Secular Change in Macromorphoscopic Trait Frequencies in Modern European Americans

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Introduction

Biological anthropologists, especially those who specialize in forensic anthropology, often employ methods of sex, ancestry, age, and stature estimation in order to build a biological profile for a set of skeletal remains. The study of secular change is important due to its potential impacts on the utility of methods employed by biological anthropologists. Recent studies have documented secular change in stature, cranial dimensions, and the expression of morphological skeletal features (Jantz 2001; Klales 2016; Meadows and Jantz 1995). Craniometric analyses of secular change have shown that the cranium is becoming overall taller and narrower while the mandible is becoming shorter and longer (Jantz and Meadows Jantz 2001, 2016; Martin and Danforth 2009). Although secular change has been documented in a number of studies focused on cranial and postcranial morphometrics, to date, few studies have addressed the potential of temporal change occurring in the expression of cranial nonmetric traits utilized in ancestry estimation.

This study examines the effect of secular change, in a European American sample, in the expression of 23 nonmetric traits frequently applied in nonmetric ancestry estimation. A total of 17 cranial and 6 mandibular traits were scored; with age-at-death, sex, and birth year of each individual documented for data analysis.

It was hypothesized that statistically significant differences in the trait frequencies of nonmetric cranial and mandibular traits would be found between the historic and modern European American sample groups.

Methodology

A total of 23 morphoscopic traits were examined from European American individuals ranging in birth year from 1824 to 1987. Trait descriptions and their respective character state definitions were followed from Hefner (2009), Hefner and Linde (2018), and Berg (2008). Data were collected from the Hamann-Todd Skeletal Collection and the William M. Bass Donated Skeletal Collection. Data were gathered from 1,000 adult individuals, with data for an additional 120 individuals donated by the Macromorphoscopic Databank (Hefner 2018). Individuals ranged from 19 to 97 years of age and were divided between six year-of-birth cohorts (Table 1). Age-at-death was recorded for data analysis in order to assess whether age-at-death affects morphological trait expression. Differences in male and female trait expression were analyzed in order to determine if a sex bias was present in any of the traits.

Table 1. Year-of-Birth Cohorts for 1,120 European Americans.

	Cohort 1 (1824-1849)	Cohort 2 (1850-1874)	Cohort 3 (1875-1899)	Cohort 4 (1900-1924)	Cohort 5 (1925-1949)	Cohort 6 (1950-1987)
Males	72	99	115	82	130	124
Females	20	85	97	62	134	100
Total	92	184	212	144	264	224

To determine if time of birth affects trait expression, the six cohorts were analyzed by frequency distribution tables, Pearson's chi-square analyses, and correspondence analyses. Ordinal regression was used to determine if age-at-death and sex have a significant impact on nonmetric trait expression.

Results

Of the 23 traits analyzed, seven traits were found to have a meaningful level of change in both males and females; an additional four traits were found to have a meaningful change in only males or females. The most notable shift in frequency expression for the majority of traits occurred at or around the turn of the twentieth century. Age-at-death was not found to affect expression in any of the traits. Results for the 11 statistically significant traits are shown by correspondence analysis factor maps (Figures 1-8) and frequency distribution tables (Tables 2-4).

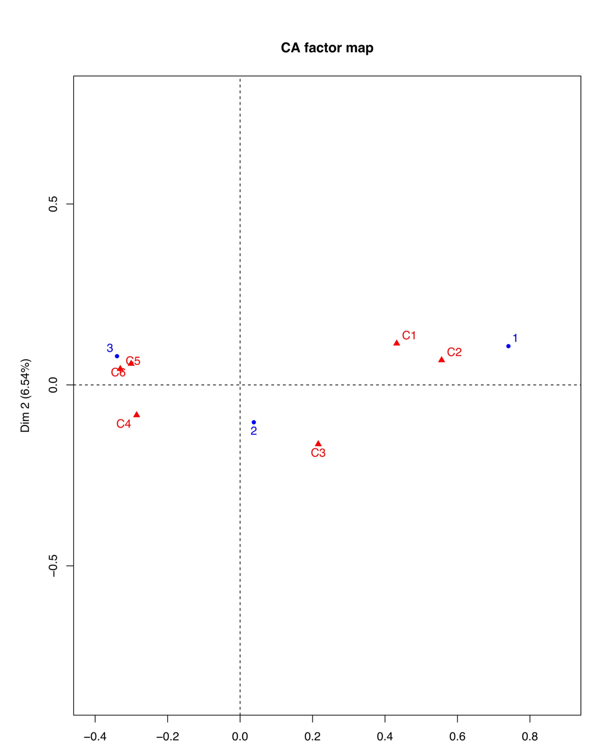

Figure 1. Anterior Nasal Spine – Males and Females.

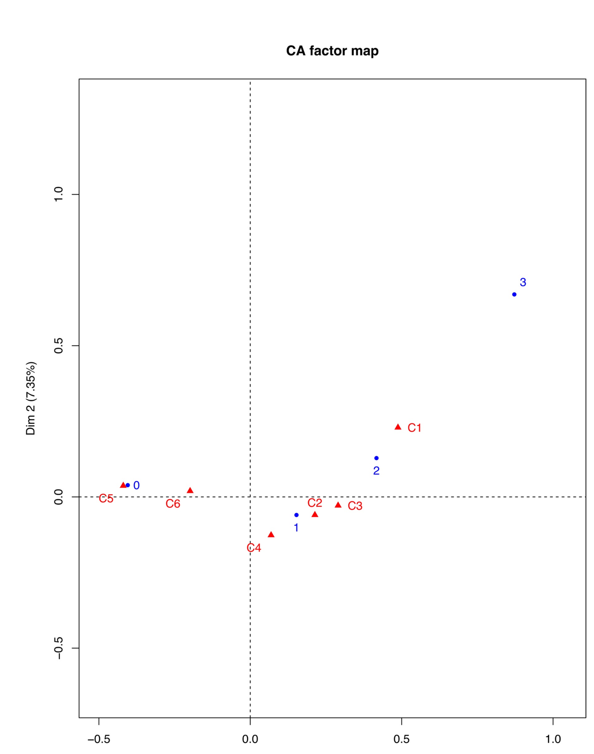

Figure 2. Malar Tubercle – Males and Females.

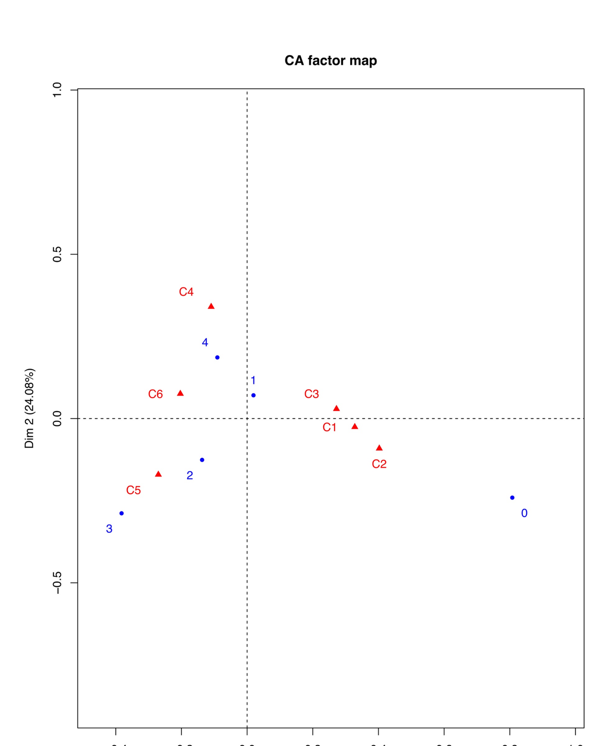

Figure 3. Nasal Bone Contour – Females Only.

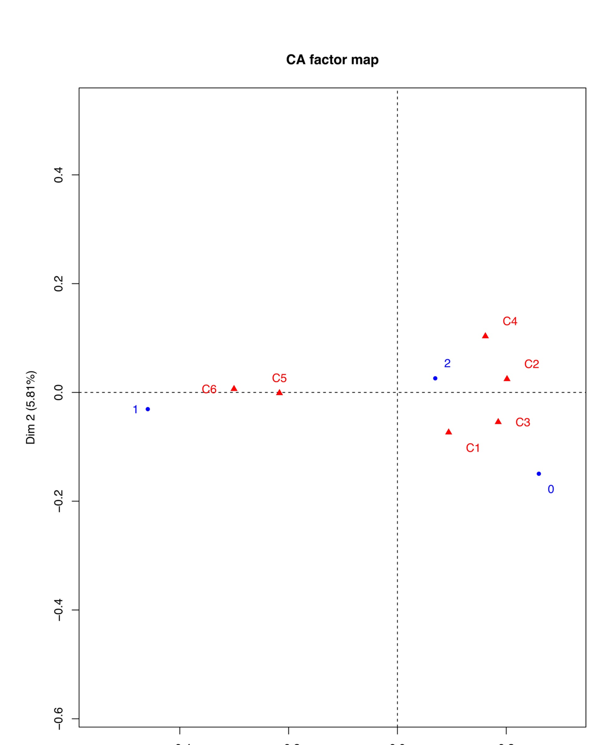

Figure 4. Supranasal Suture – Males Only.

Table 2. Postbregmatic Depression – Females Only.

	Cohort 1 (1824-1849)		Cohort 2 (1850-1874)		Cohort 3 (1875--1899)		Cohort 4 (1900-1924)		Cohort 5 (1925-1949)		Cohort 6 (1950-1987)	
Score	n	%	n	%	n	%	n	%	n	%	n	%
0	11	55.0	65	76.5	62	64.6	39	62.9	90	71.4	81	82.7
1	9	45.0	20	23.5	34	35.4	23	37.1	36	28.6	17	17.3
χ^2 = 14.17459 df = 5 p = 0.01453763												

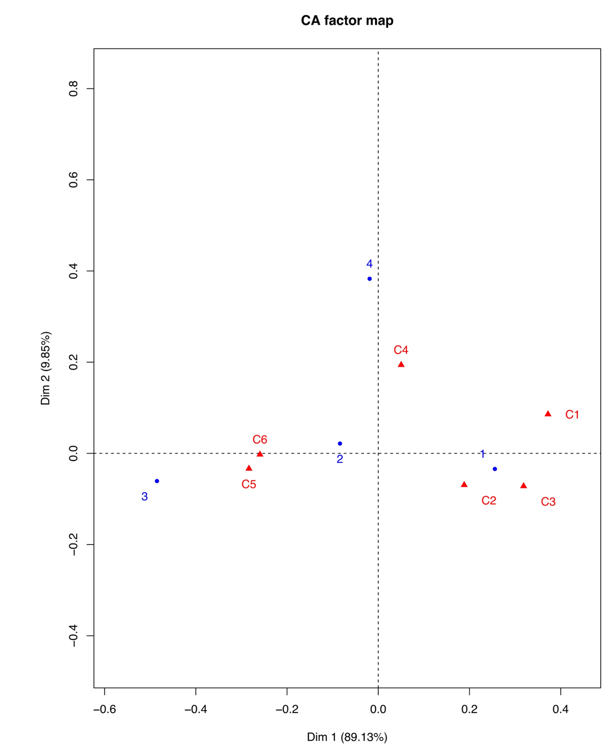

Figure 5. Transverse Palatine Suture – Males and Females.

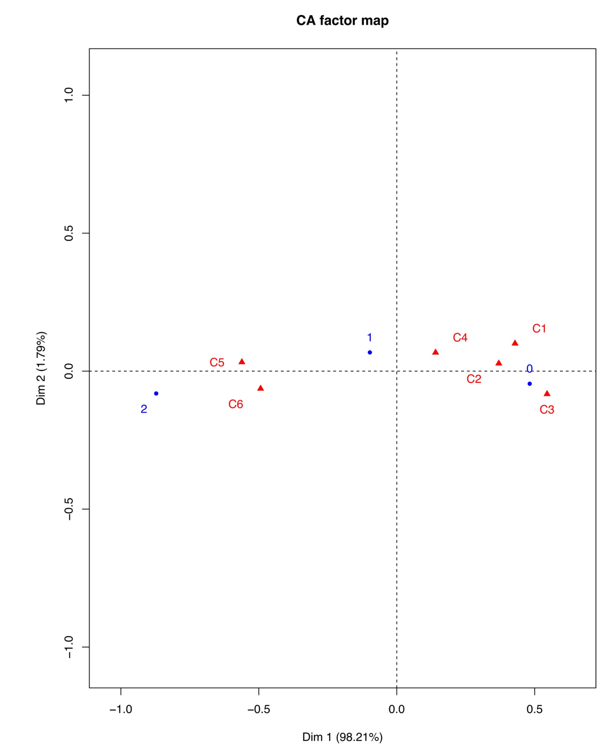

Figure 6. Zygomaticomaxillary Suture Shape – Males and Females.

Table 3. Ascending Ramus Shape – Males Only.

	Cohort 1 (1824-1849)		Cohort 2 (1850-1874)		Cohort 3 (1875--1899)		Cohort 4 (1900-1924)		Cohort 5 (1925-1949)		Cohort 6 (1950-1987)	
Score	n	%	n	%	n	%	n	%	n	%	n	%
1	60	87.0	81	88.0	92	92.0	56	70.0	73	73.7	68	66.0
2	9	13.0	11	12.0	8	8.0	24	30.0	26	26.3	35	34.0
χ^2 = 33.58671 df = 5 p = 2.877357e-6												

Table 4. Mandibular Tori – Males and Females.

	Cohort 1 (1824-1849)		Cohort 2 (1850-1874)		Cohort 3 (1875--1899)		Cohort 4 (1900-1924)		Cohort 5 (1925-1949)		Cohort 6 (1950-1987)	
Score	n	%	n	%	n	%	n	%	n	%	n	%
0	85	95.5	168	96.0	186	94.4	120	84.5	167	83.9	141	71.2
1	4	4.5	7	4.0	11	5.6	22	15.5	32	16.1	57	28.8
χ^2 = 72.39777 df = 5 p = 3.24564e-14												

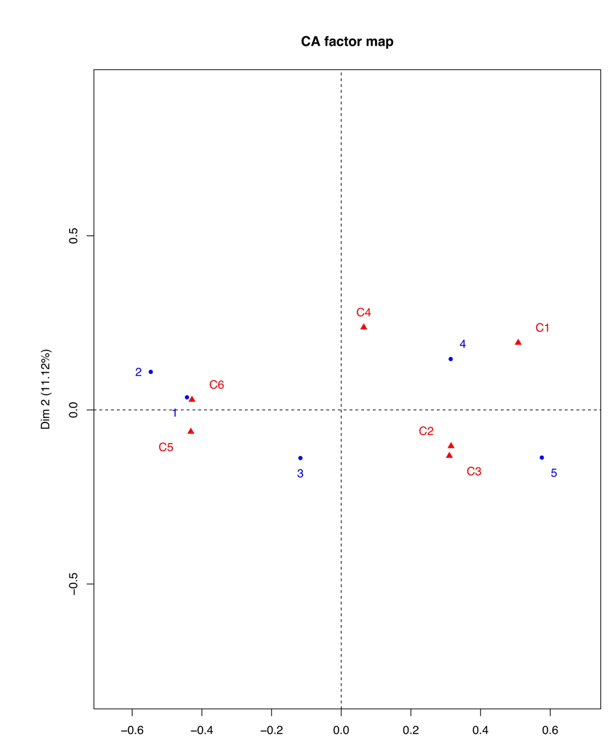

Figure 7. Gonial Angle Flare – Males and Females.

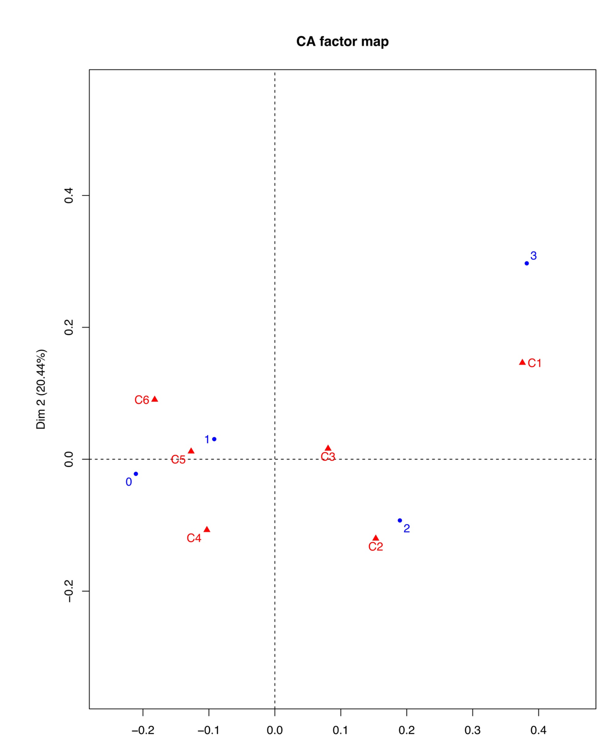

Figure 8. Posterior Ramus Edge Inversion – Males and Females.

Discussion and Conclusion

The results of this research demonstrate that statistically significant secular change between the early 1800s and late 1900s is occurring. In bony features such as the malar tubercle, gonial angle flare, and posterior ramus edge inversion (all muscle attachment sites), there is a decrease in the level of trait expression over time, suggesting a change in masticatory patterns. In contrast, the expression of traits such as the anterior nasal spine and nasal bone contour (in females) have increased in size and morphological expression. Sutural traits such as the transverse palatine suture and zygomaticomaxillary suture have substantially increased in complexity in modern individuals which may be a result of changing growth patterns. Finally, the increase in prevalence of mandibular tori is consistent with the results of previous studies where it has been suggested that increased mandibular tori may be a consequence of occlusal stress, superficial injury, vitamin deficiency, and overall diet (García-García *et al*. 2010).

Secular changes in nonmetric trait expression correlate with the results of previous studies in cranial and mandibular metric analyses (Jantz 2001; Jantz and Meadows Jantz 2000; Martin and Danforth 2009). Previous research has suggested that changing environmental variables including changes in nutrition, medical care, and living standards have influenced gene plasticity and are likely contributing factors in shifting morphological trait expression (Jantz and Meadows Jantz 2000, 2016). Increased heterozygosity due to increasing admixture and the radical drop in infant mortality have also been suggested as factors influencing changing skeletal variation (Jantz 2001; Schmidt *et al*. 1995).

The present research demonstrates that statistically significant secular change in morphological traits has occurred over a relatively short period of time. No traits were affected by age-at-death; however, some were affected by sex. Thus, morphological traits should be cautiously employed in ancestry estimation, and individuals from historic collections should be avoided in method development. Continued research is important to further explore the effects of secular change on the applicability of current methods; specifically, investigations into the effects of secular change in additional populations are necessary, along with comparisons of the patterns between populations.

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