Japan, Asia and the Pacific: A Multivariate Craniometric Investigation

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ABSTRACT

Discriminant function analysis and Mahalanobis' Generalized Distance are applied to 35 measurements recorded in 2,264 human crania representing Japanese, Asian, Australian Aboriginal and Pacific groups for assessing the historical-biological relationships of these populations. The results of three separate analyses involving 9, 21 and 43 samples, respectively, are presented. Modern Japanese are distinct members of a larger East Asian community that includes Chinese, Mongolians and Southeast Asians. Jomon and Ainu crania are distinct from modern Japanese and other East Asian populations. Modern and Shang Dynasty Chinese form a coherent group distinct from Japan. Broader comparisons group East Asians (including Japan), Southeast Asians, Polynesians and Micronesians in marked opposition to a population complex containing Australian Aboriginal and Melanesian samples. A Japan-Southeast Asian connection is demonstrated. Although a direct link between modern Japanese and Polynesians-Micronesians is unsubstantiated, there is little doubt that Polynesians are of Southeast Asian origin. Connections between Japan and Southeast Asia require additional scrutiny. Relatively few variables, notably differences in various facial width measures, cranial vault length and palate size are responsible for group separation. Multivariate statistical procedures remain a powerful investigative tool for describing craniometric variation in human populations and for generating hypotheses concerning historical-biological relationships between these groups.

Introduction

A rather impressive body of literature, in both Japanese and English, is now available for investigating the origins of modern and prehistoric Japanese using cranial and dental data (see e. g., Howells, 1966, 1973, 1986, 1990; Yamaguchi, 1967, 1982; Suzuki, 1981; Hanihara, 1979, 1985, 1986; Brace *et al.*, 1989, n.d.; Turner, 1976, 1979, 1986, 1990; Turner and Hanihara, 1977; and many others). Previous research has addressed issues such as the relationship of Jomon, Yayoi, Ainu and modern Japanese and the immediate ancestors of the modern Japanese. Large scale migrations from continental Asia and a direct derivation from the earliest occupants of the archipelago represent two polar views that attempt to explain the origins of modern Japanese. Relatively few studies have examined the cranial and dental variation of Japanese within the broader context of Asia and the Pacific. Those that have attempted broader comparisons, characteristically do not include very many samples from the Pacific region and, of these, only a few have made extensive use of multivariate statistical procedures.

In this paper I investigate essentially recent craniometric variation in Japan, East Asia, Southeast Asia, Australia and the Pacific through the application of multivariate statistical procedures. The data consist of measurements recorded in modern, near modern and prehistoric crania. The study employs multivariate statistics primarily as an exploratory tool for describing the nature and extent of craniometric variation in the region and for investigating the relationships among groups. Although the study does not test specific hypotheses of origin, the results of the present study can be compared with hypotheses generated from other recent studies in physical anthropology using different data.

The present analysis reworks and amplifies earlier work (Pietrusewsky 1984, 1990) which similarly investigates craniometric variation in Pacific and Australasian populations. The present multivariate study includes five new Chinese samples, two new samples from Viet Nam and one from Thailand, samples which have not been previously reported. The present study utilizes limited data on modern and prehistoric Japanese populations. Research in progress will hopefully soon correct this latter deficiency.

Materials and Methods

Samples

Measurements recorded in 2, 264 adult male crania representing 44 separate Asian, Australian and Pacific samples are analyzed using multivariate statistical procedures. Information on the samples, including the number of crania sampled, where the samples were examined and other information pertaining to the provenience of each sample is given in Tables 1 and 2. The approximate location of each sample is shown in Figure 1.

Figure 1. Map showing the approximate locations of the samples used in the present study.

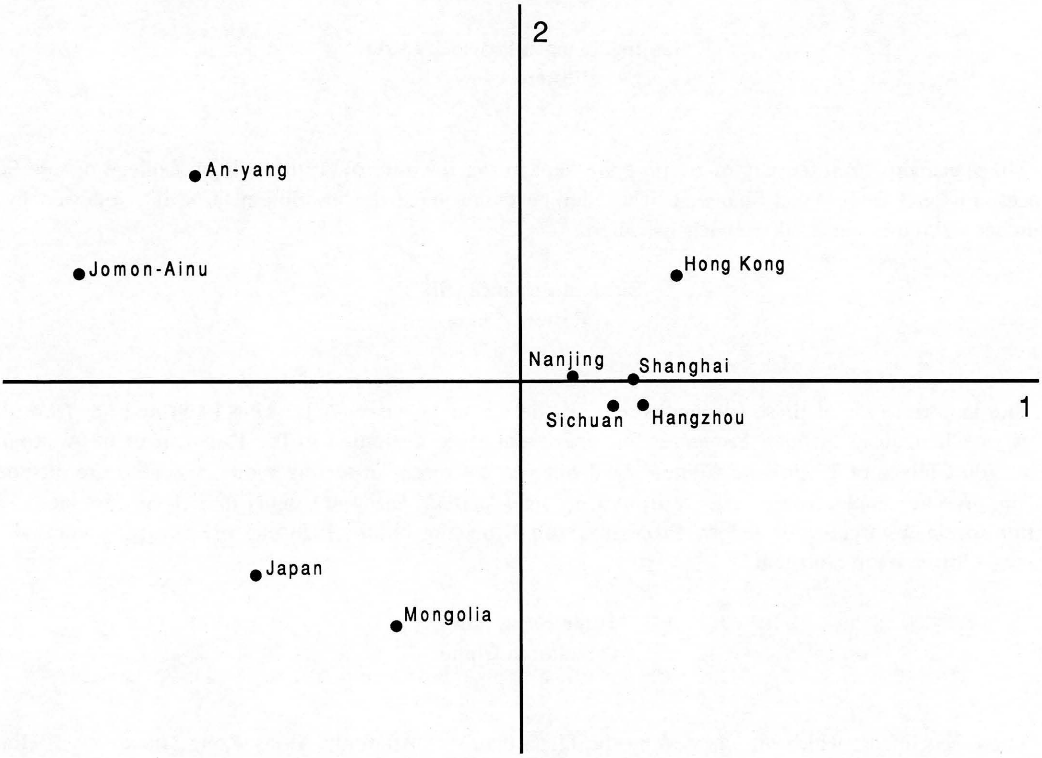

Figure 2. Plot of 9 male group means on the first two canonical variates (or discriminant functions) using 35 cranial measurements.

Table 1 Cranial Samples from East Asia and Southeast Asia

Shanghai (SHA)*
Eastern China
(N = 150)

The specimens from Shanghai were examined in 1988 at two locations, the Institute of Anthropology, College of Life Sciences, Fudan University in Shanghai and the Department of Anatomy, Chongqing Medical University in Chongqing, Sichuan Province, People's Republic of China. The specimens in Chongqing were in disinterred during the construction of the Shanghai airport between 1949-51, and were originally curated in the Shanghai Medical School in Shanghai before they were transported to Chongqing in 1956. The collection in Chongqing contains mostly male specimens which were sorted by Professor Woo Dingliang from original collection at the Shanghai Medical School prior to being transferred to Chongqing. The specimens examined at Fudan University are post-Qing in origin and were exhumed with the expansion of the modern city of Shanghai. The specimens from Shanghai at Fudan University have the inscription "IF", and a number only inscribed on each cranium.

Hangzhou, Zhejiang Province (HAN)*
Eastern China
(N = 68)

The crania from the city of Hangzhou were examined in the Institute of Anthropology, College of Life Sciences, Fudan University, Shanghai. These crania have the inscription, "HI" and a number painted on each specimen and are, for the most part, stored with associated infracranial remains in wooden boxes although the latter's association is sometimes dubious.

Table 1 (cont'd)

Nanjing, Jiangsu Province (NAJ)*
Eastern China
(N = 49)

The specimens from the city of Nanjing are kept in the Institute of Anthropology, College of Life Sciences, Fudan University in Shanghai. The Nanjing crania have the inscription "CNMI", followed by a number written in black ink on each specimen.

Sichuan Province (SIC)*
Eastern China
(N = 53)

The majority (43) of these specimens date to the Ch'en Dynasty (A.D. 1796-1908) and are from the City of Chengdu in Sichuan Province. The specimens were examined in the Department of Anatomy, Chengdu College of Traditional Chinese Medicine. A few recent dissecting room specimens are included in the present sample. Ten crania are from a site near Leshan, Lizhong County in Sichuan Province. The latter specimens were collected by Professor Woo Dingliang before 1950 and are presently curated at Fudan University in Shanghai.

Hong Kong (HK)*
Southern China
(N = 80)

These specimens, which are curated by the Department of Anatomy, Hong Kong University in Hong Kong, represent individuals who recently died in Hong Kong. The age, sex and sometimes cause of death is known for most of these specimens through hospital and forensic pathology records. With two exceptions, the present sample includes individuals of Chinese ancestry who died in Hong Kong between 1978 and 1979. Two deaths occured in 1980. These data were recorded in 1988.

An-yang, Henan Province (ANY)
Northern China
(N = 79)

The crania, presumably of sacrificial victims, are from the Bronze-age (18th century B.C.) Shang Dynasty tombs at An-yang in northern Henan Province. The material was examined by me in the Academia Sinica in Taipei, Republic of China, in 1983.

Kobe, Hyogo Prefecture, Honshu, Japan (JAP)
(N = 65)

These specimens were collected by Mr. Steenackers in or around Kobe in Hyogo Prefecture, Central Honshu Island in 1886 for the National Natural History Museum, Paris. The specimens are curated in the Laboratoire d' Anthropologie, Musée de l'Homme, Paris, where they were originally examined in 1975.

Mongolia (MOG)
(N = 31)

All specimens are curated at the Musée de l'Homme, Paris, and accessioned by the museum between 1849 and 1909. The place of origin is known for most of the specimens. They are from several different locations within the present Republic of Mongolia and Inner Mongolia.

Jomon-Ainu (JOM)*
(N = 3)

Table 1 (cont'd)

Two specimens are Ainu (one is from Hokkaido and the other is from Sakhalin ls.) and one represents Late-Latest Jomon. The Ainu crania were examined in Australia and the Jomon skull was examined at the National Science Museum in Tokyo in 1988.

Viet Nam (VNM)*
(N = 86)

This sample includes 56 specimens from northern (Hanoi) and southern (HoChi Minh City) Viet Nam curated in the Department of Anatomy, Faculty of Medicine in Ho Chi Minh City. The specimens from northern Viet Nam represent recent material from Hanoi and a municipal cemetery, Van Dien, in the suburbs of Hanoi that were excavated by Professor Nguyen Quyen in 1968. The specimens from southern Viet Nam examined in Ho Chi Minh mostly represent dissecting room material and are all of recent (post 1969) origin. These specimens were examined by the principal author in 1989. The remaining specimens are from all parts of Viet Nam which were originally examined in the Musée de l'Homme, Paris,in 1975.

Bachuc, An-giang Province, Viet Nam (BAC)*
(N = 51)

The specimens represent war massacre victims of the 1978 invasion of Viet Nam by Khmer Rouge troops from Kampuchea. Bachuc is a small village located in western An-giang Province near the border with Kampuchea. The specimens were selected from among the remains of approximately one thousand individuals currently on display in a memorial in the village. Measurements and non-metric observations were recorded in each specimen by the principal author in 1989.

Cambodia (CAM)
(N = 11)

Four specimens are Cambodian rebels killed around 1920 and donated to the Musée l'Homme, Paris by Dr. Pannetier, others are from various locations within Cambodia collected as early as 1877. All specimens were examined by the principal author in 1973 and 1975.

Laos (LAO)
(N = 29)

All specimens are curated in the Musée de l'Homme, Paris, where they were examined in 1973 and 1975. The crania are from virious locations within Laos and several are identified as representing the Kha tribes.

Thailand (THI)*
(N = 61)

All specimens were examined in 1989 at the Department of Anatomy, Siriraj Hospital in Bangkok. The majority of the specimens represent a dissecting room population, age, sex and cause of death are known for many of the specimens.

*These samples, except where indicated, represent new data not used in previous comparative studies. The information from the People's Republic of China and Hong Kong were collected by the principal author in 1988. The modern Thai and Vietnamese samples were collected in 1989.

Table 2 Additional Comparative Samples Used in the Present Study

Sample (abbrev.)	*No. of Crania*	*Location and No.*	*Remarks*
Island Southeast Asia			
Philippines (PHL)	28	BER-9; DRE-19	Most specimens are from Luzon Island.
Lesser Sundas (LSN)	45	BAS-5; BER-6; BLU-2; CHA-1; DRE-17; LEP-1; PAR-6; ZUR-7	Crania from Bali, Flores, Sumba, Lomblen, Alor, Timor, Wetar, Leti and Barbar Islands.
Southern Moluccas (SML)	13	BER-6; DRE-7	Specimens are from Ceram and Ambon Islands.
Sumata (SUM)	14	BER-1; BRE-1; DRE-5; LEP-4; PAR-3	The exact origin within Sumatra is generally not known for these specimens.
Borneo (BOR)	34	BER-2; BRE-2; DRE-6; FRE-4; LEP-8; PAR-12;	A great many of the specimens are indicated as representing Dayak tribes, some have elaborate decorations.
Sulawesi (SLW)	41	BAS-7; BER-10; DRE-4; FRE-7; LEP-5; PAR-8	An exact location is known for many of these specimens.
Java (JAV)	73	BER-2; BLU-8; CHA-9; DRE-2; LEP-24; PAR-28	Crania were collected from several different localities in Java.
Sulu (SUL)	38	LEP-1; PAR-37	The specimens in Paris were collected by Montano-Rey *circa* 1900
Polynesia			
Easter Is. (EAS)	64	BER-5; DRE-9 PAR-43; AMS-7	Most of the crania in Paris were collected by Pinart in 1887 at Vaihu and La Perouse Bay.
Hawai'i (HAW)	49	BPB-49	Specimens represent prehistoric Hawaiians from Mokapu, O'ahu Island.
Marquesas (MRQ)	51	PAR-49; LEP-1; BLU-1	Crania are from four islands, Fatu Hiva, Tahuata, Nuku Hiva and Hiva Oa.

New Zealand (NZ)	70	BRE-2; PAR-27; SAM-1; AIM-17; GOT-5; ZUR-9; DRE-8	A representative sample from North and South Islands.
Tonga-Samoa (TSM)	7	BER-3; AMS-1; BPB-1; DRE-1; PAR-1;	Three crania are from Samoa and four are from Tonga.
Tahiti (TAH)	33	PAR-33	Crania are from the island of Tahiti
Micronesia			
Guam (GUA)	46	BPB-42; PAR-4	Most of the specimens in the Bishop Museum were collected by H.G. Hornbostel at Tumon Beach on Guam during WWII.
Marianas (MAR)	29	BPB-8; PAR-21	Specimens are from Tinian and Saipan, Northern Marianas.
Caroline Is. (CAR)	24	TKO-7; DRE-9; PAR-4; GOT-3; AMS-1	Specimens are from Kosrae (1), Pohnpei (6) and Truk (7).
Melanesia			
Admiralty Is. (ADR)	79	DRE-20; GOT-9; CHA-6; TUB-28; BRE-5; BAS-11	Specimens from Hermit, Kaniet and Manus Islands.
Vanuatu (VAN)	47	BAS-47	Most of the specimens were collected by F. Speiser in 1912 from Malo, Pentecost and Espirtu Santo Is.
Fiji (FIJ)	32	BER-1; AMS-3; PAR-8; QMB-1; DRE-4; SAM-3; FRE-3; CHA-1; BPB-8;	Crania are from all major islands including the Lau Group in the Fiji Islands.
New Britain (NBR)	85	CHA-43; DRE-42	The Specimens in Dresden were collected by A. Baessler in 1900 and those in Berlin were collected by R. Parkinson in 1911.

Sepik R. (SEP)	74	DRE-33; BRE-3; GOT-31; TUB-7	The Specimens in Dresden were collected by O. Schlaginhaufen 1909.
Biak Is (BIK)	48	DRE-48	Most (45) of the specimens were collected by A. B. Meyer in 1873 on Biak Is. (Mysore), Geelvink Bay, Irian Java.
New Ireland (NIR)	53	AMS-4; BER-2; BLU-6; DRE-18; GOT-15; QMB-1; SAM-6; TUB-1	The crania in Dresden were mostly collected by Pöhl in 1887/88 from the northern end of the island; the specimens in Göttingen were collected during the Sudsee Expedition in 1908.
Solomon Is. (SOL)	49	NMV-1; QMB-3; BER-1; DAS-10; AMS-16; BAS-14; DRE-3; GOT-1	These crania from Buka, New New Georgia, Guadalcanal, San Cristobal, and other parts of the Solomon Islands.
Australia/Tasmania			
Murray R. (MRB)	85	AIA-39; DAM-46	These Crania were collected by G.M Black along the Murray River (Chowilla to Coobood) in New South Wales between 1929-1950.
New South Wales (NSW)	62	AMS-21; DAS-41	The specimens are from coastal locations in New South Wales.
Queensland (QLD)	74	AMS-21; DAS-3; DAQ-2; QMB-48	This sample is drawn the southeastern and middle-eastern parts of Queensland.
Northern Territory (NT)	75	AIA-29; AMS-3; MMS-1; NMV-38; QMB-1; SAM-3	Crania are from Port Darwin (39) and Arnhemland (36).
Tasmania (TAS)	26	THM-22; CHA-1; SAM-2; NAV-1	The crania represent Tasmanian Aborigines.

[1]AIA = Australian Institute of Anatomy, Canberra
AMS = The Australian Museum, Sydney
BAC = Bachuc Village, An-giang Province, Viet Nam

BAS = Naturhistorisches Museum, Basel
BER = Museum für Naturkunde, Berlin
BLU = Anatomisches Institut, Universität Göttingen, Göttingen
BPB = B.P. Bishop Museum, Honolulu
CHA = Anatomisches Institut der Chairé Humboldt Universität, Berlin
CHE = Dept. of Anatomy, Chengdu College of Traditional Chinese Medicine, Chengdu, People's Republic of China
CHN = Dept. of Anatomy, Chongqing Medical University, Chongqing, People's Republic of China
DAM = Dept. of Anatomy, University of Melbourne, Melbourne
DAQ = Dept. of Anatomy, University of Queensland, Brisbane
DRE = Museum für Völkerkunde, Dresden
FRE = Institut für Humangenetik u. Anthropologie, Universität, Freiburg
GOT = Institut für Anthropologie, Universität Göttingen, Göttingen
HCM = Faculty of Medicine, Ho Chi Minh City, Viet Nam
HKU = University of Hong Kong, Hong Kong
LEP = Anatomisches Institut, Karl Marx Universität, Leipzig
MMS = Macleay Museum, University of Sydney, Sydney
DAQ = Dept. of Anatomy, University of Queensland, Brisbane
NMV = National Museum of Victoria, Melbourne
PAR = Musée l'Homme, Paris
QMB = Queensland Museum, Brisbane
SAM = South Australian Museum, Adelaide
SHA = Institute of Anthropology, College of Life Sciences, Fudan University, Shanghai
SIR = Dept. of Anatomy, Siriraj Hospital Bangkok
THM = Tasmanian Museum and Art Gallery
TKO = Dept. of Anthropology, University of Tokyo, Tokyo
TPE = Academia Sinica, Taipei
TUB = Institut für Anthropologie u. Humangenetik, Universität, Tübingen, Tübingen
ZUR = Anthropologisches Institut, Universität Zürich, Zürich

Nine of the 14 East Asian and Southeast Asian samples (see Table 1) are reported for the first time, these data were recorded since 1988. With the exception of the Bronze-Age sample from An-yang in northern China and a single Late Jomon specimen, the majority of these crania represent near modern populations although some were collected a century or more ago. Two samples, Hong Kong and Bachuc village, contain individuals who are known to have died between 1978 and 1979. The Bachuc sample represents Vietnamese villagers who were massacred by the Khmer Rouge in 1978. Northern, southern, eastern and western regions of China are represented. A single sample representing disinterred individuals from Kobe in central Honshu Island represents modern Japan. These latter were collected in 1886 and sent to the Musée de l'Homme, Paris, for curation. The remaining samples, which have been used in previous research (Pietrusewsky, 1984, 1988, 1990), represent island Southeast Asia, Polynesia, Micronesia, Melanesia and Australia. With the exception of the massacre victims studied at Bachuc Village in southwestern Viet Nam, these samples represent museum or anatomical collections. The place of origin, accession dates and the collector's name are known in most cases. Only complete or substantially complete adult male specimens were selected for study. Comparable data were recorded in female crania but these will not be reported in this paper. All data were personally recorded by me, a method which avoids the potential for serious error when different observers record craniometric data (Utermohle and Zegura, 1982).

Age and Sex Determination

In rare instances, (e.g. the anatomical collections in Hong Kong), age and sex were ascertained through written records. Determining the adult status of the unknown specimens was based on the complete closure of the basilar (spheno-occipital synchondrosis) suture, the complete (or nearly complete) eruption of the third molar and ectocranial suture closure (Meindl and Lovejoy, 1985). Extremely old specimens, which were completely edentulous, were generally avoided. Sex was determined by visual assessment relying on standard craniomorphic criteria (e.g., browridge and forehead development, mastoid size, muscle markings, superior border of the eye sockets, etc.) as described in Bass (1987), Brothwell (1981), Krogman and lscan (1986) and Stewart (1979).

Cranial Measurements

A total of 36 standard measurements were initially recorded in each cranium. Because the zygomatic arches were frequently missing or damaged in these specimens, bizygomatic breadth was eventually eliminated from further analyses. The measurements used in the present study are explained at the bottom of Table 3. The majority of these measurements are taken from Martin (1957) while others are described in Howells (1973). Further information on the source of these measurements is provided in Pietrusewsky (1984).

Multivariate Statistical Procedures

Since the multivariate procedures used in this study require complete sets of data, missing measurements were replaced using the stepwise regression analysis. The program, PAM, of the UCLA Biomedical Computer P-Series was the procedure used (Dixon and Brown, 1979). Because complete or nearly complete specimens were initially selected, this procedure was utilized on a limited basis.

As a means of assessing inter-group relationships and the pattern of craniometric variation among the individuals of a population, stepwise discriminant function analysis (or canonical analysis) was applied to the cranial measurements using the computer program, BMDP-7M (Dixon and Brown, *op. cit.*). The major purpose of discriminant analysis is to maximize the ratio of between-group variance to the total variance (while taking into consideration the intercorrelation of variables) by producing a finite series of orthogonal functions. The first canonical variate, or function, accounts for most of the variation among the groups. The remaining functions, ranked in decreasing importance, are responsible for the residual variation. The technique further allows for the identification of those variables that are most responsible for differentiating groups. Interpretation of discriminant functions and the patterns of group separation in this study is based on inspection of standardized canonical discriminant coefficients. Although originally designed to assign an unknown specimen to one or more groups, discriminant analysis has proved especially useful as a measure of variation between groups. The mathematical basis of this technique is discussed by Golestein and Dillon (1978).

Discriminant analysis assumes certain conditions of the data (e. g., sample sizes should be large and of equal size, multivariate normality and homogeneity of covariance matrices) be met if formal tests of significance are involved (Corruccini, 1975). As is normally the case, the present data set does not meet all the general assumptions of multivariate normality and equality of group covariance matrices. However, in this study, no formal tests of significance are applied to the hypothesized intergroup relationships.

Mahalanobis' Generalized Distance (Mahalanobis, 1936) was applied to the same data analyzed by discriminant function analysis. Generalized Distance provides a single quantitative measure of similarity (distance) between individual groups using a large number of variables while taking into account intercorrelation between the variables. The avarage linkage (or unweighted pair-group) clustering technique, was the algorithm selected to construct the diagrams of relationship, or dendrograms, using the raw d-squared values. One advantage of cluster analysis is that it provides immediate visual appraisal of group similarity that is not immediately apparent when scanning rows and columns of large distance matrices.

Three separate analyses will be reported. The first examines nine samples representing Japan and East Asia. The second analysis investigates 21 East Asian, mainland and island Southeast Asian populations. The final analysis examines the relationships between the populations included in the two previous analyses and cranial samples representing Australia, Melanesia, Micronesia and Polynesia. The total number of groups investigated in the third analysis is 43.

Results

Japan and East Asia-Analysis 1

The means and standard deviations for 35 measurements recorded in the nine male samples investigated in the first analysis are presented in Table 3. Five additional mainland Southeast Asian samples that are used in Analysis 2 are further included in this table.

Table 3 Means and Standard Deviations for 35 Cranial Measurements for Selected Male Samples

	Shanghai N = 150		Hangzhou N = 68		Nanijing N = 49		Sichuan N = 53	
Measurement[1]	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
MAXCRANL	179.3	6.1	180.2	5.6	181.0	5.3	181.5	6.8
NASOCCIL	177.0	5.8	177.6	5.3	178.4	5.2	179.4	6.8
BASINASI	98.9	3.9	99.0	3.5	99.5	3.8	96.9	4.8
BASIBREG	136.3	4.6	135.1	6.4	136.3	5.3	133.5	5.1
MAXCRANB	142.1	5.4	140.8	6.2	138.8	5.4	139.7	5.7
MAXFRONB	119.8	4.8	119.6	5.4	118.7	5.0	119.0	5.3
MINFRONB	94.4	4.4	92.9	5.4	93.0	5.0	94.4	5.3
BISTEPHB	111.2	5.3	110.3	5.5	109.2	5.8	109.5	5.9
BIAURICB	127.6	5.0	126.3	4.8	126.8	4.6	127.9	4.8
MINCRANB	80.5	3.7	79.8	4.0	78.8	4.5	78.3	3.7
BIASTERI	110.3	5.0	109.5	4.3	108.1	4.9	107.8	4.9
BASIPROS	96.3	4.2	96.8	5.1	96.4	4.2	94.3	4.9
NASIPROS	74.2	4.4	74.1	4.0	73.9	4.7	74.1	4.2
NASALHGT	54.2	3.0	54.3	2.6	54.1	3.0	54.9	3.6
NASALBTH	25.9	1.9	26.0	1.8	25.2	1.9	25.6	1.8
ORBHGTLF	35.8	2.1	35.9	2.1	35.8	2.2	36.1	2.1
ORBBTHLF	41.6	1.9	41.5	2.2	41.0	1.9	41.1	1.8
BIJUGALB	115.4	4.1	115.2	4.5	115.2	3.8	115.2	5.9
ALVEOLAL	52.4	2.8	52.4	3.4	51.4	2.9	51.2	3.4
ALVEOLAB	66.6	3.4	65.0	4.4	64.5	3.6	63.7	3.9
MASTOIDH	27.3	2.7	27.4	3.1	27.4	2.9	25.6	2.6

MASTOIDW	20.0	2.9	20.3	3.3	20.8	3.5	19.0	3.0
BIMAXILB	100.8	4.7	100.3	4.0	100.8	4.4	99.2	4.5
BIFRONTB	105.8	3.5	105.0	4.2	104.2	3.8	104.6	4.3
BIORBITB	96.4	3.3	96.1	4.0	95.2	3.7	95.1	3.9
INTERORB	28.1	2.2	28.2	2.8	27.6	2.2	27.3	2.3
MALRLINF	34.9	3.7	35.0	3.1	35.3	2.9	35.5	3.1
MALRLMAX	53.9	3.6	53.5	3.2	54.7	3.6	53.4	3.9
CHEEKHGT	25.0	2.3	24.6	2.4	25.2	2.3	24.9	2.1
FORAMAGL	35.0	2.3	35.3	2.4	35.8	2.3	35.3	2.3
NASIBGCR	111.2	4.1	110.7	4.3	111.2	4.9	112.5	4.4
BRGLMDCR	113.5	5.8	113.8	6.6	114.7	5.2	113.8	7.4
LAMOPISC	97.2	5.0	97.2	5.4	96.2	5.3	97.3	5.8
BIMAXSUB	21.8	2.8	21.6	2.5	21.5	3.3	21.2	2.7
NASFROSB	14.1	2.5	13.9	2.2	14.3	2.2	14.2	2.4

	Hong Kong N= 80		An-yang N = 79		Japan N = 65		Jomon-Ainu N = 3	
Measurement[1]	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
MAXCRANL	180.6	6.0	182.1	5.1	180.4	6.2	185.3	6.1
NASOCCIL	178.5	6.1	179.7	4.9	177.2	6.0	182.7	5.7
BASINASI	99.9	4.2	101.7	4.1	100.5	3.5	107.0	2.6
BASIBREG	139.1	4.8	139.4	5.0	138.2	4.9	139.0	6.9
MAXCRANB	139.4	4.9	138.7	5.3	139.8	5.7	139.0	5.0
MAXFRONB	118.7	4.5	119.3	5.4	118.7	4.6	118.0	4.0
MINFRONB	92.5	4.4	94.4	3.9	96.1	5.8	97.7	5.1
BISTEPHB	110.3	5.1	108.0	6.2	113.7	5.2	116.7	4.0
BIAURICB	124.0	4.0	126.6	5.4	124.9	4.1	124.7	4.6
MINCRANB	78.6	3.3	77.3	4.3	77.0	4.3	78.7	3.5
BIASTERI	108.3	4.6	108.4	4.2	108.4	4.6	111.7	4.0
BASIPROS	97.9	5.2	98.4	5.5	98.3	4.7	108.7	3.1
NASIPROS	72.2	3.6	70.8	3.7	70.2	4.2	70.0	2.6
NASALHGT	52.7	3.5	52.5	2.6	52.5	2.3	49.7	3.5
NASALBTH	25.9	1.9	26.6	1.8	25.6	1.6	25.0	1.7
ORBHGTLF	34.2	1.7	33.7	2.0	34.8	1.9	33.3	2.3
ORBBTHLF	40.7	1.8	40.4	1.7	41.7	1.7	42.7	3.1
BIJUGALB	112.0	4.0	116.4	4.3	117.2	4.3	117.3	5.1
ALVEOLAL	52.0	3.6	52.4	3.1	52.6	2.8	56.3	2.1
ALVEOLAB	65.4	3.4	66.5	3.3	65.2	4.7	64.7	2.5
MASTOIDH	27.1	3.1	28.1	2.6	28.9	2.9	27.0	2.6
MASTOIDW	21.0	3.3	21.9	2.8	20.1	2.5	21.7	2.5
BIMAXILB	99.2	4.7	101.1	4.3	98.8	4.4	98.3	8.1
BIFRONTB	104.6	3.7	104.3	3.3	104.3	3.6	106.0	6.0
BIORBITB	94.8	3.1	94.5	3.2	97.1	3.3	97.3	7.0
INTERORB	27.3	2.1	28.4	2.1	28.4	2.2	27.0	2.0
MALRLINF	35.3	3.7	32.8	3.5	34.6	3.2	31.0	4.6
MALRLMAX	53.3	3.7	53.9	3.3	54.2	3.4	50.3	1.5
CHEEKHGT	24.9	2.3	25.4	2.3	23.7	2.1	23.3	1.5
FORAMAGL	34,8	2.6	34.0	2.4	35.2	2.2	35.0	1.0
NASIBGCR	112.6	4.3	113.4	4.3	111.7	4.0	111.7	4.7
BRGLMDCR	115.4	6.0	114.0	5.8	114.1	6.0	112.0	7.8
LAMOPISC	98.0	4.9	97.3	5.6	98.6	5.1	96.0	6.0
BIMAXSUB	22.8	2.8	20.0	2.9	22.5	2.7	20.3	4.7
NASFROSB	14.7	2.4	15.5	2.5	14.8	1.9	15.7	3.5

Table 3 (cont'd) Means and Standard Deviations for 35 Cranial Measurements for Selected Male Samples

	Mongolia N = 31		Viet Nam N = 86		Bachuc N = 51		Thailand N = 61	
Measurement[1]	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
MAXCRANL	180.4	6.6	177.4	5.4	172.1	7.0	174.1	5.5
NASOCCIL	177.5	6.6	175.2	5.1	170.7	6.7	171.6	5.4
BASINASI	99.1	3.6	99.2	4.0	97.4	3.6	98.9	4.3
BASIBREG	131.2	7.4	137.3	4.6	137.6	4.4	138.1	5.1
MAXCRANB	147.9	6.9	139.9	5.3	140.4	5.3	143.8	5.2
MAXFRONB	122.3	5.9	119.4	5.1	119.1	6.1	120.5	4.8
MINFRONB	95.5	4.7	94.6	4.0	94.6	4.2	94.8	4.4
BISTEPHB	114.1	7.3	113.4	5.5	115.8	5.9	114.7	5.5
BIAURICB	132.4	5.4	124.1	4.7	122.5	4.9	125.7	4.5
MINCRANB	77.8	4.5	76.1	4.1	78.2	4.5	79.5	5.4
BIASTERI	113.6	5.0	105.8	4.6	105.0	4.3	108.9	4.8
BASIPROS	96.5	5.2	96.2	5.0	96.3	3.7	96.5	4.9
NASIPROS	74.6	5.6	68.6	4.9	71.3	4.0	69.2	3.8
NASALHGT	56.5	3.1	52.3	3.1	53.1	3.0	52.9	3.1
NASALBTH	26.2	2.4	25.8	2.0	26.2	1.9	25.7	1.9
ORBHGTLF	35.8	2.6	34.0	1.9	33.5	2.8	33.9	1.7
ORBBTHLF	42.3	2.1	41.0	1.8	40.4	2.0	41.0	2.0
BIJUGALB	119.0	3.9	115.6	4.7	112.9	4.4	114.2	4.7
ALVEOLAL	52.2	2.9	51.8	3.1	52.2	2.8	52.6	2.7
ALVEOLAB	66.4	3.9	63.6	3.9	66.4	3.2	65.2	3.6
MASTOIDH	28.1	2.9	25.4	3.4	26.6	3.8	26.9	2.8
MASTOIDW	18.4	3.2	19.2	3.0	20.4	3.8	19.2	3.2
BIMAXILB	102.2	3.8	99.4	5.3	98.6	3.8	99.4	5.5
BIFRONTB	106.5	3.8	105.2	3.6	104.5	3.3	105.7	3.9
BIORBITB	98.5	3.7	96.3	3.4	95.2	3.2	96.1	4.0
INTERORB	27.8	1.9	28.3	2.0	27.4	1.9	27.5	2.1
MALRLINF	35.5	4.4	36.2	3.3	35.0	3.8	35.2	3.3
MALRLMAX	55.8	4.6	53.2	4.2	51.6	3.6	52.7	3.5
CHEEKHGT	27.3	2.5	23.5	2.6	24.6	2.6	24.0	2.3
FORAMAGL	36.1	2.6	34.9	2.5	34.4	2.4	34.2	2.7
NASIBGCR	112.5	4.3	112.1	3.9	112.0	4.5	112.6	4.8
BRGLMDCR	109.1	7.4	113.6	6.2	110.2	5.7	109.7	6.0
LAMOPISC	96.0	4.4	96.4	5.3	98.5	5.0	97.0	5.3
BIMAXSUB	19.7	2.8	21.8	2.6	21.9	2.6	22.8	2.6
NASFROSB	13.9	2.8	15.4	2.2	15.5	1.6	15.2	2.4

	Cambodia N = 11		Laos N = 29	
Measurement[1]	Mean	S.D.	Mean	S.D.
MAXCRANL	173.0	6.2	170.4	6.9
NASOCCIL	170.1	5.9	167.0	6.7
BASINASI	99.7	3.0	97.0	3.0
BASIBREG	139.5	3.7	135.0	4.4
MAXCRANB	142.8	5.0	140.9	5.5
MAXFRONB	119.1	5.3	118.2	4.9
MINFRONB	95.8	4.9	94.1	3.3
BISTEPHB	114.4	5.1	112.9	5.9
BIAURICB	126.0	4.0	124.6	5.1

MINCRANB	74.8	3.0	74.1	4.2
BIASTERI	106.5	4.5	105.9	4.5
BASIPROS	99.2	6.1	96.5	4.5
NASIPROS	69.1	3.3	70.1	2.7
NASALHGT	53.9	2.1	53.9	2.4
NASALBTH	26.5	1.8	26.1	1.9
ORBHGTLF	32.8	1.1	33.8	1.7
ORBBTHLF	42.4	1.7	41.0	1.5
BIJUGALB	115.3	3.3	115.4	3.4
ALVEOLAL	55.2	3.8	52.8	2.5
ALVEOLAB	67.3	3.3	65.3	2.3
MASTOIDH	28.7	2.5	26.8	2.7
MASTOIDW	20.7	3.6	18.6	2.5
BIMAXILB	100.8	5.9	100.2	4.2
BIFRONTB	106.0	4.4	104.6	2.6
BIORBITB	98.4	3.2	96.1	2.8
INTERORB	28.2	2.2	27.2	1.9
MALRLINF	35.8	5.5	35.4	4.0
MALRLMAX	54.4	4.2	53.5	3.4
CHEEKHGT	24.2	1.7	24.6	2.0
FORAMAGL	35.5	2.5	35.0	2.2
NASIBGCR	113.1	4.7	109.0	4.0
BRGLMDCR	109.9	6.4	107.6	7.3
LAMOPISC	93.4	2.0	93.1	5.3
BIMAXSUB	24.3	3.9	21.9	2.5
NASFROSB	15.9	1.9	14.4	2.1

MAXCRANL = Maximum cranial length (M-1); NASOCCIL = Nasio-occipital length (M-1d); BASINASI = Basion-nasion (M-5); BASIBREG = Basion-bregma (M-17); MAXCRANB = Maximum cranial breadth (M-8); MAXFRONB = Maximum frontal breadth (M-10);MINFRONB = Minimum frontal breadth (M-9); BISTEPHB = Bistephanic breadth (H-STB); BIAURICB = Biauricular breadth (M-11b); MINCRANB = Minimum cranial breadth (M-14); BIASTERI = Biasterionic (M-12); BASIPROS = Basion-prosthion (M-40); NASIPROS = Nasion-prosthion (M-48); NASALHGT = Nasal height (M-55); NASALBTH = Nasal breadth (M-54); ORBHGTLF = Orbital height, left (M-52); ORBBTHLF = Orbital breadth, left(M-51a); BIJUGALB = Bijugal breadth [M-45(1)]; ALVEOLAL = Alveolar length (M-60); ALVEOLAB = Alveolar breadth (M-61); MASTOIDH = Mastoid heigth (H-MDL); MASTOIDW = Mastoid width (H-MDB); BIMAXILB = Bimaxillary breadth (M-46); BIFRONTB = Bifrontal breadth (M-43); BIORBITB = Biorbital breadth (H-EKB); INTERORB = Interorbital breadth (M-49a); MALRLINF = Malar length, inferior (H-IML); MALRLMAX = Malar length, maximum (H-XML); CHEEKHGT = Cheek height [M-48(4)]; FORAMAGL = *Foramen magnum* length (H-FOL); NASIBGCR = Nasion-bregma chord (M-29); BRGLMDCR = Bregma-lambda chord (M-30); LAMOPISC =Lambda-opisthion chord (M-31); BIMAXSUB = Bimaxillary subtense (H-SSS); NASFROSB = Nasio-frontal subtense (H-NAS).M = Martin (1957); H = Howells (1973).

Stepwise Discriminant Function Analysis

At each step of the analysis, the variable that contributes the most (receives the highest F-value) to group separation is entered into the discriminant analysis after taking into account the discriminating strength of the previously selected variables. This procedure continues until all variables have been included or when the F-values of the remaining variables fall below a predetermined threshold value. Since the number of groups (nine) is less than the total number of variables investigated, only the first nine steps are presented in Table 4. Vault (basion-bregma) and facial (nasion-prosthion) heights, and facial and cranial breadths (bijugular breadth, minimum and maximum cranial breadths, bifrontal breadth and biorbital breadth) are among the variables entered earliest in the stepping process.

Table 4 A Ranking of Cranial Measurements for Nine Male Samples According to F-Values Obtained in the Final Step of Discriminant Function Analysis (Only the First 9 steps are Shown)

Step No.	Measurement	F-Value	$d.f._B/d.f._W$	P*
1	BASIBREG	13.270	8/578	*
2	NASIPROS	12.164	8/577	*
3	BIJUGALB	11.958	8/576	*
4	MINCRANB	11.719	8/575	*
5	MAXCRANB	9.797	8/574	*
6	BIFRONTB	8.989	8/573	*
7	BIORBITB	15.752	8/572	*
8	BASIPROS	7.476	8/571	*
9	MALRINF	8.115	8/570	*

*$P < .01$

Eigenvalues, the percentage of total dispersion, the cumulative percentage of dispersion and level of significance for the first eight discriminant functions, or canonical variates, are presented in Table 5. The first three functions or canonical variates account for 79.7%of the total variance. The first seven functions are significant at $p < .01$.

Table 5 Eigenvalues, Percentage of Total Dispersion, Cumulative Percentage of Dispersion and Level of Significance for the First 8 Canonical Variates, 9 Male Samples and 35 Measurements

Canonical *Variate*	*Eigenvalue*	*%Dispersion*	*Cumulative %Dispersion*	*d.f.*[1]	*p*[2]
1	1.18446	34.0	34.0	42	*
2	0.97769	28.0	62.0	40	*
3	0.61842	17.7	79.7	38	*
4	0.29175	8.4	88.1	36	*
5	0.17786	5.1	93.2	34	*
6	0.10832	3.1	96.3	32	*
7	0.08430	2.5	98.8	30	*
8	0.04333	1.2	100.0	28	NS

1 d.f. = degrees of freedom = $(P + q-2) + (p + q-4)$...
2 *$p < .01$. When eigenvalues are tested for significance according to Bartlett's criterion: $[N-1/2(p + q)$ $[\log_e (1 + \lambda)$, where N = total number of crania, p = number of variables, q = number of groups, λ = eigenvalue, which are distributed approximately as chi-square (Rao, 1952:373).
NS = not significant

Canonical coefficients for 35 cranial measurements recorded in nine male samples for the first canonical variates are given in Table 6. Group separation on canonical variate 1 is primarily the result of variation in bifrontal breadth, bijugular breadth and inferior malar length. Bimaxillary subtense, orbital height, maximum cranial length and nasion-prosthion height are the next most important discriminating variables. This function therefore can be defined as a facial breadth and facial projection discriminator. Correlations are generally weak and there are approximately twice as many positive as there are negative correlations. Canonical variate 2 is responsible for group separation primarily on the basis of differences in biorbital breadth, bifrontal breadth, nasio-occipital length, maximum frontal breadth and bistephanic breadth. In addition to being an upper facial breadth discriminator, this canonical variate is also a cranial vault length discriminator. The coefficients are weaker than in the previous canonical variate. Group separation on the third variate is primarily due to differences in biorbital breadth, bimaxillary subtense and nasio-occipital length. There is considerable overlap between the first three canonical variates which identify mid-and upper facial breadth measurements and nasio-occipital length as the most significant contributors to group separation.

TAble 6 Canonical Coefficients for Cranial Measurement Recorded in 9 Male Samples for the First Three Canonical Variates

	Canonical Variate 1	*Canonical Variate 2*	*Canonical Variate 3*
Variable	*Coefficient*	*Coefficient*	*Coefficient*
MAXCRANL	−0.10342	−0.11049	0.07368
NASOCCIL	0.05885	0.19118	−0.12948
BASINASI	−0.03568	−0.02383	0.01554
BASIBREG	−0.04251	0.11617	0.06270
MAXCRANB	0.01846	−0.03718	−0.00132
MAXFRONB	−0.01517	0.12186	−0.05678
MINFRONB	−0.08885	−0.04161	−0.05147
BISTEPHB	0.02412	−0.11794	0.07933
BIAURICB	−0.02660	0.01966	−0.10828
MINCRANB	0.11520	0.07085	0.07928
BIASTERI	0.01324	0.00099	−0.01083
BASIPROS	−0.02114	0.01643	0.04689
NASIPROS	0.10274	0.02522	−0.02608
NASALHGT	−0.07298	−0.08944	−0.11596
NASALBTH	0.03591	0.06746	0.00382
ORBHGTLF	0.11120	−0.06086	0.00720
ORBBTHLF	−0.02888	−0.04494	−0.04780
BIJUGALB	−0.19901	−0.03770	−0.03674
ALVEOLAL	−0.07714	−0.02560	−0.02509
ALVEOLAB	−0.02187	0.00914	0.01320
MASTOIDH	−0.08493	−0.07576	0.06638
MASTOIDW	0.03786	0.09276	0.02707
BIMAXILB	0.02701	0.02321	−0.02344
BIFRONTB	0.33138	0.26313	−0.01182
BIORBITB	−0.08955	−0.32943	0.14008
INTERORB	−0.05931	0.07539	0.02758
MALRLINF	0.17021	−0.03915	0.02340
MALRLMAX	−0.05304	−0.04961	0.04588
CHEEKHGT	0.03203	−0.00328	−0.10624
FORAMAGL	0.08568	−0.11597	0.02358
NASIBGCR	−0.02644	−0.05367	0.00706
BRGLMDCR	0.05314	−0.03929	0.02521
LAMOPISC	0.02323	−0.08053	0.03030
BIMAXSUB	0.12597	−0.05018	0.13825
NASFROSB	−0.08475	0.10709	−0.04468

Figure 2 is a plot of the group means on the first and second canonical variates or functions. Together these two functions account for 62.0% of the total variation described by the discriminant analysis. The separation of the groups in the plot provides a reasonable interpretation of intergroup relationships. The five modern Chinese samples cluster in a single quadrant of this diagram. An-yang (Bronze-age Chinese), Jomon-Ainu, Japan and Mongolia occupy relatively isolated positions. Japan is closest to Mongolia, and Jomon and An-yang are loosely associated.

The group classification results are given in Table 7. The total percentage of cases correctly classified is 62.6% which suggests that the groups sampled are not well differentiated. The highest rates of successful classification are obtained by Jomon-Ainu (100%), An-yang (88.6%), Japan (87.7%) and Mongolia (83.9%). The groups having the poorest classification results include Hangzhou (32.4%), Shanghai (45.3%) and Nanjing (46.9%). The latter three groups, Hong Kong and Sichuan receive the highest number of misclassifications from other (mostly from among these same) groups. The classification results suggest a great deal of similarity (homogeneity) between all the modern Chinese samples. The classification results for Japan, Mongolia and An-yang, on the other hand, indicate these groups are more distinct and generally well differentiated. One of the An-yang cases is misclassified as Jomon-Ainu.

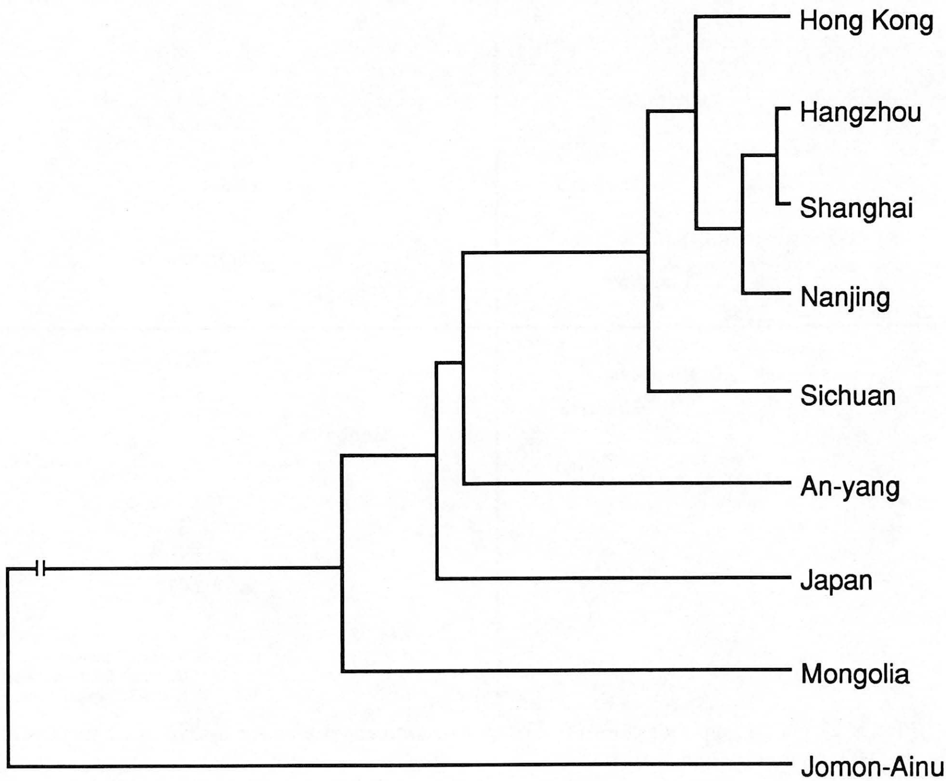

Figure 3. Diagram of relationship based on a cluster analysis of Generalized Distance results using 35 measurements recorded in 9 male samples.

Table 7 Summary of Classification Results from Discriminant Function Analysis for 9 Male Samples (Number of Cases Classified in Groups)

	HK	SIC	HAN	ANY	NAJ	JAP	MOG	SHA	JOM
Hong Kong	59	3	6	1	3	1	1	6	
Sichuan	4	34	2	1	6	1	1	4	
Hangzhou	11	11	22	4	6	4	3	7	
An-yang	1	2		70	2	2		1	1
Nanjing	3	7	8	3	23			5	
Japan		1	1		2	57	2	2	
Mongolia	1	1		2		1	26		
Shanghai	15	13	24	2	16	7	5	68	
Jomon-Ainu									3
Total Cases Orig. Assign.	80	53	68	79	49	65	31	150	3
No. Cases CorrectAssign.	59	34	22	70	23	57	26	68	3
% Correct Assign.	73.7	64.2	32.4	88.6	46.9	87.7	83.9	45.3	100.0

Percentage of grouped cases correctly classified: 62.6%

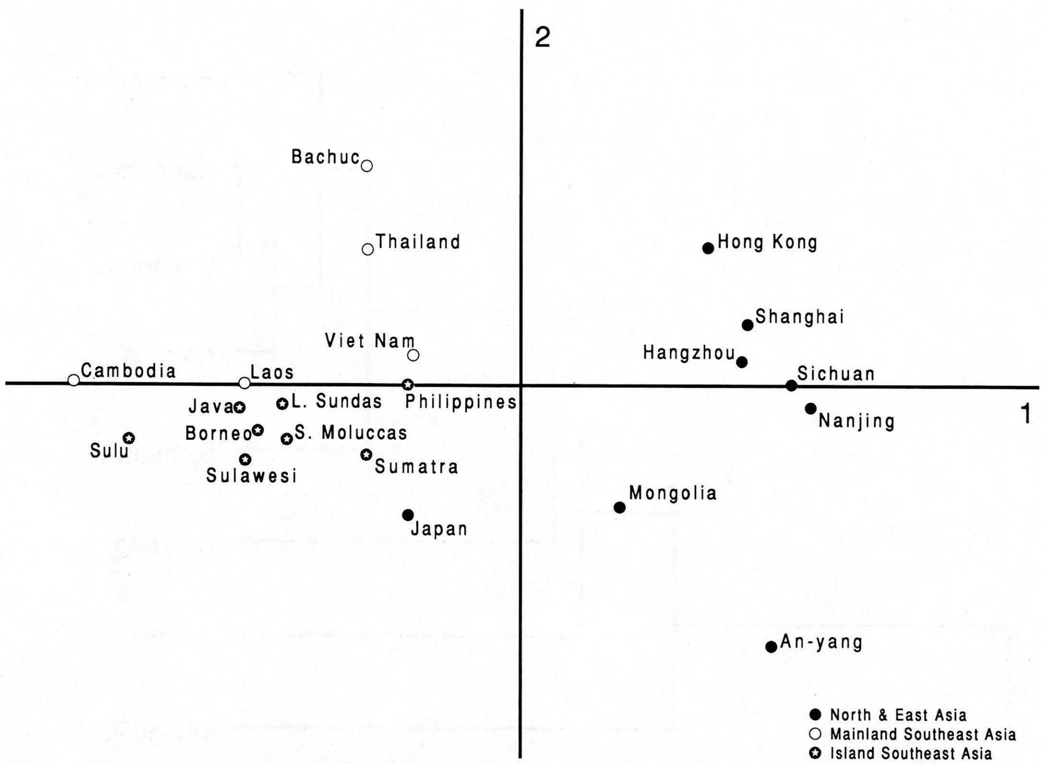

Figure 4. Plot of 21 male group means on the first two canonical variates (or discriminant functions) using 35 cranial measurements.

Generalized Distance

The results of applying Mahalanobis' Generalized Distance to the same measurements analyzed by discriminant analysis are set out in Table 8. Figure 3 is the diagram of relationship obtained when cluster analysis is applied to these raw scores. Southern and eastern Chinese samples form a cluster to which western (Sichuan) and northern (An-yang) Chinese samples then attach. Japan and Mongolia follow these with the Jomon-Ainu sample clustering last.

Table 8 Mahalanobis' Generalized Distances for 9 Male Samples Using 35 Measurements

	HONGKG	SICHUN	HANZOU	ANYANG	NANJIG	JAPAN	MONGOL	SHANGI	JOMAIN
Hong Kong	0.000	7.573	3.387	11.268	4.264	12.990	19.038	3.071	29.025
Sichuan		0.000	4.037	11.941	3.216	13.115	11.476	4.287	34.079
Hangzhou			0.000	10.278	1.609	9.017	11.258	0.911	28.814
An-yang				0.000	8.444	13.342	18.452	9.951	19.716
Nanjing					0.000	9.201	12.260	2.440	28.750
Japan						0.000	12.998	9.732	24.765
Mongolia							0.000	11.304	34.609
Shanghai								0.000	28.763
Jomon-Ainu									0.000

The general conclusion to be drawn from the results of Analysis 1 is that the region (Japan, China and Mongolia) is relatively homogeneous and not well differentiated. Less than nine variables contribute significantly to the observed pattern of variation. Variation in facial width and cranial vault length are primarily responsible for separating the five modern Chinese groups from Japan, Mongolia and Bronze Chinese. Closer inspection of these results suggests that there is considerable differentiation between the five modern Chinese groups which is supported by the canonical plots and cluster analysis of Generalized Distance. There is considerable homogeneity among the Chinese groups and Japan is well differentiated from these latter.

Japan, East Asia, Southeast Asia-Analysis 2

In this analysis, Japan is compared with samples representing East Asia, mainland and island Southeast Asia. Because the Ainu-Jomon sample is limited to three specimens, it has been eliminated from further analysis. Altogether 21 male samples, ranging in size from 11 to 150 and representing a total of 1,099 crania, are included in the second analysis.

Discriminant Analysis

The first 21 measurements, ranked according to F-values obtained at the end of the stepping process, are presented in Table 9. Nasion-prosthion height, alveolar length, nasio-occipital length, basion-bregma height, bifrontal breadth and bijugal breadth are among the variables receiving the highest F-values.

Summary statistics for the first 20 canonical variates are given in Table 10. The first three canonical variates account for 64.0% of the total variance. The first 13 canonical variates are significant at $p < .01$.

Table 9 A Ranking of Cranial Measurements for 21 Male Samples According to F-Values Obtained in the Final Step of Discriminant Function Analysis (Only the First 21 Measurements are Shown)

Step No.	Measurement	F-Value	$d.f._B/d.f._W$	P*
1	NASIPROS	20.133	20/1078	*
2	ALVEOLAL	15.557	20/1077	*
3	NASOCCIL	13.934	20/1076	*
4	BASIBREG	10.470	20/1075	*
5	MAXCRANB	7.536	20/1074	*
6	MINCRANB	7.657	20/1073	*
7	BIJUGALB	9.817	20/1072	*
8	BIORBITB	8.402	20/1071	*
9	BIFRONTB	10.721	20/1070	*
10	BIAURICB	5.921	20/1069	*
11	MALRLINF	5.344	20/1068	*
12	BIMAXSUB	6.318	20/1067	*
13	BISTEPHB	5.212	20/1066	*
14	MAXFRONB	5.133	20/1065	*
15	NASALHGT	5.191	20/1064	*
16	NASFROSB	4.987	20/1063	*
17	MINFRONB	4.249	20/1062	*
18	ORBHGTLF	4.080	20/1061	*
19	MALRLMAX	4.035	20/1060	*
20	MASTOIDH	3.484	20/1059	*
21	ALVEOLAB	3.177	20/1058	*

*P < .01

Table 10 Eigenvalues, Percentage of Total Dispersion, Cumulative Percentage of Dispersion and Level of Significance for the First 20 Canonical Variates (21 Male Samples and 35 Measurements)

Canonical Variate	Eigenvalue	%Dispersion	Cumulative %Dispersion	d. f. [1]	P[2]
1	1.54016	35.1	35.1	54	*
2	0.71597	16.3	51.4	52	*
3	0.55182	12.6	64.0	50	*
4	0.32102	7.3	71.3	48	*
5	0.28219	6.5	77.8	46	*
6	0.24166	5.5	83.3	44	*
7	0.13989	3.1	86.4	42	*
8	0.10399	2.4	88.8	40	*
9	0.09682	2.2	91.0	38	*
10	0.07682	1.8	92.8	36	*
11	0.06406	1.4	94.2	34	*
12	0.06203	1.4	95.6	32	*
13	0.05447	1.3	96.9	30	*
14	0.03952	0.9	97.8	28	**
15	0.02762	0.6	98.4	26	NS
16	0.02123	0.5	98.9	24	NS
17	0.02003	0.6	99.4	22	NS
18	0.01640	0.3	99.7	20	NS
19	0.00679	0.2	99.9	18	NS
20	0.00489	0.1	100.0	16	NS

[1] d. f. =degrees of freedom=(p+q−2)+(p+q−4)...
[2] *P<.01. When eigenvalues are tested for significance according to Bartlett's criterion : $[N-1/2(p+q)]\log_e(1+\lambda)$, Where N=total number of crania, p=number of variables, q=number of groups, λ = eigenvalue, which are distributed approximately as chi-square (Rao, 1952 : 373).
**P<.05
NS=not significant

Table 11 Canonical Coefficient for Cranial Measurements Recorded in 21Male Samples for the First Three Canonical Variates

Variable	*Canonical Variate 1* *Coefficient*	*Canonical Variate 2* *Coefficient*	*Canonical Variate 3* *Coefficient*
MAXCRANL	−0.03834	−0.08813	−0.07083
NASOCCIL	0.12371	−0.01027	0.09164
BASINASI	0.01833	0.00172	−0.02449
BASIBREG	−0.00074	−0.02862	0.13784
MAXCRANB	−0.03900	0.04067	−0.03470
MAXFRONB	0.09240	−0.05982	0.08692
MINFRONB	−0.03680	−0.09105	−0.03588
BISTEPHB	−0.08314	0.07536	−0.06606
BIAURICB	0.04192	−0.06849	−0.01716
MINCRANB	0.07932	0.11998	0.05115
BIASTERI	0.02261	−0.00814	−0.02331
BASIPROS	−0.02060	−0.01718	0.04319
NASIPROS	0.16056	0.09460	−0.04354
NASALHGT	−0.15818	−0.06497	−0.05527
NASALBTH	0.05231	0.03363	0.07066
ORBHGTLF	0.10115	0.00044	−0.09809
ORBBTHLF	−0.02403	−0.05157	−0.08377
BIJUGALB	−0.03186	−0.19062	−0.03382
ALVEOLAL	−0.12175	−0.06039	0.00291
ALVEOLAB	−0.04785	−0.02869	0.03128
MASTOIDH	0.00620	−0.04027	0.00085
MASTOIDW	0.04153	0.00251	0.06336
BIMAXILB	0.01531	0.01979	−0.00060
BIFRONTB	0.13020	0.32485	0.18796
BIORBITB	−0.19178	−0.01758	−0.20955
INTERORB	0.01240	−0.09910	0.07284
MALRLINF	−0.04989	0.16553	−0.03088
MALRLMAX	0.04115	−0.09050	−0.03665
CHEEKHGT	0.07998	0.03027	−0.05470
FORAMAGL	−0.02489	0.06805	−0.09461
NASIBGCR	−0.05805	0.00873	−0.01006
BRGLMDCR	0.00161	0.05102	−0.03208
LAMOPISC	−0.03813	0.04969	−0.03704
BIMAXSUB	−0.05194	0.10230	−0.04656
NASFROSB	−0.03520	−0.01432	0.12455

Canonical coefficients for all cranial measurements recorded in the 21 male samples for the first three canonical variates are presented in Table 11. The variables contributing most to the group separation on the first canonical variate are biorbital breadth, nasion-prosthion height, nasal height, bifrontal breadth, nasio-occipital length and alveolar length. Thus, the first canonical variate is primarily an upper facial breadth/height and cranial vault length discriminator. Group separation on the second canonical variate is primarily the result of variation in bifrontal breadth, bijugal breadth and inferior malar length. The second variate is primarily a mid-to upper facial breadth discriminator. Variation in biorbital breadth, bifrontal breadth, basion-bregma height and nasion-frontal subtense are primarily responsible for the group separation on the third canonical variate making this an upper facial breadth and cranial vault height discriminator.

Figure 4 is a plot of 21 group means on the first and second canonical variates which account for 51.4% of the total variation described by this discriminant analysis. Two relatively distinct clusters contain a large proportion of the groups plotted. The five modern Chinese samples cluster in one quadrant of the plot while mainland and island Southeast Asian samples are grouped in a second more dispersed constellation. Japan is closer to the Southeast Asian grouping than it is to the primarily East Asian cluster. Mongolia and An-yang occupy peripheral positions in this plot.

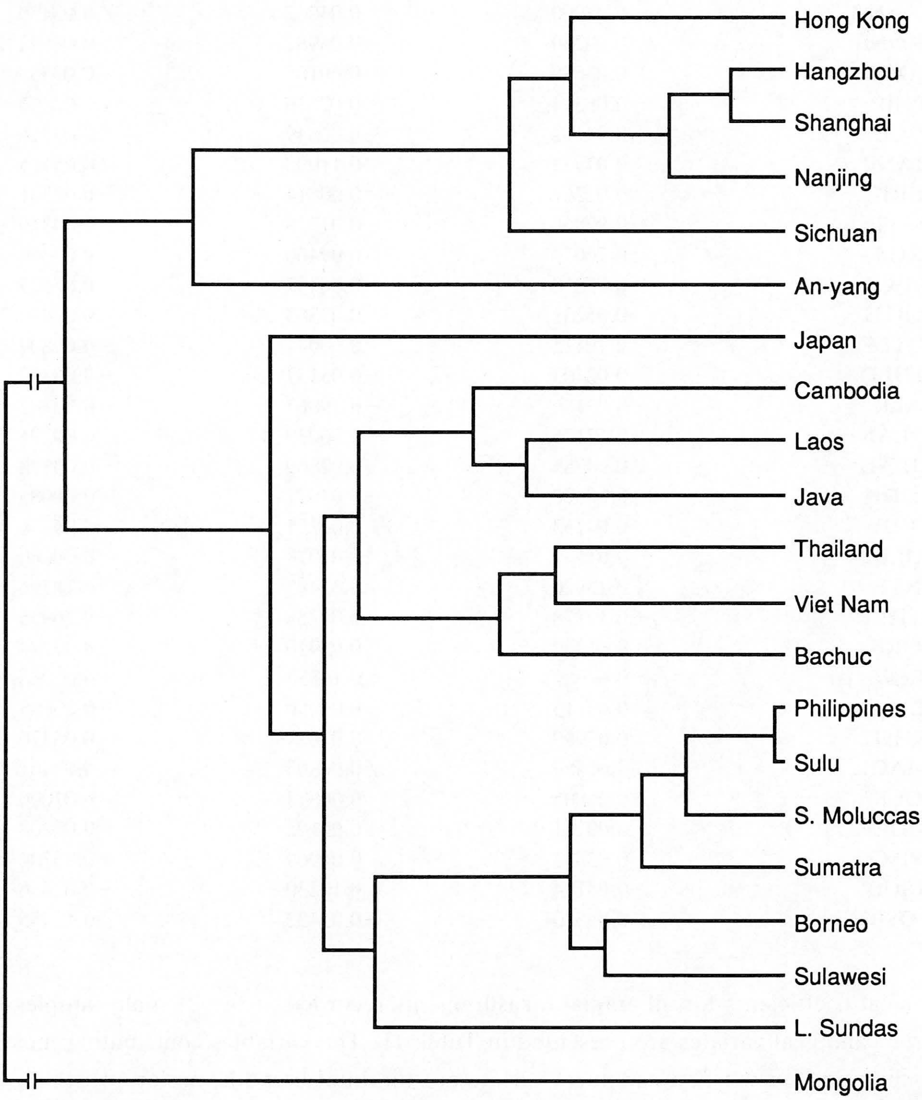

Figure 5. Diagram of relationship based on a cluster analysis of Generalized Distance results using 35 measurements recorded in 21 male samples.

The group classification results are set out in Table 12. The total percentage of cases correctly classified is 50.7%. These results indicate considerable similarity among these groups. The most successful classification results are obtained by Southern Moluccas (84.6%), An-yang (82.3%), Mongolia (80.6%) and Bachuc Village (78.4%). The groups having the poorest classification results include Sulawesi (19.5%), Shanghai (30.0%), Hangzhou (32.4%), Lesser Sundas (37.8%) and Viet Nam (39.5%). Groups receiving the highest number of misclassifications from other groups include Hangzhou, Laos, Nanjing, Sichuan and Hong Kong. Seventeen of the cases misclassified as Japanese are of Southeast Asian origin. Nineteen of the cases originally grouped as Japan are misclassified into one of the Southeast Asian samples, seven of these were misclassified as either Java or Borneo. The overall correct assignment for Japan is 64.6%. Thailand (6) and Viet Nam (5) contribute the highest number or misclassified cases to the Japan sample.

Table 12 Summary of Classification Results from Discriminant Function Analysis for 21 Male Samples (Number of Cases Classified in Groups)

	HK	SIC	HAN	ANY	NAJ	JAP	MOG	SHA	CAM	LAO	THI	VNM
Hong Kong	52	2	5	2	3	1		7			3	1
Sichuan	3	29	3		6	1	2	4				1
Hangzhou	8	9	22	2	8	2	1	7		1		1
An-yang	2	2		65	2	1	1	1				
Nanjing	3	6	5	3	21	1		6				2
Japan		1			1	42	1	1		2	1	2
Mongolia	1		1				25			3		1
Shanghai	13	12	26	4	16	4	5	45		4	9	2
Cambodia									8	1		
Laos		1				1			2	20		1
Thailand		3	1			1		1	2	4	31	5
Viet Nam	2		3	2	1	5		2		3	6	34
Bachuc	1						1		1		3	1
Philippines	1			1		1			1	1	1	
L. Sundas			1			3			2	2		4
S. Moluccas												
Sumatra							1					
Borneo				2		1	1		2			2
Sulawesi			1	2					4	7	1	
Java	1	1		1		2			3	6	3	1
Sulu						3			3	4		
Total Cases Orig Assign.	80	53	68	79	49	65	31	150	11	29	61	86
No. of Cases Correct Assign.	52	29	22	65	21	42	25	45	8	20	31	34
%Correct Assign.	65.0	54.7	32.4	82.3	42.9	64.6	80.6	30.0	72.7	69.0	50.8	39.5

Table 12 (cont'd) Summary of Classification Results from Discriminant Function Analysis for 21 Male Samples (Number of Cases Classified in Groups)

	BAC	PHL	LSN	SML	SUM	BOR	SLW	JAV	SUL
Hong Kong	1					1		1	1
Sichuan		3		1					
Hangzhou	1	1	1		2	1		1	
An-yang		3	1				1		
Nanjing	1						1		
Japan	2	1	1		2	4		3	1
Mongolia									
Shanghai	1		1	1	3	1			3
Cambodia							2		
Laos	1				1				2
Thailand	5	3	1	1				2	1
Viet Nam	4	5	1		2	3	1	7	5
Bachuc	40				1	1		1	1
Philippines	1	16			2		1	1	1
L. Sundas		3	17	3	2	2	2	3	1
S. Moluccas			1	11			1		
Sumatra		1	1	1	7	2			1
Borneo			2		3	14	2	2	3
Sulawesi	1	4	2	3	5	2	8		1
Java	2	2	5	1	1	3	3	32	6
Sulu	1		1			2	3	3	18
Total Cases Orig Assign.	51	28	45	13	14	34	41	73	38
No. of Cases Correct Assign.	40	16	17	11	7	14	8	32	18
%Correct Assign.	78.4	57.1	37.8	84.6	50.0	41.2	19.5	43.8	47.4

Percentage of grouped cases correctly classified: 50.7%

Generalized Distance

The results of applying Mahalanobis' Generalized Distance to 35 measurements recorded in 21 male samples are given in Table 13. Applying the average linkage clustering algorithm to these raw scores results in the dendrogram presented in Figure 5. The five modern Chinese samples form a separate cluster to which the Bronze-age Chinese sample is attached. Within the Chinese cluster, the three samples representing eastern China form a tight nucleus. Japan does not cluster with the latter Chinese grouping but occupies an intermediate position between China and the branch that contains all the extant mainland and island Southeast Asian samples. Mongolia is the last group to cluster. Except for the anomalous placement of Java, there is generally good separation of mainland and island Southeast Asia. As expected however, inspection of the raw d-squared results indicates Java is closest to Sulawesi, Lesser Sundas and then Laos. Examining the distances between Japan and the remaining groups demonstrates that Borneo, Viet Nam, Sulu, Java and Sulawesi (in that order) are closest to Japan.

In general, the results obtained in Analysis 2 indicate that the region (Asia and Southeast Asia) is relatively homogeneous. Variation in facial width and height, zygoma size and cranial vault length are primarily responsible for separating Chinese, mainland Southeast Asian and island Southeast Asian groups. Mongolia is the most well differentiated group. Modern Japanese are closest to Viet Nam and island Southeast Asia.

Table 13 Mahalanobis' Generalized Distances for 21 Male Samples Using 35 Measurements

	HONGKG	SICHUN	HANZOU	ANYANG	NANJIG	JAPAN	MONGOL	SHANGI	CAMBOD	LAOS	THAI	VIETNM	BACHUC
Hong Kong	0.000												
Sichuan	7.880	0.000											
Hangzhou	3.555	4.016	0.000										
An-yang	11.041	12.229	10.552	0.000									
Nanjing	4.378	3.143	1.661	8.283	0.000								
Japan	12.184	12.219	8.586	12.676	8.622	0.000							
Mongolia	18.490	10.183	10.855	18.969	11.473	13.405	0.000						
Shanghai	3.075	4.230	0.921	9.998	2.371	8.785	10.591	0.000					
Cambodia	17.226	23.256	19.066	23.996	20.972	11.533	20.913	17.156	0.000				
Laos	13.291	13.622	11.450	18.239	12.627	8.343	12.494	10.585	5.316	0.000			
Thiland	6.000	12.191	7.877	15.982	10.718	9.506	16.340	6.205	8.314	6.082	0.000		
Viet Nam	6.409	7.594	6.320	12.327	7.063	5.999	14.373	6.416	9.765	5.514	3.912	0.000	
Bachuc	8.023	13.998	11.097	19.722	13.422	12.625	21.484	9.475	12.042	8.091	4.167	5.746	0.000
Philippines	8.062	10.316	8.548	11.625	9.893	10.272	18.069	8.184	12.390	7.830	5.773	3.978	8.913
L. Sundas	9.969	12.567	10.634	15.751	12.481	8.277	19.457	10.237	8.533	7.867	7.199	4.878	11.473
S. Moluccas	15.538	17.820	16.166	19.682	18.086	14.983	21.920	15.602	13.027	12.319	9.498	9.968	16.734
Sumatra	10.283	11.468	9.797	14.227	10.837	8.385	15.030	9.495	11.470	10.363	8.667	6.276	15.045
Borneo	11.231	13.761	10.345	16.596	12.107	5.616	16.272	10.381	7.731	7.268	7.926	4.557	11.813
Sulawesi	11.692	13.270	10.350	13.991	12.252	7.221	12.917	9.525	4.724	4.167	5.308	5.142	9.822
Java	10.738	13.721	9.469	15.057	12.048	6.814	15.350	8.900	5.915	4.428	5.106	4.403	7.763
Sulu	15.910	15.933	13.975	19.966	16.376	6.277	16.307	13.362	5.150	5.895	8.186	6.043	9.876

	PHLPIN	LSUNDA	SMOLUC	SUMTRA	BORNEO	SULAWS	JAVA	SULU
Philippines	0.000							
L. Sundas	5.845	0.000						
S. Moluccas	7.423	6.696	0.000					
Sumatra	6.469	3.371	8.733	0.000				
Borneo	7.832	3.388	10.538	4.037	0.000			
Sulawesi	5.261	3.710	5.961	4.640	4.163	0.000		
Java	6.600	4.426	10.207	7.378	5.391	3.055	0.000	
Sulu	9.439	6.926	11.625	8.043	5.578	4.430	4.188	0.000

Japan, Asia and the Pacific-Analysis 3

In the final multivariate analysis 2, 261 male crania representing 43 Japanese, Asian and Pacific samples are investigated. In addition to the samples included in the previous analyses, Australia, Melanesia, Micronesia and Polynesia are broadly sampled in this analysis.

Discriminant Analysis

A summary ranking the 35 cranial measurements according to the F-values received at the termination of the stepping procedure is presented in Table 14. Among the variables contributing the most to group separation and selected in the earliest steps of the discriminant analysis are maximum cranial breadth, alveolar length, basion-nasion length, nasion-prosthion height, biorbital breadth, maximum cranial breadth and bimaxillary subtense. Variables receiving some of the lowest F-values include the mastoid height and breadth, orbital height and breadth, chord measurements of the posterior cranial vault, minimum frontal breadth, biasterionic breadth and the length of the *foramen magnum*.

Statistics for the first 25 canonical variates are presented in Table 15. The first three canonical variates account for 67.2% of the total variance. The first 24 canonical variates are all significant at $p < .01$.

Table 14 A Ranking of Cranial Measurements for 43 Male Samples According to F-Values Obtained in the Final Step of Discriminant Function Analysis (The First 35 Steps are Shown)

Step No.	*Measurement*	*F-Value*	*d. f. $_B$/d. f. $_W$*	*P**
1	MAXCRANB	49.570	42/2218	*
2	ALVEOLAL	31.479	42/2217	*
3	BASINASI	24.254	42/2216	*
4	NASIPROS	23.969	42/2215	*
5	MINCRANB	16.260	42/2214	*
6	BIORBITB	16.485	42/2213	*
7	MAXCRANL	13.864	42/2212	*
8	BIMAXSUB	13.463	42/2211	*
9	BIAURICB	12.812	42/2210	*
10	BASIBREG	10.568	42/2209	*
11	NASOCCIL	10.293	42/2208	*
12	INTERORB	9.385	42/2207	*
13	BIMAXILB	8.366	42/2206	*
14	ALVEOLAB	9.034	42/2205	*
15	NASIBGCR	7.722	42/2204	*
16	MALRLINF	7.311	42/2203	*
17	BIJUGALB	6.970	42/2202	*
18	BIFRONTB	6.014	42/2201	*
19	NASFROSB	5.789	42/2200	*
20	NASALHGT	5.257	42/2199	*
21	BISTEPHB	5.385	42/2198	*
22	MAXFRONB	5.495	42/2197	*
23	BASIPROS	4.850	42/2196	*
24	NASALBTH	4.761	42/2195	*
25	MASTOIDH	4.718	42/2194	*
26	FORAMAGL	4.303	42/2193	*
27	CHEEKHGT	4.265	42/2192	*
28	ORBHGTLF	4.204	42/2191	*
29	MALRLMAX	4.200	42/2190	*
30	BIASTERI	3.741	42/2189	*
31	LAMOPISC	3.824	42/2188	*
32	ORBBTHLF	3.515	42/2187	*
33	BRGLMDCR	3.434	42/2186	*
34	MINFRONB	3.412	42/2185	*
35	MASTOIDW	3.069	42/2184	*

*$P < .01$

Table 15 Eigenvalues, Percentage of Total Dispersion, Cumulative Percentage of Dispersion and Level of Significance for the First 25 Canonical Variates (43 Male Samples and 35 Measurements)

Canonical *Variate*	*Eigenvalue*	*%Dispersion*	Cumulative *%Dispersion*	*d. f.* [1]	P^2
1	4.45338	46.9	46.9	76	*
2	1.24477	13.2	60.1	74	*
3	0.67426	7.1	67.2	72	*
4	0.55977	5.9	73.1	70	*
5	0.38706	4.1	77.2	68	*
6	0.29644	3.1	80.3	66	*
7	0.27035	2.8	83.1	64	*
8	0.23045	2.5	85.6	62	*
9	0.21003	2.2	87.8	60	*
10	0.15123	1.6	89.4	58	*
11	0.13724	1.4	90.8	56	*
12	0.12024	1.3	92.1	54	*
13	0.11699	1.2	93.3	52	*
14	0.09229	1.0	94.3	50	*
15	0.07754	0.8	95.1	48	*
16	0.07240	0.8	95.9	46	*
17	0.05861	0.6	96.5	44	*
18	0.05421	0.6	97.1	42	*
19	0.04171	0.4	97.5	40	*
20	0.03968	0.4	97.9	38	*
21	0.03718	0.4	98.3	36	*
22	0.02966	0.3	98.6	34	*
23	0.02691	0.3	98.9	32	*
24	0.02312	0.2	99.1	30	*
25	0.01758	0.2	99.3	28	NS

[1] d. f. =degrees of freedom=(p+q−2)+(p+q−4) . . .

[2] *P<.0.1. When eigenvalues are tested for significance according to Bartlett's criterion : [N−1/2 (p+q)]$\log_e$ (1+ λ), Where N=total number of crania, p=number of variables, q=number of groups, λ = eigenvalue, which are distributed approximately as chi-square (Rao, 1952 : 373).

NS=not significant

Canonical coeffficients for 35 cranial measurements for the first three canonical variates are given in Table 16. Variation in biorbital breadth, alveolar length, nasion-prosthion height, bimaxillary breadth and interorbital breadth is primarily responsible for group separation on the first canonical variate. Mid-and upper facial breadth measurements, palate length and upper facial height define this discriminating canonical variate. The second canonical variate is responsible for group separation primarily on the basis of variation in bifrontal breadth, bijugular breadth, minimum cranial breadth and alveolar breadth. The third canonical variate is defined as a cranial vault length, nasal height and inferior malar length discriminator.

Table 16 Canonical Coefficients for Cranial Measurements Recorded in 43 Male Samples for the First Three Canonical Variates

Measurement	*Canonical Variate 1 Coefficient*	*Canonical Variate 2 Coefficient*	*Canonical Variate 3 Coefficient*
MAXCRANL	−0.08215	0.04916	0.11334
NASOCCIL	0.06709	−0.05374	0.03595
BASINASI	0.01720	−0.06575	0.02641
BASIBREG	0.02128	−0.00645	0.03224
MAXCRANB	0.03171	0.04557	−0.07234
MAXFRONB	0.01361	0.05055	0.07468
MINFRONB	−0.04519	−0.01308	0.01691
BISTEPHB	0.01964	−0.05128	−0.09108
BIAURICB	0.01600	−0.07644	0.09694
MINCRANB	0.09035	0.10366	−0.00716
BIASTERI	−0.00656	0.04259	0.03929
BASIPROS	0.01028	−0.06950	−0.02269
NASIPROS	0.11522	0.07441	0.05316
NASALHGT	−0.08086	−0.09712	−0.10148
NASALBTH	0.03686	0.09493	0.05549
ORBHGTLF	0.04463	−0.06698	−0.01728
ORBBTHLF	−0.02614	−0.07210	0.07641
BIJUGALB	0.02212	−0.11666	0.02963
ALVEOLAL	−0.12781	0.06199	−0.01374
ALVEOLAB	−0.03944	0.10186	0.02525
MASTOIDH	−0.01572	−0.05814	−0.01014
MASTOIDW	0.03161	−0.02923	−0.00914
BIMAXILB	0.06292	0.02639	−0.06923
BIFRONTB	0.01962	0.12487	0.04031
BIORBITB	−0.19302	−0.01723	−0.06079
INTERORB	0.10456	0.04154	0.00890
MALRLINF	−0.06864	0.08197	−0.10905
MALRLMAX	0.01892	−0.01867	0.04066
CHEEKHGT	0.06398	−0.08044	0.01077
FORAMAGL	0.04283	0.03540	−0.05583
NASIBGCR	−0.02930	−0.05190	−0.02214
BRGLMDCR	0.00389	0.01368	−0.04920
LAMOPISC	0.01177	−0.03263	−0.07837
BIMAXSUB	−0.10874	−0.04687	−0.07848
NASFROSB	0.00051	0.02351	−0.08250

A plot of the group means on the first and second canonical variates is presented in Figure 6. Together, the first two canonical variates account for 60.1% of the total variation described by the discriminant analysis. The six Chinese samples and Mongolia fall within a relatively tight cluster adjacent to a constellation containing all the Southeast Asian samples. Japan is closer to this latter cluster than it is to the one containing Chinese and Mongolian samples. Polynesian and several Micronesian samples, although widely spaced, represent a distinct group. Guam and the Northern Marianas border on the Southeast Asian group. The five Australian and Tasmanian group means occupy one extreme of a larger constellation that consolidates all the Australian and Melanesian group centroids. The Caroline Island mean is between the Melanesian and Polynesian group clusters.

The group classification results (Table 17) for this analysis were slightly better than in Analysis

2. The percentage of grouped cases correctly classified in Analysis 3 is 54.1%. The best classification results were obtained by Easter Island (85.9%), An-yang (81.0%), Tasmania (80.8%), Hawai'i (79.6%), and Mongolia (77.4%). The groups having the poorest classification results were Sulawesi (14.6%), Lesser Sundas (22.2%), Shanghai (32.0%) and Viet Nam (36.0%). The groups receiving the highest number of misclassified cases from other groups are Hangzhou, Hong Kong and Sichuan. These latter generally receive cases originally grouped as one of the modern Chinese samples. The classification success rate for Japan is 55.4%. The misclassifications for Japan are relatively evenly spread throughout mainland Southeast Asia (8 cases), Island Southeast Asia (10 cases) and, interestingly, among Polynesian (5 cases) groups. Japan receives relatively few of the misclassifications from other groups. The largest number of cases misclassified as Japan are from China and Viet Nam.

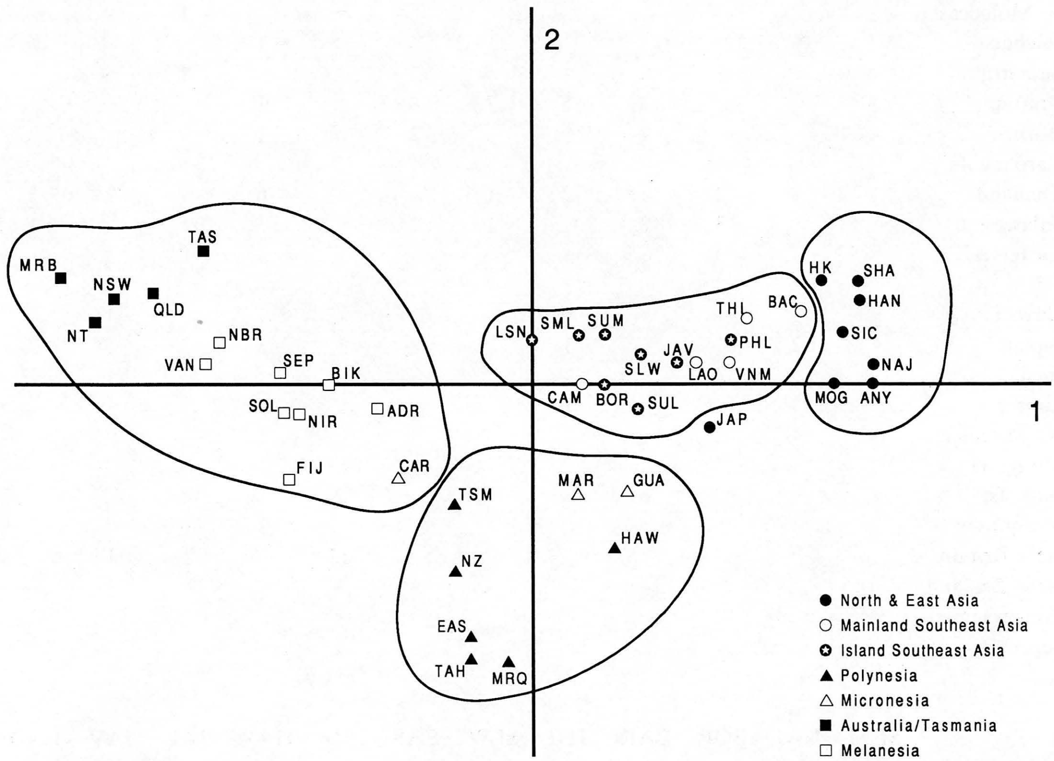

Figure 6. Plot of 43 male group means on the first two canonical variates (or discriminant functions) using 35 cranial measurements.

Table 17 Summary of Classification Results from Discriminant Function Analysis for 43 Male Samples (No. of Cases Classified in Groups)

	HK	GUA	PHL	ADM	SIC	HAN	ANY	VAN	VNT	LSN	SML	BAC
Hong Kong	57				2	3	2		1			
Guam	1	29										
Philippines	1		13	1		1	2					1
Admiralty			1	41		1			2	2		
Sichuan	3		2		34	2			1		1	
Hangzhou	7				9	26	3		1	1		
An-yang	1	1	3		2		64			1		
Vanuatu								23				
Viet Nam	4		6		2	2	2		31		1	2
L. Sundas			3						4	10	2	
S. Moluccas										1	9	
Bachuc	1								1			38
Sumatra			1							1	1	
Nanjing	5				5	7	4		1			1
Borneo				2			2		1			
Caroline Is.	1						1	2				
Thailand		1	2		2	1			6		2	5
Sulawesi			3	2		1	2			1	4	1
Easter ls.												
Fiji		1						1			1	
Hawaii		1									1	
Japan		2			1				3	2	1	2
Java	1		2		1					2	1	2
Laos					1				1			1
N. Marianas		4							1			
Mongolia	1								1			
Biak Is.				6				2				
Marquesas									1			
New Britain								13		1	1	
New Zealand	1			4				1				
Tonga-Samoa												
Sepik R.				2				1				

	SUM	NAJ	BOR	CAR	THI	SLW	EAS	FIJ	HAW	JAP	JAV	LAO
Hong Kong		1	1		3					1		
Guam									4		1	1
Philippines	2				1	1					2	1
Admiralty				1			1	1				
Sichuan	1	3								1		
Hangzhou	3	5	1						1	2		
An-yang	1	2								1		
Vanuatu								2				
Viet Nam	1	1	2		7	1				3		
L. Sundas	3		2			2		2	2		3	2
S. Moluccas						1						
Bachuc	1		1		3						2	1
Sumatra	8		2									
Nanjing		18		1		1				1		
Borneo	2		13	1		2					1	

Caroline Is.				11			1	1	1			
Thailand					28					1	1	3
Sulawesi	5		3		1	6						7
Easter Is.				1	1		55	1				
Fiji			1				1	16				
Hawaii					1		1		39		1	
Japan	1		3		1	1	2			36	1	2
Java	1		4		3	3			4	1	29	4
Laos	1									1		20
N. Marianas				1			1	2				1
Mongolia				1								2
Biak ls.	1			1								
Marquesas	1			1					1			
New Britain			1	1			1	1				
New Zealand	1	1	1				3		2			
Tonga-Samoa								2	1			
Sepik R.												2

	MAR	MOG	BIK	MRQ	NBR	NZ	TOG	SEP	SUL	TAH	NIR	SHA
Hong Kong									1			8
Guam	4			1		1	2		1		1	
Philippines									1			
Admiralty	1		4			5	1	6	2		4	
Sichuan		2										3
Hangzhou		1										7
An-yang	1	1										1
Vanuatu			1		7			2			2	
Viet Nam	3							1	3	1		2
L. Sundas			2		2			1				
S. Moluccas						1					1	
Bachuc		1							1			
Sumatra		1										
Nanjing	1											4
Borneo		2	1						3		1	
Caroline Is.	1				3					1		
Thailand	2						1		1			2
Sulawesi									1		1	
Easter Is.	1			1		1				2		
Fiji			1	1	1		2			2	1	
Hawaii	1			2		1						
Japan	2	1				3			1			
Java	1						1	1	6	2		
Laos									2			
N. Marianas	15								1			
Mongolia	1	24										
Biak ls.	2		27		1			3			1	
Marquesas		1	2	32		5				6	1	
N. Britain					46			6			5	
New Zealand	2		1	7		38	1			2	3	
Tonga-Samoa							4					
Sepik R.			5		3			51			5	

	SOL	CAM	MRB	TAS	NSW	QLD	NTR
Hong Kong							
Guam							
Philippines		1					
Admiralty	4			1	1		
Sichuan							
Hangzhou							
An-yang							
Vanuatu	2		1	4		2	1
Viet Nam	1	1					
L. Sundas	2	1			2		
S. Moluccas							
Bachuc		1					
Sumatra							
Nanjing							
Borneo	1	1				1	
Caroline Is.			1				
Thailand	1	2					
Sulawesi		3					
Easter Is.	1						
Fiji			1		2		
Hawaii		1					
Japan							
Java	2	2					
Laos		2					
N. Marianas	2	1					
Mongolia		1					
Biak ls.	2					1	1
Marquesas							
N. Britain	2		2		1	2	2
New Zealand	2						
Tonga-Samoa							
Sepik R.	2		1			1	1

	HK	GUA	PHL	ADM	SIC	HAN	ANY	VAN	VNT	LSN	SML	BAC
Sulu												1
Tahiti				1								
New Ireland				5				1		1	1	
Shanghai	16				15	26	2		1	1	1	1
Solomons				2				1		1		
Cambodia												
Murray R								1		1		
Tasmania									1	1		
New South Wales				1				1				
Queensland							1	2				
North. Territory				1				1				
Total Cases Orig. Assign.	80	46	28	79	53	68	79	47	86	45	13	51
No. Cases Correct. Assign.	57	29	13	41	34	26	64	23	31	10	9	38
%Correct Assign.	71.2	63.0	46.4	51.9	64.2	38.2	81.0	48.9	36.0	22.2	69.2	74.5

	SUM	NAJ	BOR	CAR	THI	SLW	EAS	FIJ	HAW	JAP	JAV	LAO
Sulu			2			1				2	2	5
Tahiti				2					2			
New Ireland				1				4				
Shanghai	2	12	1		8	3				4		2
Solomons			1	2			1	1			1	
Cambodia						2						1
Murray R.												
Tasmania												
New South Wales								1				
Queensland	1							1				
North. Territory								2				
Total Cases Orig. Assign.	14	49	34	24	61	41	64	32	49	65	73	29
No. Cases Correct. Assign.	8	18	13	11	28	6	55	16	39	36	29	20
%Correct Assign.	57.1	36.7	38.2	45.8	45.9	14.6	85.9	50.0	79.6	55.4	39.7	69.0

	MAR	MOG	BIK	MRQ	NBR	NZ	TOG	SEP	SUL	TAH	NIR	SHA
Sulu	1					1	1		18			
Tahiti	1			3		2				22		
New Ireland			1		6			5	1		23	
Shanghai		4				1			2			48
Solomons			1		1	1		2		2	8	
Cambodia							1					
Murray R.					1							
Tasmania			1			1	1					
New South Wales						1		2			1	
Queensland			1		2						1	
North. Territory					1			3	1			
Total Cases Orig. Assign.	29	31	48	51	85	70	7	74	38	33	53	150
No. Cases Correct. Assign.	15	24	27	32	46	38	4	51	18	22	23	48
%Correct Assign.	51.7	77.4	56.3	62.7	54.1	54.3	57.1	68.9	47.4	66.7	43.4	32.0

	SOL	CAM	MRB	TAS	NSW	QLD	NTR
Sulu	1	3					
Tahiti							
New Ireland	3		1				
Shanghai							
Solomons	18	1			2		3
Cambodia		7					
Murray R.	1		55	5	7	5	9
Tasmania				21			
New South Wales	1		5	1	38	6	4
Queensland	2		7		13	36	7
North. Territory	3		7		5	4	47
Total Cases Orig. Assign.	49	11	85	26	62	74	75
No. Cases Correct. Assign.	18	7	55	21	38	36	47
%Correct Assign.	36.7	63.6	64.7	80.8	61.3	48.6	62.7

Percentage of grouped cases correctly classified : 54.1%

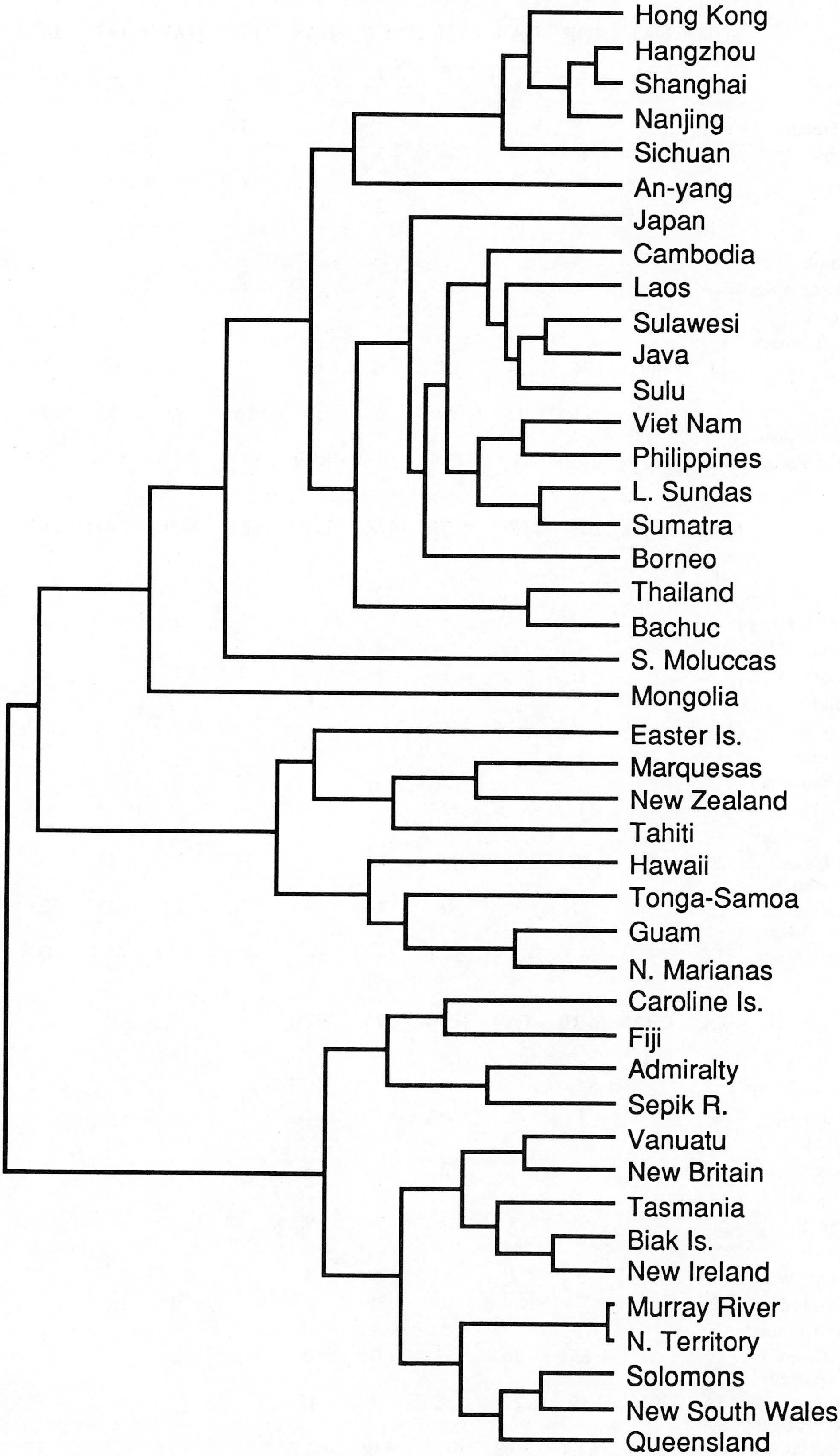

Figure 7. Diagram of relationship based on a cluster analysis of Generalized Distance results using 35 measurements recorded in 43 male samples.

The results of applying Mahalanobis' Generalized Distance to 35 measurements recorded in 43 male samples are presented in Table 18. Figure 7 is the dendrogram which results from a cluster analysis of these raw scores. This diagram of relationship closely resembles the canonical plot for these same data. The six Chinese samples, including An-yang, form a distinct cluster which is attached to a broader cluster containing all the Southeast Asian samples. Japan occupies a peripheral branch of the latter subgrouping joining just ahead of Thailand, Bachuc and the Southern Moluccas. Mongolia joins the Asian constellation just before the Polynesian and Micronesian groups. The latter (with the exception of Caroline Islands) occupy a distinct cluster that is last to join the Asian and Southeast Asian complex. The last major cluster contains all the Melanesian and Australian samples. Their placement indicates they are the most dissimilar of the groups compared. While the internal organization within the latter cluster exhibits some irregularities, the fact that this cluster excludes all Asian and Polynesizn groups is a more noteworthy observation. The internal organization of the Australo-Melanesian cluster is more a function of the clustering algorithm selected which computes the distance between the major clusters as the average of the distance between all possible pairs of cases in the resulting cluster. Since these are among the last groups to be clustered, the chance for anomalous pairing within this cluster is substantially increased.

Table 18 Mahalanobis' Generalized Distances for 43 Male Samples Using 35 Measurements

	HK	SIC	HAN	ANY	NAJ	JAP	MOG	SHA	GAM
Hong Kong	0.000								
Sichuan	8.058	0.000							
Hangzhou	3.688	4.079	0.000						
An-yang	11.579	13.323	11.232	0.000					
Nanjing	4.419	3.132	1.607	8.786	0.000				
Japan	12.144	12.498	8.356	13.038	8.464	0.000			
Mongolia	19.544	10.894	11.553	20.880	12.255	14.437	0.000		
Shanghai	3.246	4.274	0.925	10.894	2.338	8.621	11.114	0.000	
Cambodia	17.527	24.267	19.559	24.327	21.015	12.494	21.517	17.651	0.000
Laos	13.858	14.378	12.000	19.090	12.753	8.771	13.106	11.179	5.155
Thiland	6.632	12.795	8.005	17.222	10.817	9.570	16.613	6.447	8.355
Viet Nam	6.510	8.325	6.445	12.979	7.078	6.097	15.482	6.710	9.992
Bachuc	7.785	14.292	10.672	20.032	12.891	11.933	21.687	9.320	11.409
Philippines	8.327	11.060	9.167	12.371	10.184	10.760	19.534	9.041	12.680
L. Sundas	9.783	12.565	10.543	16.000	11.855	8.389	20.189	10.307	9.171
S. Moluccas	16.273	18.581	16.583	21.190	18.608	16.017	22.086	16.245	13.604
Sumatra	9.617	11.087	9.213	14.750	10.027	8.662	15.626	9.040	12.091
Borneo	10.926	13.927	10.065	16.870	11.533	5.806	17.026	10.154	8.203
Sulawesi	11.595	13.489	10.204	14.507	11.761	7.652	13.140	9.575	4.952
Java	10.751	15.046	9.908	15.632	12.155	7.012	16.643	9.461	5.793
Sulu	15.320	16.457	13.553	20.615	15.879	6.421	17.090	13.073	5.280
Easter Is.	26.190	30.519	28.595	27.245	25.618	18.623	34.862	30.365	24.748
Hawaii	17.914	20.219	18.560	22.808	19.356	13.341	20.795	18.527	12.867
Marquesas	28.159	23.968	27.001	29.891	25.352	18.046	25.782	28.174	22.745
New Zealand	21.687	20.140	21.343	23.479	19.608	11.753	24.456	21.968	16.988
Tonga-Samoa	24.183	28.145	25.342	31.276	26.226	15.682	27.117	23.555	13.759
Tahiti	30.946	29.560	30.864	34.448	29.195	20.872	35.582	31.112	23.409
Guam	19.122	16.072	17.915	18.554	15.139	11.223	20.835	16.483	15.111
Marianas	16.275	17.308	16.430	17.325	13.927	7.647	21.326	15.496	12.596
Caroline Is.	19.486	22.077	20.750	28.908	20.155	13.871	30.377	21.691	16.119

Admiralty	20.542	22.249	21.979	31.614	22.674	16.626	28.541	22.599	10.969
Vanuatu	30.419	31.464	31.550	38.508	32.814	24.775	38.305	31.836	21.809
Fiji	26.728	29.212	28.469	33.712	28.336	17.978	35.627	28.548	22.262
New Britain	28.122	32.101	30.461	36.291	31.459	24.811	40.501	30.637	21.638
Sepik R.	26.179	30.180	28.447	38.264	29.806	22.040	40.519	29.301	18.578
Murray R.	43.060	45.480	44.432	51.280	47.885	36.829	49.272	44.102	29.771
Tasmania	34.779	39.300	38.666	48.062	42.667	32.206	40.286	37.003	26.277
Biak Is	19.762	21.305	21.325	30.029	22.217	15.992	30.590	21.954	19.381
New Ireland	23.739	26.015	24.945	32.001	24.986	16.781	33.162	25.572	16.297
Solomons	21.769	25.344	23.786	29.505	23.667	16.187	33.299	24.208	14.379
New South Wales	37.760	38.993	38.433	44.994	41.571	30.595	44.131	37.609	27.570
Queensland	33.450	37.546	36.088	42.629	38.576	27.656	40.944	35.094	22.882
N. Territory	36.745	41.225	39.368	46.855	41.471	30.190	47.839	39.402	23.161

	LAO	THI	VNM	BAC	PHL	LSN	SML	SUM	BOR
Laos	0.000								
Thiland	6.274	0.000							
Viet Nam	5.666	3.956	0.000						
Bachuc	7.830	3.830	5.388	0.000					
Philippines	8.029	5.968	3.919	8.444	0.000				
L. Sundas	7.927	7.522	4.755	10.703	5.672	0.000			
S. Moluccas	12.571	9.843	10.376	16.392	7.875	7.065	0.000		
Sumatra	10.255	8.512	5.934	13.576	6.287	3.220	9.004	0.000	
Borneo	7.235	7.791	4.391	10.578	7.996	3.710	11.406	4.308	0.000
Sulawesi	4.020	5.255	5.058	9.033	5.388	3.913	6.003	4.811	4.409
Java	4.346	4.925	4.429	7.178	6.582	4.358	9.864	6.947	5.176
Sulu	5.524	7.685	5.835	8.791	9.259	6.621	11.548	7.943	5.412
Easter Is.	26.453	26.905	20.036	32.985	22.804	16.120	25.777	17.772	16.580
Hawaii	15.451	14.444	12.825	19.182	15.892	11.247	17.917	13.133	13.372
Marquesas	23.670	26.188	20.823	29.396	24.567	17.429	22.655	20.144	17.253
New Zealand	14.341	19.226	14.477	23.740	16.417	10.221	16.924	12.141	11.452
Tonga-Samoa	17.451	17.816	17.313	25.277	20.213	12.398	21.144	15.428	13.172
Tahiti	26.872	28.054	22.448	30.318	27.207	18.193	26.624	23.319	20.198
Guam	14.332	17.279	13.137	22.186	15.795	11.407	21.442	12.319	12.731
Marianas	11.255	14.045	9.249	18.161	12.962	8.654	17.869	11.493	9.113
Caroline Is.	16.337	18.409	15.213	21.630	17.264	8.338	19.106	12.114	10.841
Admiralty	15.817	17.133	13.703	20.177	15.763	8.659	16.019	11.900	11.347
Vanuatu	25.239	27.836	22.811	34.579	26.209	11.075	19.158	15.241	15.876
Fiji	24.950	25.989	21.424	30.449	25.521	11.311	22.621	16.204	14.797
New Britain	24.870	26.637	22.970	33.536	23.249	9.117	18.760	13.993	15.676
Sepik R.	19.763	23.024	19.892	24.820	21.783	9.700	18.135	15.917	15.662
Murray R.	36.248	38.576	35.921	45.142	38.498	19.563	32.346	25.355	25.773
Tasmania	32.300	30.590	29.980	39.449	32.736	18.288	24.586	19.238	21.887
Biak Is	19.203	20.361	14.798	22.093	16.996	6.785	15.696	9.965	9.962
New Ireland	17.229	21.078	16.798	26.180	19.008	7.330	15.195	12.271	12.206
Solomons	16.292	18.600	15.154	23.928	16.637	6.237	15.493	10.536	10.180
New South Wales	31.437	31.777	29.920	39.382	30.672	14.672	24.863	20.821	22.392
Queensland	27.204	28.366	25.849	35.153	28.101	13.316	24.080	19.640	18.408
N. Territory	27.709	31.872	27.924	35.465	31.246	14.436	27.147	22.469	20.331

	SLW	JAV	SUL	EAS	HAW	MRQ	NZ	TSM	TAH
Sulawesi	0.000								
Java	2.881	0.000							
Sulu	4.368	3.896	0.000						
Easter Is.	21.294	22.814	23.044	0.000					
Hawaii	12.018	9.959	10.936	11.749	0.000				
Marquesas	19.120	20.111	17.298	12.875	10.356	0.000			
New Zealand	13.443	15.713	13.008	8.731	11.092	5.865	0.000		
Tonga-Samoa	15.642	12.769	13.723	18.282	10.024	16.471	12.075	0.000	
Tahiti	21.221	19.375	19.633	16.140	13.816	6.962	11.615	18.305	0.000
Guam	13.648	12.810	13.298	15.788	9.656	16.632	12.420	9.302	18.971
Marianas	11.350	10.365	9.995	11.842	11.655	15.163	7.826	8.076	16.641
Caroline Is.	13.557	14.841	13.500	11.536	15.869	12.792	7.577	14.226	12.807
Admiralty	13.572	14.349	13.551	20.112	19.716	15.489	7.987	17.733	18.028
Vanuatu	18.729	21.873	19.732	24.928	26.898	22.817	14.243	18.705	24.467
Fiji	20.307	19.201	18.129	17.176	19.087	14.902	10.669	11.903	16.135
New Britain	17.485	19.977	21.625	23.416	26.149	26.522	16.626	18.367	26.480
Sepik R.	17.443	18.109	16.785	24.141	25.392	23.433	14.085	22.713	22.182
Murray R.	29.334	32.706	32.706	33.870	34.407	36.876	25.444	27.934	39.244
Tasmania	25.369	30.528	27.237	35.383	31.873	37.221	25.300	26.406	45.400
Biak Is	14.688	15.931	13.593	19.142	21.517	16.869	9.758	16.837	18.379
New Ireland	13.435	15.671	15.038	17.728	20.209	18.429	9.953	15.693	17.734
Solomons	12.600	13.903	14.404	15.504	18.957	17.646	8.276	13.945	17.260
New South Wales	24.902	26.417	28.279	31.078	30.769	32.796	21.794	23.018	32.939
Queensland	22.956	24.642	24.931	24.912	27.830	30.416	19.410	18.810	32.123
N. Territory	24.212	25.659	25.520	28.471	31.604	31.245	20.520	23.443	31.470

	GUA	MAR	CAR	ADR	VAN	FIJ	NBR	SEP	JRB
Guam	0.000								
Marianas	4.194	0.000							
Caroline Is.	15.131	10.645	0.000						
Admiralty	20.665	14.724	8.155	0.000					
Vanuatu	25.930	19.053	11.128	11.255	0.000				
Fiji	15.623	12.217	6.983	9.547	9.859	0.000			
New Britain	24.150	19.334	10.521	12.481	3.621	10.686	0.000		
Sepik R.	25.727	19.307	8.651	5.492	8.962	11.314	9.387	0.000	
Murray R.	33.437	31.165	22.104	20.914	10.465	17.775	10.798	17.960	0.000
Tasmania	36.162	31.160	25.577	21.516	9.819	22.004	12.449	21.757	10.567
Biak Is	19.507	13.098	6.698	5.677	5.997	6.336	8.044	5.202	15.825
New Ireland	19.230	13.702	5.173	6.512	5.213	6.598	4.371	5.031	15.813
Solomons	16.531	11.507	4.496	5.078	5.541	6.161	5.613	4.968	13.568
New South Wales	28.008	25.874	18.768	15.110	9.811	12.137	9.160	13.244	4.175
Queensland	25.578	20.409	15.460	15.424	7.954	11.360	8.748	14.203	4.708
N. Territory	27.666	23.038	14.831	12.762	8.082	11.932	8.495	8.601	5.09

	TAS	BIK	NIR	SOL	NSW	QLD	NT
Tasmania	0.000						
Biak Is	16.580	0.000					
New Ireland	16.806	5.213	0.000				
Solomons	17.488	4.778	2.615	0.000			
New South Wales	13.176	12.368	11.430	9.119	0.000		
Queensland	9.851	10.912	10.836	8.183	2.995	0.000	
N. Territory	15.775	9.456	9.080	7.315	4.968	4.337	0.000

Inspecting the relative magnitude of the raw scores in Table 18 indicates that Japan is closest to Borneo, Viet Nam, Sulu, Java, Marianas and Sulawesi. The Viet Nam-Indonesian-Northern Marianas connection is intriguing. The distances between Japan, New Zealand and Guam are moderately small suggesting possible connections between these groups as well.

The general conclusion to be drawn from Analysis 3 is that the region is relatively homogeneous with as few as twelve variables contributing most significantly to the observed pattern of regional variation. Asian, Polynesian and Australo-Melanesian groups are separated primarily on the basis of differences in facial height and width, palatal shape, zygoma size and cranial vault length measurements. Japan, while a member of the larger Asian subgrouping, is more similar to Southeast Asia than it is to China or Mongolia.

Discussion-Conclusion

The main objective of this study, as initially stated, was to investigate craniometric variation in mostly near contemporary populations of Japan, Asia and the Pacific using multivariate statistical procedures. More specific goals of this study were to assess the pattern of craniometric variation in these groups and to speculate on the possible phylogenetic relationships of these groups.

Before summarizing some of the general and more specific results of the study and how these compare with other recent studies, some discussion of the possible effects of environmental differences on craniometric variation will be addressed.

Given its exploratory nature, the present study has been more concerned with generating statements about historical-biological relationships rather than explaining the causes of these differences. The possible effects of differences in the environment, differential selection and other microevolutionary processes have not been examined. Because of the vastness of the region considered, objections might be raised concerning the effects of size variation as a possible source of bias in the present results. No standardization of the data, such as computation of Z-scores or its equivalent, which have been used by others as a means of eliminating the possible effects of size, has been applied in the present study. In partial defense of this position, at least one recent investigator has found that removing this size-based component has had little effect upon the final results of his study and that shape differences are the major source of variation between groups (Green, 1990: 311-313). The even mix of negative and positive correlations for each of the canonical variates in the present study would further support the view that the observed patterns of variation are not strongly biased by size differences.

One of the major conclusions to be drawn from this study, is that multivariate statistical procedures, especially discriminant function analysis and Generalized Distance, are particularly well suited for describing craniometric variation. These same procedures further allow tentative conclusions to be made regarding historical biological relationships.

More specific results of the study indicate that modern Japanese, when compared with Chinese, Mongolians and Southeast Asians, are members of a relatively homogeneous community and group differences are largely regional. The main differences are between populations of China (modern and Bronze-age), Mongolia and Japan. The sample representing Ainu and Jomon skulls, although very small, remains well differentiated from modern Japanese and other East Asian groups. Several previous researchers (e. g., Yamaguchi, 1982, Turner, 1979; Brace *et al.*, 1989, 1990 ; Howells, 1986; to name a few) have drawn similar conclusions. Many of these same authors generally agree that the modern Japanese are closely related to Koreans, Chinese (at least since Neolithic times), and other northeast Asian populations. Others, like Hanihara (1985), however, do not rule out connections between Jomon and modern Japanese. The results of the present study would seem to agree with the majority view. The present results, however, indicate that Jomon-Ainu is closer to Bronze-age Chinese than it is to modern Chinese or Japanese, a connection which warrants further investigation.

Turning to the relations of the modern Japanese and the populations of the Asian mainland and island Southeast Asia, the results of the present study indicate group separation is basically between China, Japan, Southeast Asia and Mongolia. Mongolia is the most isolated and well differentiated Asiatic group in Analysis 2. The Chinese samples are internally homogeneous and well differentiated from other East Asian groups. Variation in relatively few variables, primarily facial width and height, zygoma size and cranial vault length, is responsible for the separation of these groups. Previous researchers, including many of those just mentioned, have noted similarities between Japanese and East Asian groups, especially Chinese and Koreans. The results of the present study only partially support this view. Although the modern Japanese are part of a larger Asian cluster containing Chinese, Mongolians and Southeast Asians, they align more closely with several mainland and island Southeast Asian samples than they do with Chinese or Mongolians.

Extending these multivariarte comparisons to include populations from Japan, Asia and the Pacific produces a marked separation between Asia (including East and South Asia, Polynesia and Micronesia) and the populations of Australia and Melanesia. Japan, while peripheral, again groups with Southeast Asia. Polynesia and Micronesia are the last to join the Asian subdivision. In addition to the variables found to be most responsible for the group separation in the first two analyses, the length and breadth of the hard palate figure most importantly in differentiating these groups in broader comparisons.

Previous research has generally failed to demonstrate a direct link between modern Japanese and the inhabitants of the Pacific. Except for the possible connection via Southeast Asia, the results of the present study generally support this view. Prehistoric connections between Japan, the Pacific and Southeast Asia, untested in the present study, however, cannot be ruled out. Yamaguchi (1967) and, more recently, Hanihara (1985), Turner (1979, 1990) and Brace *et al.* (1989, 1990), have indicated the possibility of a connection between Jomon populations, Southeast Asians and even Polynesians. Because Polynesians are members of the larger Asian complex, studies of prehistoric and modern populations of Japan and the Pacific may be mutually instructive for understanding the origins of Japanese and Polynesians. Recent work with mitochondrial DNA for Pacific populations has provided further evidence that Polynesians are of East Asian origin (Stoneking and Wilson, 1989; Hertzberg *et al.*, 1989).

The present results demonstrate a marked distinction between Australians and Melanesians on the one hand and Polynesians, Micronesians and Southeast Asians (and by extension Asians in general) on the other. These latter (generally referred to as Mongoloids) are craniometrically unrelated to the indigenous inhabitants of Australia and Melanesia (so-called Australoids). Other recent research (Brace *et al.*, 1989, 1990 ; Howells, 1973, 1989, 1990; Pietrusewsky, 1984, 1990, 1990; Turner, 1985, 1986, 1989, 1990) has demonstrated an equally marked separation of the two groups. Most recently, Howells (1989), has surveyed craniometric variation in modern humans, finds no support for the view expressed by Wolpoff *et al.* (1984) that Asians and Australians share a common origin in the east. There is nothing in the present results which would negate the view expressed by Howells.

To summarize the main conclusions:

1. Multivariate statistical procedures, like those used in the present study, are particularly well suited for describing craniometric variation and for assessing the historical-biological relationships of human populations.
2. Modern Japanese, although members of a larger Asian community, show connections with Southeast Asia.
3. Ainu and Jomon are not closely related to modern populations of Japan and East Asia.
4. The main differentiation within the Asian complex is between northern (East Asia) and southern (Southeast Asia) groups.
5. Bronze-age Chinese are like modern Chinese, together they are well differentiated from Japan and the rest of the Asia.
6. The major separation found in this study is between Asian (including East Asia, Southeast Asia, Polynesia and Micronesia) and Australo-Melanesian populations.
7. Japan-Pacific relations (especially *vis a vis* Southeast Asia) are implied in these results. Southeast Asia may have served as the ultimate homeland of both Polynesians and modern Japanese.

The results of multivariate statistical analyses of the data presented in the present study have generally been successful in describing the patterns of craniometric variation in Japanese, Asian and Pacific populations. The study has generated several hypotheses concerning the historical-biological relationships among these groups which require further examination. Future research will require a more extensive sampling of modern and prehistoric Japanese, Korean and aboriginal populations of the Ryukyus, Taiwan and elsewhere before more definitive statements can be advanced regarding the possible biological connections between Japan, Asia and the Pacific.

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日本、アジア、太平洋：頭骨計測値の多変量解析

M. Pietrusewsky

日本人、アジア人、オーストラリア・アボリジニ、および太平洋諸集団の歴史的ならびに生物学的関係を分析するため、2,264個体の頭骨から35項目の計測値を採取して判別関数およびマハラノビスの汎距離を計算した。今回は9集団、21集団、43集団の組合せによる3種類の分析結果を報告する。現代日本人は中国人、モンゴリア人、東南アジア人など他の東アジア人とは異なり、縄文人とアイヌは現代日本人（和人）とも他の東アジア人とも異なる。さらに現代および殷時代の中国人は互いに近いが、日本人とは異なる。広い地域にわたって比較すると、東アジア人（日本人を含む）、東南アジア人、ポリネシア人、およびミクロネシア人のグループは、オーストラリア・アボリジニとメラネシア人を含むグループとは対象的な位置に分類される。したがって日本人と東南アジア人とは同系統と思われる。現代日本人とポリネシア・ミクロネシア群との直接的結びつきは立証されないが、ポリネシア人が東南アジア起源である可能性は高い。同時に、日本人と東南アジア人との系統関係についてはさらに研究を進める必要があろう。集団の分岐はかなり少数の変数によって知ることができる。とくに顔面の幅、脳頭蓋の長さ、および口蓋の大きさは重要な計測である。また多変量解析法は、人類集団における頭骨の変異に基づいて集団間の歴史的・生物学的相互関係を分析する上で有効な方法である。

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