972. The Atlantic Slave Trade: A Census. Madison, Wisconsin: University of Wisconsin Press.

Defrise-Gussenhoven E. 1967. Generalized Distance in Genetic Studies. Human Heredity 17(3):275-288.

Delgado-Burbano ME. 2007. Population affinities of African Colombians to Sub-Saharan Africans based on dental morphology. HOMO - Journal of Comparative Human Biology 58(4):329-356.

Demirjian A, Goldstein H, and Tanner JM. 1973. A new system of dental age assessment. Human Biology 45(2):211-227.

Edgar HJH. 2002. Biological distance and the African American dentition. Columbus, OH: The Ohio State University. 229 p.

Edgar HJH. 2007. Microevolution of African American dental morphology. American Journal of Physical Anthropology 132(4):535-544.

Edgar HJH. 2013. Estimation of ancestry using dental morphological characteristics. Journal of Forensic Sciences 58(S1):S3-8.

Gaarde FWI. 1993. Archaeological survey of Missouri: Site 23CY593. Jefferson City, MO: Missouri Archaeological Society - University of Missouri - Columbia. p 1-3.

Gill GW. 1998. Craniofacial criteria in the skeletal attribution of race. In: Reichs KJ, editor. Forensic osteology: Advances in the identification of human remains. 2 ed. Springfield, IL: Chase C. Thomas Publisher. p 293-317.

Grewal MS. 1962. The rate of genetic divergence of sublines in the C57BL strain of mice. Genetical Research 3(2):226-237.

Hauser G, and De Stefano GF. 1989. Epigenetic variants of the human skull: Lubrecht & Cramer Ltd.

Hefner JT. 2009. Cranial nonmetric variation and estimating ancestry. Journal of Forensic Sciences 54(5):985-995.

Hefner JT, and Ousley SD. 2014. Statistical classification methods for estimating ancestry using morphoscopic traits. Journal of Forensic Sciences 59(4):883-890.

Herrmann NP. 2002. Biological affinities of archaic period populations from west-central Kentucky and Tennessee [Dissertation]. Knoxville, Tenneessee: The University of Tennessee, Knoxville. 1-208 p.

Howells WW. 1973. Cranial variation in man - A study by multivariate analysis of patterns of difference among recent human populations. Cambridge: Harvard University Press.

Hunt DR, and Albanese J. 2005. History and demographic composition of the Robert J. Terry anatomical collection. American Journal of Physical Anthropology 127(4):406-417.

Irish JD. 1993. Biological affinities of late Pleistocene through modern African aboriginal populations: The dental evidence. Tempe, AZ: Arizona State University. 378 p.

Irish JD. 1997. Characteristic high- and low-frequency dental traits in Sub-Saharan African populations. American Journal of Physical Anthropology 102(4):455-467.

Irish JD. 2010. The mean measure of divergence: Its utility model-free and model-bound analysis relative to Mahalanobis D^2 distance for nonmetric traits. American Journal of Human Biology 22(3):378-395.

Jantz RL. 2000. DISPOP.

Jantz RL, and Ousley S. 2005a. Fordisc help file: Version 1.35. The University of Tennessee, Knoxville.

Jantz RL, and Ousley SD. 2005b. Fordisc 3.1 Personal computer forensic discriminant functions. Knoxville, Tennessee: University of Tennessee.

Jantz RL, and Owsley DW. 2001. Variation among early North American crania. American Journal of Physical Anthropology 114:146-155.

Kasper KA, Austin D, Kvanli A, Rios TR, and Senn DR. 2009. Reliability of third molar development for age in a North Texas Hispanic population: A comparison study. Journal of Forensic Sciences 54(3):651-657.

Kennedy KA. 1995. But professor, why teach race identification if races don't exist? Journal of Forensic Sciences 40(5):797-800.

Key PJ. 1983. Craniometric relationships among Plains Indians. Report of Investigations. Knoxville, TN: The University of Tennessee.

Klales AR, Ousley SD, and Vollner JM. 2012. A revised method of sexing the human innominate using Phenice's nonmetric traits and statistical methods American Journal of Physical Anthropology 149(1):104-114.

Kruskal JB, and Wish M. 1978. Multidimensional scaling. Beverly Hills, California: Sage Publications.

Lewis JM, and Senn DR. 2013. Dental age estimation. In: Senn DR, and Weems RA, editors. Manual of forensic odontology. Boca Raton, FL: CRC Press.

McMillin JA. 2012. The final victims: Forensic slave trade to North America, 1783-1810 Columbia, South Carolina: University of South Carolina Press.

Milner GR, and Boldsen JL. 2011. Transition analysis age estimation: Skeletal scoring manual.

Mincer HH, Harris EF, and Berryman HE. 1993. The A.B.F.O. study of third molar development and its use as an estimator of chronological age. Journal of Forensic Sciences 38(2):379-390.

Missouri TSHSo. 2012. Guide to American Civil War in Missouri: Callway County, Missouri. Columbia, Missouri: The State Historical Society of Missouri.

Moorrees CFA, Fanning EA, and Hunt EE. 1963. Age variation of formation stages for ten permanent teeth. Journal of Dental Research 42:1490-1502.

Osteoware. 2011. Standardized skeletal documentation software. Washington, D.C.: Smithsonian Institution.

Ousley S. 2014. ThreeSkull. 1.76 ed.

Ousley S, Jantz RL, and Freid D. 2009. Understanding race and human variation: Why forensic anthropologists are good at identifying race. American Journal of Physical Anthropology 139(1):68-76.

Ousley S, and McKeown A. 2001. Three dimensional digitizing of human skulls as an archival procedure. BAR International Series 934:173-186.

Phenice TW. 1969. A newly developed visual method of sexing the os pubis. American Journal of Physical Anthropology 30(2):297-301.

Quigley C. 2001. Skulls and skeletons: Human bone collections and accumulations. Jefferson, North Carolina: McFarland and Company, Inc.

R Development Core Team. 2010. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Relethford JH. 2009. Race and global patterns of phenotypic variation. American Journal of Physical Anthropology 139(1):16-22.

Rhine S. 1990. Nonmetric skull racing. In: Gill G, and Rhine S, editors. Skeletal Attribution of Race: Methods for Forensic Anthropology: Maxwell Museum of Anthropology.

Russell CK. 2006. Whence came the English? Exploring relationships between the Iron Age, Romano-British and Anglo-Saxon periods in Britain and Denmark: A craniometric biodistance analysis. Durham, UK: Durham University. 291 p.

Sauer NJ. 1992. Forensic anthropology and the concept of race: If races don't exist, why are forensic anthropologists so good at identifying them? Social Science and Medicine 34(2):107-111.

Schillaci MA, and Stojanowski CM. 2005. Craniometric variation and population history of the prehistoric Tewa. American Journal of Physical Anthropology 126(4):404-412.

Scott G, and Turner CI. 1997. The anthropology of modern human teeth. Cambridge: Cambridge University Press.

Spradley MK. 2006. Biological anthropological aspects of the African disapora: Geographic origins, secular trends, and plastic versus genetic influences utilizing craniometric data [Dissertation]. Knoxville, Tennessee: The University of Tennessee, Knoxville. 123 p.

Stojanowski CM, and Schillaci MA. 2006. Phenotypic approaches for understanding patterns of intracemetery biological variation. American Journal of Physical Anthropology 131(43):49-88.

Sutton MQ, and Arkush BS. 2002. Archaeological laboratory manual: An introduction. Dubuque, IA: Kendall Hunt.

Turner CGI, Nichol CR, and Scott GR. 1991a. Scoring procedures for key morphological traits of the permanent dentition: The Arizona State University Dental Anthropology System. In: Kelley MA, and Larsen CS, editors. Advances in dental anthropology. New York: Wiley-Liss, Inc. p 13-31.

Turner CI, Nichol C, and Scott G. 1991b. Scoring procedures for key morphological traits of the permanent dentition: The Arizona State University Dental Anthropology System. In: Kelley M, and Larsen C, editors. Advances in Dental Anthropology. New York: Wiley-Liss, Inc. p 13-31.

Tyrrell A. 2000. Skeletal Non-Metric Traits and the Assessment of Inter- and Intra-population Diversity: Past Problems and Future Potential. In: Cox M, and Mays S, editors. Human Osteology in Archaeology and Forensic Science. London: Greenwich Medical Media Ltd. p 289-305.

Walker PL. 2005. Greater sciatic notch morphology: Sex, age, and population differences. American Journal of Physical Anthropology 127(4):385-391.

Wedel VL, and Wescott DJ. 2011. Detecting a historical epidemic using dental cemenetum increment analysis. American Journal of Physical Anthropology 144(S52):308.

Wescott DJ, and Jantz RL. 2005. Assessing craniofacial secular change in American Blacks and Whites using geometric morphometry. In: Slice DE, editor. Modern Morphometrics in Physical Anthropology. New York: Kluwer Academic/Plenum Publishers. p 231-245.

Wheat A. 2009. Assessing ancestry through nonmetric traits of the skull: A test of education and experience. San Marcos, TX: Texas State University. p 49.