Variation Among Early North American Crania

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ABSTRACT   The limited morphometric work on early American crania to date has treated them as a single, temporally defined group. This paper addresses the question of whether there is significant variability among ancient American crania. A sample of 11 crania (Spirit Cave, Wizards Beach, Browns Valley, Pelican Rapids, Prospect, Wet Gravel male, Wet Gravel female, Medicine Crow, Turin, Lime Creek, and Swanson Lake) dating from the early to mid Holocene was available. Some have recent accelerator mass spectrometry (AMS) dates, while others are dated geologically or archaeologically. All are in excess of 4500 BP, and most are 7000 BP or older. Measurements follow the definitions of Howells [(1973) Cranial variation in man, Cambridge: Harvard University]. Some crania are incomplete, but 22 measurements were common to all fossils. Cranial variation was examined by calculating the Mahalanobis distance between each pair of fossils, using a pooled within sample covariance matrix estimated from the data of Howells. The distance relationships among crania suggest the presence of at least three distinct groups: 1) a middle Archaic Plains group (Turin and Medicine Crow), 2) a Paleo/Early Archaic Great Lakes/Plains group (Browns Valley, Pelican Rapids, Lime Creek), and 3) a spatially and temporally heterogeneous group that includes the Great Basin/Pacific Coast (Spirit Cave, Wizards Beach, Prospect) and Nebraska (Wet Gravel specimens and Swanson Lake).

These crania were also compared to Howells' worldwide recent sample, which was expanded by including six additional American Indian samples. None of the fossils, except for the Wet Gravel male, shows any particular affinity to recent Native Americans; their greatest similarities are with Europe, Polynesia, or East Asia. Several crania would be atypical in any recent population for which we have data. Browns Valley, Pelican Rapids, and Lime Creek are the most distinctive. They provide evidence for the presence of an early population that bears no similarity to the morphometric pattern of recent American Indians or even to crania of comparable date in other regions of the continent.

The heterogeneity among early American crania makes it inadvisable to pool them for purposes of morphometric analysis. Whether this heterogeneity results from different early migrations or one highly differentiated population cannot be established from our data. Our results are inconsistent with hypotheses of an ancestor-descendent relationship between early and late Holocene American populations. They suggest that the pattern of cranial variation is of recent origin, at least in the Plains region. Am J Phys Anthropol 114:146–155, 2001.   © 2001 Wiley-Liss, Inc.

Native North American populations have variously been viewed as biologically uniform, or extremely diverse. Stewart (1973) emphasized the phenotypic uniformity, while Hooton (1930) saw Caucasoid, Melanesoid, and Negritoid "types" in the American population. Recent work with classical markers (Cavalli-Sforza et al., 1994), dentition (Haydenblit, 1996), and anthropometry (Ousley, 1995) has demonstrated that modern native populations are strongly differentiated. It is obviously important to understand the extent and patterning of variation among New World populations, since this context of diversity is the framework against which models for the peopling of the New World must be tested.

A puzzling aspect of the discussion concerning the origin and history of New World populations is how little the study of ancient crania has contributed. This lack of emphasis is in large part due to the influence of Hrdlicka (1937a,b), who repeatedly attempted to show that the morphology of supposed early American crania fell within the range of variation of recent Indians, and could not be distinguished from them (Owsley and Jantz, 1999a). Fortunately, a renewed interest in the crania of early Americans has occurred, using a modern analytical framework based on multivariate statistics. Initial studies have shown that the craniometric pattern departs from contemporary American Indians, often in the direction of European or Southern Pacific

TABLE 1. Early American crania used in this study

Specimen	Sex	Location	Date	Reference (date; description)
Spirit Cave	M	Nevada	9,415 BP	Dansie, 1997; Jantz and Owsley, 1997
Wizards Beach	M	Nevada	9,225 BP	Dansie, 1997; Owsley and Jantz, 1999b
Prospect	M	Oregon	7,000 BP	Cressman, 1940
Wet Gravel	F	Nebraska		Frankforter, 1950; Key, 1983
Wet Gravel	M	Nebraska		Frankforter, 1950; Key, 1983
Browns Valley	M	Minnesota	8,900 BP	Myster and O'Connell, 1997; Jenks, 1937
Pelican Rapids	F	Minnesota	7,840 BP	Myster and O'Connell, 1997; Jenks, 1936
Medicine Crow	M	S. Dakota	5,500 BP	Bass, 1976; Key, 1983
Turin	M	Iowa	4,720 BP	Fisher et al., 1985
Lime Creek	M	Nebraska		Key, 1983
Swanson Lake	M	Nebraska		Key, 1983

groups (Steele and Powell, 1992, 1994), or even Africans and Australians (Neves and Pucciarelli, 1991; Neves et al., 1996).

What has not yet been approached in a systematic manner is variation among Paleoamerican fossils. This issue is difficult to address, because the samples are individual specimens, and standard statistical approaches designed to assess variation among samples are inappropriate. This paper addresses that issue as a preliminary step toward understanding whether the early New World populations were differentiated. If early populations are relatively homogeneous, it places a time constraint on the variation observed in present populations and forces us to consider later events for causation. On the other hand, if the early populations were strongly differentiated, then the question becomes one of how the ancient diversity relates to recent diversity, and whether continuity with recent populations can be established.

MATERIALS AND METHODS

Crania

Ancient crania available for this analysis are shown in Table 1. The sample includes those early crania that have been measured using the measurement protocol of Howells (1973) (see Measurements, below). The date range includes specimens that are considered by most archaeologists to be marginally "Paleoamerican," or definitely within the Early Archaic period. We did not require that chronometric dates be firmly established, only that the skull falls into the early Holocene, not later than 4500 BP. Several specimens have recent accelerator mass spectrometry (AMS) dates and are accurately dated (Turin, Spirit Cave, Wizards Beach, Browns Valley, and Pelican Rapids). Others have attributed geological dates, such as the Wet Gravel specimens which were pumped out of a gravel pit. Although direct stratigraphic context is missing, both have a dark stain imparted by a peat layer, a taphonomic feature shared with Pleistocene fauna from the pit that provides evidence for temporal association (Frankforter, 1950). The Wet Gravel female is especially dark and mineralized, while the male is less so, suggesting that it might be more recent. The Prospect burial was stratigraphically positioned below ash from the

Mount Mazama eruption around 7000 BP (Cressman, 1940). Dates for the remaining crania are primarily stratigraphic or archaeological and therefore imprecise, but nonetheless are likely to be early.

Fossil crania were compared to the world database by Howells (1989) of recent crania. The Howells samples are mainly from historic populations, and all are post-Neolithic. Only three of Howells' 28 samples are Native Americans (Arikara, Santa Cruz, and Peru). We have therefore supplemented the Native American samples with six historic samples of our own: Blackfoot (n = 66), Cheyenne (n = 22), Omaha (n = 16), Pawnee (n = 27), Ponca (n = 19), and Sioux(n = 28).

Measurements

The general availability of the worldwide cranial database of Howells (1973, 1989) has encouraged others to record measurements in the same format. We have followed an expanded version of this protocol for years (Key, 1983), producing an extensive North American database fully compatible with that of Howells. Complete measurement sets cannot be obtained on all crania listed in Table 1. All crania except Browns Valley were complete or nearly complete and undistorted. The major reconstruction required of Browns Valley is attachment of the face, but the base is unreconstructable. The reconstruction by Jenks (1937) of the base is unreliable, as he himself points out. However, Howells' measurements contain considerable redundancy, and it is possible to exclude certain variables and still accurately quantify morphology. Radii are particularly useful in this regard, since they parallel standard measurements taken from basion. Nasion and bregma radii, for example, are comparable to basion-nasion length and basion-bregma height, respectively, except that they are taken from the transmeatal axis rather than basion. In addition, radii quantify lateral facial projections of the upper and mid-face, which are missed in traditional measurement sets.

The resulting analysis is based on 22 measurements (Table 2). The designated measurement set quantifies overall length, breadth, facial variation, projections from the transmeatal axis (radii), and facial projections. Excluded were measurements

TABLE 2. List of common measurements

GOL, glabello-occipital length	NAS, nasion subtense
XCB, maximum cranial breadth	FRC, frontal chord
XFB, maximum frontal breadth	FRS, frontal subtense
AUB, auricular breadth	PAC, parietal chord
NPH, nasion-prosthion height	PAS, parietal subtense
NLH, nasal height	NAR, nasion radius
NLB, nasal breadth	PRR, prosthion radius
OBH, orbit height	FMR, frontomalare radius
OBB, orbit breadth	EKR, ectochonchion radius
DKB, interorbital breadth	ZMR, zygomaxillare radius
FMB, bifrontal breadth	VRR, vertex radius

missing on any one of the fossil crania, fraction measurements designed principally to calculate angles, and difficult measurements possibly subject to error or generally uninformative (for rationale, see Jantz and Owsley, 1997).

The specimens in Table 1 were measured in the same system by three observers. Swanson Lake, Lime Creek, Medicine Crow, and the Wet Gravel specimens were measured by Key (1983); Browns Valley and Pelican Rapids were measured by D. Hunt; and Turin, Spirit Cave, Wizards Beach, and Prospect were measured by R. Jantz. All of us learned Howells' system by reading his excellent definitions (Howells, 1973) and refining the technique by training on crania that had previously been measured by Howells. Crania from the Sully site in South Dakota comprised the principal training series, since they were housed at the University of Tennessee until recently, and constitute one of the three Native American series used by Howells in his various morphometric studies. Although we have not conducted a formal interobserver variation analysis, we are confident that it contributes little to variation among crania.

Measurements for Spirit Cave, Wizards Beach, Browns Valley, and Pelican Rapids can be found in Owsley and Jantz (1999b). Our measurements for the other crania are as yet unpublished. The descriptions of Turin (Fisher et al., 1985) and Medicine Crow (Bass, 1976) contain some measurements of those specimens.

Statistical methods

Fossil crania present a number of problems that make classical statistical approaches impractical. Each cranium in Table 1 must be considered as having been drawn from a different population, with each group represented by a sample of one. It is therefore not possible to estimate variances and covariances for use in standard distance and canonical analyses. Several different approaches have been employed with fossil material: 1) crania from similar time periods have been pooled to make a temporally bounded sample (e.g., Key, 1983; Steele and Powell, 1992, 1994); 2) individual crania have been compared to recent samples (e.g., Howells, 1995); and 3) fossil crania have been compared to one another using a covariance matrix from a large sample of recent crania (e.g., Van Vark, 1995). The first approach does not allow examination of variation among crania. If crania come from populations with substantial metric differences, pooling yields an unrealistic average configuration. The second approach is useful in examining whether crania resemble recent populations and, if so, which ones. These comparisons allow historical links between fossils and extant populations to be hypothesized, but say little about relationships among fossils. The last approach allows relationships among fossils to be examined, which addresses the question of how differentiated the fossil crania are and whether subpopulations might be recognized. It requires the assumption that a covariance matrix obtained from recent people applies to fossils. This assumption, although not testable, is reasonable, at least when applied to Holocene epoch remains.

In this analysis, the second and third approaches are used. The second approach is well-known in the classification literature, where an unknown is classified into the group to which it shows the smallest Mahalanobis distance. Most statistical package programs assume that an unknown belongs to one of the reference populations, and the probability that it falls into each one of the reference groups is given as the posterior probability. Mahalanobis D^2 has another important property, namely, to indicate where a given specimen falls in relation to the variability of the reference groups. This construct yields what has been termed the "typicality probability" (Albrecht, 1992). For applications such as the present one, this is more useful than the posterior probability, because it is obvious that no early American skull derives from a contemporary population, regardless of how similar it may be.

Mahalanobis D^2 between a skull and a sample is calculated by:

$$D^2 = (X - X_j)' \quad W^{-1} \quad (X - X_j)$$

where X is the vector of measurements for a skull, X_j is the mean vector for population j, and W is the pooled within-sample covariance matrix. D^2 can be referred to a chi-square table with p (number of variables) degrees of freedom to obtain the typicality probability (Albrecht, 1992). Mahalanobis D^2 between pairs of fossils can be obtained in the same way:

$$D_{ij}^2 = (X_i - X_j)' \quad W^{-1} \quad (X_i - X_j),$$

where X_i and X_j are the measurement vectors for fossils i and j, and W is an appropriate covariance matrix. However, the question of what constitutes an appropriate covariance matrix is problematic. Ideally, the covariance matrix should reflect variation within groups with a genetic structure similar to that of populations from which the fossil crania were drawn. In most cases we do not know what that population structure was, and it would probably be difficult to find parallels in recent populations in any case. The best solution is to take a conservative approach, using the pooled within-group covariance

TABLE 3. *Mahalanobis distances (D) between early American fossil crania*[1]

	Turin	Prospect	Wizard	Spirit	Pelican	Brown	MedCr	Swan	WGravF	WGravM
Prospect	7.644									
Wizard	6.128	5.633								
Spirit	7.837	6.401	5.040							
Pelican	8.546*	7.956	7.471	6.387						
Browns	9.397*	8.514*	8.174	7.342	6.443					
MedCrow	6.627	8.013	6.503	8.806*	8.196*	8.525*				
Swanson	7.951	8.448*	6.134	6.125	8.463*	8.689*	7.200			
WetGravF	7.141	5.942	4.960	5.941	8.463*	8.430*	7.396	5.851		
WetGravM	7.247	7.262	6.204	6.360	7.981	7.958	7.702	7.873	6.847	
LimeCr	8.977*	7.590	6.779	6.863	6.956	5.529	8.685*	7.811	7.228	8.790*

[1] Refer to Table 1 for full names and sex of fossil crania.
* $P < 0.05$.

matrix derived from the 34 recent populations used for comparison.

Defrise-Gussenhoven (1967) showed that the D between pairs of individuals drawn randomly from a population will be distributed as $\sqrt{(2p - 1)}$ with a variance of 1, where p is the number of dimensions. In the present instance $p = 22$, so the random expectation for the D between any two crania drawn from the same population is $\sqrt{(2 \cdot 22 - 1)} = 6.56$. This random expectation is used to test whether the distance between pairs of fossil crania is greater than would be expected if they were drawn from a single population.

Sexes were pooled by first centering the reference samples on sex-specific means. Fossil crania were then expressed as deviations from appropriate sex means. All computations were performed using software written by R.L.J.

RESULTS
Relationships among fossils

Table 3 presents the matrix of Mahalanobis distances (D) between each pair of crania. Since the random expectation is 6.56, any distance greater than 1.65 standard deviations above this value can be considered significant by a one-tailed test. There are 55 pairwise distances between 11 crania, 14 of which are significant at the 0.05 level or below. The significant differences are clearly patterned: 5 of the 14 involve differences between Browns Valley and other crania, and another 4 involve Pelican Rapids and other crania. The concentration of significant differences in these two crania marks them as the most distinctive. The Lime Creek and Swanson Lake crania account for the remaining significant differences.

Of greater interest is the general pattern of relationships shown by these crania. A principal coordinates plot of the distances is shown in Figure 1. The crania fall into three groups: 1) Browns Valley, Pelican Rapids, and Lime Creek are extreme on the first axis; 2) Turin and Medicine Crow are on the opposite end of axis one and are separated on the second axis; and 3) the remaining crania, consisting of the Wet Gravel specimens, Swanson Lake, Prospect, Wizards Beach, and Spirit Cave, comprise a

more centrally located cluster. Spirit Cave is somewhat removed from this cluster in the direction of the Browns Valley-Pelican Rapids-Lime Creek group on axis one, but is extreme on axis two. The Wet Gravel male departs from the central cluster in the direction of Turin and Medicine Crow.

These visually defined clusters vary in temporal and geographic cohesiveness. Medicine Crow and Turin represent Plains Archaic crania. Browns Valley, Pelican Rapids, and Lime Creek represent a Minnesota-Nebraska group. Temporally this group is earlier than the Plains Archaic, assuming that the suspected early date for Lime Creek is confirmed. The last and largest cluster contains crania from the Plains, Great Basin, and Northwest. All dated crania in this cluster are older than 7000 BP.

Relationships to recent groups

Table 4 provides the distance and typicality probability between each fossil skull and the five recent groups to which it is most similar. They are presented in order of increasing distance from recent groups. Several points are noteworthy. The first six fossils (Wet Gravel male, Turin, Wet Gravel female, Wizards Beach, Prospect, and Medicine Crow) fall easily within the range of variation of recent groups. The pattern of similarity to world groups is variable. The two Plains Archaic crania, Turin and Medicine Crow, show no particular resemblance to recent Native Americans, and certainly not to those of the Plains. Medicine Crow has no American Indian sample among its five most similar groups. Two non-Plains American Indian groups appear as Turin's third and fourth most similar groups. The only cranium with five American Indian groups as its nearest neighbors is the Wet Gravel male, while the Wet Gravel female has none.

The last five crania would be reluctant members of any recent group. Swanson Lake and Spirit Cave fall on the margins of some recent distributions, but Pelican Rapids, Lime Creek, and Browns Valley, all with extremely low typicality probabilities, would be highly atypical crania in any recent group used here.

In general, the 11 fossil crania do not show any particular affinity for the nine Historic period Native American samples for which we have data.
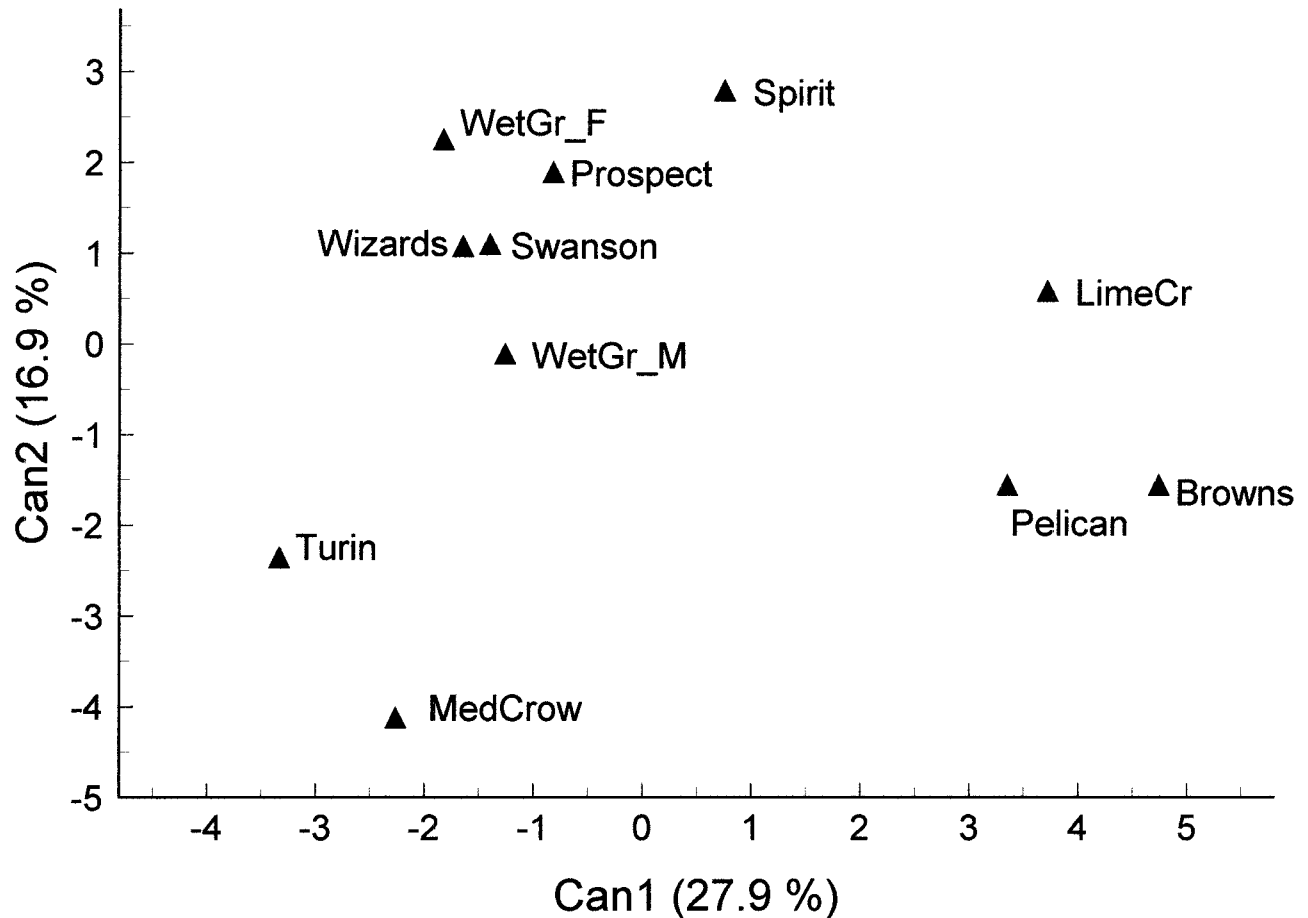
Fig. 1. Principal coordinates plot of distances among eleven Paleo and Early Archaic crania from North America.

These nine American Indian samples represent 26.5% of the 34 recent samples used, more than from any other geographical region. Only two fossils fall closest to a Native American sample, with the random expectation being about three. Taking all five nearest groups for each fossil, 19 of 55 (34.5%) are American Indians, which is slightly higher than the random expectation of 15.

Figure 2 shows the principal coordinates plot of the recent groups with the fossils. This plot was constructed from the distances among all groups and the fossils, allowing the fossils to help define the axes, as recommended by Albrecht (1992). It clearly shows the separation of Browns Valley, Pelican Rapids, and Lime Creek from all recent populations on the first axis. Spirit Cave assumes an intermediate position. These fossils also have low scores on the second axis, particularly Lime Creek and Swanson Lake. This second axis serves to separate recent Plains populations and Siberia from those of Africa and Australasia, as well as from Lime Creek and Swanson Lake. All other fossils fall closer to or within the cluster of recent populations.

Browns Valley, Pelican Rapids, Lime Creek, and, to a lesser extent, Spirit Cave are differentiated on the first axis by the combination of a wide vault base, narrow nose, flat frontal bone, and upper facial forwardness. The Browns Valley cranium was characterized in much the same way by Jenks (1937). The second axis stresses the narrow vault, short face, and long parietals of these fossils, particularly Lime Creek and Swanson Lake, as opposed to the wide, short vaults and high faces of recent Plains groups.

DISCUSSION

This analysis includes five crania that are likely early, but require dating. Until precise dates are available and additional skeletons studied, it is impossible to fully assess their meaning. All of them came into collections prior to the availability of radiometric techniques. Likely there are additional skeletons in existing collections that are quite ancient. Unfortunately, just at the very time when dating technology using small samples is available, some institutions and federal agencies are resisting even minimally invasive chemical or physical analyses. This restriction impedes understanding of early American population biology.

In spite of this limitation, our results allow observations that deserve emphasis and have implications for the early peopling of the New World. The most significant finding concerns evidence for what may be a late Pleistocene/Early Holocene population

TABLE 4. Squared distances (D^2) and typicality probabilities of each cranium relative to the five closest modern groups[1]

Specimens[2]					
West Gravel Male	Blackfoot	Arikara	Sioux	Pawnee	Ponca
	15.764	21.215	21.237	23.724	25.309
	0.827	0.507	0.506	0.362	0.283
Turin	Egypt	Norse	Peru	Santa Cr	Tasman
	16.014	16.604	18.905	22.060	27.008
	0.825	0.785	0.651	0.456	0.211
West Gravel Female	Hainan	S. Japan	Anyang	N. Japan	Tolai
	16.737	19.346	20.668	21.129	21.547
	0.778	0.624	0.541	0.513	0.487
Wizard	Norse	Peru	Santa Cruz	Sioux	Blackfoot
	17.182	17.346	19.036	19.164	20.041
	0.753	0.744	0.643	0.635	0.581
Prospect	Berg	Sioux	Arikara	Pawnee	Ainu
	21.259	21.845	22.244	22.308	22.805
	0.505	0.469	0.445	0.442	0.413
Medicine Crow	N. Japan	Ainu	Moriori	Philipp	Mokapu
	24.316	25.731	25.805	26.385	27.246
	0.331	0.263	0.260	0.236	0.202
Swanson	Santa Cruz	S. Japan	Tolai	N. Japan	Ainu
	31.089	33.491	34.003	35.519	35.577
	0.094	0.055	0.049	0.034	0.034
Spirit	Norse	Blackfoot	Peru	Zalavar	Ainu
	32.581	33.718	34.278	34.852	35.836
	0.068	0.052	0.046	0.041	0.032
Pelican	Moriori	Norse	Ainu	Pawnee	S. Japan
	46.777	47.699	48.038	49.714	49.759
	0.002	0.001	0.001	0.001	0.001
Lime Creek	N. Japan	S. Japan	Eskimo	Ainu	Norse
	48.740	50.050	52.423	52.617	53.280
	0.001	0.001	0.000	0.000	0.000
Browns	Moriori	Mokapu	Arikara	Easter Island	Pawnee
	51.767	53.377	54.973	56.814	60.805
	0.000	0.000	0.000	0.000	0.000

[1] Specimens are listed in the order of increasing distance.
[2] For the names and sex of the early American crania (in the left column), refer to Table 1. For the others, see Howells (1973).

that was quite differentiated from other early specimens and from recent populations. Evidence for this population's existence is seen in the Minnesota specimens and possibly Lime Creek as well. Since this population existed far from any point of entry into the New World, it can be argued that it represents a group entering the continent before the ancestors of recent American Indians. Just how early depends upon how we model the spread of early immigrants and upon obtaining additional dates, especially for Lime Creek. If the assessment by Howells (1938) of the Torrington crania is correct, an Archaic period population with similar features persisted in the region until the last millennium (Agogino and Galloway, 1963). Whether their differentiation from other ancient crania can be taken as evidence of their descending from different migrants, or whether they are simply part of an extremely variable early population, cannot be addressed without better dates and larger samples.

Our identification of the morphological uniqueness of the Minnesota specimens is at odds with all post-Hrdlicka assessments of these fossils (e.g., Smith, 1976; Owsley and Jantz, 1999a). The extensive study by Jenks (1936) of the Pelican Rapids skull concluded that it possessed a number of primitive features not found in recent populations, or occurred only in low frequency. Hrdlicka (1937a) responded with an extensive trait by trait compari-

son, attempting to show that the Pelican Rapids skull fell within the range of variation of recent Sioux. That sentiment has prevailed until recently in the few post-Hrdlicka assessments of early American crania. Even Jenks (1937) suggested that the morphology of the Browns Valley cranium was, apart from certain primitive features, clearly American Indian.

Recent analyses of North American (Steele and Powell, 1992, 1994; Powell and Rose, 1999) and South American crania (Neves and Pucciarelli, 1991; Neves et al., 1996) consistently show that early American crania are differentiated from recent Native Americans, although these studies have not indicated the distinct nature of the Minnesota crania. Like Steele and Powell (1992), we could argue that there is a southern Pacific or European similarity to some of these crania. Unlike the South American situation, there does not seem to be any particular resemblance to southwest Pacific or African populations. The closest example would be the Swanson Lake cranium, which exhibits features such as alveolar prognathism, a wide nasal aperture and interorbital space, guttered nasal sills, and a short upper facial height, features often associated with African and southwest Pacific populations. Swanson Lake plots closer to these two regional populations than any other cranium in two-dimensional space (Fig. 2), but the overall morphometric
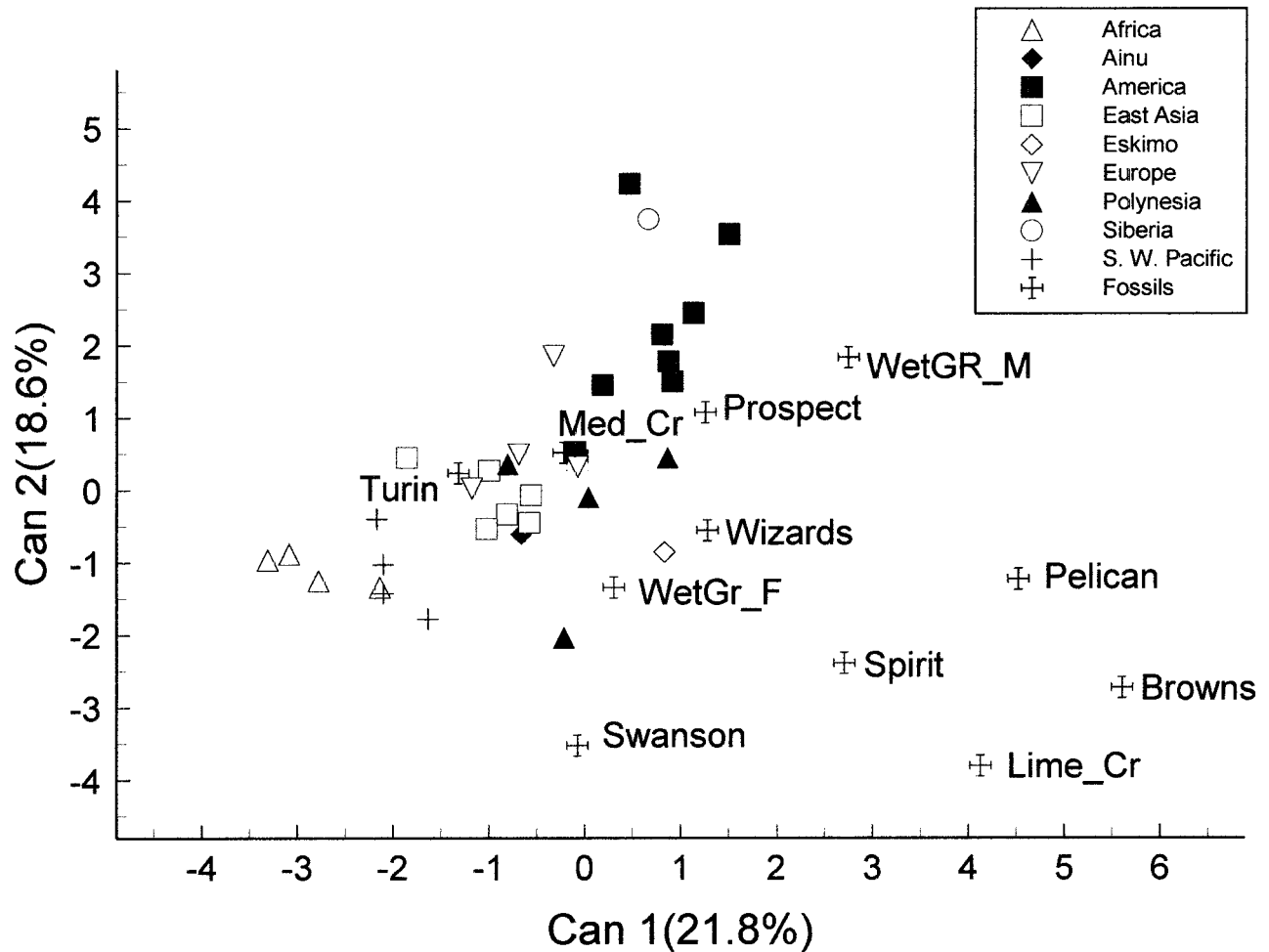
Fig. 2. Canonical plot of world populations and early American fossil crania.

configuration includes only the Tolai of New Britain as one of its five nearest groups.

It is to be expected that the populations from which these crania were drawn would be differentiated, since they are spatially and temporally distinct. What is surprising is that this differentiation can be demonstrated with individual crania. Obviously samples consisting of individual crania are not as powerful as larger samples in demonstrating variation. That, in turn, suggests that the degree of differentiation is substantial, although we have not yet attempted to assess its magnitude. The heterogeneity of early American crania points to the inadvisability of pooling them into a single Paleo sample for purposes of analysis. It is necessary to understand variation among Paleo samples in order to relate cranial variation to models of the peopling of the Americas.

The heterogeneity observed among the fossil crania in this study is not unique. Van Vark (1994) demonstrated that European Upper Paleolithic crania are more variable than recent Europeans and even more variable than crania for the entire world. In Asia, Upper Cave 101 and 103, apparently from different levels in the cave (Howells, 1983), exhibit

far greater difference than would be expected from a single population (Cornell, 1998). Whether the high degree of variation in Europe or Asia is due to fragmented population structure or other processes such as migration cannot now be specified.

High variability among early American fossil crania may not by itself provide evidence of multiple migrations, but it is consistent with an emerging consensus that different populations were involved in the early peopling of North America. MtDNA evidence, often seen as supporting a single migration (e.g., Merriweather et al., 1995; Stone and Stoneking, 1998), may also be interpreted as supporting multiple migrations (Schurr et al., 1999; Schurr and Wallace, 1999). MtDNA haplogroup X, now recognized as one of the founding New World haplogroups, suggests ancient connections with Europe (Brown et al., 1998; Schurr and Wallace, 1999; Smith et al., 1999), as does lithic point technology (Stanford and Bradley, 2000). Haplogroup B is distributed in Asia and America in a way that suggests it may have arrived via a coastal route.

There is growing realization that the pattern of cranial morphology seen in most regions of the world is relatively recent (Sarich, 1997). The limited avail-

able evidence suggests that early Asians such as the Upper Cave specimens and Liujiang from China (Howells, 1995; Kamminga and Wright, 1988), and the Gua Gunung specimen from Malaysia (Matsumura and Zuraina, 1999), are not very similar to recent Asians. Gua Gunung has been judged Australian-like (Matsumura and Zuraina, 1999), and recent morphometric analyses of Upper Cave have argued that they are unlikely ancestors for recent Chinese (Van Vark and Dijkema, 1988; Kamminga and Wright, 1988; Cornell, 1998). Recent agricultural expansions have probably erased much of the earlier variation present in these regions. The Neolithic expansions and later migrations in Europe are well-known and are widely considered to be responsible for the recent pattern of genetic variation and cranial variation (Sokal and Uytterschaut, 1987; Barbujani et al., 1995). In East Asia, expansion of rice agriculturists had a similar effect. Van Vark and Dijkema (1988) see Neolithic replacement of the Upper Cave peoples as the most reasonable explanation of the morphometric difference. Schurr et al. (1999) see Neolithic expansion in Siberia as the most likely explanation of mtDNA haplotype distribution.

When cranial morphology in the Americas achieved its modern form is a question that has yet to be systematically investigated. It has frequently been observed that the earliest immigrants came prior to the emergence in Asia of the derived cranial morphology often termed "Mongoloid" (Angel, 1966; Lahr, 1995; Neves and Puciarelli, 1991; Soto-Heim, 1994; Steele and Powell, 1992, 1999) In our results, several crania exhibit metric profiles that fall easily within the range of variation of recent Native Americans: Wizards Beach, Prospect, Wet Gravel male, and Turin. Wizards Beach and Prospect are located in the West, where the recent form might be expected to appear earliest. The significance of the Wet Gravel male is difficult to assess in the absence of a firm date. Turin, along with Medicine Crow, are the latest, yet exhibit no close affiliation with any recent Plains group. This is slender evidence, but argues that cranial morphology typical of recent tribes in the Plains had not yet appeared by early to mid Archaic times.

Other crania, excluded from the present study because they were too incomplete or data were unavailable, also illustrate the difference between Plains Archaic period crania and recent tribes. Lovvorn et al. (1999) reported on an Archaic burial with an incomplete cranium from Sidney, Nebraska (C^{14} date, 4450–4170 BP). They demonstrated that the cranium is atypical of any historic Plains tribe. Their analysis using Fordisc 2.0 (Ousley and Jantz, 1996) places it most similar to Eskimo; it is extremely long and high headed. Our own analysis assigns it to Tasmania, a choice Lovvorn et al. (1996) apparently disallowed. The Lansing cranium, placed at 5000–6000 BP by conventional radiocarbon dates (Bass, 1973), was pronounced by Hrdlicka (1903) to show no differences from recent groups in the re-

gion. It is, however, long, narrow, and high, and atypical of any recent Plains group.

Many regions of North America are known to have experienced recent incursions. In the Plains, Caddoan speakers expanded northward, displacing the resident Siouan speakers, and Athapascans moved southward. The latter are thought to have had a large impact on the morphological character of Plains tribes (Neumann, 1969; Ossenberg, 1994), seen most dramatically in the lowering of vault height (Jantz and Willey, 1983). The metric similarity of Plains groups with Siberians (Brennan and Howells, 1976) provides evidence of recent expansions out of Asia. The one Siberian sample in the present data set, the Buriat, has its lowest distances with Omaha, Pawnee, Ponca, Arikara, and Sioux, respectively, rather than with Chinese or Japanese. Alu insertions (Novick et al., 1998; see also the microsatellite data of Chu et al., 1998) support the close relationship between recent Amerindians and East Asians. The most parsimonious explanation of these morphological and genetic relationships is that the ancient immigrants have been replaced or assimilated by more recent ones. This is essentially the model advocated by Steele and Powell (1999 and references therein) after a thorough consideration of the available evidence.

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