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Biological Anthropological Aspects of the African Diaspora; Geographic Origins, Secular Trends, and Plastic Versus Genetic Influences Utilizing Craniometric Data

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To the Graduate Council:

I am submitting herewith a dissertation written by Martha Katherine Spradley entitled "Biological Anthropological Aspects of the African Diaspora; Geographic Origins, Secular Trends, and Plastic Versus Genetic Influences Utilizing Craniometric Data." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

Richard L. Jantz, Major Professor

We have read this dissertation and recommend its acceptance:

Lyle W. Konigsberg, Andrew Kramer, Karla J. Matteson

Accepted for the Council:

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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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BIOLOGICAL ANTHROPOLOGICAL ASPECTS OF THE AFRICAN DIASPORA; GEOGRAPHIC ORIGINS, SECULAR TRENDS, AND PLASTIC VERSUS GENETIC INFLUENCES UTILIZING CRANIOMETRIC DATA

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Martha Katherine Spradley
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DEDICATION

This dissertation is dedicated my husband, Shane Cummings, for his support, patience, and constant encouragement.

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ABSTRACT

The African Diaspora refers to the forced emigration of Africans to European and British colonies for the purpose of providing slave labor. Enslaved Africans that arrived in the New World were subjected to a new environment and plantation labor. When dramatic shifts in living standards or exposure to a new environment occur, physical changes may take place within the given population. These types of changes over the short-term are known as secular changes and are thought to be the result of an improvement or decline in environmental conditions, particularly nutrition (Cameron et al., 1990).

Significant craniofacial secular changes have been documented in American Whites and Blacks over the past 150 years (Jantz, 2001; Jantz and Meadows Jantz, 2000, Wescott and Jantz, 2005). Angle (1976) also noted changes in colonial to more recent American Blacks and Whites. However, Angel's sample sizes for the time periods he studied were small and he did not test for correlations with time. To date, no studies have exclusively focused on the craniofacial morphological changes taking place since the arrival of Africans to the Americas, some 350 years ago with appropriate samples, and whether these changes result from selection, environment, plasticity, or gene flow (admixture).

The hypothesis of the present research is that significant craniofacial secular change has taken place in the American Black population since the American colonies entered the slave trade. The objectives are to use new craniometric data to trace the geographical origins of enslaved Africans and early American Blacks; to use larger

samples with more time-depth and smaller birth year cohorts than previously used to assess the significance of the proposed craniofacial secular changes; and to compare new craniometric and previously published genetic data to evaluate whether or not the observed craniofacial secular changes are a result of environmental plasticity or genetic control. This research suggests that significant craniofacial secular changes have taken place from 1700 to 1975 and that a genetic association with craniofacial morphology is apparent.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

The African Diaspora was the largest forced migration of a group of people from one continent to another. Because migrations often result in adaptation to a new environment and restructuring of gene flow, they produce biological consequences in the human genotype and phenotype. Using new craniometric and published molecular data, the proposed research focuses on several biological anthropological consequences of the African Diaspora, specifically the craniofacial secular changes that have taken place since Africans were first brought to the American colonies and whether these changes result from environmental plasticity, selection, or genetic influences.

The African Diaspora refers to the forced emigration of Africans to European and British colonies for the purpose of providing slave labor. The Diaspora began in the mid 15th century and lasted until the mid 19th century and was fueled by the "triangle trade" dominated by Europeans. European merchants sent ships to West Africa loaded with guns, alcohol, and textiles that were traded for slaves. The Africans were then transported to the West Indies on a route known as the "The Middle Passage". Once in the West Indies, Africans were sold as slaves for labor on plantations in the West Indies or in the American colonies. The empty ships were loaded with sugar, rice, tobacco, and rum to sell for huge profits upon return to Europe.

Enslaved Africans that arrived in the New World were subjected to a new environment and plantation labor. Those that survived the new environment and the

arduous labor were said to have survived the "seasoning process." In other words, they adapted to a new environment. When dramatic shifts in living standards or exposure to a new environment occur, physical changes may take place within the given population. These types of changes over the short-term are known as secular changes and are thought to be the result of an improvement or decline in environmental conditions, particularly nutrition (Cameron et al., 1990).

Secular changes have been documented in the overall bodily form, including height and weight, and can be either positive or negative (Boldsen, 1995; Cameron et al., 1990; Jantz, 2001; Komlos, 1995; Steckel, 1994; Wescott and Jantz, 2005). These changes have also been documented in the cranium and post-cranium. Boas' 1910 immigrant study, referred to theses changes in as "plastic." Boas found differences in head form in foreign-born and American-born children of immigrants, which sparked the concept of cranial plasticity. Cranial plasticity is the idea that during the growth and development process, the cranium is predominantly shaped by environmental factors. The continual emphasizing of Boas' conclusions derived in 1910 continue as a major influence supporting the notion of plasticity, despite evidence to the contrary (Sparks and Jantz, 2003a; Sparks and Jantz, 2003b).

In a reanalysis of Boas' data using modern methods, Sparks and Jantz found that that the differences between U.S. born and foreign-born children were negligible and that the largest variation was found *among* the ethnic groups. Gravlee et al. (2003) reached different conclusions in their reanalysis of Boas' data. Gravlee et al. support that differences did exist between U.S. born and foreign born children of immigrants thus supporting cranial plasticity. The differences between the two separate reanalysis of

Boas' data provides enough confirmation for some to continue to cite Boas' work as evidence of cranial plasticity as the dominant force in cranial form (Williams et al., 2005).

More recent studies (than Boas) have focused on changes in craniofacial morphology over time in the U.S. (Angel, 1976; Jantz, 2001; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005). These studies have primarily focused American Blacks and Whites have found significant changes in cranial morphology over time, these changes are referred to as *secular trends* and are likely due to a combination of factors including gene flow (admixture), selection, and environment rather than solely plasticity.

In a study of colonial to modern change, Angel (1976) found that facial height increased from colonial to modern times for both Blacks and Whites. More recent studies of secular change in the U.S. in both American Whites and Blacks by Jantz (2001), Jantz and Meadows Jantz (2000), and Wescott and Jantz (2005) found that the most significant secular changes are in the cranial vault and that the cranial vault is positively and significantly correlated with birth-year cohorts.

The difference between Angel's earlier finding of secular change in the facial height, and the later studies finding the majority of changes in the vault are most likely due to the samples used. Angel's samples including adult individuals dating between 1675 to 1975. His early 'colonial' samples come from historic archaeological sites and his 'modern' samples come from the Terry and Todd anatomical skeletal collections as well as forensic anthropological cases from the Smithsonian Institution. Jantz and Wescott and Jantz's samples dates span 1840 to 1975 and 1850 to 1974, however their dates represent birth years, not the date of death, as in the case of Angel's samples. Their

earliest samples contain the Terry and Todd anatomical collections and later samples include recent forensic anthropological cases from the Forensic Anthropology Data Bank (FDB).

Observed differences may reside in sample partitioning, Angel only partitioned his samples into two cohorts, 'colonial' and 'modern' and compared the means between the two groups without testing for a correlation with time. Jantz and Wescott and Jantz parititoned their group by decade and 25 year cohorts based on birthyears and test for correlations with time. Although Jantz and Wescott and Jantz lack the time-depth of Angles samples, they have significantly larger sample sizes.

The hypothesis of the present research is that significant craniofacial secular change has taken place in the American Black population since the American colonies entered the slave trade. The objectives are to use craniometric data to trace the geographical origins of enslaved Africans and early American Blacks; to use larger samples with more time-depth and smaller birth year cohorts than previously used to assess the significance of the craniofacial secular changes; and to compare craniometric and genetic data to evaluate whether or not the observed craniofacial secular changes are a result of environmental plasticity or genetic control.

The craniometric data collected for this research provides a large reference sample for future investigations of biological relationships among early historic, late historic, and recent American Blacks, and the biological relationships among West Africans and American Blacks. In particular, the West African data collected for this research, when added to the Howells (1973) African data, provides a basis for exploring

biological relationships among African groups from diverse cultural and geographic regions.

The proposed research consists of three separate analyses (Chapters 5, 6, and 7) that attempt to provide insight to the biological anthropological aspects of the African Diaspora. This chapter has served as a brief introduction; Chapter 2 consists of a literature review that will outline the historical and theoretical framework for the following chapters. Chapter 3 provides a brief outline of the African Diaspora as it relates to the origins of enslaved Africans.

Chapter 4 provides a description of samples and methods used for partitioning each individual into an appropriate cohort for subsequent analyses. Also provided is a description of terminology used to describe the various population groups used throughout this work. Chapter 5 examines the craniometric relationships among Africans from different cultural and geographic regions and tests the appropriateness of the reference samples used in subsequent chapters.

Chapter 6 attempts to discern any craniofacial secular changes that have occurred in the American Black population from 1700 through 1975. The documentation of secular changes in the American Black population allow an opportunity to document what phenotypic changes have taken place since West Africans were brought to the American colonies, and infer which biological processes may have influenced these changes, such as gene flow, genetic drift, plasticity, or selection. Chapter 7 then compares genetic distance matrices derived from both craniofacial morphological data and molecular data in order to test whether the cranium is under more plastic or genetic control.

Chapter 8 discusses the results of chapters 5, 6, and 7 within the greater context of biological anthropological aspects of the African Diaspora. Chapter 9 highlights the major conclusions of this research.

Chapter 2

Literature Review

Morphological and genetic variation has been found among geographic and cultural groups within Africa (Herskovits, 1928b; Howells, 1973; Keita, 2004; Kittles and Keita, 1999; Relethford, 1994; Ribot, 2002; Rightmire, 1970; Rightmire, 1971; Roseman, 2004; Wolpoff and Caspari, 1997; Workman et al., 1963). This historical and genetic data has proposed that Africans brought to the New World for slavery predominantly came from west and west central Africa (Cobb, 1939; Herskovits, 1928a; Herskovits, 1928b; Herskovits, 1930; Herskovits, 1969; McMillin, 2004; Parra et al., 2001; Parra et al., 1998; Rawley, 1981). Because craniofacial morphology consists of physical variables that represent an interaction between genes and the environment, craniometric analysis has been shown to be useful in assessing the biological relationships among groups (Howells, 1973; Keita, 2004; Relethford, 1994; Relethford, 2001; Relethford and Blangero, 1990). This literature review will provide the historical and theoretical framework that will provide a foundation for subsequent chapters.

Craniometric Variation

Prior to the development of anthropology as an academic discipline, early craniometric studies were largely descriptive or typological (Busk, 1874; Crewdson-Benington and Pearson, 1912; Kitson, 1931). The mid to late 20th century saw a shift in craniometric studies, focusing more on the *processes* that influence the variation rather

than describing the variation for typological purposes (Pollitzer, 1981). Despite critics (Armelagos and van Gerven, 2003; Williams et al., 2005) that boast that population studies using craniometric data are still entrenched in the typological approach, population studies conducted in the context of biological anthropology have been shown to be important and informative.

Because craniofacial morphology is a polygenic quantitative trait (Buikstra et al., 1990; Relethford, 1982), craniometric analyses can help us to understand how humans adapt to their environments thus providing insight to the factors that influence human variation. Relethford (2004) found a moderate and significant correlation between geographic distance and craniometric distance indicating that craniometric distances are in part shaped by gene flow. Roseman (2004) found a moderate and significant correlation between craniometric distance and temperature distance (Roseman, 2004). Roseman's results indicate that geographic distance and climatic adaptation have shaped global craniometric variation and that natural selection might be an important factor in shaping among group differences in cranial morphology.

In order for natural selection to shape cranial morphology, a genetic factor must also be in play. Devor reported that the heritability index of craniofacial traits is around .55, suggesting that 55% of craniofacial morphology is genetic. The concept of a genetic component to craniofacial morphology had enabled researchers to use craniometric data to explore world-wide diversity in human populations (Relethford, 1994; Relethford, 1996; Relethford, 2001a; Relethford, 2001b; Relethford, 2004a; Schillaci and Stojanowski, 2004; Stringer and Andrews, 1988; Zietkiewicz et al., 1998). Relethford finds that craniometric data behave much the same way as molecular and protein

(genetic) data in regards to providing insight to world-wide human variation (Relethford, 1994; Relethford, 2001a; Relethford, 2001b). Studies of human variation using DNA, blood markers, and craniometric data to derive genetic distances or Wrights F_{st} (a measure of within and among group variation), using continental groups, indicate that the 85%-90% of all variation is found within groups while the remaining 10%-15% is found among continental groups (Relethford, 1994; Roseman and Weaver, 2004; Templeton, 1999; Tetushkin, 2001).

Similar studies of craniometric variation have also been conducted within continental regions in order to explore variation within and among local or regional groups. For example Kitson (1931), using the coefficient of racial likeness, a measure of similarity or divergence between groups (Pearson, 1926), found no association between distances and geography of African groups. Hiernaux (1972) found anthropomorphic variation in sub-Saharan Africa reflects caste and ethnic boundaries and corresponded little with geographic distance. However, more recently Keita (2004) found that genetic distances do correlate with geography in Africa. These differing results could result from the specific metric data used and differing skeletal collections. The effects of the Bantu expansion could also obscure any differences between biological and geographic distance.

The Bantu expansion is an excellent example of how migration can be traced using linguistic, archaeological, and genetic data (Cavalli-Sforza et al., 1994; Falola, 2002; Ribot, 2004). The term *Bantu* refers to a diverse, although related, language family that is spoken in various geographic areas in Africa (Falola, 2002; Ribot, 2004). The *Bantu expansion* refers to a large scale migration of a single Bantu speaking group

between 4,000 to 1,000 years B.C. that has been traced to modern day Cameroon, located in West Africa (Falola, 2002; Ribot, 2004). Based on the dispersion of over 450 Bantu speaking groups, the migration is thought to have occurred in two major paths, from West to East and from West to Southeast (Figure 1). Although East and West groups are in different geographic areas, they exhibit genetic and morphological similarity (Cavalli-Sforza et al., 1994; Ribot, 2004).

Because the Bantu expansion can be traced with genetic and craniometric data, craniometric data should be useful in exploring the biological relationships of the West Africans to early historic enslaved Africans in the American colonies. The Bantu expansion should not affect the relationships between enslaved Africans and the tracing of their geographic origins, since the Bantu expansion began in West Africa. Blakey et al. (2001) were able to narrow down specific geographic origins (other than continental origins) of several individuals buried in the New York African Burial Ground (NYABG) to specific countries through craniometric, dental, and molecular data. Parra et al. (2001) also traced the origins of the present day Gullah population in South Carolina to Sierra Leone, contra Rogers (2000). Analyses using craniometric data have also helped identify the oldest known Africans (initially considered Native American) living in colonial Jamestown (Owsley, 1999).

Craniofacial Secular Change

As previously discussed in terms of the Bantu expansion, craniometric data can be informative for exploring diversity within Africa as well as exploring the overall

Figure 1: Origin and direction of the Bantu expansion.

craniofacial changes that have occurred over time. Metric analyses suggest that West Africans from the 18th and 19th centuries display quite different cranial vault morphology (short and high) compared to colonial Whites (long and low) (Angel, 1976; Herskovits, 1969; Shapiro, 1930). West Africans from the 18th and 19th centuries, thought to be ancestral to recent American Blacks, also display different craniofacial morphology (short and high) when compared to recent American Blacks (long and narrow) (Trevor, 1950). Recent American Blacks (long and narrow) also differ in cranial vault morphology from recent American Whites (shorter and higher) (Jantz, 2001; Jantz and Meadows Jantz, 2000; Montagu, 1944; Moore-Jansen, 1989). A similar pattern of lengthening and narrowing of the vault is also found among South African Blacks in the Raymond Dart skeletal collection, comprised of individuals born between 1880 through 1934 (Cameron et al., 1990).

The morphological differences between West Africans and American Blacks were noticed by Cobb (1939), Herskovits (1928, 1930, 1941, 1969), and Pollitizer (1958). They noticed a "*transformation*" in the American Black population that Herskovits (1928) termed "*racial crossing*." They began to publish, from an anthropological view, articles and books to help American Blacks understand their biological origins and culture. Herskovits did much to understand what he termed the "*American Negro*" and tried to help all Americans in the early 20th century understand that American Blacks were a significant portion of the population and that they have adapted to this environment both culturally and biologically, and are therefore American.

Early studies of American Blacks, using craniometric data, attributed differences in cranial morphology between West Africans and American Blacks to admixture (Angel,

1976; Trevor, 1950). Trevor was interested in quantifying phenotypic traits American Blacks by determining specific traits that were more similar to Africans and traits that were more similar to Europeans. In his analysis, he found three variables in American Blacks that were significantly higher than values for West African and British crania, indicating that American Blacks were not just intermediate, but displayed a unique morphology. These variables include facial height, nasal height, and orbital breadth. As other studies during this time period and earlier, the increased values for the three variables were attributed to admixture. In Angel's study of colonial to modern skeletal change in both American Blacks and Whites, he attributed an increase in facial height among American Blacks specifically to admixture with American Whites and Native Americans.

More recently, significant craniofacial secular change has been documented in the American Black and White populations during the 19th and 20th century (Angel, 1976; Jantz, 2001; Jantz and Meadows Jantz, 2000). The most notable change was found in cranial vault height (Angel, 1982; Jantz and Meadows Jantz, 2000). Jantz and Meadows Jantz (2000) found that vault height parallels stature and can therefore be used as a proxy to assess the overall health of a population. Wescott and Jantz (2005) examined craniofacial secular change, in American Blacks and Whites, using larger samples and different methods and found that most of the changes have taken place in the cranial base and that changes in the vault and face are minimal. However, the height of the cranial base contributes to overall vault height. As pointed out by Wescott and Jantz, changes are observed in vault height; however it is the cranial base that is making the major contribution to vault height.

Craniofacial secular changes have occurred in both American Whites and Blacks. The West Africans brought to the U.S. had different craniofacial morphology than recent American Blacks. Colonial Whites that imported slave labor also had different craniofacial morphology than recent American Whites. Wescott and Jantz and Sparks and Jantz (Sparks and Jantz, 2003a; Sparks and Jantz, 2003b) suggest that despite sharing a common environment, genetic variation still exists between American Blacks and Whites and that their failure to converge to a common morphology does not support plasticity as the sole mechanism of secular change. Thus teasing apart environmental from genetic influences remains quite difficult. To date, no studies have exclusively focused on the craniofacial morphological changes taking place since the arrival of Africans to the Americas, some 350 years ago and whether these changes result from selection, environment, plasticity, or gene flow (admixture).

Genetic Studies of Admixture

The interaction between genes and the environment in regards to polygenic traits is not fully understood. However, genetic research has provided examples of how selective pressures have effected certain genotypes in African populations. The most well known example is the sickle cell allele. Specific areas in north, west, and central Africa have a high prevalence of the Hb S allele and are known malarial areas. Allison (1954) was the first to suggest that the presence of this allele provided protection from malaria. He proposed that those without the mutation would contract malaria and suffer adverse effects, those that were homozygous would contract the sickle cell disease, and those that

were heterozygous would be protected from malaria. Thus, the presence of the potentially harmful mutation was kept in the population by balancing selection (Allison, 1954; Lewontin, 1995).

The salt retention hypothesis is another example of how selective pressures may have influenced Africans during the Diaspora (Rogers, 2000). Dysentery, resulting in diarrhea and dehydration, was the predominant cause of death during the Middle Passage. American Blacks have higher frequencies of hypertension than other groups in the U.S. (Grimm, 1988). Grimm suggested that individuals surviving the Middle Passage were better able to retain salt, thus making them less susceptible to dysentery. Grimm's hypothesis could account for the greater prevalence of hypertension in the American Black population (Rogers, 2000).

In addition to selective forces, gene flow also played a major role in the current American Black population. Because the Trans Atlantic slave trade affected many other parts of the world, genetic research has focused on admixture estimates that stem from the slave trade. (Gattas et al., 2004) found genetic admixture in the African Brazilian populations by examination of s-transferase polymorphisms. These polymorphisms indicate that Brazilian mulattos are genetically intermediate between Black and White groups. Further (Abe-Sandes et al., 2004) investigated the genetic diversity of the Y-chromosome in six Brazilian populations in an attempt to evaluate the contribution of African, Amerindian, and European ancestry to the present Brazilian population. Abe-Sanders et al. found that the process of admixture is not homogeneous and that the majority of Y chromosomes in the Afro-Brazilians are of African origin.

In a study of Cabo Verde, a series of islands just off the coast of West Africa, Parra et al. (1995) found that admixture between Europeans males and West African females has configured the present population. Cabo Verde was founded in the 15th century by a few Europeans, mainly from Portugal, and enslaved Africans from the West African coast. Parra also found, using red cell enzymes and plasma proteins, that the present population of Cabo Verde is genetically closer to American Blacks than West Africans.

In the U.S. the level of European ancestry in American Blacks ranges from 22.5% in New Orleans, 12.7% in Philadelphia, 20.2% in Pittsburgh, and 11.6% in Charleston based on autosomal population specific alleles (PSAs) (Parra, 1998). Previous studies, using autosomal, mtDNA, and Y chromosome markers, also suggest that the north exhibits higher admixture estimates than the south (Parra et al., 2001). Using maternally and paternally derived genetic markers, Parra (1998) found that in every American Black group used in the study, men of European descent made a more significant contribution to the American Black gene pool than European descent women.

While most American Blacks in the U.S. have between 12% to 23% European admixture, an isolated group of individuals in South Carolina maintain the lowest reported European admixture estimate (3.5%), the Gullah Sea Islanders. Based on ethno-historical, cultural, and linguistic evidence the Gullah were brought to the low country of South Carolina from Sierra Leone during the Diaspora because of their expertise in rice cultivation (cite). This has been supported by anthropometric and genetic research (McClean Jr. et al., 2005; McLean Jr. et al., 2005; Parra et al., 2001). McLean (2005) further supports that the Gullah are more genetically isolated than other African

Americans. Genetic studies done by McLean using mtDNA haplotypes indicate that Sierra Leone made a significant genetic contribution to the Gullah, thus supporting historical documentation. However, Rogers (2000) unpublished dissertation does not provide the same conclusions regarding the origins of the Gullah. Using anthropometric and hemoglobin data, she finds that the Gullah are most genetically similar to the Gold and Slave Coasts.

Summary

Craniofacial morphology is a polygenic trait. Such polygenic traits are influenced by an interaction between genetics and the environment. However, this interaction is not well understood. Selection, gene flow, genetic drift, environmental plasticity, or a combination of a few or all of these factors could influence polygenic traits. Exploring craniofacial secular change from 1700 through 1975, should indicate what morphological changes have taken place since the African Diaspora. Further, the comparison of genetic distances derived from new craniometric and published genetic data between West Africans, American Blacks, and American Whites may provide insight to the factors that influence secular changes in terms of polygenic traits.

Before analyzing craniometric variation, craniofacial secular change, and genetic admixture of American Blacks, it is necessary to first review the circumstances surrounding the African Diaspora. The following chapter provides an outline of the African Diaspora and "the triangle trade." The next chapter in no way attempts to cover the entirety of the African Diaspora and the Trans Atlantic slave trade and could not do

so in just a few pages. Instead, it will serve as a brief overview of the slave trade, the slave trade in the American colonies, and the origins of the enslaved Africans in American colonies.

Chapter 3

The African Diaspora

Millions of enslaved Africans were brought to the New World during the African Diaspora. These Africans were bought with European trade goods from the west coast of Africa. In turn they came to America to provide large scale plantation labor that filled the British economy. The origin of these enslaved Africans was often documented by slaving ships and ports of entry. Since the beginnings of the slave trade, abolitionists began to compile data for anti-slavery literature concerning how many slaves were transported to various locations and where they were from. Historians have continued to pore over the ships documents and those of the abolitionists in an attempt to discern how many Africans made the Middle Passage to the Americas and where they originated. This chapter provides an overview of the slave trade, the slave trade in the American colonies, and the origins of the enslaved Africans in American colonies.

The "Triangle Trade"

The African Diaspora refers to the forced emigration of Africans to European and British colonies for the purpose of providing slave labor. The African Diaspora was fueled by the "triangle trade," which was dominated primarily by Europeans (Figure 2). European merchants would send ships to Africa loaded with guns, alcohol, and Indian textiles to trade for African slaves. The Africans were then transported to the Americas

Figure 2: The "Triangle Trade" route

on a route known as the "The Middle Passage". Once in the Americas, Africans were sold as slaves for labor on plantations. While in America, the ships were loaded with sugar, rice, tobacco, and rum to sell for huge profits upon return to Europe. After the goods were unloaded in Europe, the ships would then embark on another trip to Africa. It was the Africans who were captured, traded for European goods, and taken to the Americas to provide cheap labor that enabled European merchants to make huge profits.

The African Diaspora lasted roughly four centuries, beginning in the mid 15th century and lasting until the mid 18th century. The Portuguese became the first to exploit the West Coast of Africa, namely the Gold Coast, for the slave trade in the 15th century. They had sugar plantations in Brazil, and enslaved Africans provided the labor. The Portuguese were the first to lead the world's sugar production in the early 17th century. In the 16th century, the English and Dutch entered the slave trade, and by the 17th century the Portuguese lost their African trading posts to the English and Dutch (Falola, 2002). In the mid 17th century, the Dutch transferred sugar plantations from Portuguese Brazil to the West Indies. The English soon followed and took over Caribbean islands from Spanish control and established sugar plantations in Barbados and Jamaica, while the French established plantations in St. Dominique. With these new plantations arose an increased demand for slave labor. (Northrup, 2002)

The Slave Trade in the American Colonies

In the latter part of the 17th century, the American colonies were the last to enter the slave trade in large numbers. The first documentation of Africans in American

colonies was as early as 1526 in a colony located in what is now South Carolina under Spanish rule. Later, in 1619, approximately 20 Africans arrived with English settlers in Jamestown, Virginia. It is uncertain whether they were slaves or indentured servants.

In the American colonies, there was ample land for growing tobacco, rice and sugar. Europeans who came to the colonies did so because they thought they could have a new life of opportunity and wealth, not realizing the hardships they would endure once residing in the colonies. Some even thought they could earn enough money in a short period of time and return home. Plantation agriculture in the Chesapeake Bay area produced much tobacco. In 1616 it is estimated that America exported 2,500 pounds of tobacco to Europe, which rose to 105,000,000 pounds by 1717 (Rawley, 1981). As exportation to England grew, so did the need for labor. Europe could not, and did not want to, supply a labor force for this purpose. Their population had not grown from the 1600's to the 1700's, and they wanted to keep men to fill the positions of soldiers and seamen (Rawley, 1981).

Rice cultivation began booming in the lowlands, the coastal area ranging from North Carolina to Georgia. Just as the tobacco exports grew, so did American rice exports. In 1698 an estimated 10,407 pounds was exported to England, which jumped to 83,708,625 pounds in 1770 (Rawley, 1981). Not only did the need for more slave labor arise, but rice farming required more demanding labor and more technical expertise (Rawley, 1981). It has been published that rice farmers would "order" slaves from specific parts of Africa known for their skills in rice cultivation (Curtin, 1969; Parra et al., 2001; Rogers, 2000).

Another boom in the slaving industry emerged in the early 1800's, as cotton quickly became a profitable cash crop in the South. There was a need for labor in order to clear and cultivate land. Like those who ran the rice plantations, cotton plantation managers and owners still showed a preference for slaves from the Gold Coast and Senegambia, but with increased demand they were more willing to purchase slaves from the Bight of Benin, Bight of Biafra, Mozambique, and Angola.

The Origins of Enslaved Africans

The origins of enslaved Africans are not only of interest to historians and scholars, but also to Black Americans who wish to trace their ancestral heritage. Unfortunately, names were not usually a part of ship's manifests, although points of origin were often documented. It is generally accepted that the majority of enslaved Africans came from West and West Central Africa. Curtin (1969) provides a comprehensive literature review of the trans-Atlantic slave trade in terms of how many enslaved Africans were brought to the New World. McMillian (2004) provides a review of the origins of enslaved Africans brought to the North American colonies during 1783-1810.

While some ship's manifests contain information regarding the geographic origins of the slaves they transported, many did not. While ports of trade along the coast are often cited, it is not wise to use this information as the definite origin of the captives. Many of the points of trade on the West African coast, along with forts and castles built by the Dutch, English, or French, are either still standing or have been uncovered by

archaeological investigations, and they support that the majority of slave trading took place on the West and West Central coast. Despite uncertainty about exact origins, the majority of historians agree on eight main coastal ports of trade. These coastal regions include Senegambia, Sierra Leone, Windward Coast, Gold Coast, Bight of Benin, Bight of Biafra, Angola, and Mozambique (McMillin, 2004) (Figure 3).

Many scholars have pointed out that the geographic location of trade does not necessarily mean the geographic origin of the individuals (Herskovits, 1928; McMillin, 2004; Rawley, 1981; Rogers, 2000). There are discussions that Africans were captured from the interior and brought to the coast for trade by middlemen (Falola, 2002). Politics did play a role within the region as to which geographic areas/tribes would be captured for trade. The expansion of African states, political kingdoms, and chiefdoms was often accompanied by war, and thus dictated to some extent who would be captured and sold as slaves (Falola, 2002).

Prior to the 1720s in the American colonies, the majority of enslaved Africans were purchased from Barbados and Jamaica (McMillin, 2004; Rawley, 1981). Thus, for ships bringing slaves from the Caribbean to the American colonies, the Caribbean was often listed as their origin. The French, Dutch, and British that transported slaves to the Caribbean had specific ports in Africa where they would trade. Therefore, it is difficult to know the African origin of the slaves arriving in the American colonies from the Caribbean, whether they were American or African born.

After the 1720s the American colonies' economy had grown and could purchase direct shipments from Africa (McMillin, 2004). During this time South Carolina

Figure 3: Major slaving ports of the West African coast.

imported, in numbers greater than any other area, slaves directly from Africa (McMillin, 2004).

As discussed in the previous section, plantation managers and owners in the Southeastern American colonies had a preference for slaves from the Gold Coast and Senegambia. Due to their skills in rice cultivation, they were purchased for a premium price in the American colonies (Morgan, 1997).

Louisiana had the most diverse shipments of slaves regarding African origins, perhaps because the ownership of this land traded between the French, Spanish, and English. Louisiana was the only North American colony to import large numbers of slaves from the Bight of Benin. Estimates from the 18th century indicate that 30,000 slaves were imported. It is estimated that 66% came from Senegambia, 29% from the Bight of Benin, and 5% from West Central Africa which could be due to multiple countries having ownership Louisiana (McMillin, 2004).

As mentioned in the previous section, the emergence of cotton as a southern staple in the early 1800s created another demand for slave labor. Southerners still preferred slaves from the Gold Coast and Senegambia, but, with an increased demand, they became more willing to purchase from other areas (McMillin, 2004). Overall, the French, Spanish, and English imported large numbers of Angolans, the North American colonies imported a high percentage of Senegambians. Less than one-thrid of the 7,000 slaves imported to Florida have documented origins, and virtually nothing is known of slave imports to Mississippi (McMillin, 2004).

Summary

The African Diaspora lasted roughly four centuries, from the mid-1450s to the mid- 1850s. This forced emigration of enslaved Africans to European and British colonies fueled the triangle trade by providing the labor needed for plantation agriculture. The Portuguese were the first to enter the slave trade and the world's sugar production, but they lost their African ports to the Dutch and English. The Dutch and English soon had a sugar plantation monopoly in the Caribbean, and thus arose a marked increase in demand for slave labor. American colonies entered the trade in large numbers in the 17th century. Tobacco, rice, and sugar were the cash crops that demanded slave labor. In the 18th century, the emergence of cotton as a staple increased the labor demand even more.

The forced emigration of enslaved Africans brought new populations and new cultures to the New World. The slave trade is of interest to historians and to Black Americans who wish to trace their ancestral heritage. There is some documentation of slave origins in ship's manifests, although as Curtin states "At best, the export data of the slave trade can be suggestive" (Curtin, 1969:272). While the West African coastal trading ports are viewed as the point of origin for enslaved Africans, they do not necessarily imply the Africans' precise geographic or tribal origins. Historical documents reviewed in section 2.3 indicate that plantation owners and managers had a preference for Gold Coast and Senegambian slaves due to their expertise in rice cultivation. Genetic evidence also supports these suggestions (Parra et al., 2001; Parra et al., 1998).

Chapter 4

Description of Samples

In order to explore craniofacial secular changes resulting from the African Diaspora, data were collected from samples dating from 1650 to 1950. Some of these data were made available by previous researchers. W.W. Howells collected craniometric data from geographically-diverse, modern groups world-wide. Howells' publicly available data for African groups are used for this project. Additional craniometric data were made available from the historic craniometric database maintained by Dr. Richard Jantz at The University of Tennessee and Dr. Douglas Owsley at the Smithsonian Institution. Data from the mid 19th to early 20th century are from the W. Montague Cobb, Robert J. Terry, and Hamman-Todd collections. The most recent individuals are from the Forensic Anthropology Data Bank (FDB). These data were submitted by various researchers around the country as well as collected by individuals at The University of Tennessee. A summary of historic, anatomical and recent samples described in this chapter is provided in Table 1.

The African samples from Howells' (1973) data set include Bushman, Dogon, Teita, and Zulu. Further descriptions of these groups can be found in Howells (Howells, 1973) *Cranial Variation in Man* and will not be further described. Additional African samples collected at the American Museum of Natural History (AMNH) in New York and the Duckworth Laboratory in Cambridge, England. Samples from the AMNH include Ashanti, Calabar, Cameroon, and Gold Coast from West Africa. The Somali and

Table 1: Historic, Anatomical, and Recent Samples by Site or Collection.

Sample	Female	Male	Total
Burke Lake Cluster	1	1	2
Cactoctin Furnace	5	5	10
Clift's Plantation	-	4	4
Cobb Collection	17	24	41
Deep River	2	2	4
FDB	82	125	207
First African Baptist Church	15	11	26
Fort A.P. Hill	5	2	7
General Historic	2	4	6
Jamestown	-	2	2
Mt. Pleasant Cemetery	3	7	9
Orleans Parish	3	2	5
Providence Baptist Church	12	8	20
Terry Collection	40	80	120
Todd Collection	72	46	118
Total			582

Haya samples were collected at the Duckworth and represent East Africa. A summary of all samples (excluding the Howells data set) described in this chapter is provided in Table 2.

Data from enslaved Africans and early historic African-American samples were collected from various archaeological sites including: First African Baptist Church, A.P. Hill (44CE326), Burke Lake, Catoctin Furnace (18FR323), Clift's Plantation (44WM33), Providence Baptist Church (40SY619), and Mt. Pleasant cemetery. Three important anatomical skeletal collections also contributed to this data set by providing the majority of the late historic data; the Robert J. Terry, the Hamman-Todd Collection, and the W. Montague Cobb Collections.

West African Groups

The majority of West Africa groups (Ashanti, Calabar, Cameroon, Gold Coast) are part of the Felix von Luschan (1854-1924) collection curated at the AMNH. Curator of the Vienna Anthropological Society from 1874 to 1877, von Luschan was considered an expert on African history and culture. He received his M.D. in 1878 and eventually became director of the Royal Museum of Ethnology (Museum fur Volkerkunde) in 1905. Prior to his directorship, he was curator of Africa and Oceania and collected skulls, biological specimens, and art from German colonies in Africa. (Smith, 2002)

It was the hope of von Luschan to collect enough information from world-wide skeletal samples to refute the typological and racist ideals during his time and to support the reality of racial equality (Smith, 2002). The samples used in this research were

Table 2: African Samples by Group

Sample	Female	Male	Total
Ashanti	13	18	31
Calabar	7	18	25
Cameroon	10	39	49
Gold Coast	10	10	20
Somalia	-	50	50
Haya	17	19	36
Enslaved Africans *(Morton Collection)*	1	19	20
Total			231

collected between the late 1880's to the early 1900's, presumably while von Luschan was at the Royal Museum of Ethnology.

One additional West African group is part of the Samuel Morton collection at the Museum of Archaeology and Anthropology at University of Pennsylvania. This group is comprised of a documented sample of Africans, recently re-discovered in the Morton Collection (Renschler, personal communication). Documentation was discovered that indicates this sample consists of enslaved Africans that were brought to Cuba during the Trans Atlantic Slave Trade and were destined for sale in the Caribbean or U.S. This collection was shipped to S. Morton in 1840 from Don Jose Rodriguez Cisneros, M.D. Cisneros also provided the sexes and approximate ages of these individuals. The ports of origin were documented as West African, although the exact geographic origins of the slaves were not documented.

East African Groups

The East African groups consist of individuals from Somalia and individuals belonging to the Haya, located in Tanzania. The skulls from both groups are curated at the Duckworth Laboratory in Cambridge, England. The Somalian individuals were all male soldiers that were collected from the battlefield in Somalia. They most likely are victims of the Italian invasion of British Somaliland in 1940. The Haya collection most likely dates to the 19th century based on the overall condition of the skulls and their context within the museum. This sample contains both males and females. Sex assessments were made based on skull morphology.

Historic American Blacks

Catoctin Furnace

The Catoctin Furnace iron works, excavated by Mid-Atlantic Archaeological Research, was located in Fredrick County, Maryland. The skeletons are now curated at the Smithsonian Institution. Archaeological analyses based on coffin nails, date this site between 1790 and 1840, during which time the owners of Catoctin Furnace are documented as having slaves (Burnston and Thomas, 1981). J.L. Angel performed the osteological analysis that suggested these skeletons were Black and first or second generation slaves. Further historic documentation suggests these individuals were enslaved and worked at the iron furnace complex (Burnston, 1981; Burnston and Thomas, 1981).

A.P. Hill

Fort A.P. Hill is located in Caroline county, Virginia. A total of 43 graves were excavated at this site, dating between the 18th and 19th century (Bruwelheide, 2002). Of the 43 graves, only 29 individuals were identified. Of these 29 individuals, only 7 crania were complete enough for measurement. These graves date between the 18th and 19th century (Bruwelheide, 2002).

Clift's Plantation

The Clift's Plantation was located in Westmoreland County, Virginia. Based on archaeological dating techniques and historic documentation, the plantation was in

operation for sixty years, 1670 to 1730 (Neiman, 1980). Eighteen graves were discovered in the cemetery on the plantation in two distinct sections, the north group and the south group. The north groups contained 5 White individuals spanning the entire occupation of the plantation. The south group consisted of one White and eleven Black individuals. The White individual was thought to be an indentured servant and the Black individuals were thought to have been enslaved. All of the Black slaves buried in this plantation date to the second half of occupation of this cemetery, 1705 to 1730 (Neiman, 1980). Osteological analysis was performed by J.L. Angle and his sex and age estimates are used in the present analysis.

Deep River

This site was found along the Magothy River in Anne Arundel county, Maryland in 1975. J. Lawerence Angel analyzed the individuals found at this site. He determined that the site dated to approximately 1740 and that the individuals representing the site were most likely slaves. The above information is all that could be found on this site and comes solely from Angel's data sheets curated at the American Museum of Natural History at the Smithsonian Institution. Osteological analysis was performed by Angle and his sex and age estimates are used in the present analysis.

Burke Lake

This site was discovered in 1976 when individuals began to appear from surface erosion in Burke Lake located in Farifax County, Virginia. These individuals are known

as the "Burke Lake cluster" and are thought to represent Black individuals that date between the 18th and 19th century. This information comes solely from Angels data sheets at the SI. Similar to the Deep River site, this site information is all that could be found and comes solely from Angel's data sheets curated at the American Museum of Natural History at the Smithsonian Institution. Osteological analysis was performed by Angle and his sex and age estimates are used in the present analysis.

Mt. Pleasant Cemetery

This unmarked historical Black cemetery is thought to be that of Mt. Pleasant cemetery once located in Washington D.C. It was discovered in 1959 during a construction project in the area. This cemetery dates from 1850 to 1900 based on archaeological and historical documentation. Based on the burial dates, it is thought that several individuals might represent former slaves. Osteological analyses performed by Robert Mann indicate that these individuals are Black. His age and sex estimates for these individuals were used. (Mann and Krakker, 1989)

Providence Baptist Church Cemetery

This cemetery was discovered during an airport runway construction project in Shelby County, Tennessee. The Providence Baptist Church cemetery (40Sy619) is located in Shelby County, Tennessee. Church records and artifact analysis suggest that the area excavated dates between 1899 to1933. The context of these burials and

morphological non-metric features of the skeletal remains indicate African ancestry. Further information on the skeletal analysis of this cemetery is reported in Wilson (2005).

First African Baptist Church

The First African Baptist Church (FABC) cemetery, located in Philadelphia was discovered in the 1980s. The cemetery was in use from 1822 to 1843. (Rankin-Hill, 1997 #425). The cemetery is thought to represent freed Blacks who were "representative of the poorest segment of that community." (Rankin-Hill, 1997:1) Approximately 140 burials were excavated from the FABC cemetery and sent to J.L. Angel for analysis. L. Rankin-Hill (1997) details the analysis and results (see Rankin-Hill, 1997). Of the total burials excavated, 26 are available for analysis in the present research.

General Historic

There are several individuals that were used in the present analysis that cannot be ascribed to an archaeological site. These individuals come from the historic database maintained by Drs. Richard Jantz and Douglas Owsley. These individuals, although not part of an archaeological site, were used in the analysis because they had known demographic information including names, birth years, death years, ages of death, and known sex, and ancestry. These 4 individuals come from historic burials from South Carolina, Louisiana, Kansas, and Tennessee.

Anatomical Collections

The Robert J. Terry, Hamann-Todd, and W. Montague Cobb Collections, representing the St. Louis, Cleveland, and DC areas respectively, are three well-documented samples from different geographic areas. These collections consist of individuals with birth years primarily ranging from the mid to late 19th to early 20th century.

W. Montague Cobb Collection

In 1932 W. Montague Cobb established a laboratory of anatomy and physical anthropology at Howard University with intentions of starting a documented skeletal collection. Unclaimed or donated bodies were used for teaching and dissection and then macerated for curation. The majority of individuals in the Cobb collection died in the Washington D.C. area, although documented places of birth primarily represent the southeast.

Robert J. Terry Collection

Dr. Robert J. Terry began obtaining cadavers in the 1920's for medical school anatomy classes. The remaining skeletons comprise the collection in his name. The majority of cadavers were from unclaimed bodies or donations, primarily from the St. Louis area (Hunt, 1999), although it is likely that a portion of this collection came from other parts of Missouri.

Hamman-Todd Collection

Dr. Carl August Hamann started a comparative anatomy collection at Western Reserve Medical School in the early 1900's. When Hamann was appointed dean of the medical school, the chair of the anatomy department went to Dr. T. Wingate Todd who began to comprehensively document cadavers used in anatomy dissection classes. These cadavers were primarily from unclaimed bodies from Cleveland's Cuyahoga County Morgue, city hospitals and local mortuaries. After dissection, these cadavers were macerated and today make up the Hamann-Todd Skeletal Collection. (Quigley, 2001)

Recent American Blacks

The recent American Black sample is from the Forensic Anthropology Data Bank (FDB). The FDB consists of standard data (Howells, 1973; Moore-Jansen et al., 1994) submitted by forensic anthropologist from all over the country. Additionally, researchers at The University of Tennessee collect data for the FDB. The FDB is unique because it is derived from the population for which it is used. While most submissions are from forensic cases, a portion of the data comes from the William Bass Donated Collection at The University of Tennessee. The FDB has birth years ranging from the late 19th to late 20th centuries. Quarter centuries for those without birth years but ages were derived by subtracting age from year of case for cases with known ages at death, not for cases with age estimates or no age recorded.

Partitioning of Samples for Analysis

For purposes of investigating secular change, samples grouped by birth year would be ideal. However, archaeological samples do not provide such a luxury. Each individual with an associated archaeological context was associated with date estimations based on artifact analysis or marked headstones. The later anatomical collections contain known demographic information (age, sex, ancestry), including birth and death year. Some of the more recent forensic cases from the FDB also contain known demographic graphic and birth year.

The FDB is derived from both positive identifications and unidentified individuals. All available positive identifications from the FDB were used in analyses. However, those that were not positively identified were only used if their sex and ancestry was known based on soft tissue. Both the positively and non-positively individuals with known sex and ancestry did not always contain known birth years. However, with an age or age estimation, it was possible to subtract the age or estimation from the death date in order to obtain an approximate birth year. The birth year was then assigned to its' closest quarter-century (within 25 years). Therefore, if an age estimation was off by a few years, it should affect results little since the individual were grouped into larger 25 year cohorts. The sample size for each quarter-century cohort, after partitioning of groups, is presented in Table 3.

Table 3: Samples Partitioned Into Quarter-century Groups

Quarter-century	Female	Male	Total
1700	-	4	4
1725	3	3	6
1750	8	6	14
1775	5	11	16
1800	20	5	25
1825	4	5	9
1850	11	14	25
1875	44	77	121
1900	100	95	195
1925	18	39	57
1950	32	42	74
1975	20	23	43

Terminology

It is necessary to define terminology for the subsequent chapters. The American population is contains a large amount of diversity and no socially-derived construct will likely apply to every individual. The ability to self-identify ethnicity is an important aspect of individuality and our society in general. Conversely, in studies of populations, migrations of populations, secular changes within populations, and for purposes of identification, terminology for specific groups of people is unavoidable.

The African Diaspora resulted in the forced migration of West Africans to the Americas. In North America, the terms "Black" and "White" are referred to for individuals of African descent and individuals of European descent, respectively. Although an interesting are of investigation, whether or not these terms accurately reflect self-identity is not the scope of this research. In the present research, West African is used to describe individuals and groups specifically from West Africa.

When West Africans were brought to the Americas, they did not automatically become American. The process of "Americanization" likely took generations both culturally and biologically. The earliest quarter-century cohorts used in this study begin in the 18^{th} century. It is likely that many individuals in the samples presented here through the early 19^{th} century were slaves, some of born in America and some in Africa. However, for purposes of this research, these individuals and the groups they have been partitioned into will be referred to as American Black.

The next chapter will focus on the biological variation found among African groups. It also investigates the appropriateness of the West African samples that are used

in subsequent chapters to explore craniofacial secular change. Additionally, the rediscovered sample of documented Africans from the Morton collection allows for exploring the geographic origins of enslaved Africans in the Americas.

Chapter 5

Geographic Origins of Enslaved Africans

Africa is a continent that exhibits morphological and genetic variation among different cultural groups and geographic regions (Keita, 1990; Keita, 2004; Kittles and Keita, 1999; Ribot, 2002; Ribot, 2004; Rightmire, 1970; Rightmire, 1971). During the African Diaspora, the majority of slaving ports were located along the West African coast. Further, ethno-linguistic, anthropometric, and genetic data support historical documentation that enslaved Africans are from West Africa (Parra et al., 2001; Pollitzer, 1958; Rogers, 2000). The West African samples, described in Chapter 3, are used in subsequent chapters to explore possible secular changes in craniofacial morphology of American Blacks resulting from the African Diaspora. Because the West African sample will represent the parental population, it is therefore necessary to explore the appropriateness of this sample.

Pollitizer (1958) found American Blacks morphologically and genetically intermediate between American Whites and West Africans based on quantitative polygenic traits and genetic data. However, Pollitizer's study uses recent American Black and White and West African samples. Therefore, the comparison of craniofacial morphology of early American Blacks to that of 18th and 19th century West Africans may be informative as to how a new environment and gene flow affected the West African population as a result of the African Diaspora.

The samples representing West Africa contain little context other than the geographic location where they were collected. The only dates available are the dates written on the crania, and they thus provide a terminus post quem. Therefore, the question arises as to whether these samples accurately represent the parental population of American Blacks.

This chapter serves three main purposes 1) to demonstrate the craniometric relationships among Africans from different cultural and geographic regions, 2) to trace the geographic origins of enslaved Africans using craniometric data, and 3) to demonstrate the craniometric relationships of early American Blacks to West Africans.

Materials and Methods

In order to demonstrate craniometric relationships among Africans from different cultural and geographic regions, to trace the geographic origins of enslaved Africans using craniometric data, and to demonstrate the craniometric relationships of early American Blacks to West Africans a canonical discriminant function was run in SAS 9.1 (SAS, 2002-2004). A canonical discriminant function creates linear combinations of quantitative variables that maximize among-class variation. Sexes were pooled using PROC STANDARD, setting the mean to 0 and standard deviation to 1.0, by sex. The output of PROC CANDISC provides canonical correlations, the canonical structure, and the canonical coefficients. The first canonical component has the highest correlation with the groups, followed by the second and so on, and the eigenvalues indicate the percentage of total variation that each canonical component provides. For each analysis, the class

means of the canonical variables were plotted for each group and the between canonical structure was used to interpret the plot.

The DISTANCE option was used in PROC CANDISC to produce the squared Mahalanobis distances (D^2) and their associated significances. The D^2 value is the Euclidean distance between two *N* dimensional points in space and is used to interpret the similarities between groups, the smaller the distance, the more similar the groups being compared. The MANOVA option was also employed to test the hypothesis that the class means of each group were equal.

For the purpose of exploring the craniometric relationships among different cultural and geographic regions in Africa, all African groups described in Chapter 4 are used in the following analysis. As described above, a canonical discriminant function was used, with the PROC STEPDISC option. The STEPDISC procedure uses forward, backward, and stepwise selection techniques to find the best discriminatory variables (SAS, 2002-2004).

In order to explore craniofacial secular changes that have taken place since the African Diaspora (Chapter 6), it is essential to show the characteristic morphology of the West African ancestral population as compared to the American Black population. However, due to the limited context of the West African samples described in Chapter 2, the question arises as to whether these samples can be taken as being representative of the parental population to American Blacks. The recently re-discovered collection of African crania (described in Chapter 4) in the Morton collection allows an excellent opportunity to validate the appropriateness of the other West African samples used in this analysis, and to test the significance of secular changes occurring from the African Diaspora. The

canonical discriminant function used to demonstrate craniometric relationships among all African groups was re-run with the same craniofacial variables selected by PROC STEPDISC.

In order to demonstrate the craniometric relationships of early American Blacks to West Africans, another canonical discriminant function was run including a sample of American Whites. The early American Black samples and West African samples are described in detail in Chapter 4. The early American White samples (1650-1800) come from a historic craniometric database maintained by Richard Jantz at The University of Tennessee. This database stems from decades of collecting craniometric data from archaeological and anatomical collections all over the U.S. housed at various institutions. The early American Black samples (1700–1800) are grouped by quarter-century cohort. The early American White samples are grouped by half-century cohorts.

Results

Craniometric Relationships among Africans

The variables selected by the PROC STEPDISC options are shown in Table 4. The first and second canonical correlations are .842 and .730. The eigenvalues indicate that the first canonical variate represents 42.3% of the among-group variation and the second canonical variate 19.6%. Therefore, the first two canonical variates represent 59% of the among-group variation (Figure 4). The between canonical structure (Table 4) was used to interpret the plot of the class means of the canonical variables for each group. In addition, the West African groups cluster with one another. The first canonical axis

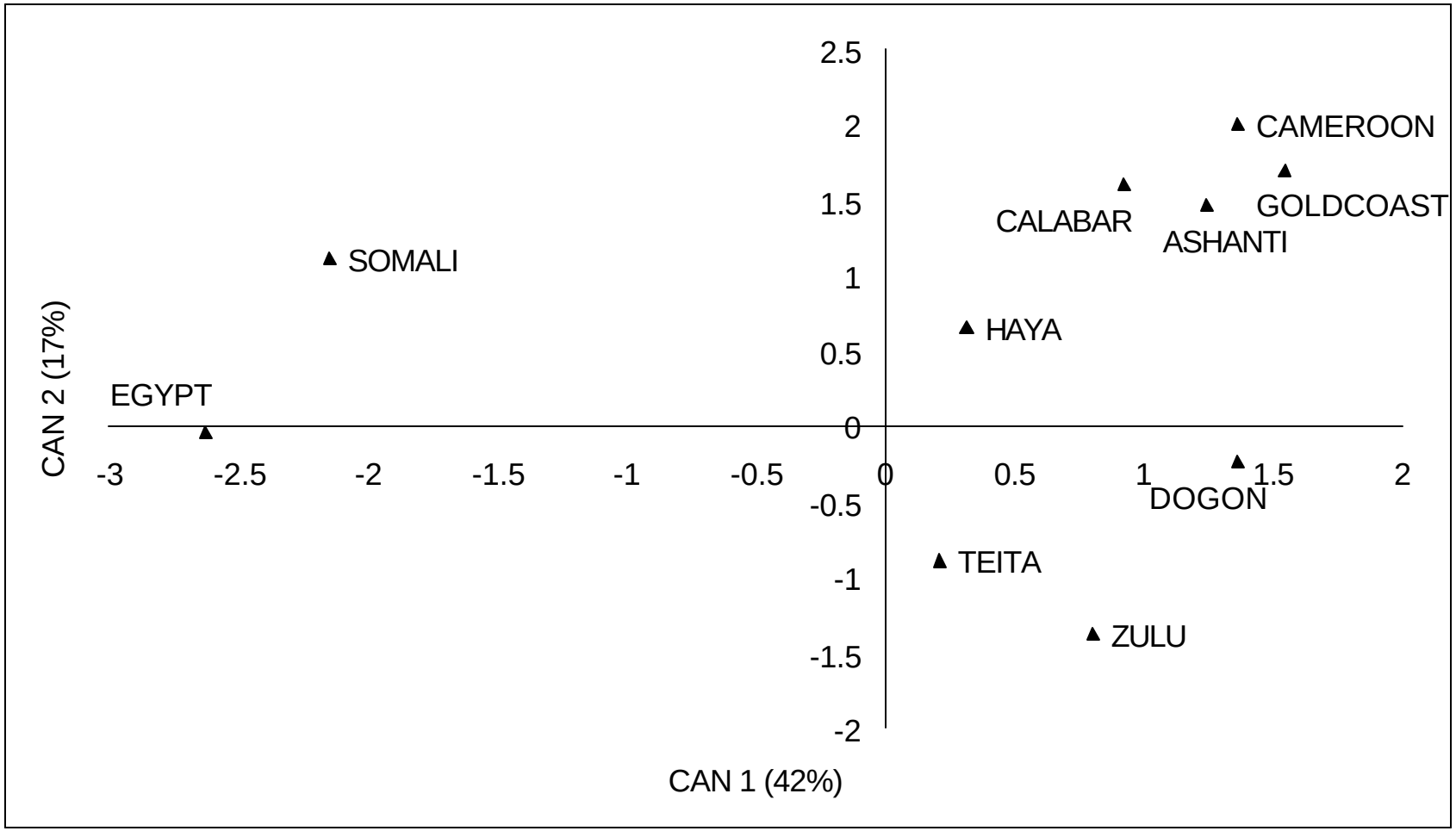

Figure 4: Canonical plot of African groups. Variables used in this analysis include: BPL, NAR, EKB, NLH, SSS, ASB, VRR, PAC, BBH, NLB, FRS, FRF, NDS, GOL, DKS, OBH, SSR, ZYB, AUB, FOL, DKB, MDH, OCS, and MAB

Table 4: Between Canonical Structure for African Groups.

Variable	Can1	Can2	Can3	Can4
NLH	-0.89027	-0.03601	0.021434	0.1259
ASB	-0.73461	0.043838	0.27104	0.471829
FRF	-0.70182	-0.17791	-0.14772	-0.47125
NDS	-0.55092	0.74131	0.299415	0.021687
OCS	-0.53061	-0.65021	0.507341	0.098993
AUB	-0.51042	-0.38988	0.441332	0.054668
DKS	-0.50191	0.618689	0.499822	0.102337
GOL	-0.44361	-0.18371	0.62761	0.466748
SSS	-0.40841	0.092922	0.223324	0.562211
NAR	-0.25868	-0.17918	0.917409	0.229292
MDH	-0.18279	0.674974	0.231167	0.431694
NAR	-0.02577	0.051701	0.027276	-0.04372
PAC	0.00982	0.607239	0.410137	0.329348
BBH	0.01205	0.529744	-0.2872	0.669627
VRR	0.081108	0.61336	-0.30028	0.509212
FRS	0.105303	-0.58488	0.414213	0.450546
SSR	0.137539	-0.01446	0.850812	0.273148
FOL	0.170172	0.234321	0.547452	0.593931
OBH	0.530244	0.53978	-0.01527	0.298154
ZYB	0.537969	-0.1182	0.498462	-0.20216
MAB	0.610751	-0.27635	-0.08782	0.539877
BPL	0.787488	-0.00594	0.435804	0.214401
DKB	0.790185	0.217599	0.51966	-0.13568
EKB	0.84003	-0.19271	0.340882	0.139734
NLB	0.959612	-0.25857	0.058249	0.008768

indicates that West African groups (Cameroon, Calabar, Gold Coast, and Ashanti) have longer cranial vaults, more facial prognathism, wider orbits, inter-orbital distances, and nasal apertures, and overall have wider faces than East African groups. The second canonical axis indicates that Somalians and Egyptians have taller cranial vaults and faces as well as taller, narrower nasal apertures. West Africans have larger, more prominent zygomatic bones.

The MANOVA results indicate that the class means of the groups are not equal, with a Wilks' lambda value of .021 and p-value of less than .0001. The D^2 distances indicate that the West African groups are closest to one another (Table 5). Somalia and Egypt are closest to one another, representing the extreme East and North East of Africa. The Teita and Zulu groups are more similar to one another.

Geographic Origins of Enslaved Africans

The MANOVA indicates that the class means are not equal with a Wilks' lambda of 0.005 and a p-value of < .0001. The class means of the canonical variates were plotted (Figure 5) and the sample of documented enslaved Africans is grouped with the other West African samples. The D^2 distances with their associated p-values are in Table 6. The interpretation of D^2 distances indicates that the enslaved Africans are most similar to West Africans. Further, the interpretation of the between canonical structure (Table 7) indicates that these enslaved Africans share similar craniofacial morphology with the West African groups (described above).

Table 5: D^2 Distances for African Groups.

Group	ASHANTI	CALABAR	CAMEROON	DOGON	EGYPT	GOLDCOAST	HAYA	SOMALI	TEITA
ASHANTI	0								
CALABAR	8.04014	0							
CAMEROON	6.02591	6.57604	0						
DOGON	7.64919	9.16934	9.44038	0					
EGYPT	19.85966	19.21564	21.94617	17.35249					
GOLDCOAST	1.76984	7.77269	7.16153	11.3084	24.24663	0			
HAYA	13.07053	13.82385	11.23344	15.26801	18.17529	12.57585			
SOMALI	17.08824	17.82148	20.24089	20.8212	8.17551	20.52732	16.67585	0	
TEITA	11.41031	14.76013	13.43881	9.54049	13.45702	13.7652	10.97863	16.15605	
ZULU	11.33308	13.10569	14.64957	5.99689	15.42326	13.08124	11.20759	18.13715	6.61839

* all distances are significantly different except Goldcoast and Ashanti

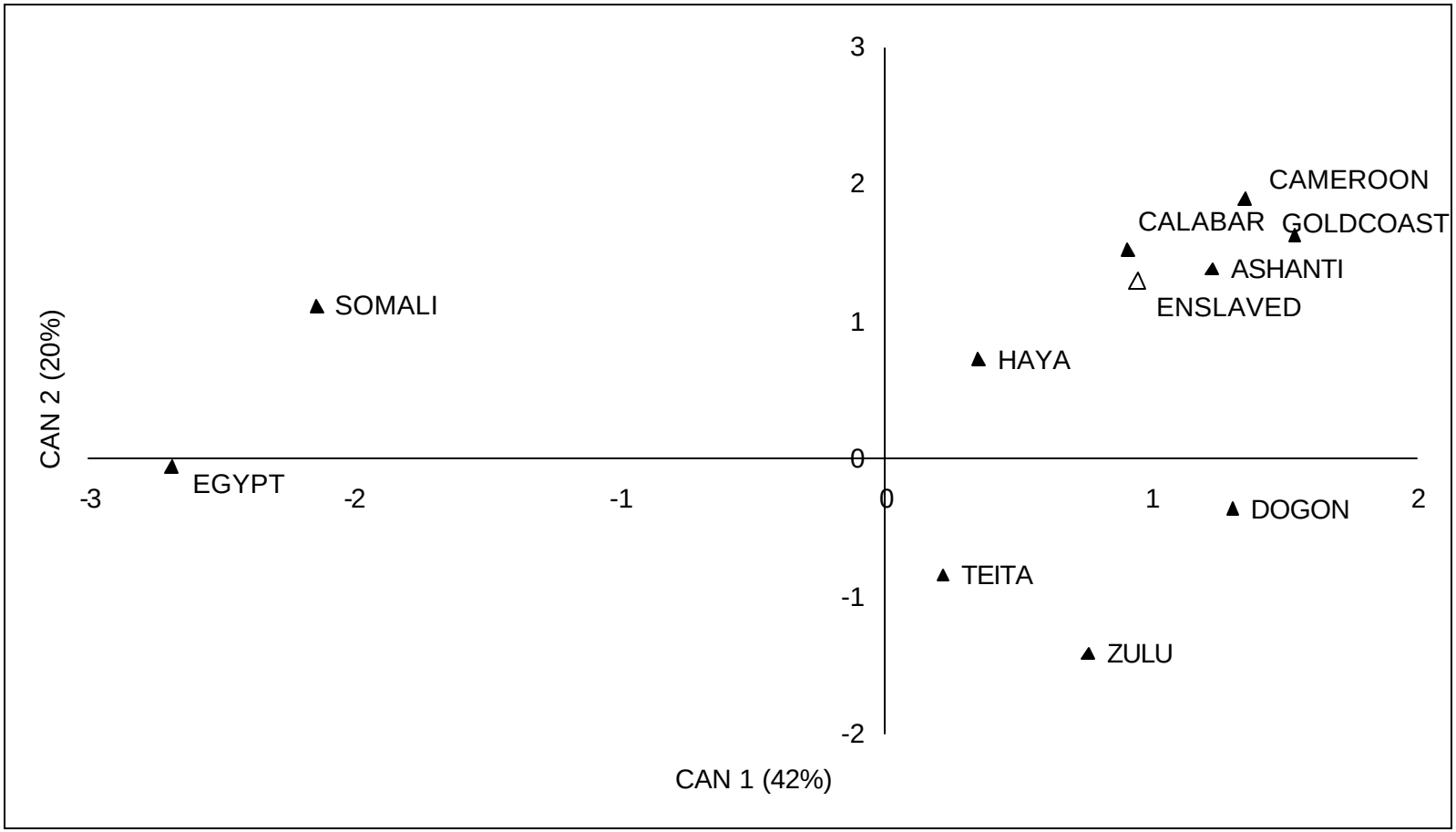

Figure 5: Canonical plot of African groups with documented sample. Variables used in this analysis include: BPL, NAR, EKB, NLH, SSS, ASB, VRR, PAC, BBH, NLB, FRS, FRF, NDS, GOL, DKS, OBH, SSR, ZYB, AUB, FOL, DKB, MDH, OCS, and MAB.

Table 6: D^2 Distance Matrix of African Groups Including Documented Sample

GROUP	*ASHANTI*	*CALABAR*	*CAMEROON*	*DOGON*	*EGYPT*
ASHANTI	0				
CALABAR	7.94695	0			
CAMEROON	6.03047	6.53765	0		
DOGON	7.45595	9.21184	9.31763	0	
EGYPT	19.77396	19.30964	21.93021	17.57268	0
ENSLAVED	4.4796	8.09603	6.78478	9.85803	19.59845
GOLD COAST	1.73793	7.6024	7.18005	11.09004	24.1501
HAYA	12.79121	13.80362	11.10786	15.15837	18.33748
SOMALIA	16.95591	17.90516	20.14554	20.52544	7.78595
TEITA	11.12372	14.87549	13.32488	9.56115	13.78038
ZULU	11.17462	13.16032	14.54612	6.0119	15.69052

GROUP	***ENSLAVED***	*GOLD COAST*	*HAYA*	*SOMALIA*	*TEITA*
ASHANTI					
CALABAR					
CAMEROON					
DOGON					
EGYPT					
ENSLAVED	0				
GOLD COAST	6.03389	0			
HAYA	8.41863	12.44439	0		
SOMALIA	13.25954	20.42734	16.6373	0	
TEITA	9.05248	13.54404	11.03512	16.12901	0
ZULU	10.70062	12.90351	11.14287	17.93243	6.67812

Table 7: Between Canonical Structure for Figure 5

Variable	Can1	Can2	Can3	Can4	Can5
NLH	-0.8556	-0.08402	-0.01745	0.105879	0.072874
ASB	-0.73207	0.037206	0.237237	0.46518	0.362142
FRF	-0.71233	-0.19273	-0.13243	-0.46301	0.270372
OCS	-0.53835	-0.61897	0.5312	0.101138	-0.01989
NDS	-0.5355	0.759301	0.255513	0.020009	0.069915
AUB	-0.51718	-0.38122	0.413832	0.062658	0.623235
GOL	-0.44478	-0.15762	0.612004	0.467922	0.264517
DKS	-0.43628	0.673058	0.483798	0.107393	0.030653
SSS	-0.40903	0.104931	0.204343	0.572427	0.615644
NAR	-0.24693	-0.13027	0.915657	0.231427	0.009973
MDH	-0.19183	0.628746	0.13642	0.41826	0.236817
BBH	0.012641	0.50671	-0.3286	0.663513	-0.06491
PAC	0.038493	0.635347	0.375454	0.322341	-0.04722
VRR	0.073026	0.575528	-0.36081	0.506553	0.227568
FRS	0.130398	-0.50448	0.47244	0.452459	-0.09636
SSR	0.154459	0.033386	0.833588	0.279688	0.280437
FOL	0.187322	0.261963	0.51753	0.590928	-0.02892
ZYB	0.492971	-0.15243	0.41538	-0.19312	0.673736
OBH	0.504041	0.473831	-0.11312	0.29163	0.517021
MAB	0.585673	-0.31415	-0.10963	0.535951	0.322064
BPL	0.794025	0.006144	0.406864	0.218392	0.283061
DKB	0.803799	0.243406	0.486346	-0.13192	0.058557
EKB	0.839520	-0.19492	0.318852	0.143004	0.343627
NLB	0.945698	-0.29038	0.036808	0.002966	0.074639

The MANOVA indicates that the class means are not equal with a Wilks' lambda of 0.0034 and a p-value of < .0001. The D^2 distance matrix (Table 8) indicates that the West African groups are more similar to one another than any other groups are to each other. The class means of the canonical variables were plotted and represent 64% of the among-group variation, Figure 6. The between canonical structure (Table 9) indicates that on the first canonical axis West Africans display more facial prognathism, wider nasal apertures, longer malars, and wider mid-facial breadth. Early American Whites display longer and wider vaults, wide biauricular breadth, larger values for cheek height, and larger values for occipital subtense.

The second canonical axis is primarily separating groups based on vault height and frontal chord values. The 1600 and 1650 White half-century groups display the lowest vault heights and the 1700 and 1750 White half-century groups display the highest values for vault height. Based on the craniofacial variables used in the present analysis, the early American Black sample is intermediate to the West African and American White samples.

Discussion

The results of the canonical discriminant functions, in conjunction with their D^2 distances, demonstrate 1) the unique craniofacial morphology of the West Africans as compared to all other African groups, 2) that craniometric analyses can be informative in

Table 8: D^2 Distance Matrix for Early Black and White Groups

Group	1600W	1650W	1700W	1725B	1750B	1750W	1775B	1800B
1600W	0							
1650W	32.91812	0						
1700W	36.38561	46.89049	0					
1725B	58.89776	55.02308	63.50844	0				
1750B	66.83922	54.92484	56.69154	57.35082	0			
1750W	47.95545	50.85325	25.29267	52.66547	43.88791	0		
1775B	51.26097	39.85404	33.21962	41.86987	17.02839	26.75178	0	
1800B	59.86276	49.28173	37.30183	50.34282	28.99292	28.10697	7.61918	0
1800W	38.68412	24.56415	22.56066	40.48334	37.76582	21.08737	16.8563	18.80575
ASHANTI	80.8552	67.28351	63.8595	57.45246	32.57747	52.86868	20.21358	15.59842
CALABAR	84.98315	71.74976	66.47591	48.38154	38.19326	53.85757	19.64557	16.15902
CAMEROON	81.45313	64.40202	63.17809	54.43165	29.59846	52.25569	15.27563	15.30341
ENSLAVED	74.10373	53.51829	57.30725	53.94845	27.00331	49.55593	16.15838	13.1124
GOLDCOAST	85.31369	75.11098	68.46518	63.88469	33.28474	56.83906	20.85355	17.66745

Table 8: Continued

Group	1800W	ASHANTI	CALABAR	CAMEROON	ENSLAVED
1600W					
1650W					
1700W					
1725B					
1750B					
1750W					
1775B					
1800B					
1800W	0				
ASHANTI	35.97737	0			
CALABAR	33.85124	6.98245	0		
CAMEROON	34.62488	4.59537	4.91275	0	
ENSLAVED	27.36866	6.02559	10.00256	7.1844	0
GOLDCOAST	37.19294	3.67051	9.6015	6.99269	9.25956

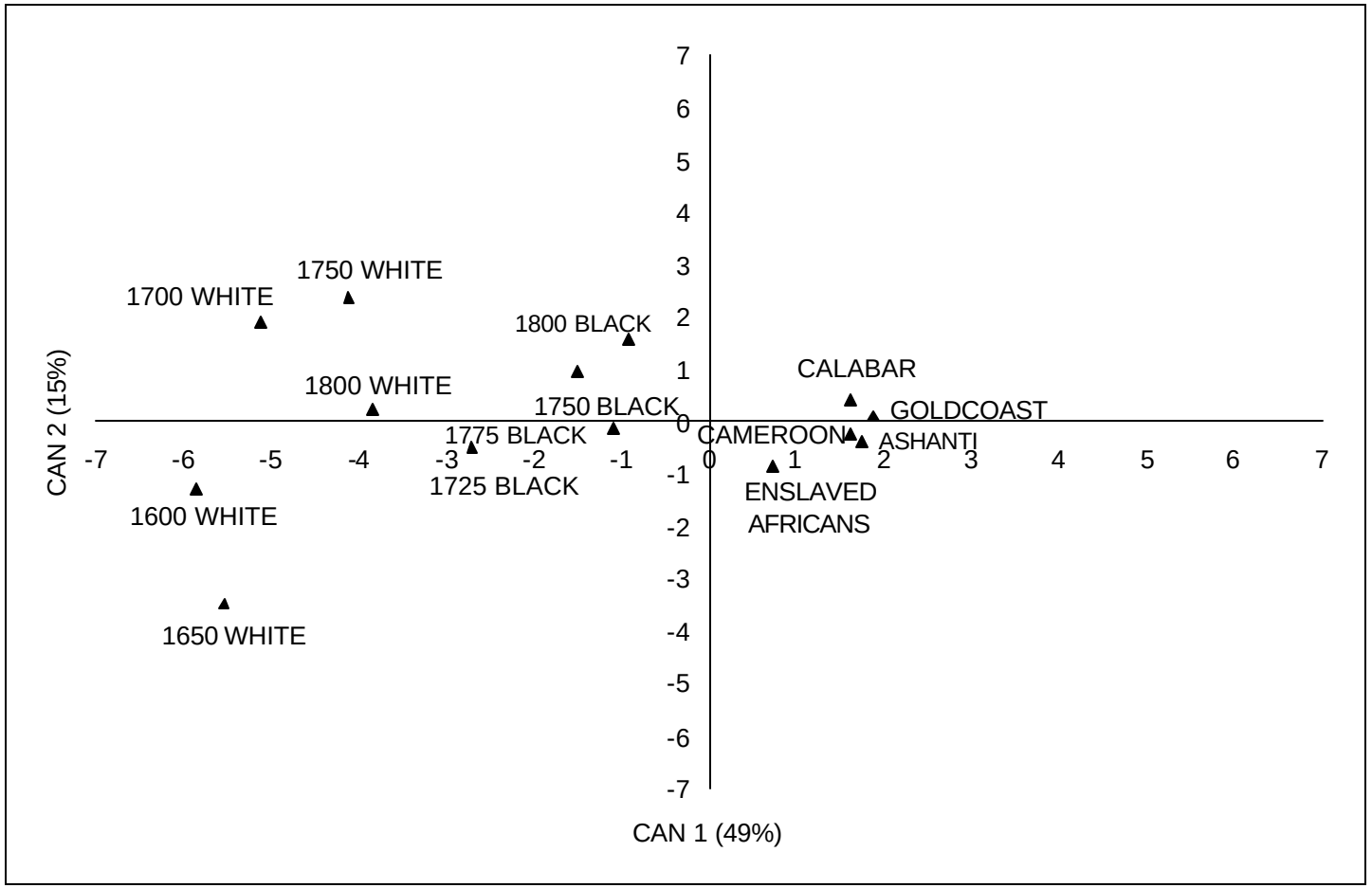

Figure 6: Canonical plot of early Black, early White, and West African groups. Variables used in analysis include are listed in Table X. Sample size includes (sas file early B and W and West African) 1600 AmWhite (n=2), 1650 AmWhite (n=6), 1700 AmWhite (n=3), 1725 AmBlack (n=1), 1750 AmWhite (n=2), 1750 AmBlack (n=2), 1775 AmBlack (n=12), 1800 AmBlack (n=13), 1800 AmWhite (n=21), Ashanti (n=25), Calabar (n=21), Cameroon (n=38), Enslaved Africans (n=17), and Goldcoast (17).

Table 9: Between Canonical Structure for Figure 6

Variable	Can1	Can2	Can3	Can4	Can5
GOL	-0.78106	0.398195	0.376879	0.020393	-0.05038
BNL	-0.46834	0.157896	0.552785	-0.09455	-0.31344
BBH	0.05581	0.584774	-0.4844	0.310794	-0.09017
XCB	-0.72195	0.387142	0.109098	0.528733	-0.02945
XFB	-0.60289	0.382119	-0.00519	0.635389	0.014258
ZYB	-0.0198	0.294618	0.738318	0.368699	-0.13684
AUB	-0.81178	0.233412	0.328998	0.207652	0.067692
ASB	-0.89874	0.283638	0.116594	0.147484	-0.08173
BPL	0.795237	0.252377	0.399548	-0.18941	0.043361
NPH	-0.3893	-0.0393	0.249532	0.159657	-0.69716
NLH	-0.62174	0.034679	0.067733	0.377275	-0.61717
JUB	0.319794	0.386803	0.770533	0.147074	-0.05561
NLB	0.901092	0.153158	0.339201	0.00731	-0.09631
MAB	0.375125	0.377741	0.581022	-0.37825	-0.01809
MDH	-0.45115	0.432044	0.169744	-0.09966	-0.18449
OBH	0.343097	0.183159	0.557461	0.574692	-0.27459
OBB	-0.21708	0.288308	0.71564	0.142239	-0.27402
DKB	0.641516	-0.00578	0.530956	0.187141	0.330252
WNB	0.328512	0.089932	0.43573	0.609769	0.009409
ZMB	0.732822	-0.1852	0.480186	0.014389	-0.16018
FMB	0.29784	0.276505	0.775934	0.290641	0.118457
EKB	0.404045	0.429766	0.751456	0.153447	0.116803
IML	0.942039	0.005955	0.21146	-0.06078	0.176548
XML	0.402023	0.124716	0.496742	0.400618	0.084599
WMH	-0.71608	0.013931	-0.26558	-0.03598	0.013711
FRC	-0.39334	0.547568	-0.28064	0.494731	-0.11276
FRS	-0.08011	-0.0276	-0.2535	0.2216	0.696637
PAC	0.660987	0.46432	-0.01489	-0.38018	0.023496
PAS	0.8154	0.141213	0.105841	0.087135	0.029998
OCC	-0.57111	0.293807	-0.1604	0.531299	-0.26658
OCS	-0.92031	0.101581	0.10293	-0.32281	-0.0766
PRR	0.791502	0.34378	0.3403	-0.15773	0.041583
VRR	0.318626	0.501598	-0.10245	0.694136	-0.13564

tracing geographic ancestral origins, and 3) early American Blacks display an intermediate nature between early American Whites and 18th and 19th century West Africans.

Different geographical and cultural groups in Africa present distinct craniofacial morphology. South and East African groups show morphological differentiation from West Africans. Although geographic distance is thought to parallel biological distance, a more complicated picture arises in Africa as a result of the Bantu expansion. The Haya, located in Tanzania, share morphological similarities with West Africans that do not conform to geographic distance. The Teita from East Africa in Kenya and the Zulu from South Africa also share morphological similarities. However, the Haya, Teita, and Zulu are all Bantu speaking groups, and their morphological similarities despite geographic location could also be due to the Bantu expansion.

Records of the Trans Atlantic Slave trade, including ethno-historical, genetic, and linguistic data, suggest that enslaved Africans brought to the New World were predominantly from West Africa. As shown in Table 6, the D^2 distances and the interpretation of the between canonical structure indicate that the sample of documented enslaved Africans from the Morton collection are more morphologically similar to the other West African groups. Therefore, the enslaved African group and other West African groups are considered appropriate for use in subsequent chapters for exploring the factors that influence craniofacial secular changes in American Blacks.

Historic records indicate that most slave owners were purchasing their slaves from the West Indies prior to 1720's, when cash crops made it affordable to import directly from Africa (Rawley, 1981). Additionally, it was cheaper for plantation owners

to get slaves from the West Indies as the owners did not have to pay overhead to outfit a slaver for a voyage to West Africa. Purchasing from the West Indies also provided "seasoned" slaves, who were already accustomed to plantation life and work (Rawley, 1981). Because the West Indies was involved in the slave trade prior to involvement by the American colonies, it is a possibility that the slaves purchased by plantation owners in the colonies may have had geographic origins other than the origins of samples used in this analysis. It is also possible that slaves coming from the West Indies may have had varying levels of European admixture.

The present chapter focuses on craniometric variation among African groups and the geographic origins of enslaved Africans using craniometric data. The following chapter of this research focuses on the secular changes that have taken place since the arrival of Africans in the North American colonies. Exploring the craniofacial changes that have occurred since the arrival of Africans in the American colonies may provide insight to factors that influence craniofacial morphology.

Chapter 6

Craniofacial Secular Change 1700-1975

West Africans from the 18th and 19th centuries brought to the U.S. during the Trans Atlantic slave trade had different craniofacial morphology than recent American Blacks (Crewdson-Benington and Pearson, 1912; Trevor, 1950). Further, recent American Blacks exhibit different craniofacial morphology compared to recent American Whites (Jantz, 2001; Jantz and Meadows Jantz, 2000; Sparks and Jantz, 2003; Wescott and Jantz, 2005). Previous research has found that significant craniofacial secular changes have occurred in both the American Black and White populations (Angel, 1976; Jantz, 2001; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005).

As previously discussed in chapter 2 of this research, these studies conclude that vault height (BBH) was the single most changed variable in both American Blacks and Whites (Jantz, 2001; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005). More specifically, Wescott and Jantz found that cranial base height was the most influential variable in the observed increase of vault height. However, the early studies either have small sample sizes (Angle, 1976) or begin with an already admixed population (Jantz, 2001; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005).

The purpose of this chapter is to describe the craniofacial secular changes in the American Black population from 1700 to 1975. Using larger samples with more time depth, and documenting any observed changes in craniofacial morphology, may provide insight to factors that influence polygenic traits such as craniofacial morphology.

Materials and Methods

Previous studies of craniofacial secular change group samples by birth year cohorts (Jantz, 2001; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005). The majority of the colonial data in the present research do not contain birth years, although the provenience is well documented. Archaeological dates and age at death estimations make it possible to assign quarter century cohorts to the colonial data (see Chapter 3, section X for details on partitioning of quarter-century cohorts).

A canonical discriminant function (CANDISC), using SAS 9.1, was used to derive canonical variables in order to summarize between-class variation and explore the morphological differences among groups. In order to increase sample sizes, sexes were pooled using PROC STANDARD, setting the mean to 0 and standard deviation to 1.0, by sex. A more thorough description of the canonical discriminant function can be found in section 4.2.

In order to consider the effects of time, a canonical correlation procedure (CANCORR) was performed in SAS. The CANCORR procedure regresses multiple y variables on multiple x variables. However, in this case, only one x variable was used, quarter-century cohorts. Using this methodology, the procedure attempts to correlate cranial variables with time and is appropriate for detecting variables that have a high correlation with the quarter century time period.

Results

Canonical Variates

The first canonical variate is separating quarter century cohorts largely on cranial base length and breadth, vault height, and orbital breadth (Figure 7). The second canonical variate is separating largely on frontal and occipital subtense. The quarter century groups for 1700-1750 share more similarities on vault morphology with the 1975 group. The groups for 1875 and 1900 exhibit the shortest vaults. Groups for 1775-1825 and 1925 are intermediate in vault morphology between the extreme ends of the axis. The canonical discriminant analysis is separating the groups based on the different craniofacial morphology of each quarter-century group. However, the analysis does not reveal a clear pattern relating to time.

Canonical Correlation

The CANCORR procedure provides more insight than the CANDISC procedure regarding specific craniofacial morphological traits and their correlation with time, in this case quarter-century cohorts. Results of the CANCORR procedure indicate a significant correlation ($R = 0.412$) for measurements regressed on quarter century. The Wilk's lambda is high (.830) , although the p-value is highly significant ($p < .0001$). Interpretation of the canonical correlations (Table 10) indicates that overall vault width, as well as inter-orbital and biorbital breadth decrease over time. Further, while nasal height (NLH) increases over time, nasal breadth (NLB) decreases. Most interesting is vault height, which in previous research (Jantz, 2001; Jantz and Meadows Jantz, 2000) is

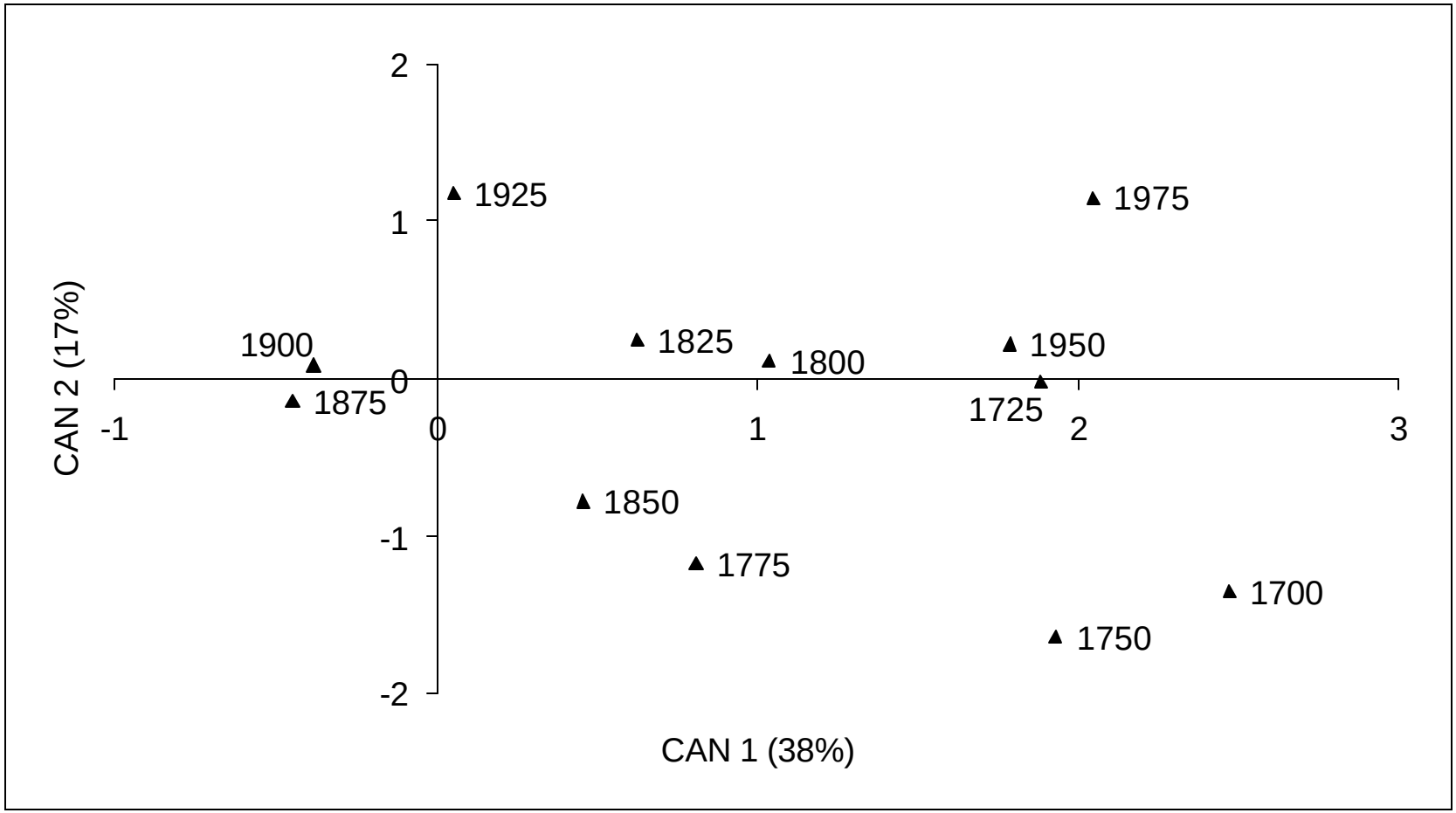

Figure 7: Canonical plot of quarter-century groups. Sample sizes used in analysis include: 1700 (n=1), 1725 (n=3), 1750 (n=3), 1775 (n=14), 1800 (n=15), 1825 (n=4), 1850 (n=19), 1875 (n=104), 1900 (n=147), 1925 (n=20), 1950 (n=17), 1975 (n=9). Variables include GOL, BNL, BBH, XCB, XFB, ZYB, AUB, BPL, NPH, NLH, NLB, MAB, OBH, OBB, DKB, EKB, FRC, FRS, PAC, PAS, OCC, OCS, and BAR.

Table 10: Correlations Between Measurements and Quarter-century

Variable	Canonical correlations
GOL	-0.1646
BNL	-0.1199
BBH	-0.1862
XCB	-0.2856
XFB	-0.3317
WMH	0.2643
WNB	-0.0334
ZYB	-0.3896
AUB	-0.1491
BPL	0.0363
NPH	0.3766
NLH	0.2625
NLB	-0.2572
MAB	0.0979
OBH	0.038
OBB	-0.1598
DKB	-0.2856
EKB	-0.2996
FRC	-0.0398
FRS	0.0611
PAC	-0.0395
PAS	0.0565
OCC	-0.0273
OCS	0.1805
BRR	0.0298
BAR	-0.2957

the most highly correlated variable with time. In this analysis, which uses earlier time periods, vault height is negatively loaded and actually declines. However, facial height (NPH) is the highest loading variable in this analysis and indicates a positive secular trend for American Blacks.

Figures 8, 9, and 10 are loess plots of the means for vault height, facial height, and cranial base height with 90% confidence intervals, created in "R" (R, 2005). Figure 9 indicates that facial height is positively loaded with time and that vault height and cranial base height are negatively loaded with time.

Discussion

This chapter has explored craniofacial secular change in the American Black population from 1700 through 1975 and the variation within each quarter-century group. Significant craniofacial secular change was found in the American Black population. The most significant positive secular trend is the increase in facial height over time. Also notable is the negative trend of vault height that appears to decrease over time. Additionally, a decrease in vault width, frontal breadth, bi-orbital breadth, and inter-orbital width were noted. Further, as nasal height increases, nasal breadth decreases.

Wescott and Jantz found that the most significant secular changes were found in the cranial vault, not in the face, and more specifically in cranial base height in American Blacks and Whites from 1850 to present with little change in the face. The present research finds that cranial base height (measured by basion radius), in addition to

* red line indicates where previous studies of secular change begin

Figure 8: Smoothed loess plot of vault height (BBH) by quarter-century. Sample sizes include: 1700 (n=1), 1725 (n=3), 1750 (n=8), 1775 (n=5), 1800 (n=20), 1825 (n=4), 1850 (n=10), 1875 (n=43), 1900 (n=96), 1925 (n=18), 1950 (n=31)

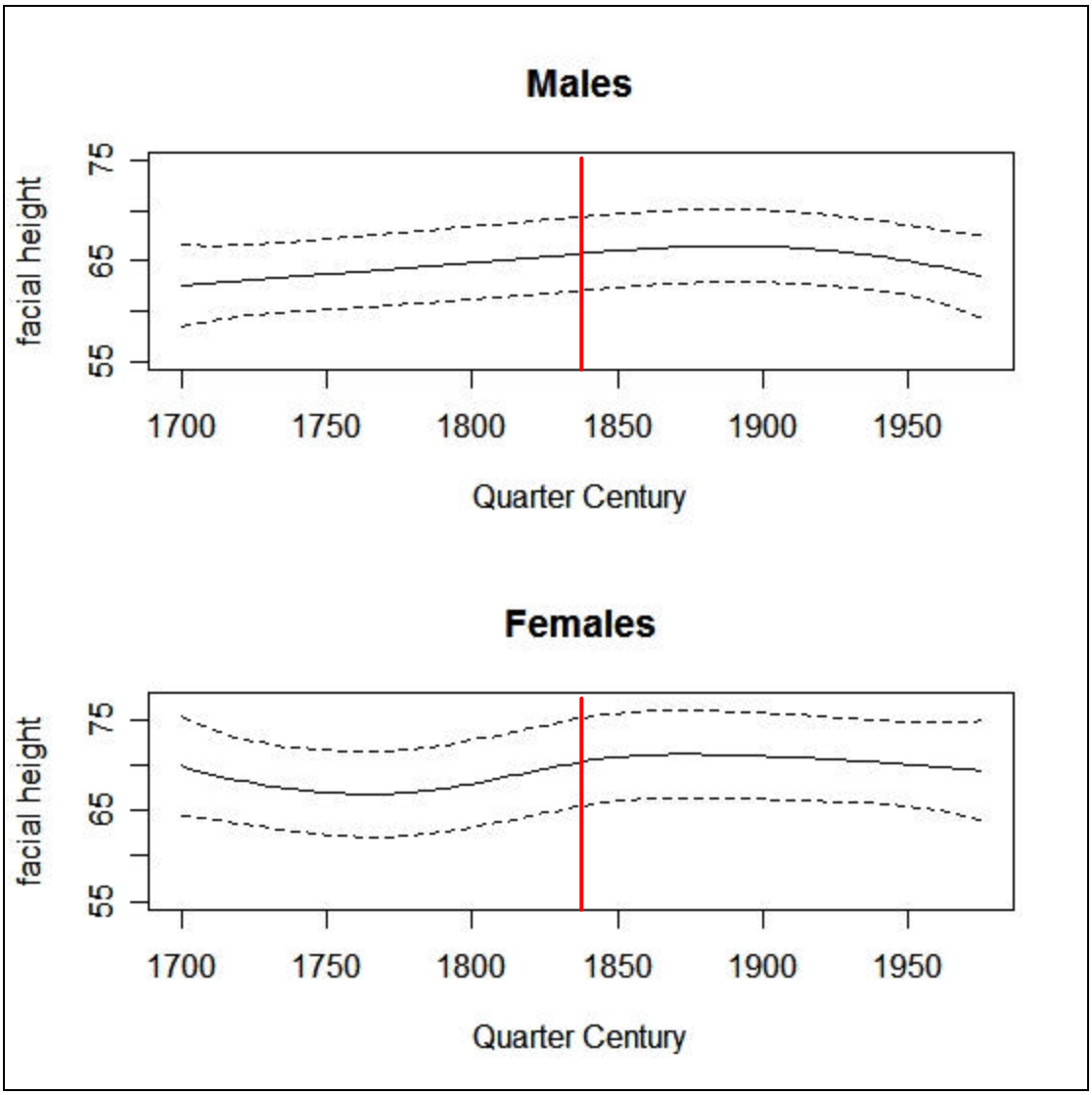

Figure 9: Smoothed loess plot of facial height (NPH) by quarter-century. Sample sizes include: 1700 (n=4), 1725 (n=6), 1750 (n=10), 1775 (n=16), 1800 (n=23), 1825 (n=9), 1850 (n=25), 1875 (n=120), 1900 (n=175), 1925 (n=38), 1950 (n=49), 1975 (n=33).

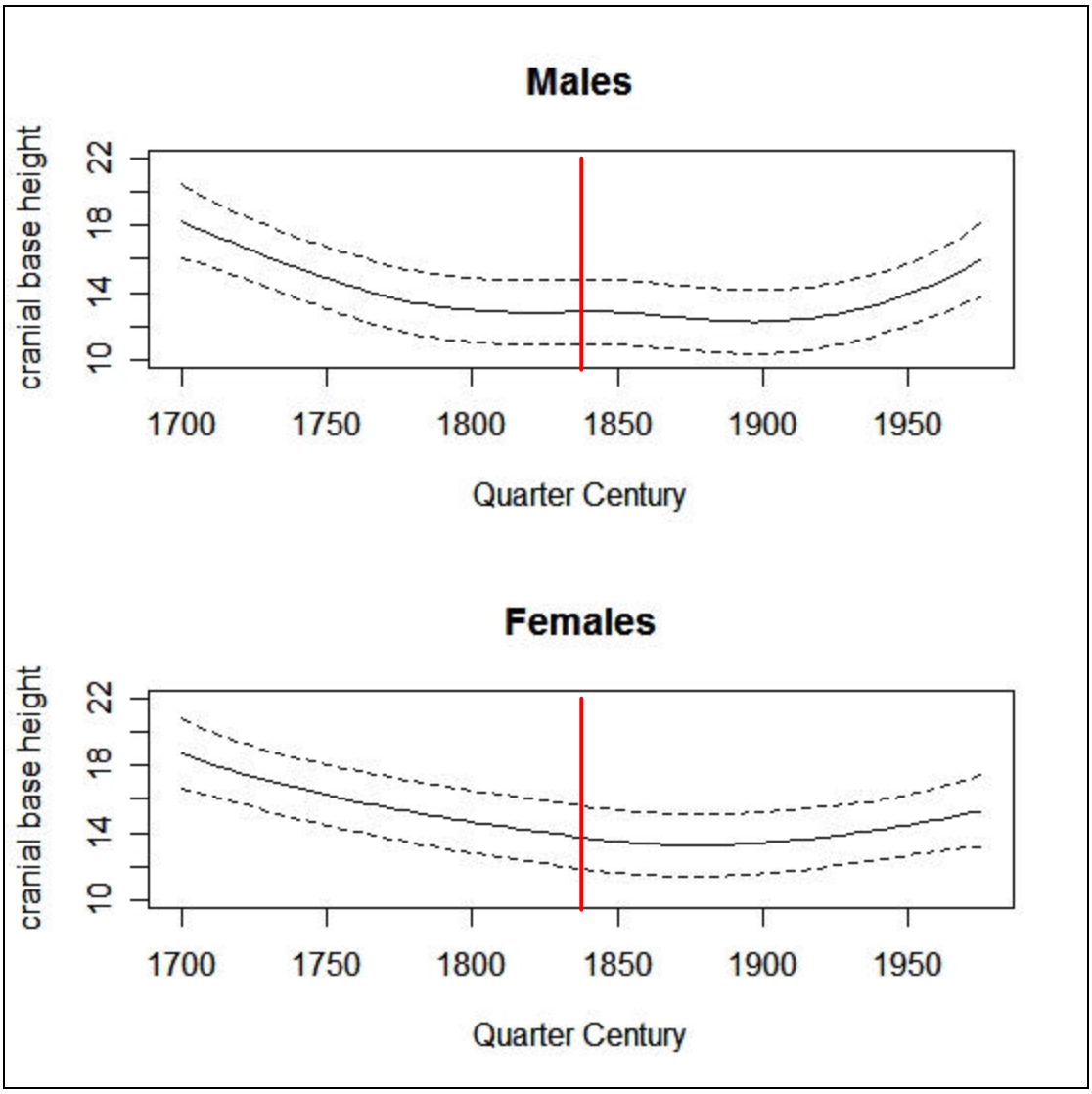

Figure 10: Smoothed loess plot of cranial base height (BAR) by quarter-century. Sample sizes include: 1700 (n=1), 1725 (n=3), 1750 (n=7), 1775 (n=5), 1800 (n=19), 1825 (n=4), 1850 (n=11), 1875 (n=43), 1900 (n=85), 1925 (n=6), 1950 (n=10)

vault height, is negatively loaded with time for American Blacks.

The different results may seem contradictory at first, although they are likely due to the difference in time-depth of the samples. When means are plotted by sex for each quarter-century cohort (Figure 10), the cranial base steadily declines from 1700 to 1850, followed by an increase. The red lines on Figures 8 - 10 indicate where Jantz, Jantz and Meadows Jantz, and Wescott and Jantz's studies begin. Thus, beginning in 1840 or 1850, a positive trend is observed, although with more time depth a negative trend is observed prior to an increase.

Jantz and Meadows, also found vault height to be more sensitive to environment and overall health than long bones, and can therefore be used as a proxy for overall health. Angel also suggested that the cranial base is sensitive to the environment, and Wescott and Jantz supported his hypothesis. The cranial base reaches its adult size early in life and therefore has little chance for catch up growth (Enlow, 1990; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005). Previous research has found that West African crania have a relatively high cranial base height (Crewdson-Benington and Pearson, 1912). Figure 10 indicates that early American Blacks, some of which may have been born in Africa, have higher cranial bases in the 1700s followed by a decline.

If the cranial base is used as a proxy for overall health, then it corresponds to an environmental stress placed on West Africans in their new and different environment during the slave trade. The face follows a different growth pattern than the vault (Enlow, 1990) and the increase in facial height is harder to explain. Both Trevor and Angel attributed this trend in American Blacks specifically to admixture. However, the increase

in facial height is most likely the result of a combination of factors including gene flow, selection, plasticity, and a new environment.

Chapter 7

Within Group Variation of Quarter-century Cohorts

The previous chapter found that significant craniofacial secular change has occurred in the American Black population from 1700 through 1975. Because secular change was analyzed based on quarter-century cohorts, and the early cohorts consist of archaeological sites or cemeteries, each cohort was examined for overall within group variation. Examining within group variation provides insight as to how these specific quarter century cohorts may have influenced the observed patterns of craniofacial secular change.

Materials and Methods

To assess the levels of craniometric variation within each quarter-century cohort, data were analyzed in DISPOP (Jantz, 2000), a multivariate program written by R.L. Jantz. To asses the level variation within each group, DISPOP uses the expected distance (D) of crania drawn at random from a population with the same covariance as the pooled within matrix of the reference sample (Defrise-Gussenhoven, 1967). Any distance greater than two standard deviations from the expected distance can be considered significant (Jantz and Owsley, 2001).

The reference groups in DISPOP include the W.W. Howells' craniometric dataset in addition to Native American groups, 20th century American Blacks and Whites, and

Terry and Todd Blacks and Whites collected by R.L. Jantz and other researchers at the University of Tennessee. West African groups (described in Chapter 2) were pooled and added to the reference sample. An appropriate covariance matrix should be used for the Defrise-Gussenhoven method. Therefore, only West Africans, Terry and Todd groups, and recent 20th century American Blacks and Whites were used in the reference sample in order to derive an appropriate covariance matrix because they are the most related to the quarter-century cohorts (Jantz and Owsley, 2001).

In addition to assessing the overall variation, DISPOP also performs a canonical variates analysis that provides a Mahalanobis D2 value and a classification of each unknown individual into one of the reference groups. The program assumes that the individual belongs to one of the reference groups, and provides a posterior probability for group membership of the unknown to the reference group (Jantz, 2000). Quarter-century groups were not run for 1825-1975 because these cohorts are also in the reference samples.

DISPOP provides a reading of which variables all individuals have in common and these were the variables used. Individuals were deleted from quarter-century cohorts if they had missing data that would severely truncate the amount of variables that could be used. Also, because missing data is variable, a standard set of variables could not be used for each quarter-century cohort. However, several measurements were excluded, even if they were present in all individuals. These variables include NDS, DKS, GLS, MLS, STB, MDH, MDB, FRF, PAF, OCF (Jantz, personal communication).

Results

A summary of the DISPOP classification results are presented in Table 11. Results of the Defrise-Gussenhoven tests are displayed in Tables 12 through 16. Each table displays the Mahalanobis distances (D) among unknowns. In this case, the unknowns are each individual within the group. The expected distance, the mean distance, and the standard deviation are also reported for each table. The results indicate that early groups (1700-1750) are more homogeneous and later groups (1775-1800) are more heterogeneous.

Tables 17 through 21 display the classification results, D^2 distances, and associated posterior probability for each individual. In each quarter-century group, individuals classify as West Africans and American Blacks. In 1775 and 1800 more individuals classify as 19th and early 20th century American Blacks.

Discussion

Based on the analyses of within group variation for each quarter-century cohort, the early groups appear to be more homogeneous than the later groups. The 1700 quarter-century group consists only of individuals from Clift's Plantation. The 1725 quarter-century group consists of individuals from two sites, Deep River and Fort A.P. Hill. The 1750 quarter-century group is also homogeneous and contains individuals from four different archaeological sites, Catoctin Furnace, Fort A.P. Hill, Orleans Parish, and Burke Lake. The 1775 and 1800 quarter-century groups contain both rural and urban sites and exhibit more heterogeneity among individuals.

Table 11: DISPOP Classification Summary

Quarter-Century Group	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African	Total
1700	2	1					1	4
1725	4		1				3	7
1750	3						4	7
1775	6	1	3	3			2	15
1800	6		5	3		1	6	21

Table 12: D^2 Distances Among the 1700 Cohort

Burial	59	61	60	62
59	0			
61	7.459	0		
60	9.674	7.812	0	
62	6.273	6.225	8.556	0

Expected distance (D) 7.8102497
Distances greater than 9.7702497 can be considered significant
Mean distance= 7.6666339 sd= 1.3346693
Variables used include:
GOL, NOL, BNL, BBH, ASB, BPL, NPH, NLH, NLB, OBH, OBB, WNB, WMH, FRC, FRS, PAC, PAS, OCC, OCS, NAR, PRR, DKR, ZOR, FMR, EKR, ZMR, BRR, VRR, LAR, OSR, BAR

Table 13: D^2 Distances Among the 1725 Cohort

Burial	28	64	66	107	108	111	112
28	0						
64	7.821	0					
66	7.563	7.054	0		.		
107	6.817	7.339	9.206	0			
108	7.09	7.749	8.782	7.133	0		
111	7.132	8.676	*9.535	8.291	8.545	0	
112	7.679	8.925	8.168	8.791	7.931	7.702	0
115	6.651	7.537	8.892	7.218	7.435	6.898	9.071

Expected distance (D) 7.5498344
Distances greater than 9.5098344 can be considered significant
Mean distance= 7.9153939 sd= .82178385
Variables include:
GOL, NOL, BNL, BBH, XCB, AUB, ASB, NLH, NLB, OBB, DKB, WNB, FMB, FRC, FRS, PAC, PAS, OCC, OCS, NAR, DKR, ZOR, FMR, EKR, BRR,VRR, LAR, OSR, BAR

Table 14: D^2 Distances Among the 1750 Cohort

Burial	*28*	*64*	*66*	*107*	*111*	*112*	*115*
28	0						
64	9.637	0					
66	8.462	8.296	0				
107	8.007	8.9	10.727	0			
111	7.837	9.864	9.925	9.28	0		
112	8.666	9.548	8.836	10.012	8.691	0	
115	7.485	9.074	9.935	7.859	8.188	9.687	0

Expected distance (D) 8.5440037
Distances greater than 10.504004 can be considered significant
Mean distance= 8.9960317 sd= .87663943
Variables include;
GOL, NOL, BNL, BBH, XCB, XFB, AUB, ASB, BPL, NPH, NLH, NLB, OBH, OBB, DKB, WNB, FMB, WMH, FRC, FRS, PAC, PAS, OCC, OCS, NAR, SSR, PRR, DKR, ZOR, FMR, EKR, ZMR, BRR, VRR, LAR, OSR, BAR

Table 15: D^2 Distances Among the 1775 Cohort

Burial	63	65	82	83	85	86	90	93	98	101	102	103	109	110
63	0													
65	11.308	0												
82	14.689	13.643	0											
83	9.591	11.301	13.823	0										
85	8.637	12.337	17.028	9.817	0									
86	9.481	10.895	13.392	9.317	9.521	0								
90	10.245	10.847	12.859	9.144	11.269	8.742	0							
93	10.351	12.022	11.873	9.048	11.584	8.191	8.79	0						
98	10.346	11.289	13.748	9.323	11.106	8.471	7.758	10.05	0					
101	11.055	12.137	12.021	7.433	11.763	10.75	12.111	9.746	11.108	0				
102	10.925	11.569	12.162	8.139	10.487	8.28	9.785	8.103	10.188	7.661	0			
103	11.617	10.716	11.838	9.467	13.066	11.276	10.419	10.26	10.53	10.509	9.353	0		
109	8.891	9.9	11.492	8.037	10.251	8.322	8.735	7.479	9.673	9.126	7	8.287	0	
110	10.008	12.665	13.541	8.794	11.608	9.779	10.351	9.732	11.07	10.059	8.932	11.653	8.456	0
113	9.556	10.922	13.996	8.183	11.273	10.87	9.652	9.657	10.402	10.189	8.461	10.154	8.491	9.419

Expected distance (D) 8.8881944
Distances greater than 10.848194 can be considered significant
Mean distance= 10.394021 sd= 1.7535565
Variables include:
GOL, NOL, BNL, BBH, XCB, XFB, ZYB, AUB, ASB, BPL, NPH, NLH, NLB, OBH, OBB, DKB, WNB, FMB, EKB, WMH, STB, FRC, FRS, PAC, PAS, OCC, OCS, NAR, SSR, PRR, DKR, ZOR, FMR, EKR, ZMR, BRR, VRR, LAR, OSR , BAR

Table 16: D^2 Distances Among the 1800 Cohort

Burial	70	72	73	75	76	77	79	81	84	87
70	0									
72	8.419	0								
73	8.292	9.344	0							
75	7.395	9.987	8.908	0						
76	6.047	9.088	8.416	7.353	0					
77	12.084	12.2	12.637	11.123	12.386	0				
79	7.794	8.589	9.987	6.268	8.135	11.178	0			
81	10.197	11.172	10.909	8.921	9.04	13.032	9.177	0		
84	6.999	8.198	8.132	6.774	6.202	10.38	7.007	8.218	0	
87	6.783	9.532	9.656	8.023	5.876	14.18	8.211	8.016	7.213	0
88	9.745	9.781	9.071	8.757	9.258	12.293	10.228	8.819	7.959	9.8
89	8.000	9.115	10.637	9.026	8.59	12.448	8.177	9.951	6.432	8.202
91	6.792	8.932	10.138	7.796	7.238	12.187	7.347	9.437	6.147	7.437
92	8.921	10.265	11.705	10.44	9.619	12.058	10.382	9.653	9.188	10.151
94	7.096	9.248	8.673	6.911	8.123	11.275	7.615	9.117	6.013	8.213
95	7.28	8.858	9.454	8.918	6.402	11.121	9.431	10.452	7.097	8.088
96	8.212	9.478	10.243	8.537	8.723	11.579	9.019	10.746	8.088	9.357
99	9.094	10.294	10.771	9.351	7.067	12.195	8.222	9.539	7.179	7.821
100	9.984	8.865	10.917	9.558	9.47	12.022	8.634	10.725	8.534	9.969
104	9.267	10.6	11.347	8.781	7.508	12.468	9.9	9.202	7.287	8.645
105	7.574	8.224	9.712	8.146	7.333	11.633	7.738	8.84	5.609	7.614

Expected distance (D) 7.9372539
Distances greater than 9.8972539 can be considered significant
Mean distance= 9.0594498 sd= 1.5794822
Variables:
GOL, NOL, BNL, BBH, XCB, ASB, BPL, NPH, NLH, NLB, OBB, DKB, WNB, ZMB, FRC, FRS, PAC, PAS, OCC, OCS, NAR, SSR, PRR, DKR, FMR, EKR, ZMR, BRR, VRR, LAR, OSR, BAR

Table 16: Continued

Burial	88	89	91	92	94	95	96	99	100	104
70										
72										
73										
75										
76										
77										
79										
81										
84										
87										
88	0									
89	10.204	0								
91	9.414	8.341	0							
92	11.683	7.663	10.475	0						
94	8.274	8.224	6.757	9.563	0					
95	9.301	7.914	8.558	10.148	8.511	0				
96	10.274	9.797	7.105	10.439	7.783	9.12	0			
99	11.176	7.654	8.881	10.275	9.375	9.554	9.723	0		
100	11.173	9.373	9.11	10.347	9.139	9.969	8.477	9.646	0	
104	9.48	9.344	7.527	11.199	8.317	8.748	8.603	8.138	9.914	0
105	9.045	6.614	6.779	9.532	8.082	6.717	6.636	7.478	7.902	8.408

Table 17: DISPOP Results, D^2, and Posterior Probabilities for the 1700 Cohort

ID	1700	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
59	AmWhite	32.396	29.242	39.838	39.857	32.437	34.867	39.875
		0.13919	*0.67391*	*0.00337*	*0.00334*	*0.13642*	*0.04046*	*0.00331*
61	AmBlack	32.104	40.987	35.06	33.109	40.145	44.864	41.657
		0.53386	*0.00629*	*0.12178*	*0.32309*	*0.00958*	*0.00091*	*0.0045*
60	West African	41.719	61.098	34.33	31.167	57.347	55.929	30.648
		0.00204	*0*	*0.08203*	*0.39888*	*0*	*0*	*0.51705*
62	AmBlack	25.736	27.569	28.803	27.673	28.811	28.909	30.512
		0.39888	*0.15957*	*0.08608*	*0.15148*	*0.08574*	*0.08163*	*0.03662*

Table 18: DISPOP Results, D^2, and Posterior Probabilities for the 1725 Cohort

ID	1725	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
28	AmBlack	24.418	37.69	25.77	31.09	33.039	36.872	27.69
		0.56967	*0.00075*	*0.28964*	*0.02026*	*0.00765*	*0.00113*	*0.11091*
64	West African	34.125	47.647	32.704	33.811	45.406	45.758	26.457
		0.01981	*0.00002*	*0.04033*	*0.02319*	*0.00007*	*0.00006*	*0.91652*
66	AmBlack	37.514	52.887	41.747	50.641	59.044	56.377	38.962
		0.62213	*0.00029*	*0.07496*	*0.00088*	*0.00001*	*0.00005*	*0.30169*
107	West African	40.609	55.827	35.355	36.328	52.129	51.104	22.422
		0.00011	*0*	*0.00155*	*0.00095*	*0*	*0*	*0.99738*
108	Terry Black	37.185	39.675	29.126	32.861	33.1	33.074	33.909
		0.01151	*0.00331*	*0.64732*	*0.1*	*0.08875*	*0.08989*	*0.05921*
111	AmBlack	39.408	49.123	41.041	41.252	51.887	54.881	46.659
		0.53298	*0.00414*	*0.23549*	*0.21193*	*0.00104*	*0.00023*	*0.01419*
112	West African	52.318	59.225	54.394	61.278	67.329	69.885	44.998
		0.02484	*0.00079*	*0.0088*	*0.00028*	*0.00001*	*0*	*0.96527*
115	AmBlack	26.532	32.678	28.522	28.559	36.95	35.91	34.378
		0.55147	*0.02552*	*0.20386*	*0.20016*	*0.00301*	*0.00507*	*0.01091*

Table 19: DISPOP Results, D^2, and Posterior Probabilities for the 1750 cohort

ID	1725	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
28	AmBlack	28.458	46.68	29.963	36.266	42.746	44.027	33.339
		0.63308	0.00007	0.29818	0.01276	0.0005	0.00026	0.05514
64	West African	54.874	68.207	50.383	49.35	64.899	64.775	40.998
		0.00095	0	0.00894	0.01498	0.00001	0.00001	0.97512
66	West African	49.291	70.328	52.67	58.479	76.586	68.862	45.449
		0.12465	0	0.02302	0.00126	0	0.00001	0.85107
107	West African	47.739	65.072	42.496	45.679	60.173	61.774	39.834
		0.01437	0	0.19758	0.04023	0.00003	0.00001	0.74779
111	AmBlack	45.22	56.565	47.16	47.002	59.715	60.432	53.797
		0.55325	0.0019	0.20969	0.2269	0.00039	0.00028	0.00759
112	West African	65.524	81.837	64.142	70.564	89.06	89.455	53.769
		0.00278	0	0.00554	0.00022	0	0	0.99146
115	AmBlack	34.905	47.78	35.414	36.598	50.844	49.932	47.575
		0.45276	0.00072	0.35107	0.19424	0.00016	0.00025	0.0008

Table 20: DISPOP Results, D^2, and Posterior Probabilities for the 1775 Cohort

ID	1775	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
63	Todd Black	59.532	83.363	49.103	44.799	71.47	66.509	63.103
		0.00057	0	0.10406	0.89527	0	0.00002	0.00009
65	Terry Black	99.239	114.075	97.36	101.792	105.968	116.943	101.915
		0.24181	0.00015	0.61871	0.06747	0.00836	0.00003	0.06346
82	Terry Black	137.745	135.297	123.574	129.539	124.641	127.765	133.553
		0.00047	0.00161	0.56476	0.02861	0.33124	0.06947	0.00384
83	AmBlack	35.845	58.637	37.205	43.408	59.218	60.11	43.922
		0.64649	0.00001	0.32738	0.01473	0.00001	0	0.01139
85	AmBlack	77.924	96.625	79.701	79.204	95.966	98.152	86.949
		0.51282	0.00004	0.21096	0.27047	0.00006	0.00002	0.00563
86	Todd Black	48.622	69.131	46.094	44.242	69.093	67.832	53.266
		0.07367	0	0.26086	0.65823	0	0	0.00723
90	Terry Black	51.985	72.739	47.98	53.702	62.745	68.964	59.076
		0.11284	0	0.83554	0.04781	0.00052	0.00002	0.00326
93	Todd Black	46.078	69.696	40.799	39.144	61.928	54.954	42.48
		0.01883	0	0.26375	0.60341	0.00001	0.00022	0.11378
98	AmBlack	56.324	80.532	56.645	65.244	79.35	83.913	75.891
		0.53667	0	0.45708	0.00621	0.00001	0	0.00003
101	West African	63.391	79.929	65.625	73.647	84.754	83.362	57.691
		0.05368	0.00001	0.01757	0.00032	0	0	0.92841

Table 20: Continued

ID	1775	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
102	AmBlack	34.061	38.876	41.339	46.815	45.837	48.196	35.654
		0.63595	0.05725	0.01671	0.00108	0.00176	0.00054	0.2867
103	AmWhite	55.541	46.406	60.328	70.013	47.707	54.099	68.916
		0.00668	0.64328	0.00061	0	0.33568	0.01374	0.00001
109	AmBlack	25.148	34.489	26.566	27.612	29.944	31.413	28.959
		0.48153	0.00451	0.23707	0.1405	0.04377	0.021	0.07163
110	West African	54.076	73.823	48.272	45.73	74.287	68.211	31.688
		0.00001	0	0.00025	0.00089	0	0	0.99884
113	AmBlack	49.012	57.349	52.411	52.398	56.843	55.962	50.487
		0.52314	0.0081	0.0956	0.09623	0.01043	0.0162	0.2503

Table 21: DISPOP Results, D^2, and Posterior Probabilities for the 1800 cohort

ID	1800	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
70	Terry Black	29.573	38.766	28.895	30.058	38.595	40.712	35.33
		0.30587	*0.00308*	*0.42928*	*0.24005*	*0.00336*	*0.00117*	*0.01719*
72	Todd Black	61.058	90.698	51.853	51.061	85.369	73.978	51.795
		0.00284	*0*	*0.28366*	*0.42153*	*0*	*0*	*0.29197*
73	Todd Black	81.444	93.729	72.815	72.004	86.318	80.862	74.916
		0.00464	*0.00001*	*0.34693*	*0.52045*	*0.00041*	*0.00621*	*0.12136*
75	Todd Black	42.652	53.42	40.464	39.235	43.247	46.41	52.627
		0.09603	*0.00044*	*0.28675*	*0.53011*	*0.07134*	*0.01467*	*0.00066*
76	Todd White	25.152	22.051	21.276	22.692	18.954	17.207	32.576
		0.01094	*0.05157*	*0.076*	*0.03744*	*0.24263*	*0.58114*	*0.00027*
77	Terry Black	122.425	152.099	119.985	122.739	149.39	149.064	127.734
		0.18825	*0*	*0.63768*	*0.16084*	*0*	*0*	*0.01324*
79	West African	47.643	60.599	44.334	41.662	59.038	55.441	41.122
		0.01916	*0.00003*	*0.10016*	*0.38109*	*0.00006*	*0.00039*	*0.49911*
81	West African	58.973	62.1	60.012	60.53	66.295	64.992	53.575
		0.05813	*0.01217*	*0.03457*	*0.02669*	*0.00149*	*0.00287*	*0.86408*

Table 21: Continued.

ID	1800	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
84	Terry Black	23.491	35.764	22.793	24.652	35.534	32.744	27.684
		0.32113	*0.00069*	*0.45517*	*0.17963*	*0.00078*	*0.00314*	*0.03945*
87	AmBlack	27.911	28.775	28.043	27.934	30.94	28.548	31.342
		0.21269	*0.13811*	*0.19911*	*0.21032*	*0.04678*	*0.15472*	*0.03827*
88	Terry Black	71.672	88.502	67.04	69.161	86.586	88.749	77.521
		0.06804	*0.00002*	*0.68946*	*0.23877*	*0.00004*	*0.00001*	*0.00365*
89	AmBlack	29.994	42.646	32.472	36.029	43.183	43.822	39.937
		0.74092	*0.00133*	*0.21462*	*0.03625*	*0.00101*	*0.00074*	*0.00514*
91	West African	30.827	49.718	33.509	34.129	51.63	51.399	26.382
		0.09357	*0.00001*	*0.02448*	*0.01796*	*0*	*0*	*0.86398*
92	AmBlack	52.987	74.743	57.182	60.386	75.48	74.645	53.593
		0.53008	*0.00001*	*0.0651*	*0.01311*	*0.00001*	*0.00001*	*0.39168*
94	AmBlack	35.23	53.514	38.904	40.925	55.548	57.716	40.897
		0.78357	*0.00008*	*0.1248*	*0.04543*	*0.00003*	*0.00001*	*0.04607*
95	Terry Black	33.456	34.227	32.725	37.512	33.983	35.656	42.898
		0.22917	*0.15585*	*0.33038*	*0.03016*	*0.17611*	*0.07628*	*0.00204*

Table 21: Continued.

ID	1800	AmBlack	AmWhite	Terry Black	Todd Black	Terry White	Todd White	West African
96	West African	52.972	66.441	54.699	55.712	69.661	71.203	44.544
		0.01443	*0.00002*	*0.00608*	*0.00367*	*0*	*0*	*0.9758*
99	AmBlack	45.752	52.03	47.546	47.572	52.312	49.28	53.564
		0.48011	*0.0208*	*0.19578*	*0.19328*	*0.01807*	*0.0823*	*0.00966*
100	West African	71.916	88.118	68.445	70.351	91.259	81.566	57.277
		0.00066	*0*	*0.00374*	*0.00144*	*0*	*0.00001*	*0.99416*
104	AmBlack	43.256	51.696	47.879	49.792	57.249	56.035	57.615
		0.86558	*0.01273*	*0.08581*	*0.03298*	*0.00079*	*0.00145*	*0.00066*
105	West African	30.184	37.02	31.135	30.853	37.968	37.644	25.781
		0.08733	*0.00286*	*0.05427*	*0.06248*	*0.00178*	*0.00209*	*0.78918*

The majority of individuals in the 1800 cohort are from FABC. The FABC was an urban cemetery in Philadelphia. Following emancipation, many free Blacks moved to urban areas in the North and South to gain better wages and more freedom (Rankin-Hill, 1997). Philadelphia is in close proximity to Virginia, Maryland, and Washington D.C. and it is thought that many free blacks migrated there (Rankin-Hill, 1997), which could explain the higher degree of within group variation found in this group from a predominantly urban setting. The earlier groups, despite being comprised of individuals from geographically different archaeological sites, are more homogeneous.

Chapter 8
Comparison of Genetic and Craniometric Variation

The isolation by distance model predicts that as geographic distances between populations increase, genetic similarity will decrease due to a decrease in gene flow (Relethford, 2004b). Genetic drift, selection, and plasticity may also influence a decrease in genetic similarity. Using craniometric data, differences in morphology can be expressed in terms of the genetic distances that can be used to study relationships within and among populations. Further, using protein or allele frequency data, genetic distances can also be derived. Both craniometric and genetic distances have been shown to offer insight into population histories.

However, determining which component (gene flow, genetic drift, selection, or plasticity) has the biggest effect on geographic distances based on craniometric or allele frequency data is difficult. The purpose of this chapter is to compare craniometric data to genetic data in order to determine if craniofacial morphology is under more genetic or plastic control. If the craniofacial morphology is under more genetic control, then the craniometric data will be similar to the genetic data. If the cranium is plastic, then the craniometric data will not be similar to the genetic data.

For the purpose of this study, genetic distances are derived from both craniometric and genetic data using R matrix analysis. The genetic data comes from previously published classical genetic markers, single nucleotide polymorphisms, and autosomal markers using R matrix analysis. Once genetic distances are derived,

craniometric data are then compared to the three different sets of genetic data using the Mantel test and Procrustes analysis.

Materials

Craniometric Data

West African and American Black samples are described in Chapter 3. The American Black and Whites samples consist of individual born after 1900, to better approximate the time periods of the samples from which the genetic data was drawn. The American White sample comes from the Forensic Anthropology Data Bank (FDB), maintained by Richard Jantz at The University of Tennessee. Only individuals with birth years from 1900 to 1975 were used. The FDB has a Southeastern bias; however it is comprised of forensic cases from all over the U.S. Samples sizes are presented in Table 22. Craniometric measurements used in this analysis are part of the Howells (1973) data set and are presented in Figure 11.

Classical Genetic Markers

The classical genetic markers used in this study are from Workman et al. (1963) and include a variety of red blood cell polymorphisms including the ABO blood group. The use of ABO blood groups dates back to 1900, with Landsteiner (Cavalli-Sforza et al., 1994; Pollitzer, 1981), which led to a considerable amount of published literature.

Workman et al. were interested in the roles of selection, migration, and drift and how these forces acted upon the frequencies of polymorphic traits in American Black.

Table 22: Sample Sizes for Craniometric Data

Group	N
West African	134
American Black	65
American White	168

GOL	NLH	IML	SSR
XFB	OBB	FRS	EKR
NPH	EKB	NAR	BAR
OBH	FRC	FMR	XCB
FMB	OCS	OSR	BPL
STB	ZOR	BBH	MAB
OCC	LAR	ASB	ZMB
DKR	BNL	NLB	WMH
BRR	AUB	WNB	PAS
NOL	JUB	XML	PRR
ZYB	DKB	PAC	ZMR

Figure 11: Listing of craniometric variables for R matrix analysis. (see Howells, 1973)

Workman et al. used data from previously published research as well as from their own data. The West African data comes from several researchers. The American Black and White samples were from Claxton, Georgia. It is the West Africans and the American Blacks and Whites from Claxton that are used in the present analysis. Sample sizes are not available from the publication of Workman et al.

If a frequency was missing or 0.0 for each group, the allele was dropped, leaving 19 out of 21 alleles for the present analysis including: R^0(cDe), R^1(Cde), R^2(cDE), r(cde), A, B, O, M, S, Fy^a, P, Jk^a, K, Lu^a, T, Hp^1, G6PD, Hb^s, and Tf^{D1}. For several frequencies a range was provided and for the purpose of my analysis the midpoint of the range was used. Workman et al. calculated an estimate of gene migration for each allele. They found that two groups appeared, one group consisting primarily of the red cell antigens and a second group that included red cell antigens in addition to the sickle cell hemoglobin.

Workman et al. concluded that the climate in the south of the U.S. possibly influenced the detection of two groups. Because the climate in the south U.S. is somewhat similar to that of West Africa, Workman et al. concluded that migration alone accounted for the observed similarities between American Blacks and West African in Group I. In the second group (Group II), they found that migration alone could not account for the frequencies and concluded that these traits result from selection and gene flow, creating more separation between American Blacks and West Africans. The results presented Workman et al. used the latest technology available during their research (in 1950) and must be considered in that context.

Single Nucleotide Polymorphisms (SNPs)

Single nucleotide polymorphisms (SNPs) used in this analysis come from a publication by Han et al. (2005). A SNP is a single nucleotide, adenine (A), thymine (T), cytosine (C), or guanine (G) that becomes altered. The resulting alteration must be present in at least 1% of a population to be considered a SNP. SNPs are considered selectively neutral (Rogers et al., 1999), evolutionarily stable, and good for tracing population origins (Han et al., 2005).

Using 38 global populations, Han et al. tested a previously published hypothesis that human alcohol dehydrogenase (ADH) genes, specifically ADH7, play an epistatic role against alcoholism. These data were chosen for this analysis because of the well defined groups of West Africans, American Blacks, and American Blacks that provide good comparative samples to the other genetic and craniometric data used in these analyses.

All SNPs volunteers were considered healthy and did not suffer from alcohol abuse. The seven SNPs of the ADH7 used in the analysis include rs1154469 (intron 1), HinfI (exon 6), StyI (intron 6), rs2851011 (intron 8), rs284784 (intron 8), rs284786 (3' downstream), and rs729147 (3' downstream). An additional 3 SNPs in ADH1B were also used in their analyses and include: rs1159918 (5' upstream), Arg47His (exon 3), and RsaI (intron 3). The genotypes and allele frequencies for each site were calculated (by Han et al.) by gene counting assuming biallelic codominant inheritance. Only a subset of the Han et al. samples were used that matched the appropriate geographic population samples. Table 23 lists samples used from the previously published data set by Han et al.

Table 23: Samples for SNPs Data from Han et al.

Group	Location/tribe	N
West African	Yoruba	156
	Ibo	96
	Hausa	78
	Total	**330**
American Black	North America	-
	Total	**182**
American White	North America	-
	Total	**176**

Autosomal Population-specific Alleles (PSAs)

In an attempt to define admixture proportions of present day American Blacks, Parra et al. (1998) have done extensive studies using genetic data. The allele frequencies of this genetic data are used in the present study because of the diverse geographic locations of samples and because of their geographic correspondence to the craniometric samples used in this research. Parra et al. selected population-specific alleles (PSAs) or alleles that show a frequency of >45% between parental populations in order to maximize differences among groups. These alleles include FY-Null, ICAM, AT3, APO, GC-1F, GC-1S, LPL, OCA2, RB2300 and Sb19.3. FY-Null and ICAM are only found in persons with African ancestry.

The samples of American Blacks were collected in Maywood Illinois; Detroit, Michigan, New York, New York, Philadelphia, Pennsylvania, Pittsburgh, Pennsylvania,

Baltimore, Maryland, Charleston, South Carolina, New Orleans, Louisiana, and Houston, Texas. These samples are described in detail in the original publication. Specific groups and their sample sizes are presented in Table 24. The American Black data includes individuals that took part in paternity tests, anthropological studies, and volunteers in medical studies including obesity, hypertension, HIV, and prenatal lead screening tests. The African data includes individuals that participated in hypertension and anthropological studies.

Methods

The comparison of craniometric and genetic distances would ideally require that the genetic data come from the same samples as the craniometric data. However, this is not possible in the preceding analyses. Collection of DNA has only been possible for the last few decades. Therefore, the majority of genetic data are from recent populations. Craniometric data used are from the West African samples described in Chapter 3. The West African crania are contemporary with the Trans Atlantic slave trade. However, both the craniometric and allele frequency data are from populations in roughly the same geographic areas in West Africa.

Genetic distance matrices derived from different types of data are not initially comparable. In order to make the allele frequency data more informative and comparable to the craniometric data, genetic distance matrices were obtained for all data types using R matrix analysis (Relethford, no date) and the Harpending and Jenkins (1973) kinship coefficient. The resulting craniometric and genetic distance matrices were subjected to

Table 24: Samples for Autosomal PSA Data from Parra et al.

Group	Location		N
West Africans	Nigeria-1		46
	Nigeria-2		100
	Central African Republic		49
		Total	**195**
American Black	Maywood, Ill.		100
	Detroit		47
	New York		93
	Philadelphia-1		175
	Philadelphia-2		126
	Pittsburgh		84
	Baltimore		96
	Charleston, S.C.		94
	New Orleans		105
	Houston		100
		Total	**1020**
American White	Detroit		48
	Pittsburgh		30
	Louisiana (Cajuns)		47
		Total	**125**

mantel tests. To visualize the results, the eigenvectors produced from the R matrix analysis were subjected to Procrustes analysis.

Preliminary Procedure

A given data set must contain no missing data in order to use the Rmet program for R matrix analysis. Therefore, prior to R matrix analysis with the craniometric data, a preliminary procedure of data estimation was employed. Data estimation for genetic data was not necessary because these are previously published complete data sets. Data were estimated, for all groups, using NORM 2.03 (Schafer, 1999), which provides multiple imputation of incomplete multivariate data under a normal model. NORM uses an E-M algorithm, then performs a data augmentation and imputation. Data was only imputed for individuals with 9 or fewer missing measurements out of a possible 59 measurements.

R matrix analysis

An R matrix analysis (coefficient of kinship) provides an estimate of kinship within and among groups based on allele frequency data (Harpending and Jenkins, 1973 and 1974). This method can also be applied to quantitative polygenic traits such as craniometrics. Distance and kinship matrices were obtained for genetic data using Kship (Jantz, n.d.), a program written by Dr. Richard L. Jantz. Kship uses the methods outlined by Harpending and Jenkins (1973, 1974) to obtain kinship coefficient matrices from allele frequency data. Distance and kinship matrices for craniometric data were obtained using Rmet (Relethford, no date). Rmet uses a method outlined by Harpending and Jenkins (1973). Both provide a kinship matrix, a distance matrix, an Fst estimate, and

eigenvalues and eigenvectors. The distance matrices can further be used for matrix correlation analyses. The eigenvectors are then plotted for visual interpretation.

Mantel Test

In order to compare distance matrices derived from differing types of data, a matrix correlation analysis is necessary. A common way of testing for matrix correlation was derived by Mantel in 1967. The Mantel test is used to compare multiple matrices of pairwise distances or affinities from different types of data (Smouse and Long, 1992). The Mantel test assumes that the relationships of the matrices are independent of one another.

For the present analysis, the kinship matrix from the craniometric data is compared to each kinship matrix derived from the classical markers, SNPs, and autosomal PSAs. A correlation coefficient is provided to see how well each matrix derived from genetic data correlates with the craniometric distance matrix. In order to test the significance of the correlation, random permutations are performed holding one matrix constant while the other rows and columns are permuted (Smouse and Long, 1992). With each permutation, the correlation coefficient is recalculated.

Procrustes Analysis

Using the NTSYS program (Applied Biostatistics Inc, 1986-2000) the eigenvectors from each genetic data set were subjected to a Procrustes analysis with the eigenvectors from the craniometric data. A Procrustes analysis takes *n* dimensional data

from one configuration and centers, scales, and rotates the data to fit another configuration. In this case, the craniometric data were centered, scaled, and rotated to best fit the eigenvectors of each genetic data set. Two-dimensional plots were produced for a visual comparison of the results.

Results

Mantel Test

Although the correlations are not significant, the results of the Mantel tests (Table 25) indicate a high correlation for all genetic data with craniometric data. Each data type consisted of a three by three matrix. Small matrices often provide high correlations that are not significant. However, the eigenvectors from each of the kinship matrices were subjected to a Procrustes analysis and plotted in two-dimension space to help reveal the relationship pattern among the differing types of data better than the Mantel.

Procrustes Analysis

Craniometric Data and Classical Markers

Group I and Group II were each plotted separately in comparison to cranmetric data, providing very different results (Figure 12 and 13). In Figure 12, the Group I classical markers indicate a closer relationship between American Blacks and West African than the craniometric data. However, Figure 13 indicates that Group II classical markers follow a similar pattern to the craniometric data. The Group II classical markers

Table 25: Mantel Test Results for Genetic and Craniometric Data

Data	*Matrix correlation*	*one-tail probability random Z > = observed Z*
Classical markers *Group I*	r = 0.61897	0.3400
Group I & II	r =0.72737	0.3630
SNPs	r =0.82370	0.3460
Autosomal PSAs	r = 0.64054	0.3550

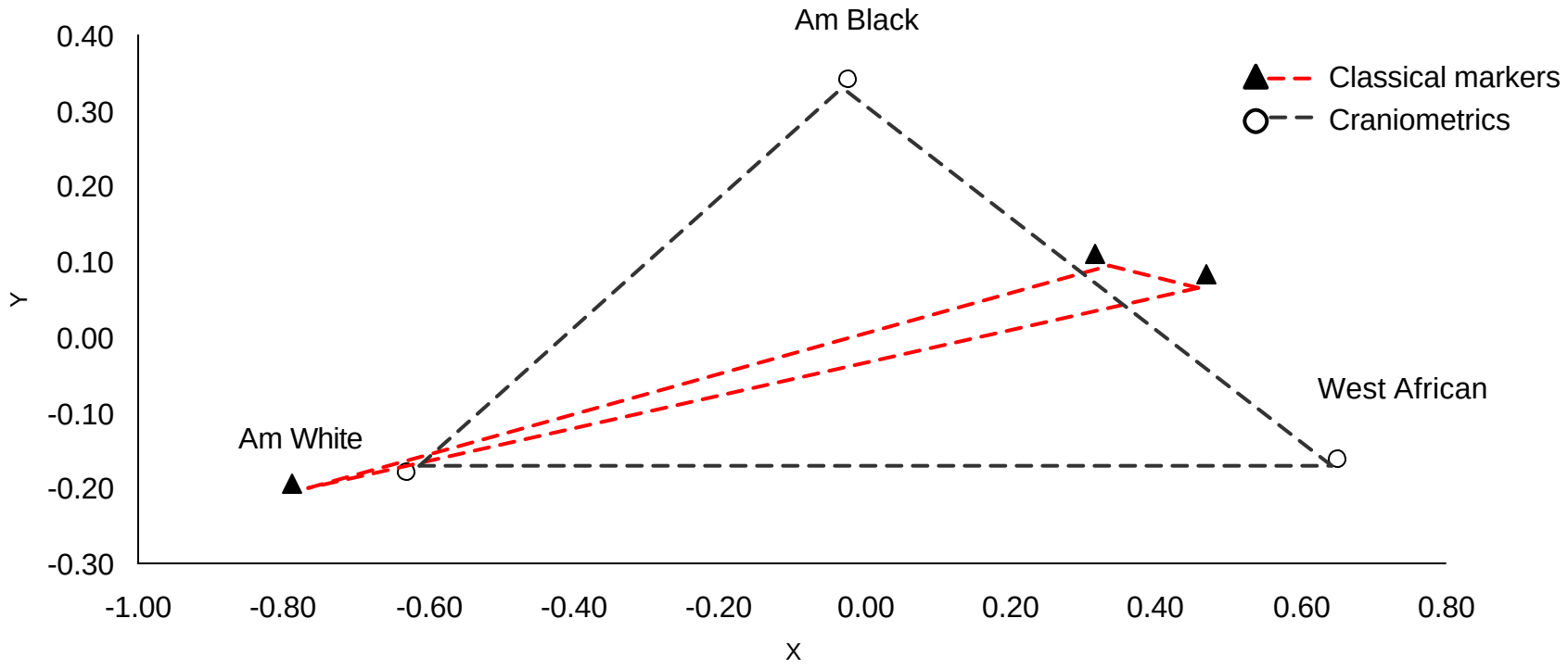

Figure 12: Procrustes plot of group I classical markers and craniometric data.

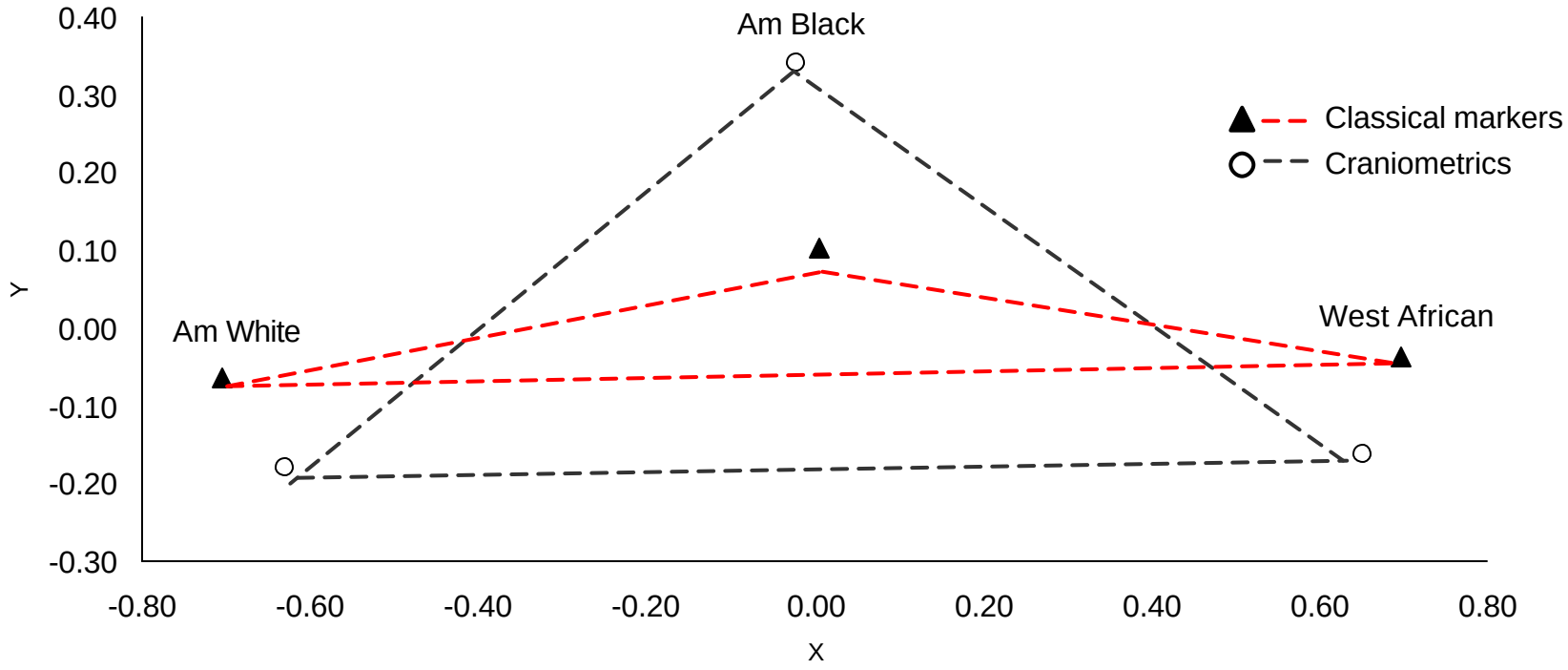

Figure 13: Procrustes plot of group II classical markers and craniometric data.

indicate that American Blacks intermediate between West Africans and American Whites. The Group II markers are thought to have adaptive significance.

Craniometric Data and SNPs

The plot of the SNPs and craniometric eigenvectors show little difference based on the superimposed plots. American Blacks are intermediate between West Africans and American Whites (Figure 14). Additionally, the craniofacial morphologies of American Black and White groups are moving toward the same direction, as indicated by the arrows. The scaled distances between the craniometric and genetic eigenvectors are small, indicating that the phenotype is reflective of the genotype. The plotted genetic eigenvectors for West Africans and American Blacks fall within the eigenvectors for corresponding craniometrics.

Craniometric Data and Autosomal PSAs

A slightly different result is reached using ancestrally informative autosomal markers. These PSA markers were selected by Parra et al. to maximize differences between ancestral groups. Therefore, the autosomal PSA eigenvectors are not as reflective of the craniometric data. The PSA markers show a closer relationship between American Blacks and West Africans as would be expected using population specific alleles for Africans (Figure 15).

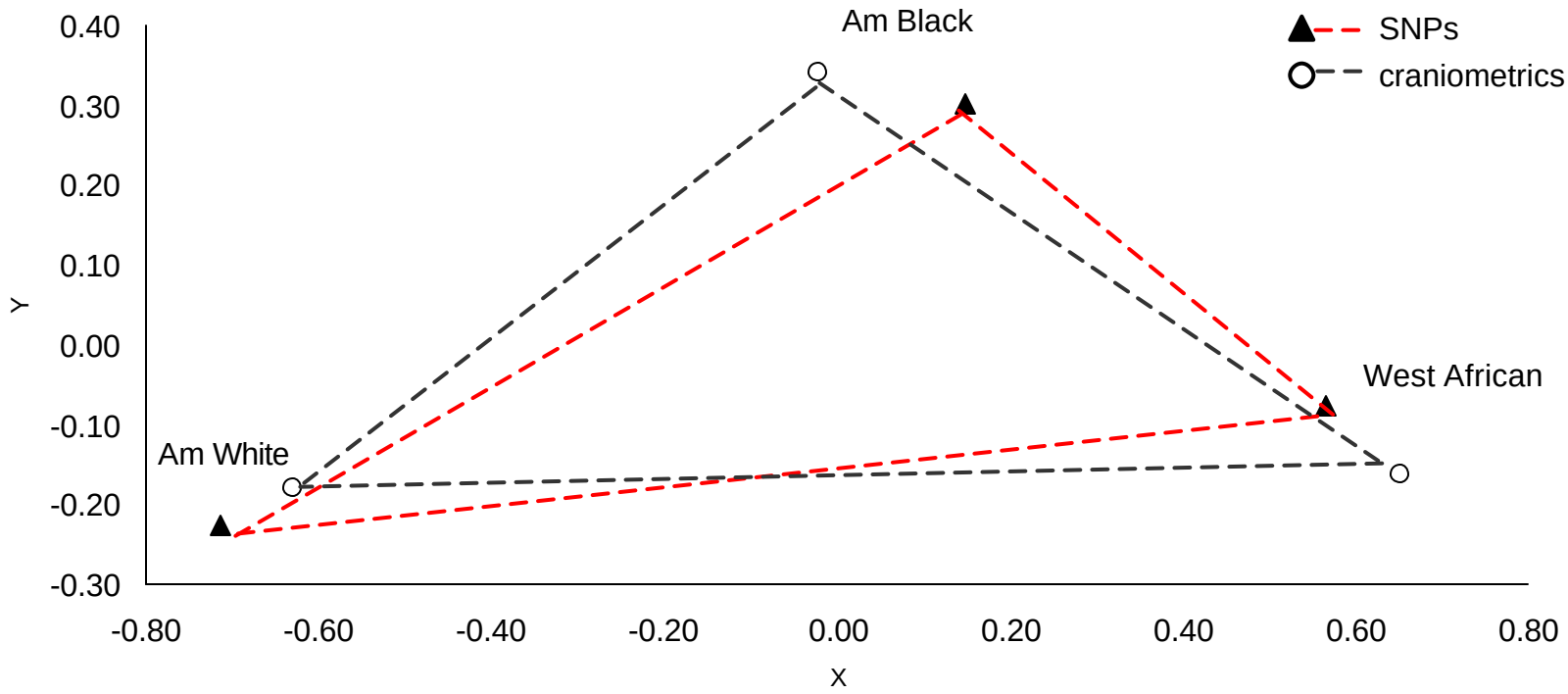

Figure 14: Procrustes plot of SNPs and craniometric data.

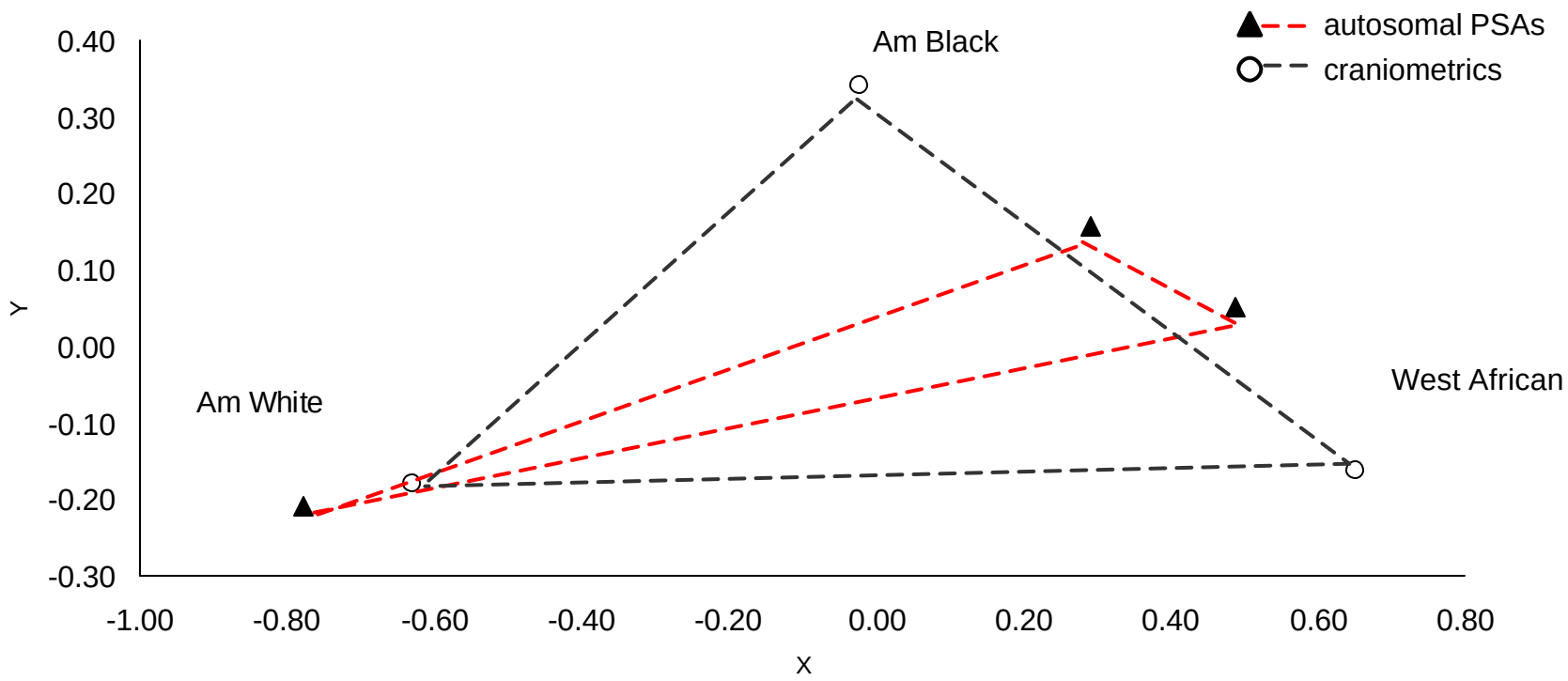

Figure 15: Procrustes plot of autosomal PSAs and craniometric data.

Discussion

Autosomal PSAs and Group I classical markers indicate a close genetic relationship between American Blacks and West African. Given that autosomal PSAs are population specific, it is not surprising that these results were found, indicating that autosomal PSAs are good for identification of ancestry. Group II classical markers and SNPs both produce more separation between American Blacks and West African, reflecting intermediate values. The relationship demonstrated by PSAs in contrast to the craniometric data is not surprising, since the PSAs are population specific and are found in individuals of African origin. The differences between the Group I and II markers indicates the dramatic differences that can be reached with classical markers, which have been previously demonstrated as the least reliable in detecting population relationships (Relethford, 1982).

The most interesting relationship was found between SNPs and craniometrics, both indicating American Blacks to be intermediate between West Africans and American Whites. If craniofacial morphology was influenced by plasticity more than genetics, then the craniometric data would not "fit" well with the SNPs data. While plasticity does likely affect craniofacial morphology, the fit between the SNPs and craniometric data supports a genetic influence.

The present chapter focuses on genetic versus craniometric variation and finds that there is a genetic influence in craniofacial morphology. The following chapter presents a discussion of chapters 5 though 8 and how they relate to the hypothesis of this research, that craniofacial secular changes has taken place in the American Black

population from 1700 – 1975, and how they relate to the objectives of this research, to trace the geographical origins of enslaved Africans and early American Blacks; to use larger samples with more time-depth and smaller birth year cohorts than previously used to assess the significance of the craniofacial secular changes; and to compare craniometric and genetic data to evaluate whether or not the observed craniofacial secular changes are a result of environmental plasticity or genetic control.

Chapter 9

Discussion

The hypothesis of the present research is that significant craniofacial secular change has taken place in the American Black population since the American colonies entered the slave trade. Analyses presented in this research support this hypothesis, suggesting that significant craniofacial secular changes have taken place from 1700 through 1975. The main objectives of the present research were to use craniometric data to trace the geographical origins of enslaved Africans and early American Blacks; to use larger samples with more time-depth and smaller birth year cohorts than previously used to assess the significance of the proposed craniofacial secular changes; and to compare craniometric and genetic data to evaluate whether or not the proposed craniofacial secular changes are a result of environmental plasticity or genetic control. The remainder of this chapter discusses the major conclusions of each objective.

Prior to exploring the geographic origins of enslaved Africans and early American Blacks, craniofacial morphology was analyzed between and within African groups from different geographic locations. These analyses suggest that West Africans are biologically similar and share similar craniofacial morphology as compared to other groups in Africa from different geographic locations. Further, the documented sample of enslaved Africans from the Morton collection is morphologically similar to the West African sample, suggesting that this sample of enslaved Africans is from West Africa. The craniofacial morphology of early American Blacks (1700 - 1850) was also compared

to 18th and 19th West African samples and a sample of early American Whites (1600 - 1800). Because these early American Blacks had birth-year cohorts indicating that they could have been born in Africa, the hypothesis was that early American Blacks would be morphologically similar to West Africans. The results indicate that the early American Black samples display intermediate morphology between the West Africans and the early American Whites. These results could imply several scenarios; it is possible that gene flow between West Africans and Europeans had taken place prior to their arrival in the American colonies, that the samples of early American Blacks used in the present research are not representative of the greater population of American Blacks during 1700 through 1850, or that the West African groups do not represent appropriate ancestral populations.

Portugal began exploiting the West African coast for the purposes of slavery beginning in the mid 15th century to provide labor for sugar plantations in Portuguese Brazil. In the mid 17th century sugar plantations were moved from Brazil to the West Indies, and it is likely that the plantation labor also made the move. Given that American colonies predominantly purchased slaves from the West Indies prior to the 1720s, the potential of European and West African admixture prior to arrival of slaves in the American colonies is a possibility. Also possible is that the samples of early American Blacks used in this research are not entirely representative of the greater population of early American Blacks.

Samples used in the present research are predominantly from the southeastern U.S., and were major slaving states. The least plausible explanation of American Blacks appearing intermediate between West Africans and American Whites is that the West

African sample does not represent an appropriate parental population. Because the enslaved African sample from the Morton collection clusters well with the West Africans, and based on D^2 distances, these samples appear to be closely related regardless of their time depth.

The second main objective of this research was to document the specific craniofacial secular changes that occurred in the American Black population from 1700 though 1975. The present research, with larger samples and more time-depth finds that the variable most correlated with time is facial height. Facial height exhibits a positive secular trend, meaning it has increased over time. Further, vault height and cranial base height are found exhibit a negative secular trend.

The present observations of craniofacial secular change differ from those found by Jantz (2000), Jantz and Meadows Jantz (2001), and Wescott and Jantz (2005). Their results indicate that the majority of craniofacial secular changes are apparent in the vault with little or no change in the face. However, the differing results can be explained by the time-depth of the samples used in the present research. The present samples provide 140 to 150 years more time-depth, beginning in 1700 rather than 1840 or 1850. Using different samples and methods, Trevor (1950) and Angle (1976) found an increase in facial height in American Blacks. Angel and Trevor suggested that the increased facial height in American Blacks is due to admixture alone.

Gene flow (admixture) between West Africans and Europeans has influenced gene frequencies for American Blacks, resulting in varying levels of African and European ancestry (Parra et al., 1998 and 2001). However, it is unlikely that admixture is the sole cause of the observed craniofacial secular changes. Colonial Whites were not

characterized by tall faces, rather they are described as having flattened cranial bases and longer cranial vaults (Angel, 1976; Crewdson-Benington and Pearson, 1912; Shapiro, 1930). In contrast, West Africans from the 18th and 19th century display higher (not flat) cranial bases, and shorter cranial vaults (Angel, 1976; Crewdson-Benington and Pearson, 1912). Because colonial Whites and 18th and 19th century West Africans started out with differing craniofacial morphology in the American colonies, have both experienced craniofacial secular changes in differing ways (Jantz, 2001; Jantz and Meadows Jantz, 2000; Wescott and Jantz, 2005), further supports that admixture alone is not the sole influence of the observed craniofacial secular changes presented in this research.

While plasticity may account for some of the craniofacial secular changes found in this research, it is also unlikely that it is sole cause of the secular changes. Plasticity is often referred to as ontogenetic adaptation (Boldsen, 1995; Lasker and Mascie-Taylor, 1988; Schell, 1995). Plasticity or ontogenetic adaptation refers to the ability of the human phenotype to adjust to the environment during growth and development, leaving a permanent change in a specific trait of the adult phenotype. Following Boas' concept of plasticity, the observed secular trends in craniofacial morphology in the present research would be regarded solely as plastic. Sparks and Jantz (2002) noted that American Blacks and Whites, despite sharing a common environment still do not exhibit a common morphology, as would be expected if following Boas' concept of plasticity.

The genetic distances derived from SNPs, which are neutral and considered evolutionarily stable, when compared to the genetic distances derived from the craniometric data, show a close relationship between phenotype and genotype for American Blacks, although somewhat intermediate between West Africans and American

Whites. This further suggests that plasticity is not the sole cause of the observed secular changes. These observed secular changes are likely more complicated than admixture or plasticity. Because craniofacial morphology is polygenic, and depends on gene and environment interaction which is not fully understood, it is most likely that a combination of factors, gene flow, selection, and plasticity influenced the observed secular trends presented in this research, not just one factor alone.

The present research has used samples of American Blacks with more time-depth than previous studies, dating to early years of the slave trade in the U.S. Further, the West African samples were validated as appropriate ancestral groups using the enslaved African sample from the Morton collection. Even with the present samples, the effects of polygenic traits (in terms of craniofacial morphology) still cannot be fully understood, because the interaction between genes and the environment is complex. However, despite the complex nature of these polygenic traits, significant craniofacial secular change has occurred in the American Black population from 1700 through 1975 with the underlying genetic structure of this population still maintained. While some argue that these secular changes are largely plastic (Gravlee et al., 2003a; Gravlee et al., 2003b), the present research finds a strong genetic association with craniofacial morphology.

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