National Library
of Canada

Acquisitions and
Bibliographic Services Branch

395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale
du Canada

Direction des acquisitions et
des services bibliographiques

395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file   Votre référence

Our file   Notre référence

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

Canada

UNIVERSITY OF ALBERTA

DENTAL AND CRANIAL NONMETRIC STUDY OF THE JIANGZHAI NEOLITHIC POPULATION AND ITS GENETIC AFFINITY WITH OTHER EAST ASIANS

BY

Yong Fu ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master of Arts.

Department of Anthropology

Edmonton, Alberta

Fall 1994

National Library of Canada
Acquisitions and Bibliographic Services Branch
395 Wellington Street
Ottawa Ontario
K1A 0N4

Bibliothèque nationale du Canada
Direction des acquisitions et des services bibliographiques
395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file Votre référence

Our file Notre référence

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-94914-7

Canada

Abstract

Dental and cranial nonmetric research have been regarded as important tools for the exploration of population history and biological relationships among extinct and living populations. Numerous publications have been produced in North America and Asia since the 1970s, there are, however, no similar studies on Chinese Neolithic populations in the Yellow River Valley in northern China. This research investigated both dental and cranial nonmetric traits of the Jiangzhai Neolithic skeletons. The scoring methods for dental and cranial nonmetric traits, and the East Asian populations used by Ossenberg (1969, 1970, 1986, 1992), Turner (1987, 1989) and Turner *et al.*(1991), are chosen as my basic research methods and comparative populations in East Asia. These data are analyzed by using the mean measure of divergence (MMD) and cluster analysis. The results of this research are very important in three aspects: (1) Two local populations (Jiangzhai in middle Shaanxi and Anyang in Henan) in the Yellow River Valley, are found to be different in dental morphology, which is also supported by archaeological, cultural and other biological studies.
(2) Analyses of eight diagnostic dental nonmetric traits of 13 East Asian populations and their MMDs, show that the Neolithic Jiangzhai population was Sinodont, and was distinct from the Sundadont group which includes Japanese Ainu, prehistoric Jomon and modern Thai. (3) The results of the MMD analysis of cranial and dental nonmetric traits of East Asians show that modern Japanese share the most genetic characteristics with populations from southern China and Hong Kong, secondly with Northeast Asians, thirdly with the populations from the Yellow River Valley, Mongolia and Lake Baikal, and least of all with Jomon, Ainu and Thai.

Acknowledgements

I would like to thank my supervisors Drs. Mary Jackes and David Lubell (Department of Anthropology); and the members of my examination committee, Dr. Nancy Lovell (Department of Anthropology) and Dr. Jennifer Jay (Department of History).

I would also like to thank Mr. Qiang Gao, assistant curator at Banpo Museum in Xian, China, who offered me free access to the materials stored at Banpo Museum. Without his help and cooperation, it would have been impossible for me to accomplish this thesis.

Financial support was provided by the Department of Anthropology, University of Alberta, in the form of teaching and research assistantships, as well as by short contracts from Drs. David Lubell, Mary Jackes and Charles Schweger. My travel to China was funded by a grant from the Central Research Fund, University of Alberta, to Drs. Jackes and Lubell, and also by a Travel Assistance Award from the Faculty of Graduate Studies and Research.

Dr. Nancy Ossenberg, Queen's University, generously offered me unpublished data on Siberian populations and advice on how to work on the cranial nonmetric study. Dr. Mary Jackes provided me with the ASU dental plaques for coding dental traits, the MMD program for cranial analysis, and spent many hours in Canada and in China instructing me in the methods of data collection and analysis. Several of my fellow students were instrumental in helping me to complete this thesis: Andrew Johnson offered me an MMD program for the dental analysis, advice on how to do the analysis, and proofread part of my thesis; François Larose was always there to help me solve some computer and statistical problems; Sean Beckett proofread part of my thesis and spent one night printing the first draft of my thesis; Murielle Nagy, a dedicated scholar in archaeology and my model in anthropology, generously helped me finishing some figures. Terry Taerum, Statistical Consultant, Computing and Network Services, assisted me in finishing the cluster analyses of cranial and dental data.

The Department offered me diverse choices in my education of Anthropology. In particular, I would like to thank Drs. Owen Beattie, Jean DeBernardi, Clifford Hickey, David Lubell, Michael Wayman, Charles Schweger and Pamela Willoughby, who offered me excellent classes, and laid the basic background in Anthropology. Without their direct education and encouragement, my present thesis would be almost impossible. So many people in and outside the Department helped me one way or another that it is not possible for me to acknowledge all of them. However, I would like to say that I have appreciated everything they have done.

The successful completion of my thesis is fully supported by my wife Jeong and my new born daughter Sujin.

In the end, my thesis is dedicated to my father Guo-guang Fu, and my mother Rui-zhen Chen. Their love and support is my eternal force to pursue a career in anthropology.

TABLE OF CONTENTS

List of Tables

LIST OF FIGURES

Chapter One

Research purpose, outline and background of Jiangzhai Neolithic site

Research purpose and outline

This thesis is an attempt to reconstruct biological affinity among the Neolithic population of Jiangzhai in middle Shaanxi, northern China and other East Asian populations through the study of both cranial and dental nonmetric variation. Because nonmetric skeletal characteristics are genetically controlled, they are regarded as important tools for the exploration of population history and biological relationships among populations.

Since the 1970s, many physical anthropologists (e.g. Buikstra 1972; Dodo 1974, 1975; Ossenberg 1974, 1976; Scott 1973; Turner 1969, 1971, 1976) have investigated cranial and dental nonmetric traits in a large number of populations in various parts of the world, and their studies provide valuable sources which make the present research possible. In East Asia, nonmetric studies on dentition and crania have been undertaken in Japan, Siberia, Mongolia, Taiwan, Hong Kong and Southeast Asia (Dodo 1974, 1975, 1987; Dodo *et al.* 1992; Ishida 1990; Ishida and Dodo 1993; Kozintsev 1990, 1992, 1993; Ossenberg 1986, 1992a, 1992b; Pietrusewksi 1981, 1984; Turner 1976, 1979, 1984, 1986, 1987, 1989; Turner and Lien 1984). Only very few studies, however, have been done in China (Turner 1984, 1986, 1987, 1989; Turner and Lien 1984; Dodo *et al.* 1992; Ishida and Dodo 1993). The biological relationships between populations in China and the rest of the East Asia are thus still unclear. As the dental and cranial nonmetric variation of the Neolithic populations in the Yellow River Valley of northern China has never been studied before, this study of Neolithic Jiangzhai will offer an important insight on its genetic relationship with populations in the surrounding areas in both space and time.

This thesis consists of five chapters. Chapter One presents an introduction and a review of studies on Neolithic Jiangzhai, including the development of Chinese archaeology, the characteristics of the site, the archaeological contexts of Neolithic Jiangzhai, the cemeteries, and the results of analyses of faunal, pollen and plant remains at the site. Chapter Two provides a summary of biological studies in China, especially in craniometric, odontometric and genetic studies of Chinese materials. Chapter Three contains a summary of dental nonmetric studies in East Asia, and the results of the analysis of Neolithic Jiangzhai and its comparison with other East Asian populations. Chapter Four includes a survey of cranial nonmetric studies in East Asia, materials studied, the methods for scoring, descriptions and comparison, and the result of the analyses. Chapter Five is a summary of both cranial and dental nonmetric studies at Jiangzhai, a discussion as well as the direction for future study.

Development of Chinese Archaeology

A brief introduction to the development of Chinese archaeology, especially Neolithic archaeology, will help to understand the Neolithic Jiangzhai site and the skeletal collection under study. Trigger (1988) has provided a description which represents well the recent situation in China:

> "The cultural historical approach, with its emphasis on prehistory of specific peoples, provided a model for national archaeologists not only in Europe but around the world. ... What archaeology can study is also influenced by resources that are available for archaeological research, the institutional context in which research is carried out, and the kinds of investigations societies and governments are prepared to let archaeologists undertake..." (Trigger 1988:174).

There are two kinds of forces pushing Chinese archaeologists to develop

Neolithic archaeology in China. One is nationalism which has deeply influenced Chinese scholars since the late nineteenth century. They started from extreme dissatisfaction with the belief of Western scholars (e.g. Andersson 1923) that the Chinese Neolithic was derived from the Near East, and tried to find evidence to prove an independent development of Chinese prehistory. However, this nationalism was joined by another powerful force with the appearance of the socialist government in 1949. As the new government was based on Marxist theory, the orientation of research in archaeology has been to support the legitimacy of the current society and the unity of the country. Chinese archaeologists were rewarded by generous support from the government as their enthusiasm agreed with the government policy on research. The duty of Chinese archaeologists is to reconstruct the unilineal evolution of human culture, a model set up first by Lewis Henry Morgan and favoured by Frederick Engels. Development of technology is strictly related to the social forms. A unilineal evolution model is used to explain the development of Chinese societies from primitive society, to slave society, to feudal society, to socialism, and finally to a Utopian society/communist society.

In these circumstances, Neolithic discoveries related to technology and social forms, such as pottery, tools, layout of settlements and mortuary goods, are regarded as cultural artifacts. Human skeletons, faunal remains and pollen are treated as unimportant, as they can not offer so much information for the model of unilineal evolution, and there are also no systematic methods and theories on osteology, zooarchaeology and environmental archaeology as there are in North America.

Northern China, specifically, the Yellow River Valley, is regarded by Chinese scholars as the center where Chinese civilization developed for five thousand years. This is the key area where questions on the origins of Chinese civilization can be answered. Archaeological study of Chinese origins began only in the 1920s; J.G. Andersson, a Swedish paleontologist and archaeologist, discovered the Chinese Neolithic site at Yangshao village, Henan (Andersson 1934:164-7). Andersson (1923) compared the painted Yangshao ceramics with those from West Asia, and concluded that Chinese civilization came directly from Yangshao culture and the latter had its origin in West Asia. In 1931, his theory was discredited by Liang Siyong who discovered three consecutive archaeological cultures at the Hougang site in Henan (Xia 1986:290): the earliest culture represents Yangshao Culture, the middle one represents Longshan Culture, and the latest one belongs to the Bronze Age Shang. His results show that Chinese civilization was not borrowed from foreign areas but grew up independently. Nevertheless, there were no large excavations of the Neolithic sites in the area before 1949.

Since the 1950s, prehistoric subsistence and settlement patterns in the Yellow River Valley have been of major concern to most Chinese archaeologists; a dozen large Neolithic settlements have been excavated in the Yellow River Valley. The Jiangzhai Neolithic site in middle Shaanxi, discovered in 1972, is one of the largest settlements ever excavated in China, and a brief review of the research on Neolithic Jiangzhai will be presented here.

The site

Neolithic Jiangzhai is situated on a secondary terrace on the eastern bank of the Linhe River, about one km north of Lintong County town at the foot of Mt.Li (**Figure 1.1**). Jiangzhai site is about four km south of the present Wei River. This site is very well preserved and its total area is over 30,000 square meters. During 1972-1979, eleven large scale excavations were carried out, and the total area excavated is about 17,084 square meters. Five consecutive cultural levels were discovered, and they were attributed to five phases (see **Table 1.1**). The archaeological remains

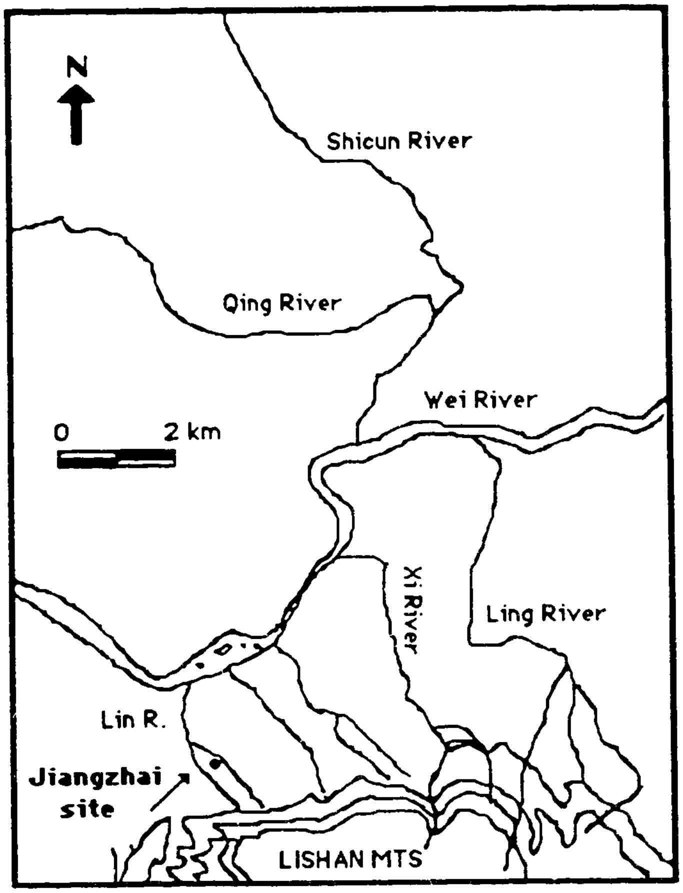

Figure 1.1 Location of Neolithic Jiangzhai site, in Lintong County, Shaanxi, China
(After Lee 1993:92)

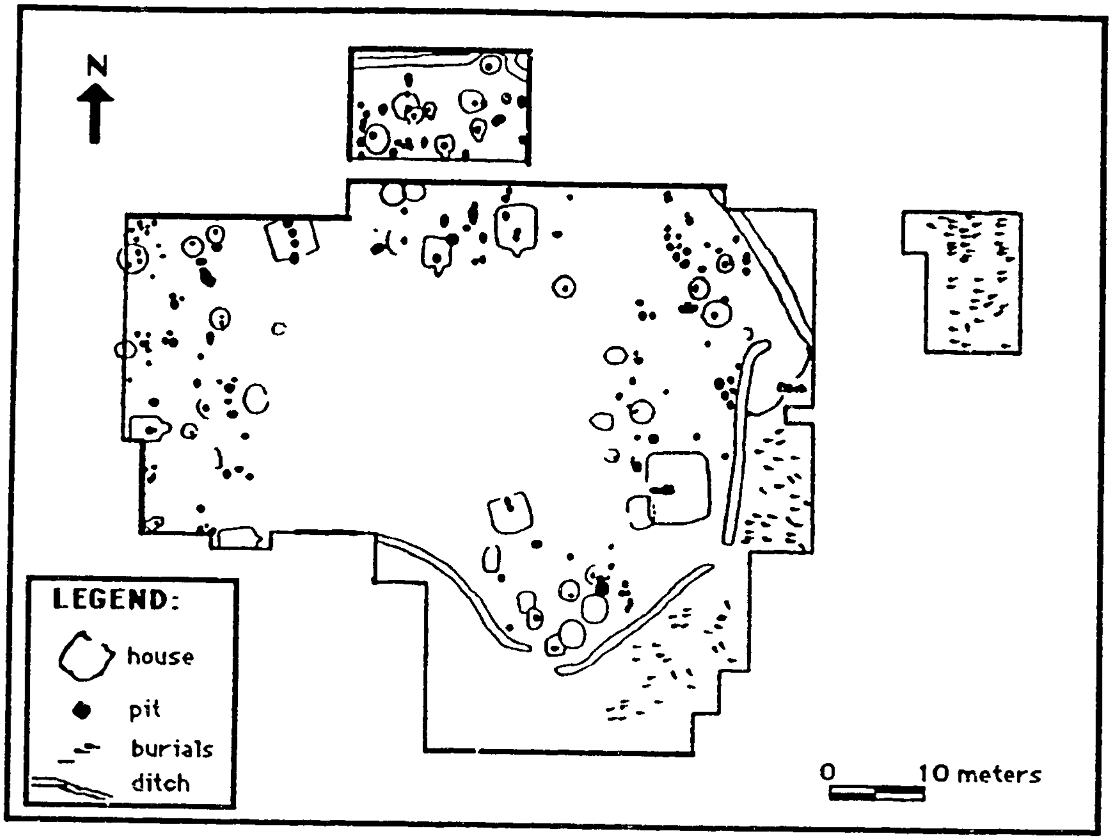

Figure 1.2 Layout of the settlement of Jiangzhai site, phase I (After Lee 1993:97)

of phase I are the richest, and include a complete layout of a Neolithic village (**see Figure 1.2**), which consisted of three components: (1) a dwelling area composed of 120 houses (associated with over 200 hearths and over 300 storage pits); (2) a central plaza of about 4,000 square meters with a depressed center; (3) mortuary areas separated from other components by segments of ditches which were probably joined by palisade-style fences (see **Figure 1.2**). The archaeological remains of phase II show only a few houses with a few storage pits and funeral urns, and a large, complete common cemetery located in the residential area of the phase I. A few features were uncovered in the rest of the three phases.

Table 1.1 Date of five phases of Jiangzhai and corresponding typical phases in the Middle Yellow River Valley (After Lee 1993)

Phase of Jiangzhai	Sites equal to Jiangzhai	Calibrated date (BC)	Archaeological period
V	Keshengzhuang II	ZK975 2030±80	Longshan Culture
IV	Xiwancun	unavailable	Yangshao Culture
III	Miaodigou	ZK115 3037±120	
II	Shijia	ZHT12M238 3902±85	
I	Banpo	ZK265 4770±170	

Jiangzhai:local development of the Yangshao Culture and its interaction with neighbouring cultures

The Neolithic Jiangzhai culture developed in the Middle Yellow River Valley and shares many common characteristics with other Neolithic cultures in the area. The four early phases of the Neolithic at Jiangzhai belong to the Yangshao Culture, while the last phase is the Longshan Culture. The Yangshao and Longshan and their continuity has been well studied in the Middle Yellow River Valley (Xia 1984). An (1988) shows that the Yangshao covers almost all of the middle reaches of the Yellow River and dates to ca. 5100-3000 B.C.. Yangshao sites fall into a number of different complexes chronologically correlated by stratigraphic and typological studies, and by C14 dating. Painted pottery is one of the distinctive features of the Yangshao. In the early phase it was characterized by simple designs; in the middle phase these became greatly complicated with increased stylization and frequent use of human faces and animal motifs such as frogs, fish, birds, pigs, and deer; in the late phase the painted pottery returned to a simple pattern. The Longshan Culture, dated to ca. 2900-2000 BC, began with only grey pottery; a little later wheel-made pottery, black eggshell ware, and occasional copper objects appeared.

According to the pottery typology and stratigraphy of Xia (1984, 1986), at least three types of Yangshao Culture developed in the Middle Yellow River Valley: (1) The Banpo-Miaodigou-Xiwancun type in middle Shaanxi, western Henan and southern Shanxi; (2) The Dahecun-Wanwang type in central Henan; (3) Hougang-Dasikong type in northern Henan and southern Hebei (see **Figure 1.3**).

At least two evolutionary series of cultures are recognized (Xia 1984). Types II and III of Yangshao Culture evolved locally into Henan Longshan Culture, and late Henan Longshan Culture merged into the pre-Shang dynastyCulture which became a major cultural component of the Shang Empire. Type I Yangshao Culture evolved locally into Shaanxi Longshan Culture, which is clearly distinguished from Henan Longshan Culture.

The late Shaanxi Longshan Culture merged into the pre-Zhou Empire Culture. During the Shang dynasty, the Zhou people were conquered by the Shang people, and while styles of bronze artifacts were the same as in the major Shang culture, the Zhou pottery remained different from that of the Shang culture (Xia 1984). This suggests that the majority of pre-Zhou culture had been retained under the Shang Empire. Around 1000 BC, Zhou people conquered the Shang Empire, and Shang people in Anyang (which was then the capital of the Shang Empire) were moved to other areas and replaced by

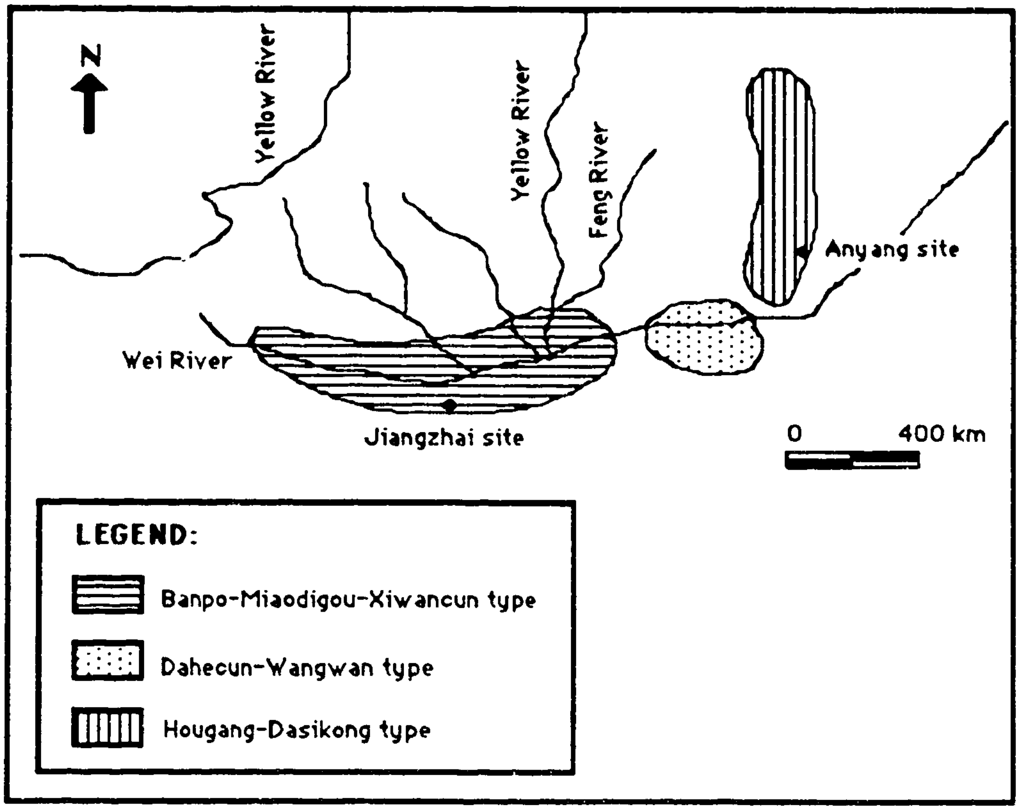

Figure 1.3 Three types of Yangshao Culture in the Middle Yellow River Valley (After Chang 1986:110)

Zhou people. Thus the Zhou Culture spread in both areas where formerly three types of Yangshao Culture had developed. Neolithic Jiangzhai is equal to Type I Yangshao Culture and Shaanxi Longshan Culture (see **Table 1.2**).

Table 1.2 Two local variations of Yangshao culture in the Middle Yellow River Valley and related cultures in later periods (based on Xia 1984)

Archaeological period in the Middle Yellow River Valley		Type I middle Shaanxi western Henan southern Shanxi	Type II and III Henan and southern Hebei	Time
Bronze period	Zhou dynasty	Zhou dynasty Culture center	Zhou Culture dominant	1000 BC - 300 BC
	Shang dynasty	Shang influenced pre-Zhou dynasty Culture	Shang dyansty Culture center e.g. Anyang tombs	2000 BC - 1000 BC
Long-shan Culture period	Pre-Shang dynasty	Early Zhou people Culture	Early Shang people Culture	3000 BC - 2000 BC
		Shaanxi Longshan Culture e.g. Jiangzhai V Keshenzhuang II	Henan Longshan Culture	
Yang-shao Culture period	III	Xiwancun Jiangzhai IV	Dahecun III-IV Dasikong	3000 BC
	II	Miaodigou Jiangzhai III	Dahecun I-II Hougang	4000 BC
	I	Banpo Jiangzhai I-II		5000 BC

Again based on pottery typology, stratigraphy and other evidence (Xia 1984), the Jiangzhai Neolithic and its related local Yangshao and Longshan in the middle Yellow River Valley had influence on neighbouring areas. For example, the Yangshao is also found in Hunan in southern China, and it coexisted with the Daxi culture, a different type of Neolithic independently developed in the Yangtze River Valley (An 1988). Neighbouring areas, such as the southern China could have influenced the Jiangzhai and its related cultures. The adoption of rice agriculture from southern China, for example, is evidence of influence from elsewhere.

The Cemeteries

The cemeteries were very important archaeological features of the Neolithic at Jiangzhai, but as noted above, they were limited to phase I and phase II. Because there are many differences in mortuary practices between phase I and II, they will be introduced separately.

Phase I

A total of 174 burial pits and 206 funeral urns were excavated from phase I. Most of the burials were in three cemeteries which were outside the defensive ditches on the east, northeast and southeast of the village (see **Figure 1.2**). Each cemetery contained 40-50 tombs of adults and adolescents, generally placed in single primary burials with only a few individuals placed in secondary or double burials. The bodies of the single primary burials were laid in extended position on their backs, with the head pointing towards the west. There was a limited variety of grave goods for daily use in most of the burials.

Funeral urns were used for infants, and these were often buried among the dwellings. Only a few funeral urns were buried in the cemeteries. Most funeral urns were not accompanied by grave goods. The urns were made of earthen jars covered by basins or bowls, sometimes with punctures through the tops of the urns.

Phase II

A total of 191 burial pits and 103 funeral urns were excavated from this stage, and the skeletons represented at least 2194 individuals. Most of the burials were in a common cemetery, located in the center of the phase I village. The burial pits were rectangular or square with vertical sides. The majority of burials were secondary, but there were a small number of primary burials. Most of the adults and adolescents were placed in secondary collective burials containing about 20 individuals of both sexes. Only a few were in secondary-single or double burials. The skulls were generally placed towards the west with the face upward, the long bones were placed on both sides of the skull, and the short bones on the east side of the skull. An individual skeleton in a joint burial was arranged either in a single layer consisting of the bones of the skeleton, or in many layers with each layer containing only parts of the skeleton. In some secondary-collective burials, there were many small burials within a large burial. In each of these small burials, the bones of the skeleton were also arranged in order. However, there were also joint burials in which the bones of different individuals were just thrown together in a disorderly manner. The grave goods from the primary burials were generally thrown together in a corner, those from the secondary burials were placed on one side of the burials. Occasionally grave goods, consisting of practical objects for daily use, were placed below the owner's feet.

As with phase I, funeral urns were often distributed in the residential area, and only a few were found in the common cemetery. Most of the funeral urns contain skeletons of children; some of them, however, contain adult skeletons. The funeral urns were always buried, and the size of the burial pit is dependent upon the size of the urn. If the urn is small, then the burial will be in a small pit with the urn placed vertically; but if it is big, the size of the burial pit is larger, and the urn would be placed horizontally. Most of the funeral urns are earthen bowls and basins cupped one above the other. But there are also large earthen-ware vessels with pointed bottoms coupled with the bowls and basins to form funeral urns. There were rarely grave goods with funeral urns, although a few had some daily use artifacts.

Skeletal collection

The present skeletal collection from Jiangzhai represents 55 individuals, which is equal to only about two percent of individuals originally reported (approximally 2578 individuals from phases I, II). The original skeletal collection from Jiangzhai in the Banpo Museum consisted of at least half of all excavated individuals. Unfortunately most were reburied later because of lack of storage space (Gao, personal communication, 1993).

The age and sex breakdown of the remaining skeletal collection is shown in **Table 1.3**, based on examination by both Jackes and myself. Observation of the pelvis and of cranial morphology were used primarily in sex determination, following the criteria of Brothwell (1981) and Bass (1987). Observation of dental eruption patterns, tooth attrition, epiphyseal closure, closure of the basicranial suture, development of the third molar and initial changes at the pubic symphsis were used in age estimation based on the criteria set up by Brothwell (1981), Stewart (1957) and Ubelaker (1978).

Table 1.3 Age and sex of the Jiangzhai sample

PHASE	Child, adoles-cent 3-17 years old	Young adult 18-30 years old			Adult and old above 30 years			Sum
		Male	Female	Sex ?	Male	Female	Sex ?	
I	9	4	6	0	3	1	0	23
II	1	9	9	1	9	3	0	32
Sum	10	13	15	1	12	4	0	55

Faunal remains

Faunal collections from Jiangzhai comprise only a very small portion of the animal remains left by the Neolithic Jiangzhai people. Most of the faunal bones were reburied by the excavators or not picked out from the soil, and only 3542 specimens were analyzed by Qi (1988). Only two invertebrate species were identified: *Cipangopaludina cathayensis* and *Unio douglasiae*. The vertebrate faunal remains will be discussed in detail below.

The importance of faunal analysis lies in two aspects: reconstruction of the prehistoric economy and the paleoenvironment. As shown in **Table 1.4**, based the analysis by Qi (1988), the Jiangzhai people had very diverse meat sources including fish, birds and mammals. In phase I for example, the total MNI is 217, the three major meat sources are *Sus domesticus* (domesticated pig; 39.2%), *Cervus nippon* (spotted deer) and other deer (30.9%), and *Hydropotes inermis* (hornless river deer; 9.7%). Domesticated pig thus makes up less than half of the total, and almost the same in terms of MNI as large wild animals such as spotted deer and hornless river deer. Qi (1988) considered that the prehistoric Jiangzhai people may have depended heavily on hunting to obtain animal protein.

Another use of faunal analysis is to reconstruct paleoenvironments. Thehornless river deer is frequent in the Jiangzhai sample, but is now found only in the well watered terrain on the Lower Yangtze. Its presence at Jiangzhai implies a nearby terrain of pond and marsh which no longer exists, with surrounds of high grass, and somewhat warmer climate than is at present experienced in the Yellow River Valley. The bamboo rat (*Rhizomy sinensis*) is also no longer to be found in the vicinity of Jiangzhai, and its ancient presence is further indication of warmer climate, greater abundance of surface water, and thickets of bamboo. A similar conclusion was reached by Fu (1988) in an analysis of faunal remains from the Anban Neolithic site, about 200 km away in the same

Pollen remains

Jiangzhai were analyzed by Wang (1988). He selected only two sets of samples from deposits equivalent to the cultural layers and the overlying recent soils, and used these to reconstruct the paleoenvironment of Neolithic Jiangzhai. The pollen spectra for the Jiangzhai Neolithic

Table 1.4 MNIs of vertebrate faunal remains from different phases of Neolithic Jiangzhai (After Qi 1988)

Species	Phase I	Phase II	Phase IV	Phase V	Total
Cyprinus sp.	2				2
Ctenopharyngodon sp.	2				2
pisces indet.	n.a.				n.a.
Pelecanus sp.	1				1
Aquila sp.	1				1
Grus sp.	1				1
Gallus sp.	1				1
Erinaceus europaeus	1				1
Scaptochirus moschatu	1				1
Macaca mulatta	1				1
Myospalax fontianieri	4				4
Rhizomys sinenesis	2	2	2		6
Lepus sp.	1	1	2		4
Canis familiaris	2		2	1	5
Cuon alpinus	1				1
Nyctereutes procyonoides	5	1	4	3	13
Selenarctos thibetanus	2				2
Meles meles	4		1	1	6
Actonyx collaris	2		1		3
Panthera tigris	1				1
Felis sp.	1		1		2
Sus domesticus	85	8	12	4	109
Moschus moschiferus	3				3
Hydropotes inermis	21	4	16	1	42
Cervus nippon	48	7	19	11	85
Prodorcas gutturosa	2		1	1	4
Bos sp.	3	2		1	6
Artiodactyla indet.	n.a.	n.a.	n.a.	n.a.	n.a.
Mammalia indet.	n.a.	n.a.	n.a.	n.a.	n.a.
Vertebrata indet.	n.a.	n.a.	n.a.	n.a.	n.a.
Total	217	32	66	29	344

MNI represents the minimum number of individuals
n.a. represent unapplicable

represents forest-grassland: the samples are dominated by Aneimia, Chenopodiaceae, Compositae and Gramineae, all grassland types. On the hills nearby grew *Pinus*, *Larix* and other needlelike trees, while on the slopes of the nearby mountain grew the broad leaf trees, such as *Salix*, *Quercus*, *Betula*, *Ulnus* etc. There were also many water-born plants such as Potamogetonaceae, Typha, Zyghema and Concentricysles, which represent an environment closer to water or the river.

About 200 km away, at Anban, the Holocene pollen samples were systematically collected and studied by Wang and Fu (1991). **Table 1.5** summarizes these data and shows a clear picture of changing environments since the postglacial period in this area.

Cultivated plants and gathered plants

Grains from a pottery bowl (ZHT42(4):7) in phase II at Jiangzhai were identified by Di (1988) as broom corn millet (*Panicum miliaceum*). There are, however, no other early plant remains from the site which have been studied. Just about 20 km away, at the Banpo Neolithic site, equivalent in age to Jiangzhai I, many domesticated plants and gathered remains were recovered, including broom corn millet and Foxtail millet (*Setaria var. germanica*). Other plant remains, including Chinese cabbage (leaf mustard), chestnut and hazelnut were also identified at Banpo. Rice has been widely discovered in the Neolithic sites in southern China. The earliest rice was discovered at Hemudu in the lower Yangtze River Valley, dated to about 7000 years ago (Xia 1984, Yan 1989). Even though rice was not found at Jiangzhai, the Neolithic population of Jiangzhai may have used rice (*Oryza sativa*) as a supplementary food, because rice was present at Neolithic Anban, equivalent in age to phase V of Jiangzhai (Xie 1988). There are also some reports of rice in late Neolithic sites in the Yellow River Valley (Andersson 1934, Yu and Ye 1986). The Jiangzhai people could possibly have learned rice growing techniques from neighbouring southern

Table 1.5 Comparison of Holocene pollen compositions at Anban with archaeological periods in the Yellow River Valley in Northern China

Geological age		Anban site				Archaeological period in Middle Yellow R. Valley	
		Sediments	Pollen composition	Climate	Time		
HOLOCENE Q_4	LATE Q_4	Recent sediments	Grass: *Artemisia*, *Aster*, Compositae Chenopodiaceae Trees: high *Pinus*	decrease in temperature	3000 BP to present	Historical period with beginning of writing	
		Zhou dynasty sediments	Grass: *Artemisia* *Aster*, Compositae Chenopodiaceae Trees: few *Picea*				
	MIDDLE Q_4	Longshan Culture sediments	Grass: *Artemisia* *Aster*, Compositae Chenopodiaceae Trees: *Carpinus* *Acer*, *Castanea* *Pinus*, *Cupressus*	warm and wet	8000 BP to 3000 BP	Late Neolithic	Longshan Culture period
		Yangshao Culture sediments	Grass: *Artemisia* *Aster*, Compositae Chenpodiaceae Trees: high *Quercus*, *Carpinus* *Juglans*, *Rhus*; low *Pinus*, *Cupressus*			Middle Neolithic	Yangshao Culture period
							Pre-Yangshao
	EARLY Q_4	Black loam sediments	Grass: high *Artemisia*, *Aster*, Compositae Chenopodiaceae Trees: *Quercus* *Betula*, *Carpinus* *Pinus*, *Cupressus*	Increase in temperature	10,000 BP to 8000 BP	Early Neolithic	no discovery
		Loess sediments	Grass: high *Artemisia*, *Aster*, Compositae, Chenopodiaceae Trees: high *Pinus* next *Quercus*, *Betula* and *Corylus*		12,000 BP to 10,000 BP	Mesolithic	

Chinese, and the relatively warmer Neolithic climate would also have enhanced the opportunity to raise rice at Jiangzhai. More archaeological work needs to be done on this question.

Summary

This chapter presents the economic and environmental context for Neolithic Jiangzhai and its cultural exchanges with other areas. The review of the archaeological background in China will help us to understand the differences between China and North America in research, and certain limitations of applying cranial and dental nonmetric methods to the skeletons at Jiangzhai. Second, the description of the Neolithic at Jiangzhai, as well as the local variations and evolution of the Yangshao Culture, offers cultural backgrounds for the populations (such as Jiangzhai and the later burials at Anyang) which will be later used in cranial and dental nonmetric comparison. The following analyses of nonmetric data may answer the question whether there is a biological micro-difference between the two populations associated with different archaeological cultures. Third, the interaction of the Jiangzhai population with neighbouring populations from other parts of the Yellow River Valley as well as southern China, sheds light on possible genetic contributions from neighbouring populations.

Chapter Two

Biological distance studies of populations in China

Methods for the study of biological distance

Systematic research in Chinese physical anthropology started in 1927, when Peking Man was first discovered at Zhoukoudian. Since then, Chinese scholars have concentrated on palaeoanthropological studies. Research on genetic variations and relationships among peoples in China from the Neolithic to the present has been studied only by means of craniometrics. Recently, there have been changes in research trends, as overseas physical anthropology has increasingly influenced Chinese research. An exploration into the biological relationships between Neolithic Jiangzhai and other Asian populations, in terms of dental and cranial morphology, will add a different perspective to this form of study.

Dental and cranial morphological techniques are only two of many methods that can be used to explore the relationships between populations. Buikstra (1976) studied nonmetric variation among Hopewell populations suggesting the following methods: 1. metric: a) cranial (excluding dental); b) dental; c) postcranial; 2. nonmetric: a) cranial (excluding dental); b) dental; c) postcranial. Recently, modern genetic studies are being considered as important methods for exploring the origins of populations (Etler, 1992). To date, there have been very few postcranial studies in China. Cranial and dental morphology will be discussed in chapters four and five. Here, I will only discuss the three methods commonly used to study the populations in China and elsewhere in Asia: cranial metrics, dental metrics, and genetic markers.

Craniometric variation

Craniometrics used in association with descriptive morphological observations are the traditional data sources for assessing biological relationships between prehistoric and historic populations in China. Cranial measurements are used to differentiate between major geographic races and large populations from the Neolithic to the present, covering eastern, northern, western and southern China. Research on the craniometric variation in China will be reviewed under two headings: The Neolithic, and the Bronze Age and later.

Neolithic

The use of craniometric studies to investigate the genetic relationship between Neolithic and modern peoples was first done by Davidson Black (1928). He compared Neolithic skeletons from Sha-kou-tun in western China, and Yangshao in northern China, with a recent burial site in northern China. Black (1928) believed that although there were some variations among these three populations, they all belong to a type essentially similar to modern northern Chinese.

After this initial work by Black, cranial remains from many Neolithic archaeological sites were studied by a few Chinese physical anthropologists. Yan (1962, 1972, 1973; Yan *et al.* 1960a, 1960b) worked on skeletons from a series of very important Neolithic sites in the middle and lower Yellow River Valley in northern China, including the samples from Banpo, Baoji and Huanxian. He demonstrated that the Neolithic populations in this area were more related to the southern Asian populations based on comparison of six individual metric traits: cranial index, simotic index, upper facial height, alveolar angle, orbital index and nasal breadth. Yan (1962) discussed two local variations in middle Shaanxi and Henan, emphasizing differences between Neolithic skeletons in the two areas based on two metric traits: upper facial height and nasal index. Yan (1972, 1973) showed that the Neolithic skeletons from Dawenkou and Xixahou in Shandong, a coastal province in northern China, were more related to the Polynesians based on comparison of 19 cranial metric traits. Han (1988, 1990; Han and his associates 1976, 1979, 1980, 1982, 1983) also worked on some Neolithic populations from the Yellow River Valley in northern China, but his most important work is on the Neolithic populations in southern China. Han (1988) indicated that the Neolithic populations in southern China are closer to Southeast Asian Mongoloids in terms of cranial index, upper facial height, nasal index and simotic index. Han (1988) also pointed out the limitation in the research by Yan who believed Yangshao populations were related to South Asian Mongoloiods based on only a few cranial metric traits; he used multivariate statistical analyses on the original cranial metric data from Yangshao sites (Yan 1962, 1972, 1973; Yan and associates 1960a, 1960b) and concluded that the Yangshao populations in the Yellow River Valley are closer to modern East Asians.

Recently, Chen (1989), Wang (1986), Zhang (1981, 1988) and Zhang *et al.* (1982) also applied multivariate statistical analyses to the osteometric data of Neolithic skeletons in both northern and southern China. Chen (1989) investigated Neolithic populations (including 15 samples of males and 12 samples of females) and Palaeolithic peoples (the Upper Cave Zhoukoudian and Liujiang Man). She used 11 cranial measurements in comparing the different populations: maximum cranial length, maximum cranial breadth, cranial height, orbital height, minimum frontal breadth, maximum bizygomatic breadth, upper facial height, orbital breadth, nasal breadth, nasal height and the total prognathism. The statistical methods she used include Penrose's shape distance (Penrose 1954) and principal component analysis (Sneath and Sokal 1973).

Her results show that there are two groups among Chinese Neolithic populations. The southern group includes four populations: Tanshishan, Hedang, Zengpiyan and Hemudu. The northern group can be divided into three subgroups. The first subgroup consists of Xiawangang, Miaodigou and

Yedian, and the main characteristics are brachycranial skulls, with a high vault, narrow cranial breadth, low or medium orbital height and medium nasal breadth. The second subgroup consists of Shigu, Dawenkou and Xixiahou, characterized by mesocranial skulls, high vault, rather narrow or medium cranial breadth and upper facial breadth, medium orbital height and medium to wide nasal breadth. The third subgroup consists of Baoji, Huaxian and Banpo in Middle Shaanxi and Hongshanhou in Inner Mongolia, characterized by mesocranial skulls, high vault, narrow cranial breadth, medium or narrow upperfacial breadth, medium orbital height and a medium or a wide nose. Hengzhen in western middle Shaanxi possesses a special status in the taxonomy between the southern and northern Chinese groups, and Chen (1989) believes that this provides good evidence of genetic exchange between southern and northern Chinese Neolithic populations.

Zhang (1981, 1988), Zhang and associates (1982) agree with the division between the northern and southern Neolithic populations in China. At the same time, Zhang argues that each group may have descended from a different type of early *Homo sapiens*, one discovered at Liujiang in southern China and the other at Zhoukoudian in northern China, and that the process of differentiation may have begun perhaps as long ago as the Late Pleistocene. The differences between the populations of northern and southern China continue in present-day Chinese populations. Wu and Zhang (1985) also added that the Neolithic peoples of northern China could be further divided into a western group and an eastern group based on vertical craniofacial index, total facial angle, zygomaxillary angle, and nasal index.

As to the relationship between Neolithic populations in China and Japan, Wu (1988, 1992) believes that the anatomically modern humans of East Asia originated in China, and that they were proto-Mongoloids. According to Wu, the southern branch of this population dispersed eastwards into Japan and southwards into Southeast Asia during the late Pleistocene, and Liujiang Man is the ancestor of Minatogawa Man from Japan. Wang (1987) adds that, with a drop in sea level of 100 meters or more during the Quaternary glacial epoch, the area between the Asian continent and Japan became a land bridge which allowed the immigrants from southern China to colonize Japan.

Yamaguchi (1982) used inter-site distance analysis based on craniometric data, and showed that the Neolithic peoples in middle Shaanxi (Middle Yellow River Valley) are morphologically distant from the Jomon Population and are much closer to the modern Japanese. Hanihara (1987) believed that since the Aeneolithic Yayoi age, the emigrants from the Asian Continent, who moved through the Korean Peninsula, were likely responsible for rapid changes in culture as well as the physical characteristics of modern Japanese.

Bronze age and later periods

The skeletons from the Bronze Age and later periods have been studied less than those of the Neolithic. Han (1975) studied two individuals of the Bronze Age from Shenyang in northeastern China based on 15 cranial metric traits and concluded that the Shenyang sample is closer to modern northeastern Asian Mongoloids. Han (1980), Han and Pan (1980, 1985, 1992) studied the cranial collection from the small Bronze Age tombs in Anyang, which are believed to be the remains of common people of the Shang dynasty. Their results show that: 1. the sample from the small Bronze Age tombs is closer to East Asian Mongoloid than to northern and South Mongoloids based on cranial height, upper facial index, vertical craniofacial index, nasal breadth; 2. most cranial measurements from the small Bronze Age tombs are close to those of the sacrifical skeletons of the same period, that is, the two samples belong to the same kind of local population. The sacrifical victims from Anyang are now stored in Taiwan and were also studied by Howells (1973) and Yang (1969, 1985). Zhang and Wang (1992) studied the cranial sample from the Bronze Age tombs at Changyang, southern China. They indicated the Changyang sample is closer to the modern Southeast Asian and Neolithic southern Chinese samples based on a cranial metrics study, and the Changyang population evolved from the Neolithic southern Chinese populations. They also believed that there was a morphological division of populations between northern and southern China in the Bronze Age period.

There are also a few studies done on historic and modern populations in both northern and southern China including those of Han and Pan (1988) on a population from the Eastern Han Dynasty; Pan (1990) on historic material from Helongjiang; Wang (1989) on a modern population from Hong Kong; Wang and Sun (1988) on modern skulls from Taiyuan. It is very clear that there is a division between modern northern and southern Chinese.

Odontometric variation

Studies of odontometric variation are generally based on two measures: maximum crown length (mesial-distal diameter), and breadth (buccal-lingual length). There are two opposing views as to genetic control of tooth size. Scott and Turner (1988) believe that absolute tooth size is not a good indicator of population relationships, while tooth morphology is likely under tight genetic control.

Brace (1978), however, believes that tooth size is under genetic control. Using data on tooth size from northern China, Brace (1978) argues that peoples in northern China and other parts of North Asia began migrating into Japan around 300 BC. The intruders were the ancestors of modern Japanese who have larger teeth, different from both the modern Japanese Ainu and the Japanese Neolithic Jomon.

Measurement of tooth size of Chinese Neolithic and historic skeletons has been undertaken by Chinese scholars; however, there has been no discussion of the question of genetic control of tooth size. Chou (1958) measured only one individual from more than 70 tombs, and Wei *et al.* (1988) measured seven individuals from Western Han dynasty tombs in southern China. Wei *et al.* compared tooth size among Neolithic, prehistoric and modern southern Chinese samples. Their results show that there are many similarities between historic and modern southern Chinese, but they are different from the Neolithic samples. Unfortunately, the sample sizes of Chinese materials under study are still too small to permit definitive conclusions.

Genetic variation

Biological studies of genetic variation among different Chinese ethnic groups started in the late 1970s, and they are becoming more and more important in reconstructing the population history of China. The research done in neighbouring countries also helps to elucidate genetic relations between Chinese and adjacent populations in Asia. These studies can be divided into five different research areas.

Dermatoglyphics research in China

The earliest record of fingerprints in China are impressions on pottery from the 6000-year-old Neolithic site of Banpo in Xian (Zhao 1982). During the Tang dynasty (A.D. 618-906), fingerprints were affixed to receipts and contracts (Chen 1983), a practice that continued until fairly recent times. The use of fingerprinting in criminal investigations was introduced to China from abroad in 1909, however, the large scale dermatoglyphics survey of the majority of Han Chinese and other minorities did not begin until the 1980s. Zhang (1988) assembled data previously published which document the dermatoglyphic parameters of 52 Chinese populations, representing 28 Chinese nationalities. His cluster analysis shows that there are three major groupings in China: 1) a southern Chinese group, including 18 populations representing 11 nationalities (4 Han, Shui, Buyi, 3 Miao, Dongxiang, Gelao, Maona, Zhuang, Jinpo, 3 Dong, and Dai); 2) a northern Chinese group, including 13 populations and 5 nationalities (3 Qiang, 4 Tibetans, 3 Yi, 2 Hui, and Baohan); and 3) a heterogeneous group consisting of 21 populations representing 17 nationalities (including northern, northwestern and southern Chinese).

Blood group research in China

Weng *et al.* (1989) synthesized data from 22 Chinese ethnic groups and analyzed allele frequencies of various red blood cell groups. Their results reflect two aspects of variation in Chinese populations. First, there is gene flow from western Eurasian populations (characterized by high frequencies of the *cde, cDe,* and P_1 alleles) to typical East Asian populations (which have high frequencies of the *CDe, cdE* and P_2 alleles). Second, their study also showed the division between northern and southern Chinese. Southern populations are distinguished by high frequencies of P_1, M, O and *CdE* alleles. Northern Chinese groups have high frequencies of the *cDE,* and N alleles. Zhao and Lee (1989) also demonstrated the division of the Chinese population into northern and southern clusters from their study of the distribution of immunoglobulin GM and KM allotypes in 74 Chinese populations representing 24 ethnic groups.

Physical character study of modern Chinese

There exists a clinal variation among Chinese populations according to a nonmetric and metric study by Zhang (1988). He demonstrated a clinal change between northern and southern Chinese in a study of the morphological features of Chinese populations: southern Chinese are characterized by a greater absence of the Mongolian fold, a more horizontally oriented aperture of the eye, a broader eye opening, a thicker red lip, broader nasal alae and a lower nasal root vis-a-vis northern Chinese. His metric results also support clinal variation: the cephalic index shows a clear decrease in brachycephaly from north to south; there is a similar decrease in leptoprosopy and an increase in mesoprosopy from north to south, with southwestern Chinese minorities characterized by a high incidence of euruprosopy; leptorrhiny also decreases from north to south with a concomitant increase in mesorrhiny. With respect to overall cranial and facial dimensions, Zhang points out that southern Chinese, in comparison to northern Chinese, are characterized by a longer, narrower skull, a narrower bigonial breadth, a lower facial height, a lower and broader nose, and shorter stature. Stature is another parameter that shows a clear clinal decrease from north to south.

Genetic studies by Japanese and other overseas researchers

Japanese researchers are attempting to look for their ancestors through various genetic methods, as modern Japanese are thought to have migrated from the Asian continent to the islands in recent times. Several studies have been done by Japanese relating to the Chinese. First, studies have been done concerning alcoholic sensitivity among Japanese, Chinese and other Asian populations (Harada 1992). Studies show that the ALDH2 deficiency produces an aversion to alcohol. Individuals possessing the ALDH2*2 gene may refrain from excessive drinking due to adverse reactions such as flushing, increase of heart rate and headache, caused by raised blood acetaldhyde levels. The ALDH2*2 gene has been found only among individuals belonging to the Mongoloid race, but not among Caucasoid and Negroid groups. The gene frequency of ALDH2*2 was found to be higher in Japan and China than in Thailand, the Philippines and Malaysia.

Another Japanese research team, headed by Tokunaga and Juji (1992), studied the distribution of haplotypes in various districts in Japan, Beijing and Seoul. They suggest several routes by which migrations may have previously occurred. The most frequent haplotype in the Japanese, A24-Bw52-BFS-C4A3+2-C4B1-DR2, was not found in southern China, while it has a 2-4% in frequency in Beijing and Seoul. It is possible that the ancestral group with this haplotype migrated from somewhere in northern China through the Korean Peninsula to northern Kyushu and western Honshu. The most common haplotype in Koreans, B44-BFF-C4A3-C4B1-DRw13, was not found in Beijing and is rare in southern China. However, the frequency of this haplotype was also over 6% in central and northwestern Honshu in Japan. This may suggest that there was a group which migrated directly from the Korean Peninsula to northwestern Honshu across the Japan Sea. The most common haplotype in southern China, Cw11-Bw46-BFS-C4A4-C4B2-DR9 was observed at 1% and 0.5% in Koreans and Japanese, respectively, so it is possible that this haplotype reached northern Kyushu and the Korean Peninsula from southern China across the East China sea. Tokunaga and Juji believe that several ancestral groups came to Japan by various routes, then mixed and hybridized to form the present Japanese, so modern Japanese are not genetically homogeneous at all, but rather are heterogeneous.

Cavalli-Sforza *et al.* (1992) also demonstrate that a genetic cline is limited to the eastern part of Asia and shows a distinct division between northern and southern Mongoloids. Their results are similar to those of Zhang (1988).

Summary and Conclusion

The results based on craniometrics, odontometrics, and biological studies on modern Chinese populations show that the peoples of China are not homogenous, but rather are heterogeneous. Two conclusions can be drawn from the research cited above:

1) There is a clinal change in populations from northern to southern China. Since the late Pleistocene peoples in different regions have

been constantly exchanging and migrating and making war and so on. The area between the two regions produced mixed populations and buffered the difference between populations in northern and southern China.

2) The genetic relationship between peoples in China and Japan is very complicated. Since the late Pleistocene, the populations in Japan might have come from different migrations from mainland Asia. The earliest migrants were the people of Minatogawa who migrated from southern China, their descendants were Neolithic Japanese Jomon, and present Japanese Ainu; since the Yayoi, there might be many other migrations from eastern Asia which have contributed to the Japanese populations.

Chapter Three

Dental nonmetric study of the Jiangzhai Neolithic population and its affinity with other East Asians

Introduction

Supernumerary teeth, crown fissure patterns, cusp numbers, accessory crown features and root number, combine with a variety of other traits under the heading of dental nonmetric variation (White 1991). Dental nonmetric variation has been studied extensively by various scholars for more than one century, and it is regarded as one of the better resources for archaeological reconstruction of human population affinities and origins (Turner 1986).

The use of dental nonmetric variation in studying population relationships goes back to the first half of this century. Classic comparative studies on crown morphology (Dahlberg 1945, 1951; Hellman 1928; Hrdlicka 1920, 1921) indicated the potential of such traits to discriminate among the major geographic races. For some traits, including shovel-shaped incisors, Carabelli's trait, and cusp 6, the between-group differences are so pronounced that workers have defined Mongoloid (Hanihara 1969) and Caucasoid (Mayhall *et al.* 1982) dental complexes. In order to assess population affinities by tooth morphology, distance statistics are used to estimate relative degrees of similarity among groups that diverged from common ancestors.

There are many studies on dental nonmetric variation, and most of them relate to the Asian and Asian-derived populations (Turner 1987). Turner (1987) described a large number of mainland Asian and Pacific populations. He delineated not a single Asian or Mongoloid dental complex, but two basic patterns within Asia: Sinodonty and Sundadonty. Eight key morphological variants distinguish these two patterns: shovelling and double shovelling of upper incisors, root number in upper distal premolars, peg or reduced upper third molars, deflecting wrinkle and root number of lower first molars, enamel extension in upper first molars, and cusp number in lower second molars.

The Sinodont pattern, characterized by morphologic trait intensification (high frequencies and pronounced expressions of the eight traits), is evident not only in modern Chinese, Japanese, and Siberian groups but also in all New World populations. Turner (1987) also infers that all native Americans were derived from parts of the Sinodont complex in North Asia.

The Sundadont pattern involves these eight traits with retention and simplification (low frequencies and less expression of the eight traits). It is observed in Southeast Asians, Polynesians, Micronesians, and the Jomon Neolithic populations of Japan. Turner (1987) believes that Sinodonty is a specialized derivative of Sundadonty because the latter exhibits more generalized crown and root trait frequencies.

The origin of the Japanese Ainu has long been a mystery for physical anthropologists. Turner (1979) suggested that the prehistoric Jomon were ancestral to modern Ainu based on dental nonmetric evidence. Turner indicated (1976) that Ainu characteristics resemble those of Micronesians and Polynesians more than those of Chinese and modern Japanese groups; Ainu and Jomon teeth fit the Sundadont pattern. He also believes that the modern Japanese population shows the Sinodont pattern, and it is thus descended from mainland Asian groups that invaded Japan beginning about 2200 years ago. Turner (1987) suggests that Southern China is one possible area from which the ancestors of modern Japanese could have originated.

Hanihara (1990) also studied dental nonmetric variation in eleven populations in the Pacific, East Asia, and North America through the application of distance analyses. His results show that modern mainland Japanese, the Aeneolithic Yayoi population of Japan and the Pima Indians of North America are grouped together. On the other hand, some geographically isolated populations in Japan show closer affinities to the Neolithic Jomon population, Negritos and Pacific populations than to modern mainland Japanese. Hanihara (*ibid.*) also believes that the Proto-Mongoloid population of late Pleistocene Southeast Asia gave rise to the Neolithic Jomon population and later Ainu, but he thinks modern Japanese show considerable admixture with one of the groups of the Aeneolithic Yayoi population who migrated from Northeast Asia during the Yayoi period and afterwards. This opinion is in contrast to that of Turner (1987:306) who claims that the modern Japanese may have their ancestry in Southern China.

Chinese physical anthropologists started to do dental morphological analyses in the late 1950s. Research on dental morphology was initially done by Mao and Yan (1959) on the skeletons from the small Bronze Age tombs in Anyang which were discovered after 1949 and are kept in China. Mao observed three traits: congenital absence of third molars, four-cusped lower second molars and shovelling of incisors. He demonstrated that the frequency of congenital absence of third molars is between 17-25%, the frequency of four-cusped lower second molars is between 14-17%, the frequency of shovelling of the upper first incisors is between 66-80%. His observations are very similar to Turner's on the Chinese Anyang sample stored in Taiwan. These three traits are included among the eight diagnostic morphological traits of the Sundadont and Sinodont divisions of the Mongoloid dental complex (Turner 1987). Zang (1985) studied the skeletons from the sacrificial burials at Anyang which are now stored in Taiwan. His observations on the incisors from the Bronze Age Anyang Chinese gave a frequency of shovelling of the upper first incisors which, at 84%, is almost the same as Turner's observation (1987) on the same sample.

Woo (1961) worked on a Neolithic Southern Chinese sample from Nanjing. His observations showed that this population represents the basic characteristics of Mongoloids in terms of the presence of shovelled incisors and the high percentage of five-cusped second molars. Recently, Wei *et al.* (1987, 1988) and Zhang *et al.* (1985) worked with modern Southern Chinese material. However, the studies above provided data on only a few dental nonmetric traits such as shovelled incisors and cusp numbers of molars, and hence broad systematic data on dental nonmetric variation are not available. More recently, Zhang (1993) observed a few dental nonmetric traits from the Changyang Bronze Age sample in Southern China and the Tatong historic population in northern China, based on the methods of classification of nonmetric dental variation suggested by Turner (1970). He concluded that the two populations belong to the Sinodont pattern; however, a few nonmetric traits from the Bronze Age Changyang population are closer to those of Sundadonty.

Chinese materials were also studied by some non-Chinese researchers (Lee and Goose 1972; Turner 1984, 1986, 1987, 1989). Turner (1987, 1989) assigned the dental pattern of the Bronze Age Anyang population in northern China to the Sinodont Complex. He further pointed out that the boundary between Sinodonty and Sundadonty seems to lie in Southern China, and that Japanese teeth closely resemble those of Southern Chinese in and around Hong Kong.

Nonmetric studies based on Chinese materials, however, are far from sufficient. A few studies carried out by Chinese researchers are obviously not enough, and a systematic method is required to allow for comparative studies. Studies done by Turner (1984, 1986, 1987) are very important because his research follows a well established scoring procedure, and the hypothesis of division of Sinodonty and Sunadonty is well tested. This hypothesis, however, still needs more dental evidence from different areas and different time periods in China, because of the diversity of populations in China. The current dental nonmetric study of the Neolithic Jiangzhai sample is very important in three aspects. First of all, it will set up basic morphological data for the Neolithic population in the Middle Yellow River Valley: there is no systematic study of dental nonmetric variants in this area. Secondly, it will test the effectiveness of Turner's Sinodonty-Sundadonty hypothesis in this area, and investigate the biological relationships among populations in northern and southern China, Japan and Southeast Asia. Thirdly, it will allow an exploration of the genetic continuity of the Chinese population from the Neolithic to the present.

Materials

Two sets of samples are used for the present research. The first one is a sample of the Neolithic Jiangzhai skeletons which has never been reported with regard to its dental morphology (see **Table 3.1**). It is stored at the Banpo Museum in Xian, was observed and scored twice by the author during the summer of 1993. This sample is from both stage I and II of the Jiangzhai Neolithic site, but the sample from stage II is small because most of the skeletons in the sample came from secondary burials and suffered postmortem tooth loss. No deciduous teeth were used in the present study, and due to the small sample size, teeth of both males and females were pooled together for analysis.

Another set of data derives from eleven East Asian samples (see **Table 3.1**). Though several researchers have done similar studies in East Asia (e.g. Hanihara 1990), the eleven East Asian samples studied by Turner (1987, 1989) were chosen as the only sources for comparison with Neolithic Jiangzhai. Firstly, Turner (1987, 1989) has done extensive work in East

Asia. Secondly, Turner *et al.* (1991) provides the Arizona State University Dental Anthropology System (ASU) and its plaques which have been widely used by many scholars. The use of standard plaques avoids the difficulty of comparing the results obtained by different methods and by various researchers. ASU plaques were also used in the investigation of dental morphology of Neolithic Jiangzhai. **Figure 3.1** shows the geographical locations of the dental samples represented in this study and **Table 3.2** presents detailed results of the observations.

Table 3.1 A list of comparative populations in East Asia

Sample	N	Provenance and collection
Jiangzhai	45	22 male adults, 20 female adults and 3 adolescents, Neolithic Jiangzhai, Xian, China.
Amur*	106	Ulchi, Goldi, Orochi, Negedal, Tungus.
Mongol**	220	Urga (Ulan Bator), and pan-Mongolia, recent.
Anyang**	277	From Anyang victim tombs, Shang Dynasty, 1000 B.C.
NE Siberia*	264	Siberian Eskimo (Ekven and Uelen) and other Paleo-Asiatics, 200 BC to recent.
Lake Baikal*	45	Two series, Lake Baikal Neolithic and West Lake Baikal.
Recent Japan*	552	Japan, Hiogo, Kamakura, Kanto, recent Japanese.
South China*	124	South China 1 & 2, China.
Hong Kong*	319	Hong Kong recent, live, prehistoric.
Thailand*	206	Bangkok, recent Thailand, Yao, Meo, Mrabri hill tribes.
Jomon*	377	Jomon, Ota, Tsukumo, Yosekura, Hokkaido, Yoshiko
Ainu**	142	Ainu, Hokkaido 1 & 2

* the sample from Turner (1987)
** the sample from Turner (1989)

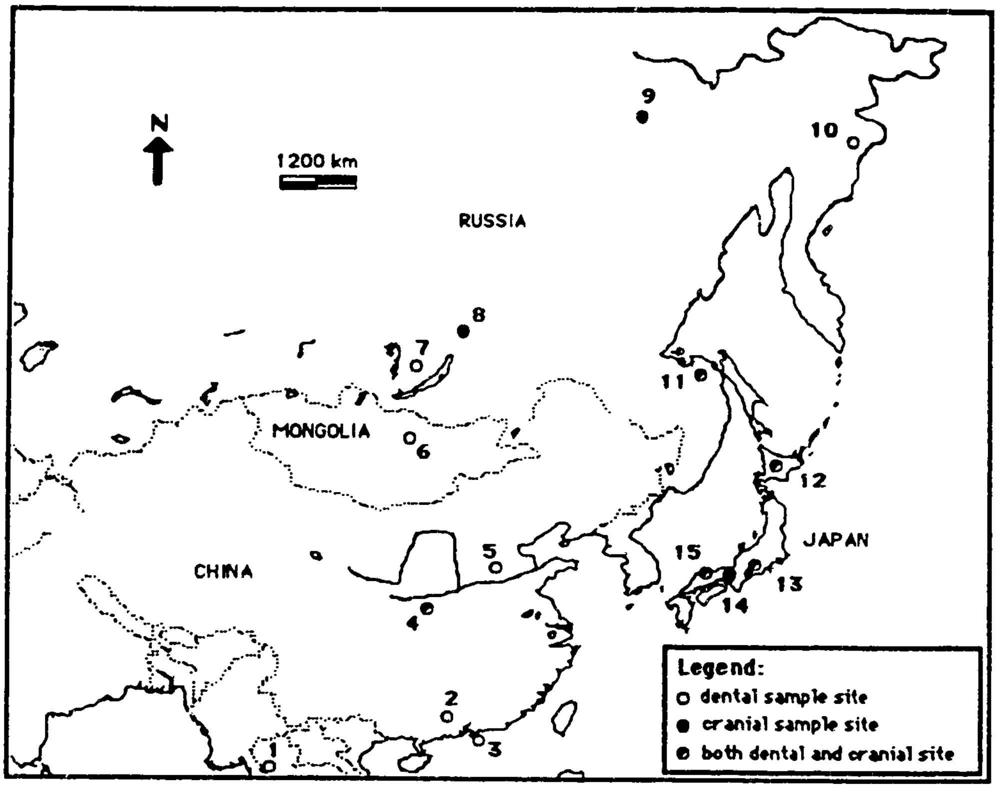

Figure 3.1 Geographical locations of dental and cranial samples represented in this study

Site Legend:

1. Thailand
2. Southern China
3. Hong Kong
4. Jiangzhai
5. Anyang
6. Ulan Bator
7. Lake Baikal
8. Tungus
9. Yukaghir
10. Northeastern Siberia
11. Ulchi
12. Hokkaido (Ainu)
13. Kanto
14. Kinki
15. Honshu (Jomon)

Table 3.2 Jiangzhai dental morphology based on Turner (1991). N refers to number of individuals observed, frequencies are %.

trait and expression	Tooth and frequency		
Winging	UI1		
1 bilateral	33.3		
2 unilateral	0.0		
3 straight	66.7		
4 counter-winging	0.0		
N	3		
Shovelling	UI1	UI2	UC
0 none	0.0	0.0	0.0
1 faint	0.0	0.0	36.4
2 trace	42.9	15.4	36.4
3 semishovel	28.5	15.4	0.0
4 semishovel	0.0	46.1	9.1
5 shovel	14.3	7.7	0.0
6 marked shovel	0.0	7.7	0.0
7 barrel	0.0	0.0	0.0
9 larger than 2	14.3	7.7	18.1
N	7	13	11
Double-shovelling	UI1	UI2	UC
0 none	14.3	25.0	46.1
1 faint	14.3	25.0	15.4
2 trace	14.3	16.7	15.4
3 semi	28.5	25.0	15.4
4 double	28.5	8.3	7.7
5 pronounced	0.0	0.0	0.0
6 extreme	0.0	0.0	0.0
N	7	12	13
Interruption groove	UI1	UI2	
0 absence	100.0	57.1	
1 presence	0.0	42.9	
N	7	14	
Tuberculum dentale (TD)	UI1	UI2	UC
0 none	33.3	72.7	9.1
1 faint ridging	16.6	9.1	0.0
2 trace	33.3	18.2	36.4
3 strong	16.7	0.0	9.1
4 pronounced	0.0	0.0	45.4
5-6 strong free cusp	0.0	0.0	0.0
N	6	11	11
Mesial ridge	UC		
0 equal to distolingual ridge	42.9		
1 larger than distolingual ridge	14.3		
2 moderately attached to TD	42.8		
3 much larger than distolingual ridge	0.0		
N	7		
Distal accessory ridge	UC		
0 absent	40.0		
1 trace	20.0		
2 weak	40.0		
3-5 moderate to strong	0.0		
N	5		
Metacone	UM1	UM2	UM3
0 absent	0.0	0.0	13.3
1 a rigde present	0.0	0.0	0.0
2 a fain cuspule	0.0	0.0	0.0
3 weak cusp	0.0	0.0	20.0
4 large	10.7	9.1	33.3
5 very large	89.3	80.9	33.4
N	28	22	15

Table 3.2 continued

Hypocone	UM1	UM2	UM3
0 no expression	0.0	4.5	27.8
1 weak ridges	0.0	0.0	0.0
2 faint cuspule	0.0	0.0	5.6
3 small cusp	0.0	18.2	33.3
3.5 moderate size	0.0	9.2	5.6
4 large cusp	81.5	63.6	27.7
5 very large cusp	18.5	4.5	0.0
N	27	22	18

Cusp 5	UM1	UM2	UM3
0 absence	80.0	79.0	82.3
1 faint cuspule	4.0	10.5	5.9
2 trace cuspule	8.0	5.2	0.0
3 small cuspule	8.0	0.0	0.0
4 small cusp	0.0	5.3	5.9
5 medium-sized cusp	0.0	0.0	5.9
N	25	19	17

Carabelli trait	UM1	UM2	UM3
0 absent	84.0	95.7	100.0
1 a groove	3.2	0.0	0.0
2 pit	3.2	4.3	0.0
3 small Y-shape	3.2	0.0	0.0
4 large Y-shape	3.2	0.0	0.0
5-7 small to large cusp	0.0	0.0	0.0
9 larger than grade 0	3.2	0.0	0.0
N	31	23	19

Parastyle	UM1	UM2	UM3
0 absent	96.8	100.0	94.4
1 pit	3.2	0.0	0.0
2-3 small to medium cusp	0.0	0.0	0.0
4 large cusp	0.0	0.0	5.6
5-6 very large cusp	0.0	0.0	0.0
N	31	23	18

Enamel extension	UP1	UP2	UM1	UM2	UM3
0 absent	11.1	23.5	3.3	4.5	20.0
1 faint	33.3	35.3	56.7	40.9	40.0
2 medium	38.9	29.4	36.7	45.5	26.7
3 lenghty extension	16.7	11.8	3.3	9.1	13.3
N	18	17	30	22	15

Root Number	UC	UP1	UP2	UM1	UM2	UM3
1 one	100.0	75.0	100.0	6.7	13.4	63.3
2 two	0.0	25.0	0.0	0.0	13.3	9.1
3 three	0.0	0.0	0.0	93.3	73.3	27.3
N	33	24	21	15	15	11

Peg/reduced congenita absence	UI2	UP2	UM3
0 absent	100.0	100.0	56.7
1 present	0.0	0.0	43.3
N	28	27	30

Premolar lingual cusp	LP1	LP2
0 absent	14.3	0.0
1 one cusps	0.0	0.0
2 one or two	14.3	90.9
3 two, mesial much larger than distal	71.4	9.1
4 two, mesial larger than distal	0.0	0.0
N	7	11

Y groove pattern	LM1	LM2	LM3
1 Y cusps 2,3 in contact	60.0	0.0	0.0
2 + cusps 1-3 in contact	10.0	72.2	100.0
3 X cusps 1,4 in contact	30.0	27.8	0.0
N	10	18	15

Table 3.2 continued

Cusp number	LM1	LM2	LM3
4 cusps 1-4	17.4	34.8	5.2
5 cusp 5 also present	39.1	21.7	42.1
6 cusp 6 also present	34.8	30.4	31.6
9 at least 4 present	8.7	13.0	21.1
N	23	23	19

Deflecting wrinkle	LM1	LM2	LM3
0 no expression	33.3	100.0	77.8
1 cusp 2 medial ridge is straight, midpoint constriction	16.7	0.0	0.0
2 medial ridge deflected distally	16.7	0.0	0.0
3 the same as 2 but forming an L-shaped ridge	33.3	0.0	22.2
N	6	4	9

Distal trigonid crest	LM1	LM2	LM3
0 absent	87.5	100.0	100.0
1 present	12.5	0.0	0.0
N	8	15	12

Protostylid	LM1	LM2	LM3
0 absent	95.2	85.7	76.5
1 pit in buccal groove	0.0	9.5	23.5
2 curved buccal groove	4.8	4.8	0.0
3-6 samll to large cusp	0.0	0.0	0.0
N	21	21	17

Cusp 5	LM1	LM2	LM3
0 absent	14.3	38.9	12.5
1-2 small	0.0	0.0	0.0
3 medium-sized	9.5	38.9	25.0
4 large	52.4	11.1	25.0
5 very large	23.8	11.1	37.5
N	21	18	16

Cusp 6	LM1	LM2	LM3
0 absent	57.9	62.5	26.7
1 much smaller than cusp 5	0.0	6.3	0.0
2 smaller than cusp 5	31.6	25.0	40.0
3 equal in size to cusp 5	0.0	6.2	13.3
4 larger than cusp 5	5.3	0.0	13.3
5 much larger than cusp 5	5.2	0.0	6.7
N	19	16	15

Cusp 7	LM1	LM2	LM3
0 absent	100.0	100.0	100.0
1 present	0.0	0.0	0.0
N	21	19	16

Tome's root	LP1
0 absent	66.7
1 developmental groove a shallow V-shaped cross section	33.3
N	3

Root number	LC	LP1	LP2	LM1	LM2	LM3
1 one	100.0	100.0	100.0	0.0	27.4	0.0
2 two	0.0	0.0	0.0	62.5	45.4	71.4
3 three	0.0	0.0	0.0	37.5	9.1	0.0
4 four	0.0	0.0	0.0	0.0	9.1	28.6
N	22	14	16	18	11	7

Odontome	U+LP1,2
0 absent	92.8
1 present	7.2
N	14

Methods

Scoring procedure

The observation of a dental nonmetric trait is quite different from that of a cranial nonmetric trait in that cranial traits can be observed and analysed as present or absent. Hrdlicka (1920) worked on incisor shovelling, and noted that the characteristics, when present, take on different forms ranging from minimal to maximal expression, and he gave descriptions and photographs to aid others in making the same sort of observations. A. A. Dahlberg (1956) developed standardized techniques for the observation of dental morphology, by which he not only developed graded standards for a large array of characteristics, but also made the important step of devising plaster plaques which could be distributed among other workers in dental anthropology.

Recently, Turner *et al.* (1991) continued Dahlberg's work on the development of standards for the observation of dental morphological variants in the permanent dentition, and further refined the Arizona State University Dental Anthropology System. This system permits observation beyond the presence/absence dichotomy, and at the same time promotes replicability of results between observers. The traits used in the system have been selected for standardized study because they are those most easily and reliably observed, persist for many years even under conditions of harsh attrition, and most have little or no sexual dimorphism. The fossil record has shown that they evolve very slowly and these traits are powerful indicators of population affinity. This system and its plaques were used in observing and scoring dental morphology of the Neolithic Jiangzhai population.

Counting procedure

As the dentition is composed of a series of bilaterally symmetrical structures which exhibit varying degrees of fluctuating asymmetry in terms of size and morphological detail (Scott 1980), three methods of counting are commonly used by many researchers, including total tooth count (Dahlberg 1963, Harris 1977), unilateral count (Hanihara 1977) and individual count (Turner 1967, Turner and Scott 1977). The individual count is used in this study, as the dental traits of the Neolithic Jiangzhai of this study will be compared with the 11 East Asian populations documented by Turner (1987, 1989) who also used the individual count.

The individual count method used by Scott is followed in the present study: "... the basic premise of this method is that an individual has only a single genotype for any specific trait and should therefore be classified in only one phenotypic category. A secondary assumption is that, when asymmetric expression is evident, the antimere exhibiting the greatest degree of trait expression is the most accurate indicator of this genotype. In symmetrical cases, an individual is scored once relative to the expressed grade, but, when asymmetry exists, the individual is scored relative to the highest grade of expression on either the left or right side" (Scott 1980:66-67). Scott adds that this method also maximizes sample size relative to the number of individuals with one observable antimere.

Statistics

The Chi-square statistics was used to calculate the intra-observer error. Dental traits were transformed using the Freeman and Tukey transformation recommended by Green and Suchey (1976) for small sample size. Comparisons were made among 12 East Asian populations using the multivariate mean measure of divergence (MMD) statistic (Berry and Berry 1972; Green and Suchey 1976; Sjøvold 1973). The standard deviations were calculated according to the mathematical method of Sjøvold (1973). A further discussion of the statistical techniques employed will be found below (see pages 67-69).

Results

Intra-observer error

Two sets of observations were made; the first during May of 1993, and the second in late June the same year. A comparison of intra-observer error between the two sets of observations is done using the chi-square statistic.

Table 3.3 Intra-observer comparison of Jiangzhai dental nonmetric traits

Traits	May 1993		June 1993		P
	n/N	%	n/N	%	
1 shovelling UI1	6/7	85.7	7/7	100.0	0.84
2 shovelling UI2	11/13	84.6	13/13	100.0	0.77
3 Shovelling UC	5/8	62.5	11/11	100.0	0.51
4 double-shovelling UI2	8/12	66.7	9/12	75.0	0.85
5 double-shovelling UC	4/11	36.4	7/13	53.8	0.72**
6 tuberculum dentale	4/8	50.0	10/11	90.9	0.42
7 mesial ridge	2/6	33.3	4/7	57.1	1.00**
8 distal accessory ridge	3/5	60.0	5/7	71.4	1.00**
9 * metacone UM1	24/28	85.7	25/28	89.3	0.91
10 * metacone UM2	18/22	81.8	20/22	90.9	0.81
11 cusp 5 UM1	4/23	17.4	5/25	20.0	1.00**
12 cusp 5 UM2	4/19	21.0	5/20	25.0	1.00**
13 cusp 5 LM2	12/20	60.0	13/20	65.0	0.88
14 cusp 6 LM1	9/21	42.9	10/21	47.6	0.84
15 cusp 6 LM2	5/18	27.8	8/18	44.4	0.47
16 * cusp number LM1	18/23	78.3	19/23	82.6	0.90
17 * cusp number LM2	14/23	60.9	15/23	65.2	0.89

*Metacone (UM1,UM2): total grades = 7(0-6), grades of absence = 0-5. Cusp number (LM1,LM2): total grades = 7(0-6), grades of absence = 0-4.

**Fisher exact test is used when total sample size and expected values are small (in a 2 x 2 table, less than 5).

n represents the number of sides with trait present, N represents the total number of sides examined, P represents probability.

Table 3.3 shows the results of the tests on seventeen studied traits. In most cases, the grade of absence is zero; only metacone and cusp number have different grades of absence which are noted at the end of the table. There are no significant intra-observer differences between the two observations, indicating that that the ASU Dental Anthropology System was consistently used in both set of observation.

Eight diagnostic dental traits of the Neolithic Jiangzhai population

The main purpose here is to provide new descriptive information on Neolithic Jiangzhai dental features which have not previously been reported by physical anthropologists. Twenty-seven traits were observed. **Table 3.2** provides a detailed summary of these observations. Turner (1989) gives the eight diagnostic morphologic traits which distinguish Sinodont and Sundadont within the Mongoloid dental complex: upper central incisor shovelling, upper central incisor double-shovelling, single-rooted upper first premolar, upper first molar enamel extension, peg/reduced/congenital absence (PRC) of upper third molars, mandibular first molar deflecting wrinkle, three-rooted mandibular first molar, and four-cusped mandibular second molars. Each of these eight traits from Jiangzhai will be examined and used to compare with 11 other populations in East Asia (see **Table 3.4**).

1. Upper central incisor shovelling

The frequency of shovelling for Jiangzhai is only 57.1%, which is lower than the mean frequency for Sinodonts (71.1%), but much higher than the mean frequency for Sundadonts (30.8%) (Turner 1989). The incidence of shovelling at Jiangzhai is closest to NE Siberia (61.4%), next closest to Hong Kong (63.8%), Recent Japanese (66%), and Amur (68.7%). The latter four populations are all Sinodont. Occurrence of shovelling in the Jiangzhai sample is, however, unlike that of Jomon (only 25.7%), Ainu

Jiangzhai sample is, therefore, much more like that of the Sinodonts.

2. Upper central incisor double-shovelling

As shown by Turner (1989) in his study of shovelling in forty populations, the Sundadonts of Southeast Asia have generally low frequencies of double-shovelling whereas higher frequencies occur in Sinodonts of Northeast Asia. The frequency of double-shovelling at Jiangzhai is 71.4%, which is much higher than the mean of the Sinodonts (55.8%) (Turner 1989). The Lake Baikal sample (50%) is the closest to the Jiangzhai sample. Recent Japanese (19.5%), and people from NE Siberia (25%), Southern China (24.2%) and Hong Kong (28.5%) are quite similar to each other and close to 22.7%, the mean value of the Sundadonts (Turner 1989). The incidence of double-shovelling at Jiangzhai is very markedly Sinodont.

3. Single-rooted upper first premolar

The frequency of this trait at Jiangzhai is 75%, almost the same as for Recent Japanese (75.1%) and Jomon (75.5%), and between the means of Sinodonts (78.8%) and Sundadonts (70.6%) (Turner 1989). Turner also concludes that Sinodonts generally have more one-rooted upper first premolars than do Sundadonts and Australians. At the same time, he notices that some Sundadont samples are well within the Sinodont range, and vice versa. He suggests that there may be reduced genetic regulation of upper first premolar root number and that it may be more easily influenced by random changes in gene frequencies, an as yet unproven hypothesis. In this study (*ibid.*), the frequency for Ainu is 83.2% which is much higher than many Sinodonts, such as Hong Kong (61.9%) and Anyang (69.9%).

4. Upper first molar enamel extension

The frequency of this trait at Jiangzhai is 40%. Turner (1989) shows that enamel extensions are less frequent in Sundadonts and Australians than in Sinodonts: the mean value for Sinodonts is 50.1%, and the mean value for

Table 3.4 Frequency distribution of tooth crown traits in 12 East Asian populations

Sample	Shovelling		Double shovel		1-Root		Enamel extension		*PRC		Deflecting wrinkle		3-Root number		Cusp number	
	UI1(3-7/0-7)**		UI1(2-6/0-6)		UP1(1/1-3)		UM1(2-3/0-3)		UM3(PRC/all)		LM1(3/0-3)		LM(3/2,3)		LM2(4/4-6)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Amur	16	68.7	18	44.5	106	98.1	84	51.2	98	42.8	38	39.5	74	20.3	52	11.5
Mongol	56	82.1	53	34.0	114	78.9	147	42.9	138	45.7	25	32.0	90	38.9	63	14.3
Jiangzhai	7	57.1	7	71.4	24	75.0	30	40.0	30	43.3	6	33.3	8	37.5	23	34.8
Anyang	118	89.9	142	32.4	143	69.9	224	57.4	215	32.6	8	62.5	172	38.4	103	12.6
NE Siberia	44	61.4	24	25.0	264	91.3	239	48.5	256	21.9	43	39.5	164	23.0	86	3.5
Lake Baikal	13	92.3	10	50.0	30	80.0	32	18.7	32	15.6	2	0.0	30	23.3	18	22.2
Recent Japanese	276	66.0	267	19.5	506	75.5	522	54.6	504	42.1	262	14.9	429	24.2	345	13.6
Southern China	35	74.4	33	24.2	113	67.3	107	59.8	124	25.0	39	17.9	100	15.0	77	19.5
Hong Kong	307	63.8	299	28.5	113	61.9	97	55.6	238	37.4	215	9.8	98	18.4	296	24.3
Thai	127	37.0	111	9.0	168	66.1	166	38.5	206	18.4	80	18.8	186	10.8	163	25.8
Jomon	117	25.7	138	1.4	241	75.5	278	9.7	338	13.0	162	4.9	377	3.4	244	28.7
Ainu	51	29.4	48	20.6	107	83.2	105	40.9	104	25.0	63	4.7	116	9.5	92	29.4

* PRC represents peg/reduced/congenital absence

**The present\absent dichotomy follows Turner (1987:312-15). UI1(1/1-4) is a formula for observations of shovelling on upper first incisors indicating grades of shovelling present versus the total sample count. The rest formulae are based on the same reason.

Sundadonts is only 26.4%. The Jiangzhai sample shows stronger evidence of Sinodonty than Sundadonty. Jomon at only 9.7%, is very typical of a Sundadont population. However, the Ainu at 40.9% and Thai at 38%, show that the Thai and Ainu could have been admixed with Sinodonts

5. Peg/reduced/congenital absence of upper third molars

The frequency of this trait in the Jiangzhai sample is 43.3%. Turner (1989) shows that third molar reduction and absence are much less common in the Sundadonts and Australians than in Sinodonts; the mean of the Sundadonts is only 16.3%, and the mean of the Sinodonts is 32.4%. This trait in Jiangzhai is much closer to the Sinodont pattern. The Jomon sample (13%) belongs to the Sundadont pattern, but the Ainu (25%) and Thai (18.4%) populations are a little high and may be partly influenced by northern Sinodonts. It is worth noting that the southern China (25%), NE Siberia (21.9%) and Lake Baikal (15.6%) samples are quite low and close to the mean of the Sundadonts, indicating a possible influence of Sundadonts on these populations.

6. Mandibular first molar deflecting wrinkle

The frequency of this trait in Jiangzhai is 33.3%. There were only six individuals in the Jiangzhai sample with good molar occlusal surfaces for the observation of the trait, and only two occurrences of the trait were recorded. This trait in the Jiangzhai sample was observed on two children less than 12 years. Turner (1989) states that since the molar occlusal surface begins to wear away within a few years of eruption, and is completely lost in most individuals by age 15-18 years, the trait is most accurately studied in unerupted molars, and in individuals less than 12 years old. He points out that there is broad overall range of frequency variation for the deflecting winkle, and on the average, Sundadonts and Australians have lower frequencies of this trait than do Sinodonts. He further indicated that the frequency for the adult Anyang Chinese series should not be taken seriously, since only eight individuals were usable for this trait. The trait incidence in Jiangzhai is close to those of many northern Sindonts; Mongol (32%), Amur (39.5%) and NE Siberia (39.5%). Southern China (17.9%), Hong Kong (9.8%), Recent Japanese (14.9%) and Thai (18.8%) are fairly intermediate, suggesting possible influences from both Sinodonts and Sundadonts. The Jomon (4.9%) and Ainu (4.7%) are close to the Southern Sundadonts.

7. Three-rooted mandibular first molar

The frequency of the trait in Jiangzhai is 37.5%. The sample size is quite small: only eight individuals are scorable for this trait. Caution should be taken when the trait incidence of Jiangzhai is compared with other populations in East Asia. Turner (1989) shows that there is a decisive division between Sundadonts and Sinodonts, the latter (mean 24.7%) having higher frequencies of the trait than the former (8.8%). Jiangzhai, Anyang (38.4%) and Mongol (38.9%) are very close to each other, with the high values of the Sinodont pattern. Hong Kong (18.4%) and Southern China (15%) are intermediate. The lower value groups are Jomon (3.4%), Ainu (9.5%) and Thai (10.8%), indicative of the Sundadont pattern.

8. Four-cusped mandibular second molars (LM2)

The frequency of the trait in Jiangzhai is 34.8%, and 23 individuals were scorable for the trait. Turner (1989) found that four-cusped lower second molars have a generally higher frequency in Sundadont (the mean value is 30.7%) than Sinodont (the mean value is 6.9%) peoples. The Jiangzhai sample is very similar to the Sundadont groups, such as Ainu (29.4%), Jomon (28.7%) and Thai (25.8%). This suggests that there is a chance of Sundadont influence on the Neolithic Jiangzhai population. Lake Baikal (22.2%), Southern China (19.5%) and Hong Kong (24.3%) also show some similarity to the Sundadont pattern. The rest of the studied populations, such as Amur (11.5%), Mongol (14.3%), Anyang (12.6%), NE Siberia (3.5%)

and recent Japanese (13,6%) have very low values for the trait, and they fit very well into the Sinodont pattern. Attention should be paid to this single trait since it has been studied by Chinese researchers. Zhang *et al.* (1985) investigated the cusps of lower second molars among 1024 young students aged from 6 to 27 years old in Nanjing. They show that the frequency of this trait is 42.6% among 669 scorable individuals. Wei and Lee (1987) studied a sample representing over 100 individuals in Guangxi province, an area next to Vietnam. They discovered that the frequency of the four-cusped mandibular second molars from the area is 38.2%. Zhang (1993) also observed the frequency of this trait in historic Tatong (29.5%) and Bronze Age Changyang (25%). This trait needs to be further investigated in more samples and more areas in both southern and northern China before firm conclusions can be drawn.

In conclusion, most of the eight diagnostic traits of Jiangzhai show affinity to Sinodont populations, and only four-cusped mandibular second molars may show the influence of Sundadonts. It is certain that the Neolithic Jiangzhai population is Sinodont, and much different from Sundadont populations. The presence of some element of Sundadonty may support the hypothesis of Turner (1989) that Sinodonts evolved from Sundadonts, as the Jiangzhai population may have kept some of the traits of Sundadonts after separation from Sundadonty.

Biological Distance

Each of the eight diagnostic traits of 11 East Asian populations above has been evaluated by Turner (1989) using chi-square and Spearman's ranked correlation coefficient for independence, and most of them are independent or only weakly correlated. In order to assess the biological affinity of the Neolithic Jiangzhai, these eight traits are analyzed with MMD statistics developed by C.A.B.Smith (Berry and Berry 1967), using the Freeman-Tukey transformation as suggested by Green and Suchey (1976) as the correction method for small sample size, and Sjøvold's (1973) procedure for calculating MMD significance and their standard deviations. The distance between each pair of populations is presented in **Tables 3.5** and **3.6**. Ward's clustering method (Sneath and Sokal 1973) provides two dendrograms of the relationship between Jiangzhai and other populations in East Asia (**Figures 3.1 and 3.2**).

Table 3.5 Mean measure of divergence (MMD) matrix for 12 East Asian populations (below the diagonal) and their standard deviations in boldface (above the diagonal)

	1	2	3	4	5	6	7	8	9	10	11	12
1	-	**0.057**	**0.063**	**0.051**	**0.058**	**0.117**	**0.050**	**0.065**	**0.058**	**0.052**	**0.049**	**0.055**
2	0.032	-	**0.024**	**0.011**	**0.013**	**0.083**	**0.010**	**0.029**	**0.018**	**0.013**	**0.008**	**0.015**
3	0.065	0.059	-	**0.017**	**0.025**	**0.085**	**0.017**	**0.031**	**0.025**	**0.019**	**0.018**	**0.022**
4	0.103	0.104	0.196	-	**0.011**	**0.082**	**0.006**	**0.022**	**0.011**	**0.006**	**0.007**	**0.009**
5	0.129	0.076	0.144	0.006	-	**0.085**	**0.009**	**0.011**	**0.018**	**0.013**	**0.009**	**0.011**
6	0.065	0.058	0.154	0.097	0.068	-	**0.076**	**0.096**	**0.082**	**0.078**	**0.029**	**0.080**
7	0.166	0.055	0.120	0.023	0.019	0.124	-	**0.022**	**0.011**	**0.005**	**0.004**	**0.008**
8	0.132	0.038	0.142	0.231	0.134	0.202	0.175	-	**0.027**	**0.024**	**0.007**	**0.025**
9	0.167	0.086	0.032	0.180	0.099	0.165	0.093	0.128	-	**0.013**	**0.012**	**0.016**
10	0.269	0.272	0.310	0.108	0.100	0.243	0.125	0.387	0.186	-	**0.006**	**0.010**
11	0.648	0.603	0.646	0.385	0.405	0.434	0.402	0.846	0.476	0.117	-	**0.007**
12	0.233	0.307	0.264	0.106	0.141	0.219	0.161	0.526	0.223	0.045	0.139	-

1. Jiangzhai 2. Mongol 3. Amur 4. Hong Kong 5. Southern China 6. Lake Baikal 7. Recent Japanese 8. Anyang 9. NE Siberia 10. Thai 11. Jomon 12. Ainu

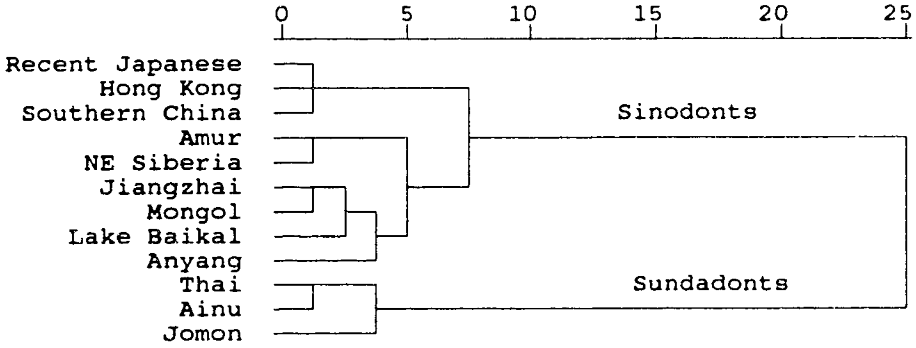

Figure 3.2 Dendrogram of 12 East Asian populations

Table 3.5 and **Figure 3.1** show that East Asian Mongoloids are divided into two clusters. Cluster One contains exclusively people who, in Turner's dental scheme, would be classed as Sinodonts. In the upper level of

Cluster One, Recent Japanese, Hong Kong and Southern China are separated from the rest of the Sinodont groups; Amur and NE Siberia again separate from Jiangzhai, Mongol, Lake Baikal and Anyang. The Neolithic Jiangzhai dentition is among the Sinodont groups, it is closest to Mongol, next to Lake Baikal. Bronze Age Anyang is only loosely connected with Neolithic Jiangzhai even though it is geographically close to Jiangzhai. There is a possibility that a diversity of populations could have developed in the Middle and Lower Yellow River Valley. In Cluster Two, the samples from Thai, and of Ainu and Jomon peoples form a distinct Sundadont group, as shown by Turner (1987).

Table 3.6 Mean measure of divergence (MMD) matrix for eight East Asian populations (below the diagonal) and their standard deviations in boldface (above the diagonal)

	1	2	3	4	5	6	7	8
1	-	**0.057**	**0.063**	**0.050**	**0.065**	**0.058**	**0.049**	**0.055**
2	0.032	-	**0.024**	**0.010**	**0.029**	**0.018**	**0.008**	**0.015**
3	0.065	0.059	-	**0.017**	**0.031**	**0.025**	**0.018**	**0.022**
4	0.166	0.055	0.120	-	**0.022**	**0.011**	**0.004**	**0.008**
5	0.132	0.038	0.142	0.175	-	**0.027**	**0.007**	**0.025**
6	0.167	0.086	0.032	0.093	0.128	-	**0.012**	**0.016**
7	0.648	0.603	0.646	0.402	0.846	0.476	-	**0.007**
8	0.233	0.307	0.264	0.161	0.526	0.223	0.139	-

1. Jiangzhai 2. Mongol 3. Amur 4. Recent Japan
5. Anyang 6. NE Siberia 7. Jomon 8. Ainu

It is necessary to compare the results derived from dental nonmetric traits with those of the cranial nonmetric traits, to be presented in the next chapter, based on eight samples from Jiangzhai, NE Siberia and Japan. Eight dental samples are presented in **Table 3.6** and **Figure 3.2**, allowing comparison between the results of the dental and cranial analyses. The final result from the dental analysis is quite similar to the nonmetric cranial cluster analysis which shows that Recent Japanese is closer to NE Siberian and Amur populations than Neolithic Jiangzhai, Mongol and Anyang. It suggests that the local evolution of populations in the Yellow River Valley and the Republic of Mongolia is different from that of the populations in Amur and NE Siberia, possibly Korea, and northeastern China including Helongjiang Province and Jilin Province. Modern Japanese populations derive genetic contributions from Southern China, less from Northeast Asia, and least from the Yellow River Valley and the area of the modern Republic of Mongolia. This analysis gives a general map of macro-evolution in East Asia, and more detailed work needs to be done in the future.

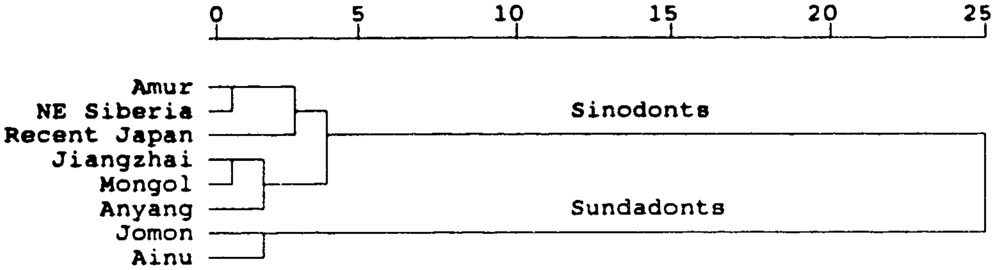

Figure 3.3 Dendrogram of eight East Asian populations

Summary

Investigation into dental nonmetric traits of the Neolithic Jiangzhai population in the Middle Yellow River Valley was carried out using the ASU Dental Anthropology System and its dental casts were used for data collection. This research is important in three aspects.

1) A basic data set of dental morphological traits is presented for the Middle Yellow River Valley in northern China where no systematic research on teeth has ever been carried out, whether on Neolithic or later samples.

2) Eight diagnostic dental traits from Neolithic Jiangzhai are compared with those of 11 populations in East Asia collected by Turner (1987,1989). The results of single trait comparisons show that most of dental nonmetric traits of the Neolithic Jiangzhai population exhibit the Sinodont pattern. The four-cusped lower second molar is the one exception in that it has the high frequency

indicative of the Sundadont pattern. The high frequency of the trait is found to be present among some populations in Southern China and northern China. This might suggest that diverse populations exist in China in terms of different frequencies of the four-cusped lower second molar. This also supplies some evidence in support of the hypothesis suggested by Turner (1987, 1989) that Sinodont populations may have evolved from the Sundadont and kept some Sundadont elements after separation during the late Pleistocene.

3) The mean measure of divergence and cluster analyses are applied to samples from both 12 and eight East Asian populations. The results show that the Neolithic Jiangzhai population finds its place among the Sinodont groups and is different from the Sundadont groups including populations of Ainu, Thai and Jomon. Among the Sinodont groups in East Asia, there are at least three subgroups. The Neolithic Jiangzhai population is in the same group as Mongol, Lake Baikal and Anyang. Populations in Amur and NE Siberia are in a second group, while Recent Japanese, populations from Hong Kong and southern China cluster closely in the third subgroup. Recent Japanese show a closer relationship with populations from NE Siberia and Amur than with those of Jiangzhai, Mongol and Anyang. Among the populations from Neolithic Jiangzhai, Mongolia, Lake Baikal and Anyang, Neolithic Jiangzhai is unexpectedly less closely grouped with the population from Anyang. The Neolithic inhabitants of Jiangzhai might be the ancestors of Zhou people who set up a capital around the area of Jiangzhai, and replaced another population who once had a capital in Anyang. Recent Japanese share more genetic characteristics with the populations of southern China than with the populations of the Northeast Asia including northeastern China, NE Siberia, Amur and very possibly Korea. Ainu and Jomon have few affinities with Recent Japanese.

Chapter Four

Cranial nonmetric study of the Jiangzhai Neolithic population and its affinity with Japanese and Siberians

Introduction

Nonmetric variants, also known as discontinuous morphological traits, epigenetic variants, quasi-continuous traits or discrete traits, are observed in bones in the form of differently shaped tubercles, processes, crests, foramina, articular facets and other similar features. They have aroused the curiosity of anatomists for many decades.

It was Wood-Jones (1930) who first proposed that different incidences of these minor variants would occur in different populations and might therefore be useful in population studies. But it was the work of Gruneberg (1952) on mice which established the potential value of nonmetric skeletal variants to population studies because the variants were shown to be under genetic control. Nonmetric traits are widely used in studies of wild populations of several species: mouse (R.J.Berry 1963; Berry *et al.* 1967; Petras 1967), rat (Gruneberg 1962), vole (Hilborn 1974), frog (Grewal *et al.* 1967), deer (Rees 1969) and seal (R.J.Berry 1969). These studies show that each variant is determined by a number of genes acting additively, and that a developmental threshold in the genotype distribution leads to the manifestation of phenotypic alternatives or variants, rather than to a continuously distributed character. The threshold may vary in the presence of modifying genes or relevant environmental conditions.

The experimental results on animals have encouraged physical anthropologists to apply nonmetric variation to the study of human population affinity in various parts of the world. Berry and Berry (1967) suggested that a wide range of these variants could be used to calculate biological distance between populations, and this was the starting point for a renewal of interest among anthropologists in studies of population affinities. From that time on, numerous studies have followed and the statistical techniques used for assessing population variation in time and space based on nonmetric skeletal research (Ossenberg 1976) have been determined. As my concern in this chapter is the population affinities in North, East and Southeast Asia, the review will concentrate on these areas.

Nonmetric studies on the Japanese population were initiated by Yamaguchi (1967). This research has expanded into an exploration of the population history of Japan carried out by both Japanese and a few non-Japanese researchers. A close resemblance between the Jomon and Ainu has been demonstrated on the basis of cranial nonmetric traits (Ossenberg 1986; Dodo 1986, 1987; Mouri 1988; Kozintsev 1990; Dodo and Ishida 1990). Moreover, it has been indicated from data on cranial nonmetric traits that the Yayoi and protohistoric Kofun, who were immediately post-Jomon Japanese populations, are much closer to modern Japanese than to the Jomon (Yamaguchi 1985; Dodo 1987; Dodo and Ishida 1990; Kozintsev 1990). Dodo *et al* (1992) show that one cranial sample from Laining in Northeastern China joins the historic Japanese samples, and is loosely connected with modern Mongolians from Ulan Bator in the Republic of Mongolia. They suggest that modern Japanese and Northeastern Chinese share common ancestors who may be related to the continental immigrants of the Yayoi period. Their results also suggest that the ancestors of modern Mongolians have less genetic contribution to the modern Japanese than the ancestors of the Northeastern Chinese.

Cranial nonmetric research on Siberian populations has been undertaken by a few researchers. Ossenberg (1986) discussed the relationship between Siberian and Japanese populations. She demonstrated that modern Japanese populations have closer affinities with Siberians than with Ainu and Jomon, and that Japanese tend to have closer affinities with Tungus than Chukchi-Eskimo. This accords with the geographical hypothesis of Sciulli (1990) that the biological distances between samples are directly associated with the between-sample geographical distances. Ishida (1990) studied the skeletal collections of five Siberian populations in Amur and one Ainu population in Sakhalin. He used both the superorbital foramen and hypoglossal canal bridging to discriminate between major racial groupings, and concluded that recent and prehistoric Siberian populations in the Amur region are intermediate between Asian Mongoloid and North American Mongoloid in the incidences of these two variant traits, while the Sakhalin Ainu are intermediate between the Asian Mongoloid and Hokkaido Ainu. Kozintsev (1990, 1992, 1993) concluded that Sakhalin Ainu are mixed with northern Mongoloids.

Pietrusewski (1981, 1984) undertook the major studies on cranial nonmetric variation among prehistoric and modern Southeastern Asian populations. He made comparisons among East and Southeastern Asians, and aboriginal Australian populations. His research (1981) shows that the prehistoric populations in mainland Southeast Asia are distantly separated from all the recent populations in this area; the major populations from the islands of Southeast Asia show differences from the populations of mainland Southeast Asia; populations from Japan, Mongolia and Siberia are loosely connected with Southeast Asians; one sample from China is closely related to the sample from Lao. He further suggests (1984) that there exists a single major complex of populations (Southeast Asia-Melanesia) and two isolated populations which include one Australian (Tasmania and Solomon Island are also in the group) and one Polynesian (except New Zealand).

Wood-Jones (1933) was the first physical anthropologist to initiate nonmetric research on one population from northern China. However, his research was followed by a long gap until recently when nonmetric studies have been undertaken again. It is now accepted as a useful means of studying biological distances between populations in China and in neighbouring countries. Wang (1988) observed 65 nonmetric traits from a sample representing a total of 144 individuals, which included the original sample studied by Wood-Jones and an additional sample from northern China. His conclusions are in close agreement with Wood-Jones's (Wang 1988), but he also suggests the existence of variation among the populations in China. This suggestion resulted from a comparison of frequencies of his data with the nonmetric data of other authors based on samples from other areas (IGCAA 1986). Zhang (1992) observed nonmetric traits from a sample representing twenty Bronze Age people in Changyang, Hubei province, in southern China. He also compared his data with the data from Pietrusewski (1984) and Wang (1988). He concludes, based on a simple frequency analysis, that the Changyang population is similar to Southeast Asians and different from Siberian and Mongolian populations. The results from Zhang and Wang (1992) need to be taken with caution as their methods of trait scoring are not comparable with those employed in the present study.

The nonmetric research on the Neolithic Jiangzhai population presented here differs from that of previous researchers in China. It will add basic observational data on skeletal nonmetric traits in the middle Yellow River Valley in northern China. The methodology was more rigorous than that of previous Chinese scholars. Side difference, sex difference, intra-observer error and inter-trait correlation will be discussed, and the mean measure of divergence (MMD) will be used to explore the biological distance between Neolithic Jiangzhai and other populations in North and East Asia.

Materials

There are two sets of materials for the present study. One is from Neolithic Jiangzhai and includes forty two adult individuals not previously reported (See **Table 4.1**). The other set of materials is used for comparative purpose, and includes three Siberian populations and four Japanese populations.

Table 4.1: Eight cranial nonmetric samples from eight East Asian populations

Sample	N	Provenance and Collection
Jiangzhai	42	The sample is stored in the Banpo Museum in Xian, China. It represents the Neolithic population in the middle Yellow River Valley, about 5000-4000 BC (including 22 males and 20 females)
*Jomon	56	Most skeletons are from the Tsukumo site in western Honshu and are now stored in the Laboratory of Physical Anthropology at Kyoto University. A few are stored in the National Science Museum in Tokyo, Japan. Late phase Jomon (ca. 3000-500 B.C.)
*Ainu	119	Samples stored in the University Museum of Tokyo, representing a 19th century population from central and northeast Hokkaido, and claimed to be the least influenced by Wajin (modern Japanese) (Yamaguchi 1967)
*Kanto	50	The sample stored in the University Museum at University of Tokyo, represents recent Japanese from the Kanto district
*Kinki	45	The sample stored in the Laboratory of Physical Anthropology at Kyoto University, represents recent Japanese from the Kinki district
**Ulchi	30	The sample from the Laboratory of Physical anthropology of the USSR Institute of Ethnography in Lenigrad represents recent population from Siberia
**Tungus	27	Ditto
**Yukaghir	27	Ditto

* published data from Ossenberg (1987,1992).

** unpublished data kindly provided by Ossenberg and used with her permission.

Even though several researchers have worked on East Asian samples, only the cranial nonmetric results of Ossenberg (1986, 1992) will be used in combination with my data for biological distance analysis. As Hauser and

De Stefano (1989:16) have pointed out, while there are abundant published data on nonmetric traits, the use of different terminologies and different scales for scoring makes meaningful comparisons among the results of different studies impossible. They further suggest that an internationally agreed upon standardisation is required not only of research techniques, but also of the methods of presenting the data. There are, however, no universally agreed upon criteria at present accepted for scoring and analysis in population affinity studies. The methods and results of Ossenberg (1986, 1992) will be consistently followed in my study, in order to avoid the difficulties in comparing results from different researchers (see **Table 4.1**). **Figure 3.1** shows the geographical locations of cranial samples represented in this study.

Scoring and trait descriptions

A battery of 33 discrete cranial traits were originally chosen, based on the methods of Ossenberg (1976) and Jackes (1988). As these traits are minimally influenced by factors such as sex, age, intertrait correlations and artificial deformation, they can be used in the study of population affinity in Asia (Ossenberg 1976). Twenty-four traits were finally selected for the present study. The scoring of the twenty-four nonmetric traits follows the method of Ossenberg (1970, and *in litt.*, 10/3/1994) (see **Table 4.3** for a list of nonmetric traits from Jiangzhai).

1. **Trace of Os Japonicum**. This is a posterior trace, 2 to 10 mm, of the anomalous transverso-zygomatic suture which, if complete, would divide the malar in two parts. In contrast to the extremely rare full Os Japonicum, the "trace" of the sutures is fairly common in many populations, particularly Asiatic and New World (Ossenberg 1970).

2. **Tympanic dehiscence**. This well known anomaly is a foramen, rarely a cribriform defect, in the tympanic plate. It is a normal developmental feature in preadolescent juveniles (Anderson 1962). It decreases rapidly

in incidence between the ages of eight and twelve and thereafter remains stable (Ossenberg 1970).

3. **Foramen spinosum open.** Foramen spinosum is a constant foramen located on the inferior surface of the greater wing of the sphenoid near the spine. It transmits the middle meningeal vessels, the recurrent branch of the mandibular nerve and sometimes part of the sphenoidal venous rete (Korey 1970). Normally it is discrete but occasionally the posteromedial wall fails to develop, resulting in a confluence of the spinosum with the spheno-petrous fissure (in the dried skull). All defects, regardless of size or appearance, were counted as 'present'.

4. **Wormian bones.** This is a weighted trait which combines asterionic, occipito-mastoid and parietal notch bones as suggested by Ossenberg (1976, and *in litt.* 10/3/1994). For example, given asterionic bone (3/25 sides), occipito-mastoid (1/30 sides) and parietal notch (4/35 sides), the frequency of wormian bone will be:

$$8/((25+30+35)/3) = 8/30 \ (27\%)$$

4a. **Asterionic Ossicle.** This ossicle occurs at the junction of posterior inferior angle of the parietal bone with the occipital bone and mastoid portion of the temporal bone (Berry and Berry 1967).

4b. **Occipito-mastoid ossicle.** Any distinct ossicle located inferior to asterion in the occipito-mastoid suture was placed in this category (Molto 1980).

4c. **Parietal notch ossicle.** A notch or separate ossicle may occur at the intersection of the parieto-mastoid and squamous sutures. Occasionally two or more bones may be present, and Ossenberg (1969) notes that they vary in size from two mm in diameter to large ossicles completely filling the notch. Molto (1980) noticed that most recording errors (1.3%) involved deep narrow notches in which it was difficult to discern if any isolated bone was present or the parietal notch was intact below the sutural line. These cases were most often were scored as 'unanalysable' in the present study, following Molto (*ibid.*).

5. **Upper third molar suppressed**. The individuals are fully developed adults without occurrence of upper third molars: there is no sign of premortem tooth loss, and in the absence of X-rays, no third molar development can be discerned (Jackes 1988).

6. **Marginal foramen of tympanic plate**. This canal or foramen occurs in the lateral and inferior margin of the tympanic plate and is formed by the ossification of the cartilage that surrounds the auriculo-temporal nerve in this region (Ossenberg 1976). Although most often it develops in the peripheral margin, ossification can occur anywhere along the auriculo-temporal groove in the cartilaginous precursor of the external auditory meatus. It varies considerably in size. This trait does not appear until puberty when the full lateral growth of the plate is completed. Thereafter it is age-stable (Ossenberg 1970).

7. **Squamo-parietal synostosis**. As Ossenberg (1976) has noted that most cases involve the posterior portion of the suture, none involves the anterior portion. Age-regression of this feature is absent in the series examined. Pedigree analyses suggest the craniostenoses are inherited (Nance and Engel 1967). No fusion was observed in the Jiangzhai sample.

8. **Divided hypoglossal canal**. The hypoglossal canal is a constant feature of the lateral portion of the occipital bone at the base of the occipital condyles. According to Korey (1970) it transmits the hypoglossal nerve and occasionally a posterior meningeal branch of the ascending

pharyngeal artery and the hypoglossal vein connecting the transverse sinus with the vertebral and deep cervical veins. The canal can be separated by one or more complete, bony septa that occur at the interior orifices and/or in the middle of the canal (Ossenberg 1969).

9. **Intermediate condylar canal.** A groove for a small emissary vessel, sometimes occurs immediately lateral to occipital condyle (Ossenberg 1976). The groove connects the suboccipital plexus and the postcondylar emissary vein with the anterior condylar emissary vein and/or the jugular bulb . This groove converts to a canal when an outgrowth of bone from the lateral lip grows medially to fuse with the side of the condyle. The canal is variable in terms of size and location, sometimes occurring 3-5 mm from the lateral margin of the occipital condyle. Only completely formed canals were recorded as 'present'. In the New World series studied by Ossenberg (1970), this trait does not achieve expression before adulthood, but between young and older adult age categories it is stable.

10. **Clinoid bridging.** It has been seen as early as the third foetal month preformed in cartilage (Keyes 1935). Postnatally, the anomaly is fairly age-stable in New World crania (Ossenberg 1970). Cases recorded as 'present' are those in which the clinoid processes are joined by complete bony bridges, or by opposing spicules of bone flattened at their free extremities which approach each other so closely as to give the appearance of a tiny joint. The anterior and middle, anterior and posterior, or all three clinoid process may be so joined.

11. **Trochlear spur.** This tiny spur projects from the medial wall of the orbit just behind the superomedial angle of the orbital margin. It represents ossification into one of the two ligaments attaching the cartilaginous trochlear to the frontal bone. This trait is best detected by touch although it is easily observed and was scored with absolute

precision. In the New World series, the trochlear spur achieves expression at about the age of puberty, and thereafter retains fairly stable frequencies (Ossenberg 1970).

12. **Pterygospinous bridge.** As noted by Ossenberg (1970), this is also called Foramen of Civinini. The pterygo-spinous ligament stretches from a point near the middle of the posterior border of the lateral pterygoid plate to, or to some point near, the sphenoid spine. The anomaly consists in ossification of this ligament. A foramen is thereby produced, oriented more or less in a sagittal plane and situated inferior to the foramen ovale. Cases recorded include only complete bridging. This trait is age-stable (Ossenberg 1970).

13. **Pterygo-basal bridge.** Also called porus crotaphytico-buccinatorius, this is a very rare, age-progressive anomaly. It is formed by ossification of a ligament stretching from a point on the posterior border of the lateral pterygoid plate near its root to a point lateral to the foramen ovale (Ossenberg 1970). According to the suggestion by Ossenberg (*in litt.* 10/3/94), only well-developed spurs, near-contact spurs and complete bridges are counted as present.

14. **Mylohyoid bridge.** Ossification of the spheno-mandibular ligament at its insertion on the medial side of the mandibular ramus converts the mylohyoid groove to a bony canal. The bridge varies from 2 to 25 mm. Only very rarely does this trait achieve expression before adulthood in New World populations studied, but between young and older adult categories it does not increase in frequency (Ossenberg 1970, 1976).

15. **Lateral pterygoid plate foramen.** As noted by Ossenberg (1969), this trait is a small round or oval foramen, 1 to 2 mm in diameter, piercing the lateral pterygoid plate close to its posterior border. There is no

presence of the trait in Jiangzhai sample.

16. **Posterior condylar canal absent.** Immediately posterior to each occipital condyle lies a condylar fossa which is commonly pierced by the posterior condylar canal. This canal transmits an emissary vein connecting the lower end of the sigmoid sinus with the suboccipital and vertebral plexuses (Ossenberg 1969). Occasionally it is absent, and the incidence of this state is recorded in this study.

17. **Frontal grooves.** These are occasional grooves, paired or single, made on the frontal bone by the supraorbital nerve in its passage backwards into the scalp. This variant is relative age stable (Ossenberg 1970). It was explained by Dixon (1904) as the result of insufficient growth in length of ophthalmic nerve branches in relation to the expansion and increased curvature of the frontal bone, whereby the nerves act as constricting cords and leave their impression upon the growing bone. Following Ossenberg (1969), any groove regardless of expressivity found running in a sagittal plane between the temporal crest and the frontal eminence is scored 'present'.

18. **Supraorbital foramen.** Normally the supraorbital nerve and vessels lie within the medial half of the supraorbital margin. Typically a single foramen or notch is present although the nerve often bifurcates into medial and lateral branches before leaving the orbit, in which case various combinations of foramina and/or notches occur. The supraorbital foramen is likely formed by the ossification of a ligament bridging the supraorbital notch (Ossenberg 1969). Any completed foramen connecting the roof of orbit and external squama of the frontal bone in the medial half of the orbit margin is recorded as 'present'.

19. **Parietal process of temporal squama.** This is a slender style

projecting from the upper margin of the temporal squama in articulation with the parietal bone. The process varies from 1 to 4 mm in width and 2 to 25 mm in length. During life it shields an anomalous middle temporal artery which, arising intracranially, emerges above the tip of the style and etches a pattern of branching grooves in the parietal notch (Ossenberg 1976).

20. **Accessory optic canal.** The optic canal is normally single, but occasionally an accessory canal pierces the bony floor of the optic foramen. This canal, which probably transmits the ophthalmic artery, may be completely or incompletely separated from the optic canal (Ossenberg 1969). Any canal whether complete or incomplete piercing the floor of the optic canal was counted as 'present'.

21. **Accessory mental foramen.** The mental foramen is situated on the external surface of each side of the mandible generally in the area below the premolars, and most frequently below the apex of the second premolar (Hauser and De Stefano 1989). It may be double or multiple with varying distances between the foramina. In most cases of multiple foramina these are not of equal size; they may be situated vertically one above the other, horizontally side by side or diagonally to each other (Gershenson *et al.* 1986).

22. **Pharyngeal fossa.** A median round or oval depression in the ventral surface of the basiocciput anterior to the pharyngeal tubercle. It varies in depth from less than 1 to 5 mm. Etiology is unclear; the fossa is possibly a remnant associated with the pharyngeal pouch of Luschka (Ossenberg 1976).

23. **Paracondylar process.** Cases recorded vary from small tubercles on the condylar process of the occipital bone to large processes, some bearing a

facet for articulation with the transverse process of the atlas. (Ossenberg 1970).

24. **Odonto-occipital articulation.** This is a very rare facet articulating with the axis dens at the anterior margin of the foramen magnum (Ossenberg 1969, Jackes 1988).

Statistical methods

Three different statistical methods will be used to explore intra-observer error, sex and side differences, as well as the biological distance between populations. They will be discussed in detail below.

Chi-square and Fisher's exact test

Chi-square has been commonly used by many researchers (e.g.Buikstra 1976, Jackes 1988, Molto 1980, Pietrusewsky 1984, Sciulli 1985). It will be used for testing intra-observer error, sex, and side differences in the Jiangzhai sample. The data will be tested by chi-square using SPSS (Norusis 1990) in a series of 2 X 2 contingency tables with one degree of freedom. The significant level is 0.05. The Fisher's exact test using SPSS (Norusis 1990) will be used when the total sample size and any expected cell value in a 2 X 2 table is less than 5.

Mean Measure of Distance

A measure of biological distance, as noted by Ossenberg (1976), is a statistic which expresses the sum or average of differences between two population samples with respect to n attributes. The Mean Measure of Distance (MMD) was devised by C.A.B. Smith (Grewal 1962, Berry and Berry 1967). Its calculation first involves transforming the original percentage of the trait frequencies into angular values, denoted as Theta (Θ). This is done in order to stabilize the variance of the sample proportion (k/n). The original formula of Mean Measure of Distance suggested by C.A.B. Smith and used by Grewal and Berry is as follows:

$MMD = (1/t)\ \Sigma_{i-1}^{a}((\theta_{1i} - \theta_{2i})2 - (1/n_{1i} + 1/(n_{2i}\ )$

θ = $\sin^{-1}(1-2k/n)$.

k = the number of times the trait occurs,

n = the number of sides examined for the trait,

θ_{1i} = the transformed proportion of the *ith* trait in the first population,

θ_{2i} = the transformed population of the *ith* trait in the second population,

n_{1i} = the number of sides examined for the *ith* trait in population 1,

n_{2i} = the number of sides examined for the *ith* trait in population 2,

t = the number of traits considered.

Green and Suchey (1976) have shown that this transformation is inadequate for stabilizing the variances of small sample sizes commonly used in skeletal research. In order to solve the problem, they tested three of the alternative transformations suggested by other researchers (Anscombe 1948, Freeman and Tukey 1950, Sjøvold 1973).

1) Grewal-Smith transformation with Bartlett's correction: when a frequency 0 or 1 is observed, zero is replaced by (1/4n), and 1 is replaced by (1-(1/4n)) (Sjøvold 1973).

2) Anscombe transformation (Anscombe 1948):

$\theta = \sin^{-1}(1-2(k+3/8)/(n+3/4))$.

3) Freeman and Tukey transformation (Freeman and Tukey 1950):

$\theta = 1/2\sin^{-1}(1-\ 2k/(n+1))+1/2\sin^{-1}(1-2(k+1)/(n+1))$.

Green and Suchey (1976) show that the Freeman-Tukey transformation works best with small sample size. It is now widely used by many researchers for biological distance studies, and will be used here for comparison of Neolithic Jiangzhai and other East Asian populations. Bartlett's adjustment is also combined with the Freeman-Tukey transformation. In addition, the MMD as modified by Green and Suchey (1976) is also used here:

$$MMD = \Sigma_{i=1}^{n} ((\Theta_{1i} - \Theta_{2i})2 - ((1/(n_{1i} + 1/2) + 1/(n_{2i} + 1/2)))/t.$$

The standard deviation of MMD is calculated according to the formula recommended by Sjøvold (1973). MMD is statistically significant when equal to or greater than twice its standard deviation.

Cluster analysis

Ward's clustering method (Sneath and Sokal 1973) is used here to analyze the distance matrix of MMDs in East Asian populations. The process will be carried out using SPSS (Norusis 1990).

Results

Intra-observer error

There are several methods used in studying inter- or intra-observer error (Turner and Hanihara 1977, Molto 1980). Chi-square was used by Turner and Hanihara to compare their different observations on dental morphology. The study of intra-observer error from the Jiangzhai collection will follow their methods.

Two observations were carried out on the cranial nonmetric traits from Jiangzhai. The first observation was done in May, 1993, and the second one was done between mid-June and early July in the same year. The intra-observer errors were recorded and then tested by chi-square. Among 33 traits coded, only 11 show intraobserver errors (**Table 4.2**).

Table 4.2 Intra-observer comparison of Jiangzhai cranial traits

Traits	First time		Second time		P
	n/N	%	n/N	%	
1 supraorbital foramen	16/65	24.62	18/66	27.27	0.73
2 frontal grooves	2/64	3.13	3/67	4.48	0.69
3 trochlear spur ossification	2/58	3.45	2/59	3.38	0.99
4 pterygobasal bridge	1/45	2.22	1/50	2.00	1.00*
5 hypoglossal canal bridged	3/41	7.32	3/43	6.98	1.00*
6 pterygospinous bridge complete	1/46	2.17	1/47	2.13	1.00*
7 accessory mental foramen	2/54	3.70	3/54	5.56	1.00*
8 lateral foramen	12/66	18.18	14/66	21.21	0.91
9 foramen ovale open	1/37	2.70	2/39	5.13	1.00*
10 infraorbital foramen	42/53	79.26	43/53	81.13	0.81
11 zygofacial foramen single	18/53	33.96	19/54	35.18	0.89

n represents the number of sides with trait present, N represents the total number of sides examined. For large samples, the Pearson and likelihood ratio chi-square statistics give very similar results, and the likelihood ratio probability is reported.

* represents Fisher's exact test which is used when total sample size and expected values are small.

P is probability.

No traits show significant intra-observer difference at the 0.05 probability level. This means that the methods for scoring nonmetric traits from Jiangzhai skeletons were consistent. Errors were caused by the condition of skeletons (related to the preservation of the material and excavation techniques) and changes may have resulted from the observer gaining more experience after the first coding. Some traits were originally coded as not present or unobservable, and later were considered as present or observable, and vice versa. For example, the frontal groove, which showed two " trait present " on 64 observable sides on the first set of observations, increased to 3 " trait present " on 67 observable sides. One frontal groove was regarded as 'trowel trauma' when first observed, but was confirmed as a frontal groove during the second observation. Three sides were added to observable sides on the second observation of frontal grooves.

Sex difference

Sex of the skeletal remains from the Jiangzhai Neolithic site were examined and accepted by both Jackes and Fu. The sample for the present study, including 22 males and 20 females, is controlled to the extent of including only adult individuals determined by completion of dental development (M3 eruption and root development) and epiphyseal union (tuber ischia, iliac crest, medial clavicle, and distal femur). Of the traits listed in the **Table 4.3**, only the upper M3 suppressed gives a significant sex difference ($X^2 = 5.9$, $P = 0.02$), the female sample having a much higher frequency (38.7%) of upper M3 suppressed than that of males (12.5 %).

Side difference

An important aspect to consider when utilizing the side method is the degree to which significant asymmetry in incidence between the sides characterizes the data. If significantly different incidences between sides are found, the sides should not be pooled. As shown in **Table 4.4**, the results of testing difference of incidences on each of the two sides produced no significant difference (no P is equal to or less than 0.05).

Further Considerations

Age dependency of traits and inter-trait correlations must also be considered in the choice of traits for distance studies. Preliminary work on these questions has been done by Jackes (pers. comm.), with the analyses being undertaken on a data file reworked to provide information on unilateral/bilateral occurrence of traits in their binary form (i.e., as present or absent).

Table 6.3 Results of analyses which test the equality of trait incidences between males and females

Traits	Male		Female		χ^2	P
	n/N	%	n/N	%		
1 supraorbital foramina	10/34	29.4	8/32	25.0	0.16	0.69
2 frontal groove	0/35	0.0	3/32	9.4	4.95	0.10*
3 trochlear spur ossification	2/31	6.5	0/28	0.0	2.64	0.49
4 Os Japonicum trace	3/24	12.5	3/19	15.8	0.10	1.00*
5 accessory optic canal	1/11	9.1	1/16	6.3	0.08	1.00*
6 wormian bones	17/29	58.6	11/22	50.0	0.38	0.54
6a asterionic bones	7/31	22.6	3/23	13.0	0.82	0.49*
6b occipito-mastoid bones	4/24	16.7	4/18	22.2	0.20	0.71*
6c parietal notch bone	6/31	19.4	4/25	16.0	0.11	1.00*
7 parietal process of temporal squama	0/28	0.0	0/24	0.0		n.s.
8 squamo-parietal synostosis	0/31	0.0	0/31	0.0		n.s.
9 marginal foramen tympanic plate	4/31	12.9	3/29	10.3	0.10	1.00*
10 pharyngeal fossa	0/12	0.0	0/9	0.0		n.s.
11 tympanic dehiscence	0/29	0.0	1/31	3.2	1.34	1.00*
12 clinoid bridge	0/8	0.0	2/14	14.3	1.92	0.52*
13 lateral pterygoid plate foramen	0/8	0.0	0/11	0.0		n.s.
14 pterygobasal bridge complete	1/29	3.4	0/21	0.0	1.10	1.00*
15 intermediate condylar canal	2/17	11.8	1/12	8.3	0.09	1.00*
16 foramen spinosum open	2/25	8.0	2/15	13.3	0.29	0.62*
17 paracondylar process	0/12	0.0	0/9	0.0		n.s.
18 upper M3 suppressed	4/32	12.5	12/31	38.7	5.90	0.02
19 post-condylar canal absent	6/20	30.0	3/17	17.6	0.78	0.46*
20 hypoglossal canal bridged	1/23	4.3	2/20	10.0	0.53	0.59*
21 pterygospinous bridge complete	1/28	3.6	0/19	0.0	1.05	1.00*
22 odonto-occipital articulation	1/10	10.0	0/7	0.0	1.11	1.00*
23 mylohyoid bridge	1/23	4.3	0/28	0.0	1.62	0.45*
24 accessory mental foramen	3/25	12.0	0/29	0.0	4.83	0.09*

* represents Fisher's exact test which is used when total sample size and expected values are small. For the others the probability given is for G.

n/N represents traits observed as present/total sides observed.

P represents probability.

Table 4.4 Results of analyses testing the equality of trait incidences between right and left sides

Traits	Right		Left		x^2	P
	n/N	%	n/N	%		
1 supraorbital foramina	8/33	24.2	10/33	30.3	0.31	0.58
2 frontal groove	1/33	3.0	2/34	5.9	0.32	1.00*
3 trochlear spur ossification	1/30	3.3	1/29	3.4	0.00	1.00*
4 Os Japonicum trace	2/23	8.7	4/20	20.0	1.15	0.39*
5 accessory optic canal	0/13	0.0	2/14	14.3	2.78	0.48*
6 wormian bones	17/26	65.4	16/25	64.0	0.01	0.92
6a asterionic bones	6/28	21.4	4/26	15.4	0.33	0.73*
6b occipito-mastoid bones	5/22	22.7	3/20	15.0	0.41	0.7[illegible]*
6c parietal notch bone	6/29	20.7	4/26	15.4	0.26	0.73*
7 parietal process of temporal squama	0/26	0.0	0/26	0.0		n.s
8 squamo-parietal synostosis	0/31	0.0	0/31	0.0		n.s
9 marginal foramen tympanic plate	2/32	3.1	5/28	17.9	1.99	0.23*
10 pharyngeal fossa	no side data					
11 tympanic dehiscence	0/31	0.0	1/29	3.4	1.47	0.48*
12 clinoid bridge	1/11	8.3	1/10	10.0	0.02	1.00*
13 lateral pterygoid plate foramen	0/10	0.0	0/9	0.0		n.s
14 pterygobasal bridge complete	0/26	0.0	1/24	4.2	1.49	0.48*
15 intermediate condylar canal	2/15	13.3	1/14	7.1	0.31	1.00*
16 foramen spinosum open	2/19	10.5	2/21	9.5	0.01	1.00*
17 paracondylar process	0/12	0.0	0/9	0.0		n.s
18 upper M3 suppressed	10/32	31.3	6/31	19.4	1.19	0.[illegible]
19 post-condylar canal absent	6/20	30.0	3/17	17.6	0.78	0.[illegible]*
20 hypoglossal canal bridged	0/22	0.0	3/21	14.3	4.54	0.[illegible]*
21 pterygospinous bridge complete	1/24	0.0	1/23	4.3	1.45	0.[illegible]*
22 odonto-occipital articulation	no side data					
23 mylohyoid bridge	1/24	0.0	1/27	3.7	1.29	1.00*
24 accessory mental foramen	2/27	7.4	1/27	3.7	0.36	1.00*

* represents Fisher's exact test which is used when total size and expected values are small. Other samples have large n and G values are reported.

n/N represents traits observed as present/total sides observed.

P represents probability.

Age differences. The method employed for the analysis of age dependency was the grouping of individuals into broad relative age categories on the basis of the attrition of cheek teeth, examining crown heights and lengths, enamel exposure and resorption of the alveolar crest. Relative age categories comprised: 1) child aged 5 - 12 years, 2) adolescent, 3) young adult, 4) adult and 5) old adult. Jackes found no trait to have a significant association with age, but cautions that the small sample sizes limit the general value of the study.

Inter-trait correlations. Jackes searched for inter-trait correlations on the raw data file, across the eight populations used in the MMD analyses, and within the reworked Jiangzhai data file. While correlations exist, the criteria for significance were not met. The criteria established in Jackes' preliminary study referred to positive correlations with very significant phi values between traits that had some biologically meaningful relationship (e.g. hyperostotic characters) in several of the tests: on both the right and left sides, across the samples, and, finally, within the unilateral/bilateral data set. No inter-trait correlations met the criteria.

Biological distance

As sex, side and age differences and trait correlations have little influence on the sample from Neolithic Jiangzhai, it is possible to use MMD to compare biological distances among the Neolithic Jiangzhai population and seven other East Asian populations which were studied by Ossenberg (1986, 1992). Twenty four nonmetric traits for MMD have been selected in each of the eight East Asian populations (see **Table 4.5**). The distances between each pair of populations based on MMD are presented in **Table 4.6**. A dendrogram (see **Figure 4.1**) based on the MMD distance matrix is constructed using the Ward cluster method (Sokal and Sneath 1973). The eight samples can be divided into two distinct clusters. One cluster,

Table 4.5 Side incidences of nonmetric traits in the eight cranial series from East Asia

	Jiangzhai Author			Jomon *Ossenberg			Ainu *Ossenberg			Kanto *Ossenberg		
	P	N	%	P	N	%	P	N	%	P	N	%
1 supraorbital foramen	18	66	27.3	19	98	19.4	60	232	25.9	42	99	42.4
2 frontal groove	3	67	4.5	19	92	20.7	26	212	12.3	21	94	22.3
3 trochlear spur ossification	2	59	3.4	0	69	0.0	10	223	4.5	7	98	7.1
4 os Japonicum trace	6	43	14.0	75	85	88.2	103	191	53.9	29	97	29.9
5 accessory optic canal	2	27	7.4	0	14	0.0	5	207	2.4	4	99	4.0
6 wormian bones	28	51	54.9	55	87	63.2	132	236	55.9	65	100	65.0
7 parietal process of temporal squama	0	52	0.0	2	86	2.3	5	232	2.2	3	99	3.0
8 marginal foramen tympanic plate	7	60	11.7	4	76	5.3	7	218	3.2	7	99	7.1
9 pharyngeal fossa	0	21	0.0	14	35	40.0	28	115	24.3	10	50	20.0
10 tympanic dehiscence	1	60	1.7	37	99	37.4	39	233	16.7	37	100	37.0
11 clinoid bridge	2	20	10.0	0	22	0.0	15	214	7.0	4	100	4.0
12 lateral pterygoid plate foramen	0	19	0.0	0	6	0.0	24	154	15.6	10	97	10.3
13 pterygobasal bridge complete	1	50	0.0	13	80	16.3	41	225	18.2	7	100	7.0
14 intermediate condylar canal	3	29	10.3	5	32	15.6	53	210	25.2	22	100	22.0
15 paracondylar process	0	21	0.0	3	44	6.8	34	192	17.7	5	97	5.2
16 upper M3 suppressed	16	63	25.4	6	69	8.7	43	158	27.2	42	76	55.3
17 post condylar canal absent	9	37	24.3	12	51	23.5	48	226	18.1	32	100	32.0
18 hypoglossal canal bridged	3	43	7.0	11	75	14.7	50	231	21.6	7	100	7.0
19 odonto-occipital articulation	1	17	5.9	2	36	5.6	7	115	6.1	0	50	0.0
20 mylohyoid bridge	2	52	3.9	10	104	9.6	19	152	12.5	4	104	3.8
21 accessory mental foramen	3	54	5.6	16	114	14.0	31	144	21.5	19	103	18.4
22 foramen spinosum open	4	40	10.0	6	51	11.8	36	229	15.7	19	100	19.0
23 squamo-parietal synostosis	0	60	0.0	0	92	0.0	99	236	41.9	0	100	0.0
24 pterygospinous bridge	1	47	2.1	3	62	4.8	10	229	4.4	2	100	2.0

Table 4.5 contiuned

	Kinki *Ossenberg			Ulchi **Ossenberg			Tungus **Ossenberg			Yukaghir **Ossenberg		
	P	N	%	P	N	%	P	N	%	P	N	%
1 supraorbital foramen	56	90	62.2	42	56	75.0	46	54	85.2	28	52	53.8
2 frontal groove	15	90	16.7	11	56	19.6	7	51	13.7	7	42	16.7
3 trochlear spur ossification	9	90	10.0	0	54	0.0	8	53	15.1	7	45	15.6
4 os Japonicum trace	24	88	27.7	13	51	25.5	25	52	48.1	15	44	34.1
5 accessory optic canal	0	90	0.0	6	56	10.7	9	54	16.7	7	52	13.5
6 wormian bones	35	90	38.9	24	51	47.1	25	53	47.2	36	46	78.3
7 parietal process of temporal squama	0	90	0.0	1	60	1.7	1	54	1.9	2	51	3.9
8 marginal foramem tympanic plate	11	90	12.2	9	54	16.7	8	53	15.1	16	54	29.6
9 pharyngeal fossa	7	45	15.6	6	28	21.4	6	27	22.2	6	24	33.3
10 tympanic dehiscence	32	90	35.6	6	54	11.1	17	54	31.5	8	54	14.8
11 clinoid bridge	1	90	1.1	0	58	0.0	0	54	0.0	10	52	19.2
12 lateral pterygoid plate foramen	10	90	11.1	2	42	4.8	3	44	6.8	4	41	9.8
13 pterygobasal bridge complete	86	90	6.7	0	60	0.0	2	54	3.7	0	53	0.0
14 intermediate condylar canal	21	90	23.3	15	52	28.8	18	51	35.3	17	47	36.2
15 paracondylar process	19	90	21.1	8	56	14.3	5	46	10.9	2	44	4.5
16 upper M3 suppressed	21	79	26.6	22	41	53.7	21	49	42.8	30	47	63.8
17 post condylar canal absent	33	90	36.7	26	56	46.4	18	52	34.6	17	48	35.4
18 hypoglossal canal bridged	6	90	6.7	6	56	10.7	6	52	11.5	1	48	2.1
19 odonto-occipital articulation	0	45	0.0	0	28	0.0	1	27	3.7	0	24	0.0
20 mylohyoid bridge	1	90	1.1	2	37	5.4	1	32	3.1	0	22	0.0
21 accessory mental foramen	8	90	8.9	5	42	11.9	3	32	9.4	4	21	19.0
22 foramen spinosum open	14	90	15.5	4	60	6.7	10	54	18.5	10	53	18.9
23 squamo-parietal synostosis	0	90	0.0	1	60	1.7	0	54	0.0	0	52	0.0
24 pterygospinous bridge	2	90	2.2	2	60	3.3	1	54	1.9	0	53	0.0

* published data from Ossenberg (1992)

** unpublished data provided by Ossenberg and used with her permission equivalent to Turner's Sinodont (1987), includes three Siberian samples, two recent Japanese samples and the Neolithic Jiangzhai samples. In the lower level of the cluster, the Neolithic Jiangzhai sample is distinctly separated from the recent Japanese and Siberian samples. In the further lower level of recent Japanese and Siberian samples, the Japanese Kinki and Kanto samples cluster closely together; they have a closer connection with Siberian Ulchi and Tungus samples, and lie relatively further from the Siberian Yukaghir sample. The relationships among Siberian and recent Japanese samples fit the geographical hypothesis of Sciulli (1990) who states that the biological distances between samples are directly associated with the between-sample geographical distances. The other cluster, equal to Turner's Sundadonty, shows that the Jomon and Ainu group together and are isolated from the rest of the studied populations.

Table 4.6 Mean measure of divergence (MMD) matrix for eight populations in East Asia (below the diagonal) and their standard deviations in boldface (above the diagonal)

	1	2	3	4	5	6	7	8
1.Jiangzhai	-	**0.014**	**0.013**	**0.022**	**0.011**	**0.016**	**0.016**	**0.017**
2.Kanto	2.483	-	**0.007**	**0.016**	**0.005**	**0.010**	**0.011**	**0.012**
3.Kinki	2.883	0.842	-	**0.016**	**0.006**	**0.011**	**0.011**	**0.012**
4.Jomon	5.322	3.050	3.863	-	**0.015**	**0.018**	**0.019**	**0.019**
5.Ainu	4.476	3.196	3.653	2.814	-	**0.008**	**0.009**	**0.010**
6.Ulchi	2.687	1.271	1.170	4.248	4.248	-	**0.014**	**0.015**
7.Tungus	4.025	1.088	0.716	4.426	4.426	0.408	-	**0.015**
8.Yukaghir	3.243	0.870	2.660	5.041	5.041	1.557	1.588	-

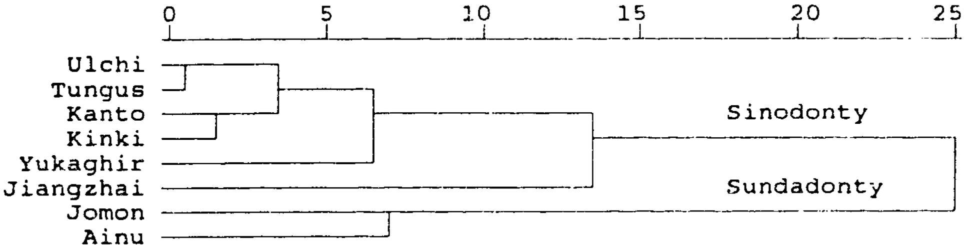

Figure 4.1 Dendrogram of the Jiangzhai, Japanese and Siberian populations

Summary

This chapter has concentrated on the study of cranial nonmetric traits in the Neolithic Jiangzhai sample and its biological relationship with East Asian populations. In order to represent nonmetric information available within East Asia as completely as possible and overcome the difficulty of different cranial nonmetric traits and scoring used by various searchers, it was decided to use the selected nonmetric traits, scoring techniques and data from Japan and Siberia studied by Ossenberg (1969, 1970, 1986, 1992) and Jackes (1988) as the major comparative source for the present research.

In order to understand the distributional characteristics of cranial nonmetric data from Neolithic Jiangzhai, intra-observer error, side difference, sex difference, age dependency and inter-trait correlation were studied. The result of intra-observer error testing shows that there are no significant differences between the first and second set of observations. Thus the method followed in this study provides consistent results. As most of the twenty-four nonmetric cranial traits lack significant differences between sexes and sides, pooling all the twenty-four nonmetric cranial traits from the Neolithic Jiangzhai sample and comparing them with those of the Siberian and Japanese samples studied by Ossenberg (1986, 1992) offers the possibility of exploring genetic relationships among the populations under study here.

The results of MMD and cluster analyses among the eight samples from Neolithic Jiangzhai, Japan and Siberia show that the sample from Neolithic Jiangzhai joins the Sinodont group, and is separated from the samples of the Sundadont group including the Neolithic Japanese Jomon and recent Japanese Ainu. Among the Sinodont group, Neolithic Jiangzhai is distantly separated from the rest of the group. Recent Japanese Kanto and Kinki together form one group, and the Siberian Ulchi and Tungus form another group; the two groups join together and are separated from the Siberian Yukaghir. This result is very similar to the results obtained by Ossenberg (1986) on the same samples.

Chapter Five

Summary and conclusions

Introduction

Both cranial and dental nonmetric traits have been investigated in the Neolithic Jiangzhai population. The purpose of this research is to explore the genetic affinity among the Neolithic Jiangzhai and the other East Asian populations using dental and cranial morphology. The approach followed in the current study is composed of two steps.

The first step is to choose currently well established research methods for cranial and dental morphology which are widely used in the study of population affinity in East Asia. Even though there are many publications on cranial and dental nonmetric studies in East Asia, it is very hard to pool the nonmetric traits of different eastern Asian populations studied by different researchers, because current research (especially cranial nonmetric research) lacks well-accepted standards for scoring and selecting nonmetric traits for biological distance studies. In order to solve the problem, the methods and populations used by Ossenberg (1969, 1970, 1986, 1992), Turner (1987, 1989) and Turner *et al.* (1991) are chosen as my basic research methods and comparative populations in East Asia. Both scholars have contributed most in either cranial or dental nonmetric research in eastern samples, and their data on cranial and dental traits can be used to explain genetic characteristics of local populations as well as local evolution.

The second step is to examine whether cranial and dental nonmetric variations show the same kind of genetic relationships among the Jiangzhai and other populations in East Asia. Many scholars study cranial and dental morphology separately when they investigate biological affinity among populations. It is thus usually impossible to get data on both kinds of morphological studies on the same population. It is still not certain whether cranial and dental nonmetric variations on the same population show the same kind of genetic relationships among populations. This research represents an effort to integrate two kinds of skeletal morphological studies using the Jiangzhai collection.

These data are analyzed by using the mean measure of divergence and cluster analysis. The results of the analyses offer interesting evidence on the biological affinities of the Neolithic Jiangzhai with other populations in East Asia.

Summary of findings

Cranial nonmetric study

Chi-square tests of intra-observer error show no significant differences between the two sets of observations. This suggests that the scoring method used by Ossenberg was followed consistently, although more experience during the second observational period led to the correction of some errors. In order to understand the distributional characteristics of the nonmetric traits of Jiangzhai, side and sex differences were tested by chi-square, and the results show that no significant difference was found among the traits under study.

As side and sex have no influence on the cranial nonmetric trait incidences in the Jiangzhai sample, twenty-four nonmetric traits from Neolithic Jiangzhai and those of seven other populations in East Asia for which pooled data have been provided by Ossenberg (1986, 1992) were selected for the MMD. The results show that the eight samples studied can be divided into two clusters. One cluster includes Jiangzhai, three Siberian populations and two recent Japanese populations. In the lo level of the cluster, Jiangzhai is, however, only loosely connected with the five other populations. Recent Japanese, the Siberian Ulchi and Tungus are grouped together and have their next closest relationship with Yukaghir (the latter is geographically the closest to the Arctic among the three Siberian populations). This subclustering may reflect the geographical hypothesis proposed by Sciulli (1990), that the biological distances between samples are directly associated with between-sample geographical distances. The other cluster includes only Jomon and Ainu, and these samples are very distantly separated from the rest of the East Asian populations. Even though they are closest to the two recent Japanese samples geographically, the geographical hypothesis held by Sciulli does not work well here.

Dental nonmetric study

The Arizona State University dental procedure together with the associated dental casts were used in data collection to provide descriptions of the Jiangzhai dentition. This research is very important in three aspects.

First, a basic set of data on 27 dental morphological traits is presented for the Middle Yellow River Valley in northern China where no systematic research has previously been ever carried out on the Neolithic or later periods.

Second, eight diagnostic dental traits from the Neolithic Jiangzhai sample are compared with data from 11 populations in East Asia collected by Turner (1987, 1989). The results of single trait comparisons show that most of the dental nonmetric traits of the Neolithic Jiangzhai population have the Sinodont pattern. Only the four-cusped lower second molar is exceptional in showing the Sundadont pattern, with a relatively high frequency of presence for the trait. The high frequency of the trait is also found among some populations in southern and northern China. This might suggest a diversity of populations in China in terms of different frequencies of the four-cusped lower second molar. This might also accord with the hypothesis suggested by Turner (1987, 1989) that the Sinodont populations may have evolved from the Sundadont and kept some Sundadont elements after separation from the Sundadont people during the late Pleistocene.

Third, mean measure of distance and cluster analysis were applied to both twelve and eight East Asian populations. The results show that the Neolithic Jiangzhai population is among the Sinodont group and different from the Sundadont group (including Ainu, Thai and Jomon populations). Among the Sinodont group in East Asia, there are at least three subgroups. Neolithic Jiangzhai groups with the Mongol, Lake Baikal and Anyang samples. Populations from Amur and Northeastern Siberia group together. Recent Japanese, and populations from Hong Kong and southern China are closely tied. Recent Japanese show a closer relationship with the populations from NE Siberia and Amur than those of Neolithic Jiangzhai, Mongol and Anyang. Among the populations from Jiangzhai, Mongol, Lake Baikal and Anyang, Jiangzhai is unexpectedly least closely grouped with the population from Anyang. Recent Japanese are closest with the populations in the southern China and Hong Kong, and next closest with populations of Northeast Asia including Northeastern China, Siberia, Amur and possibly Korea. Ainu and Jomon have few affinities with Recent Japanese.

Discussion

Jiangzhai and Anyang

There are no nonmetric cranial data available for the comparison of the two populations. The results of the dental nonmetrical research provide the main biological explanation, which is that the Jiangzhai is less closely connected with Anyang than with the Mongol and Lake Baikal samples. This result is supported by the archaeological, ethnographic and cranial metric research.

As discussed in Chapter One, the culture of the Neolithic Jiangzhai people has many similarities with that of the Zhou people, and it is considered that the Jiangzhai population might be the direct ancestor of the Zhou people who later set up their capital in the area close to Jiangzhai during the Zhou dynasty. The Shang people, who settled in middle Henan, set up their capital at Anyang during the Shang dynasty. Geographically, the Shang people (e.g. Anyang) and Zhou people (e.g. Jiangzhai) were neighbors, yet the modern populations in the two different areas speak different dialects, and have different kinds of traditions and cultures. The dental sample from Anyang studied by Turner (1987) represents sacrificial victims of the Shang period, who may have had three different origins (Yang 1985): (1) they may be captives from foreign countries; (2) they may be criminals or slaves; or (3) they may be relatives or close senior officials of Shang kings. Based on his statistical analyses, Yang (1985) pointed out that the victims of Anyang are closer to the Neolithic Henan populations than modern northern Chinese. Han and Pan (1985) studied the cranial metrics of skeletons from the small tombs of Anyang which are believed to be burials of lower or middle class free Shang inhabitants. Their results show that the samples from the victim tombs and small tombs of Anyang are the same group of people.

Jiangzhai is closer, in terms of dental nonmetric cluster analyses studied here, to Mongolian and Lake Baikal populations than to the Anyang skeletal sample. This result is echoed by the cranial metrical study of the Chinese Neolithic samples by Chen (1989), which is mentioned in detail in Chapter Two. In her northern group, three subgroups are defined. The first subgroup consists of Xiawanggang, Miaodigou and Yedian; the second subgroup consists of Shigu, Dawenkou and Xixiahou; the third subgroup consists of Baoji, Huaxian and Banpo in Middle Shaanxi and Hongshanhou in Inner Mongolia. In dental nonmetric variation in the present study, the Jiangzhai, Mongolia and Lake Baikal samples ar equal to the third subgroup of the northern Chinese Neolithic group defined by Chen (1989); the Anyang sample is equal to the first subgroup in the northern Chinese Neolithic group. As to the modern populations in Anyang and Shaanxi, Li and his associates (1987) show that there exists a significant difference in orbital breadth (d-ek) between two populations in the two areas.

Jackes (pers. comm.) has undertaken preliminary studies of eastern Asian craniometry based on Jiangzhai and 34 Neolithic to modern samples from northern, northeastern and southern China, Korea and Japan (sample sizes 6 to 156 male skulls, Martin measurements 1, 5, 8, 9, 17, 54, 55). Jackes shows that the Anyang sacrificial victims do not differ from the Shang small tombs group 1, and that this sub-cluster groups loosely with a wide range of modern samples from northeastern China, Korea, Hong Kong and Japan, as well as two Neolithic samples from Shaanxi (Banpo) and Gansu. The Shang small tomb groups 2 and 3 cluster with Neolithic samples from southern China and, more distantly, with Ainu and prehistoric Japanese samples. Anyang, as represented by both the Shang tombs and by the sacrificial burials, is therefore clearly heterogeneous and quite different from the majority of Neolithic samples from the Wei and Yellow River Valleys, including Jiangzhai.

Jackes' preliminary work on Jiangzhai craniometry (pers. comm.) indicates that Jiangzhai finds its place with the majority of Wei and Middle Yellow River Valley Neolithic sites. Only Banpo groups with an Upper Yellow River site. Neolithic sites south to the Yangtze River cluster loosely with the general Wei/Yellow River group, confirming that there was genetic interchange to the south, as well as to the east downriver, along the Yellow River Valley. She notes that biological heterogeneity among the Neolithic sites in the Wei River Valley may explain the existence of fortified settlements and the strong evidence for high rates of violence at Jiangzhai (Jackes *et al.* 1993)

Jiangzhai and Jomon

Both cranial and dental nonmetric data of the two Neolithic populations are available. The results of both analyses agree with each other, in showing that the Jiangzhai sample is closer to Northeast Asians than to Jomon and its descendant Ainu.

Yamaguchi (1982) draws a similar conclusion. He pooled five Neolithic male populations in the Yellow River Valley including populations from the three subgroups as defined by Chen (1989), and compared them with Jomon and recent Japanese Kinai. His results show that the average Neolithic population in the Yellow River Valley is much closer morphologically to Recent Japanese than to the Jomon people. Jackes (pers. comm.) confirms that Jiangzhai and Jomon samples are completely distinct craniometrically.

From the studies above, it can be concluded that the Sinodonts had already occupied the Middle Yellow River Valley at least 7,000 years ago, while the Sundadonts dominated Japan by at least 10,000 years ago.

Origin of recent Japanese

The results of dental nonmetric research on Jiangzhai and other East Asian populations lead to the conclusion that recent Japanese are closest to southern Chinese including Hong Kong; next closest to Northeast Asians such as the Siberian Ulchi, Tungus and Yukaghir; further related to Jiangzhai, Mongol and Lake Baikal. The Jomon and Ainu are widely separated from the recent Japanese population. Cranial nonmetric analyses show that the recent Japanese population is closest to Siberians in Northeast Asia, next to Jiangzhai, while Jomon and Ainu are isolated. Since cranial nonmetric data from southern China and Hong Kong are still unavailable, whether they will show the same kind of genetic indication as dental nonmetric variation is unknown.

Turner (1987,1989) suggests two alternative explanations for the origin of Recent Japanese. Based on his statistical results for East Asian populations, Turner (1987) proposes that the Japanese similarity to southern Chinese may be an artifact of admixture in Yayoi times, and that the addition of Jomon genes to the incoming mainland population may have shifted their dental characteristics from the pattern found in northern China to a slightly more Sundadont-like southern China condition. Later, he considers another hypothesis advanced by the linguist Paul K. Benedict (Turner 1989), that since the Japanese language originated in southern China, the majority of Recent Japanese might come from southern China. Further evidence to support the hypothesis of large scale of migration to Japan from southern China during the historical period is required.

Ishida and Dodo (1993) investigated cranial nonmetric variation in 16 samples from Japan and overseas, and demonstrated that the historic Japanese are closer to the sample from Liaoning in Northeastern China than Mongolia, while Ainu and Jomon samples are isolated from other Asian populations. As they did not collect data from southern China, the relationship between southern Chinese and the modern Japanese is unknown.

Conclusion and future study

The cranial and dental nonmetric research on the Chinese Neolithic Jiangzhai presented here is an initial effort which sheds light on biological relationships among recent and prehistoric Chinese Neolithic populations and other East Asian populations, in time and space. The results of this research are very stimulating in three aspects.

1. Two local populations (Jiangzhai in middle Shaanxi and Anyang in Henan) in the Yellow River Valley, are found to be different in dental morphology. Chang (1977) once pointed out there could be a Shang people from which the Shang rulers sprang but they could not be recognized

archaeologically. He was only partly right, because the studies of cranial nonmetric variation presented here, combined with archaeological data, all support an hypothesis that Shang people (Anyang) and Zhou people (possibly direct descendants of Jiangzhai people) in middle Shaanxi were different biologically and culturally. These differences started at least as early as the middle Neolithic (7000 to 4000 BP).

2. The population of Neolithic Jiangzhai was Sinodont. Based on the MMDs of eight diagnostic dental nonmetric traits of 13 East Asian populations, Neolithic Jiangzhai joins the Sinodont group, and is separated from the Sundadont group which includes the Ainu, prehistoric Jomon and modern Thai. If Turner's hypothesis, which assumes Sinodont populations evolved out of Sundadont populations, is correct, then Jiangzhai is a well developed Sinodont population. However, the influence of Sundadonty can still be seen in some of the traits of Jiangzhai such as four-cusped mandibular second molars.

3. Recent Japanese are a population composed of immigrants from different parts of East Asia since the Yayoi period (2300 BP). The results of the MMDs of cranial and dental nonmetric traits of East Asians show that modern Japanese share most genetic characteristics with populations from southern China and Hong Kong, secondly with Northeast Asians, thirdly with the populations from the Yellow River Valley, Mongolia and Lake Baikal, and least of all with Jomon, Ainu and Thai. Though the morphological similarities may not be absolutely equivalent to the real populations that migrated from East Asian mainland into Japan, the data do suggest that immigrants from southern China, Northeast Asia, the Middle Yellow River Valley, Mongolia, and Siberia, mixed with Jomon and Ainu populations and evolved into recent Japanese. This conclusion is supported by results of studies of HLA genes by Tokunaga and Juji (1992) who conclude that modern Japanese are genetically heterogeneous.

The research presented here is very preliminary, and future study is urgently required. I suggest the following program of research:

1. In order to further understand the microevolution of two local populations in middle Shaanxi and Henan, it is necessary to investigate dental and cranial nonmetric variation in the two areas in time and space by investigating more samples in these areas.

2. As our understanding of variation in the Sinodont pattern in China is still not very clear, and variations of dental morphological traits might exist in China, it is necessary to accumulate more data from the coastal area as well as inland in both northern and southern China.

3. Dental and cranial morphological data from the areas of southern and northeastern China are still very scarce. Thus the conclusion on the relationship between modern Japanese and populations in southern and northeastern China will be refined after more data on cranial and dental morphology are collected and studied.

References Cited

Anderson, J.E. (1962) The development of the tympanic plate. Nat. Mus. of Canada. Bull., 180. Anthropological series, 57:33-36.

Andersson, J.G. (1923) An early Chinese culture. Bulletin of the geological survey of China, no.5: 1-68.

Andersson, J.G. (1934) Children of the Yellow Earth. London: Kegan Paul, Trench, Trubner.

Anscombe, F.J. (1948) The transformation of Poisson, binomial and negative-binominal data. Biometrika 35:246-254.

An, Z.M. (1988) Archaeological Research on Neolithic China. Current Anthropology 29(5):753-59.

Bass, W.M. (1987) Human Osteology: A Laboratory and Field Manual. Columbia: Missouri Archaeological Society.

Berry, A. C. and R. J. Berry (1967) Epigenetic variation in the human cranium. Journal of Anatomy 101:361-79.

Berry, A.C. and R.J. Berry (1972) Origins and relationships of the ancient Egyptians. Based on a study of nonmetric variation in the skull. Journal of Human Evolution 1:199-208.

Berry, R.J. (1963) Epigenetic polymorphism in wild populations of *Mus musculus*. Genetic Research 4:193-220.

Berry, R. J. (1969) Nonmetric skull variation in two Scottish colonies of the grey seal. Journal of Zoology 157:11-18.

Black, D. (1928) A study of Kansu and Honan Aeneolithic skulls from later prehistoric sites in comparison with North China and other recent crania. Palaeontologia Sinica, Series D 6(1).

Brace, C.L. (1978) Tooth reduction in the Orient. Asian Perspective 19:203-19.

Brothwell, D.R. (1981) Digging up Bones. Ithaca: Cornell University Press.

Buikstra, J. (1972) Hopewell in the lower Illinois River Valley: A regional approach to the study of biological variability and mortuary activity. Ph.D dissertation, University of Chicago.

Buikstra, J. (1976) Hopewell in the Lower Illinois Valley. Evanston: Northwestern University Archaeological Program.

Cavalli-Sforza, L.L., P. Menozzi and A. Piazza (1992) Genetic History and Geography of Asia. In T. Akazawa, K. Aoki and T. Kimura (eds.): The Evolution and Dispersal of Modern Humans in Asia. Tokyo: Hokusensha, pp. 613-24.

Chang, K.C. (1977) The Archaeology of Ancient China. Third Edition. New Haven: Yale University Press.

Chang, K.C. (1986) The Archaeology of Ancient China. Fourth Edition. New Haven: Yale University Press.

Chen, De Zhen (1989) The taxonomy of Neolithic Man and its phylogenetic relationship to Later Palaeolithic Man and Modern Man in China. Human Evolution 4(1):73-86.

Chen, Ying (1983) A dermatoglyphic study of hands of 300 people of Han nationality in the Zhejiang region. Acta Anthropologica Sinica 2:272-80 (in Chinese).

Chou, Da Cheng (1958) Dental study on the human skeletons of War State Period in Changsha, Hunan. Chinese Journal of Stomatology 4:265-93 (in Chinese).

Dahlberg, A.A. (1945) The changing dentition of man. J. Am. Dent. Assoc. 32:676-90.

Dahlberg, A.A. (1951) The Dentition of American Indians. In Laughlin, W.S. (ed.): The American Anthropology of American Indian. New York: Viking Fund, pp. 138-76.

Dahlberg, A.A. (1956) Materials for the establishment of standards for classification of tooth characteristics, attributes, and techniques in morphological studies of the dentition. Zoller Laboratory of Dental Anthropology, University of Chicago.

Dahlberg, A.A. (1963) Analysis of the American Indian Dentition. In Brothwell, D.R.(ed.): Dental Anthropology. New York: Pergamon Press, pp. 149-78.

Dixon, A.F. (1904) On certain markings due to nerves and blood vessels upon the cranial vault; their significance, and the relative frequency of their occurrence in the different races of mankind. Journal of Anatomy 38:377-98.

Di, Yun Di (1988) The Identification of Millets From Neolithic Jiangzhai. In Gong, Q. M. (ed.): Jinagzhai: Report on the Excavation of the Neolithic Site at Jiangzhai. Beijing: Cultural Relics Publishing House, pp. 543-543 (in Chinese).

Dodo, Y. (1974) Non-metric cranial traits in the Hokkaido Ainu and the northern Japanese of recent times. Journal of the Anthropological Society of Nippon 82:31-51.

Dodo, Y. (1975) Non-metric traits in the Japanese crania of Edo period. Bulletin of the National Science Museum, Tokyo, Series D 1:41-54.

Dodo, Y. (1986) A population study of jugular foramen bridging of the human cranium. American Journal of Physical Anthropology 69:15-9.

Dodo, Y. (1987) Supraorbital foramen and hypoglossal canal bridging: The two most suggestive nonmetric cranial traits in discriminating major racial groupings of man. Journal of the Anthropological Society of Nippon 95:19-35.

Dodo, Y. and H. Ishida (1990) Population history of Japan as viewed from cranial nonmetric variation. Journal of the Anthropological Society of Nippon 98:269-87.

Dodo, Y., H. Ishida and N. Saitou (1992) Population History of Japan: A Cranial Nonmetric Approach. In T. Akazawa, K. Aoki and T. Kimura (eds.): The Evolution and Dispersal of Modern Humans in Asia. Tokyo: Hokusensha, pp. 479-92.

Etler, D.A. (1992) Recent developments in the study of human biology in China: a review. Human Biology 64(4):567-85.

Freeman, M.F. and J.W. Tukey (1950) Transformations related to the angular and square root. Ann. Math. Stat. 21:607-611.

Fu, Yong (1988) Zooarchaeological study of the Neolithic site at Jiangzhai. Archaeology and Cultural Relics (Kau gu yu wen wu) 50:203-208 (in Chinese).

Gershenson, A., H. Nathan and E. Luchansky (1986) Mental foramen and mental nerve. Acta Anat. 126:21-28.

Gong, Qi Ming (1988) Jiangzhai: Report on the Excavation of the Neolithic Site at Jiangzhai. Beijing: Cultural Relics Publishing House (in Chinese).

Green, R.F. and J.M. Suchey (1976) The use of inverse sine transformation in the analysis of nonmetric cranial data. American Journal of Physical Anthropology 45:61-68.

Grewal, M.S. (1962) The rate of genetic divergence of sublines in the C57BL strain of mice. Genetic Research 3:226-37.

Grewal, M. S. and S. Dasgupta (1967) Skeletal polymorphism and genetic drift in a Dehli frog, *Rana cyanophlictis*. Genetic Research 9:229-307.

Gruneberg, H. (1952) Genetic studies on skeletons of the mouse. IV. Quasi continuous variation. J. Gene. 51:95-114

Gruneberg, H. (1962) Evidence for genetic drift in the Indian rat. Evolution 15:256-62.

Han, Kang Xing (1975) A study of the two Bronze Age human skeletons unearthed at Zheng-Jia-Wa-Zi in Shenyang. Acta Archaeological Sinica 1:153-164 (in Chinese).

Han, Kang Xing (1980) An examination of the ethnic groups in the Yin dynasty. Historical Research 2:89-98 (in Chinese).

Han, Kang Xing (1988) Racial characteristic research of Yangshao skeletons. Prehistory (Shi-qian-yan-jiu) 19:240-256 (in Chinese).

Han, Kang Xing (1990) A study of the Neolithic skeletons from Zuchengzi, Shandong. Archaeology (Kao-gu) 7:644-54 (in Chinese).

Han, Kang Xing and Qi Feng Pan (1979) A study of the human skeletal remains unearthed from the tombs of the Miaodigou II culture at Shaanxi, Henan. Journal of Archaeology 2:255-70 (in Chinese).

Han, Kang Xing and Qi Feng Pan (1980) On the racial type of the Dawenkou population. Acta Archaeologica Sinica 3:387-402 (in Chinese).

Han, Kang Xing and Qi Feng Pan (1982) Late Neolithic Human skeletons from Hedang site, Foshan, Guangdong. Acta Anthropologica Sinica 1:42-52 (in Chinese).

Han, Kang Xing and Qi Feng Pan (1983) Early Neolithic Human skulls from Hemudu, Yuyao Zhejiang. Acta Anthropologica Sinica 2:124-31 (in Chinese).

Han, Kang Xing and Qi Feng Pan (1985) The Study of the Human Bones of the Middle and Small Cemeteries of Yin Sites, Anyang. In Yang, Xi Mei (ed.): Contributions to the Study on the Human Skulls From Shang Sites at Anyang. Beijing: Cultural Relics Publishing House, pp. 50-81 (in Chinese).

Han, Kang Xing and Qi Feng Pan (1988) The study of the human bones from the Eastern Han cemeteries of prisoners in Louyang, Henan. Archaeology 3:277-283 (in Chinese).

Han, Kang Xin and Qi Feng Pan (1992) Multivariate analysis of human bones from sacrificial pits. Archaeology 10:942-49 (in Chinese).

Han, Kang Xing, Zhen Biao Zhang and Fan Zeng (1976) The Neolithic human skeletons unearthed at Tanshishan in Minhou county, Fukien. Acta Archaeologia Sinica 1:121-130 (in Chinese).

Hanihara, K. (1969) Mongoloid dental complex in the permanent dentition. Proc. VIII *th* Intern. Congress Anthropol. and Ethnol. Science, 1968, Tokyo and Kyoto, I, pp. 298-300.

Hanihara, K. (1977) Dentition of the Ainu and Australian Aborigines. In A.A. Dahlberg and T.M. Graber (eds.): Orofacial Growth and Development. Mouton: The Hague, pp. 195-200.

Hanihara, K. (1987) Estimation of the number of early migrants to Japan: A simulative study. Journal of the Anthropological Society of Nippon 95(3):391-403.

Hanihara, T. (1990) Dental anthropological evidence of affinities among the Oceania and the Pan-Pacific populations: The basic populations in East Asia. Journal of the Anthropological Society of Nippon 98(3):233-46.

Harada, S. (1992) Molecular Basis of Alcohol Sensitivity and its Application to Anthropology. In T. Akazawa, K. Aoki and T. Kimura (eds.): The Evolution and Dispersal of Modern Humans in Asia. Tokyo: Hokusensha, pp. 591-598.

Hauser, G. and G. F. De Stefano (1989) Epigenetic Variants of the Human Skull. Stuttgart: Schweizerbart.

Hellman, M. (1928) Racial characters in human dentition. Proc. Am. Philos. Soc. 67:157-74.

Hilborn, R. (1974) Inheritance of skeletal polymorphism in *Microtus californicus*. Heredity 33:87-89.

Howells, W.W. (1973) Cranial variation in Man: A study by multivariate analysis. Peabody Museum Papers, 67. Cambridge, Mass.

Hrdlicka, A. (1920) Shovel-shaped teeth. American Journal of Physical Anthropology 3:429-65.

Hrdlicka, A. (1921) Further studies of tooth morphology. American Journal of Physical Anthropology 4:141-76.

IGCAA (Investigation Group of Chinese Anatomy Association) (1986) Investigation of Chinese physical characteristics. Shanghai Scientific Press (in Chinese).

Ishida, H. (1990) Cranial morphology of several ethnic groups from the Amur basin and Sakhalin. Journal of the Anthropological Society of Nippon 98:137-48.

Ishida, H. and Y. Dodo (1993) Nonmetric cranial variation and populational affinities of the Pacific peoples. American Journal of Physical Anthropology 90:49-57.

Jackes, M. (1988) The osteology of the Grimsby site. Department of Anthropology, University of Alberta.

Jackes, M., Q. Gao and Y. Fu (1993) Preliminary remarks on the Jiangzhai skeletal remains at Banpo Museum, Xian, Shaanxi, PRC. Paper presented to the 21st Annual Meeting, Canadian Association for Physical Anthropology, St. John's, Newfoundland, October 1993.

Keyes, J.E.L. (1935) Observations on four thousand optic foramina in human skulls of known origin. Arch. of Ophthalm. 13:538-68.

Korey, K. (1970) Characteristics of the distributions of nonmetric variants. M.A. thesis. University of Chicago.

Kozinstev, A. G. (1990) Ainu, Japanese, their ancestors and neighbours: Cranioscopic data. Journal of the Anthropological Society of Nippon 98:247-67.

Kozinstev, A. G. (1992) Ethnic epigenetics: A new approach. Homo 43(3):213-44.

Kozinstev, A. G. (1993) Ainu origin in the light of modern physical anthropology. Homo 44(2):105-127.

Lee, G.T.R. and D.H. Goose (1972) The inheritance of dental traits in a Chinese population in the United Kingdom. Journal of Medical Genetics 9:336-39.

Lee, Yun-Kuen (1993) Tribal segmentation and spatial variability: The social organization of prehistoric Yangshao village community. Ph.D thesis, University of Michigan.

Mao, Yin Jun and Yan Yan (1959) Dental study on the skeletons of Shang Dynasty in Anyang, Henan. Vertebrata Palasiatica 1(4):165-72 (in Chinese).

Mayhall, J.T., S.R. Saunders and P.L. Belier (1982) The Dental Morphology of American Whites: A Reappraisal. In Kurten, B. (ed.): Teeth: Form, Function, and Evolution. New York: Columbia University, pp. 245-58.

Molto, J.E. (1980) Biological relationships of Southern Ontario Woodland Peoples: The evidence of discontinuous cranial morphology. Ph.D. Thesis. University of Toronto.

Mouri, T. (1988) Incidences of cranial nonmetric characters in five Jomon populations from West Japan. Journal of the Anthropological Society of Nippon 96:319-37.

Nance, W. E., and E. Engel (1967) Autosomal deletion mapping in man. Science 155:692-94.

Norusis, M.J. (1990) SPSS/PC+ 4.0 Base Manual for the IBM PC/XT/AT and PS/2-SPSS, Statistical Data Analysis. Chicago: SPSS, Inc.

Ossenberg, N.S. (1969) Discontinuous morphological variation in the human cranium. Ph.D. Thesis. University of Toronto.

Ossenberg, N.S. (1970) The influence of artificial cranial deformation on discontinuous morphological traits. American Journal of Physical Anthropology 33(3):357-71.

Ossenberg, N.S. (1976) Within and between race distances in population studies based on discrete traits of the human skull. American Journal of Physical Anthropology 45(3):701-716.

Ossenberg, N.S. (1986) Isolate conservatism and hybridization in the population history of Japan: The evidence of nonmetric cranial traits. Univ. Tokyo Mus. Bull. 27: 199-215.

Ossenberg, N.S. (1992) Microevolutionary parallels in the population history of Japan and Aboriginal North America: The evidence of cranial nonmetric traits. In K. Hanihara (ed.): Japanese as a member of the Asian and Pacific populations. International Symposium No.4. Kyoto: International Research Center for Japanese Studies, pp. 65-77.

Ossenberg, N.S. (1992) Microevolutionary Parallels in the Population History of Japan and Aboriginal North America: The Evidence of Cranial Nonmetric Traits. In T. Akazawa, K. Aoki and T. Kimura (eds.): The Evolution and Dispersal of Modern Humans in Asia. Tokyo: Hokusensha, pp. 493-530.

Pan, Qi Feng (1990) The study of skeletal collection at Pinyang, Helongjiang. Report on the archaeological discoveries at Bronze Age Pingyang. Beijin: Cultural and Relic Press (in Chinese)

Penrose, L.S. (1954) Distance, Size and Shape. Ann. Eugen., 18:337-47.

Petras, M.L. (1967) Studies of natural populations of *Mus*. IV. skeletal variations. Can. J. Genet. and Cytol. 9:515-88.

Pietrusewsky, M. (1981) Cranial variation in Early Metal Age Thailand and Southeast Asia studied by multivariate procedures. Homo 32:1-26.

Pietrusewsky, M. (1984) Metric and nonmetric cranial variation in Australian Aboriginal populations compared with populations from the Pacific and Asia. Occasional papers in human biology N. 3, Canberra: Australian Institute of Aboriginal Studies.

Qi, Guo Qing (1988) Faunal Analysis From Neolithic Jiangzhai. In Gong, Qi Ming (ed.): Jiangzhai: Report on the Excavation of the Neolithic Site at Jiangzhai. Beijing: Cultural and Relic Press, pp. 504-38 (in Chinese).

Rees, J. W. (1969) Morphologic variation in the cranium and mandible of the white-tailed deer: A comparative study of geographical and four biological distances. Journal of Morphology 128:95-112.

Sciulli, P (1990) Cranial metric and discrete trait variation and biological differentiation in the Terminal Late Archaic of Ohio of Ohio: The Duff site cemetery. American Journal of Physical Anthropology 82:19-29.

Sciulli, P. and K.N. Schneider (1985) Cranial variation in the Terminal Late Archaic of Ohio. American Journal of Physical Anthropology 66:429-43.

Scott, G.R. (1973) Dental morphology: A genetic study of American White families and variation in living Southwest Indians. Ph.D thesis, Arizona State University, Tempe.

Scott, G.R. (1980) Population variation of Carabelli's trait. Human Biology 52:63-78.

Scott, G.R. and C.G. Turner II (1988) Dental Anthropology. Annual Review of Anthropology 17:99-126.

Sjøvold, T. (1973) The occurrence of minor nonmetric variants in the skeleton and their quantitative treatment for population comparisons. Homo 24:204-233.

Sneath, P.H.A. and R.R. Sokal (1973) Numerical Taxonmy. San Francisco: W.H. Freeman and Company.

Stewart, T.D. (1957) Distortion of the symphyseal surface in Females and its effect on age determination. American Journal of Physical Anthropology 15: 9-18

Tokunaga, K. and T. Juji (1992) The Migration and Dispersal of East Asian Populations as Viewed From HLA Genes and Haplotypes. In T. Akazawa, K. Aoki and T. Kimura (eds.): The Evolution and Dispersal of Modern Humans in Asia. Tokyo: Hokusensha, pp. 599-612.

Trigger, B. (1989) A History of Archaeological Thought. Cambridge: Cambridge University Press.

Turner, C.G. II (1967) Dental genetics and microevolution in prehistoric and living Koniag Eskimo. Journal of Dental Research, 46: 911-17

Turner, C.G. II (1969) Microevolutionary interpretations from the dentition. American Journal of Physical Anthropology 30:421-26.

Turner, C.G. II (1970) New classifications of nonmetric dental variation. American Journal of Physical Anthropology 32(1):193-8.

Turner, C.G. II (1971) Three-rooted mandibular first permanent molars and the question of American Indian origins. American Journal of Physical Anthropology 34:229-42.

Turner, C.G. II (1976) Dental evidence on origins of the Ainu and Japanese. Science 193:911-13.

Turner, C.G. II (1979) Dental anthropological indications of agriculture among the Jomon people of central Japan. American Journal of Physical Anthropology 51:619-36.

Turner, C.G. II (1984) Notes on middle Neolithic and later Hong Kong dentition. Journal of Hong Kong Archaeological Society 10:80-3.

Turner, C.G. II (1986) Recent Hong Kong dentition: A probable southern affinity. Journal of Hong Kong Archaeological Society 11:142-6.

Turner, C.G. II (1987) Late Pleistocene and Holocene population history of East Asia based on dental variation. American Journal of Physical Anthropology 73:305-21.

Turner, C.G. II (1989) Major features of Sundadonty and Sinodonty,including suggestions about East Asian microevolution,population history, and Late Pleistocene relationships. American Journal of Physical Anthropology 82:295-317.

Turner, C.G. II, and C.M. Lien (1984) Diachronic differences in Taiwan dental morphology. Bull. Indo-Pacific Prehist. Assoc. 5:74-82.

Turner, C.G. II and G.R. Scott (1977) Dentition of Easter Islanders. In A.A. Dahlberg and T.M. Graber (eds.): Orofacial Growth and Development. Mouton: The Hague, pp. 229-49.

Turner, C.G. II and K. Hanihara (1977) Additional features of Ainu dentition. American Journal of Physical Anthropology 46:13-24.

Turner, C.G. II, C.R. Nichol and G.R. Scott (1991) Scoring Procedure for key Morphological Traits of the Permanent Dentition: The Arizona State University Dental Anthropology System. In M.A. Kelley and C.S. Larsen (eds.): Advances in Dental Anthropology. New York: Wiley-Liss, pp. 13-31.

Ubelaker, D.H. (1978) Human skelet remains. Chicago: Aldine publishing company.

Wang, Kai Fa (1988) Pollen Analysis From Neolithic Jiangzhai. In Gong, Qi Ming (ed.): Jiangzhai: Report on the Excavation of the Neolithic Site at Jiangzhai. Beijing: Cultural Relics Publishing House, pp. 539-542 (in Chinese).

Wang, Ling Hong (1986) Secular change and geographical variation in Chinese Neolithic and modern inhabitants: A statistical study of cranial metric traits. Acta Anthropologica Sinica 5(3):242-58 (in Chinese).

Wang, Ling Hong (1987) Research on the genetic relationship between Chinese and Japanese: A craniometric study by using statistical analysis. Acta Anthropologica Sinica 6(1):10-18 (in Chinese).

Wang, Ling Hong (1988) Observations of nonmetrical traits in the Northern Chinese skulls. Acta Anthropologica Sinica 7(1):17-27. (in Chinese)

Wang, Ling Hong (1989) A study of recent human skulls from Hongkong: assessment of sex and of regional population. Acta Anthropologica Sinica 8(3):230-238 (in Chinese).

Wang, Ling Hong and Feng Kai Sun (1988) A study of the skulls from Taiyuan, Shanxi. Acta Anthropologica Sinica 7(3):206-14 (in Chinese).

Wang, Shi Her and Yong Fu (1990) Pollen Analysis of the Neolithic Site at Anban. In Zhou, Kun Shu and Qi Ming Gong (eds.): Environmental Archaeology. Beijing: Science Press, pp. 56-65. (in Chinese)

Wei, Bo Yuan and Xu Guang Lu (1987) The dimensions and cusp types of the teeth of modern Southern Chinese. Acta Anthropologica Sinica 6(2):139-43 (in Chinese).

Wei, Bo Yuan, Shu Ling Peng and Wen Guang Zhang (1988) Dental study on the Western Han skeletons from Luopowan, Guangxi. Acta Anthropologica Sinica 7(3):249-54 (in Chinese).

Wei, Hai Bo and Zheng Biao Zhang (1989) The study of the Bronze Age skeletal collection from Benxi, Liaoning. Acta Anthropologica Sinica 8(4):320-28 (in Chinese).

Weng, Zili, Yida Yuan and Ruofu Du (1989) Analysis of the genetic structure of human populations in China. Acta Anthropologica Sinica 8:261-68 (in Chinese).

White, T.D. (1991) Human Osteology. San Diego: Academic Press.

Wood-Jones, F. (1930) The nonmetrical morphological characters of the skull as criteria for racial diagnosis. Journal of Anatomy 65:179-195.

Wood-Jones, F. (1933) The nonmetric morphological characters of the skull as criteria for racial diagnosis. Part 4: The nonmetric characters of the Northern Chinese skulls. Journal of Anatomy 68:96-108.

Woo, Ding Liang (1961) A study of the Neolithic human mandibles from the Bei-yin-yang site, Nanjing. Vertebrata Palasiatica 3(1):49-53 (in Chinese).

Wu, Xing Zhi (1988) The relationship between Upper Palaeolithic human fossils of China and Japan. Acta Anthropologica Sinica 7:235-38 (in Chinese).

Wu, Xing Zhi (1992) The Origin and Dispersal of Anatomically Modern Humans in East Asia and Southeast Asia. In A. Takeru, K. Aoki and T. Kimura (eds.): The Evolution and Dispersal of Modern Humans in Asia. Tokyo: Hokusensha, pp. 373-378.

Wu, Xing Zhi and Zhen Biao Zhang (1985) *Homo Sapiens* Remains From Late Palaeolithic and Neolithic China. In R.K. Wu and J.W. Olsen (eds.): Palaeoanthropology and Palaeolithic Archaeology in the People's Republic of China. Orlando: Academic Press, Inc., pp. 107-133.

Xia, Nai (1984) Archaeological Excavation and Research in New China. Beijing: Cultural Relics Publishing House (in Chinese).

Xia, Nai (1986) Chinese Encyclopedia-Archaeology Part. Beijing: Chinese Encyclopedia Press (in Chinese).

Xie, Wei (1988) Identification of agricultural remains from the Neolithic site at Jiangzhai. Archaeological and Cultural Relics (Kau gu yu wen wu) 50:209-213 (in Chinese).

Yamaguchi, B. (1967) A comparative osteological study of the Ainu and the Australian Aborigines. Australian Institute of Aboriginal Studies. Occasional Paper No. 10. Human Biology Series No. 2. Canberra.

Yamaguchi, B. (1982) A review of the osteological characteristics of the Jomon population in prehistoric Japan. Journal of the Anthropological Society of Nippon 90:77-90.

Yamaguchi, B. (1985) The incidence of minor nonmetric cranial variants in the protohistoric human remains from eastern Japan. Bulletin of the National Science Museum, Tokyo, Series D. Vol. 11, pp.13-24.

Yan, Weng Ming (1989) Further comments on the origins of rice in China. Agricultural Archaeology 18(2):72-83 (in Chinese).

Yan, Yan (1962) A study of the Neolithic human skeletons from Huaxian, Shaanxi. Acta Archaeologica Sinica 2:85-104 (in Chinese).

Yan, Yan (1972) The Neolithic human skeletons from the Dawenkou site, Shandong. Acta Archaeologica Sinica 1:91-122 (in Chinese).

Yan, Yan (1973) The Neolithic human skeletal remains from Xixiahou. Acta Archaeologica Sinica 2:91-126 (in Chinese).

Yan, Yan, Chang Zhi Liu and Yu Ming Gu (1960a) Study of the Neolithic human skeletons from the Baoji site, Shaanxi. Palaeovertebrata et Palaeoanthropologia 2(1):33-43 (in Chinese).

Yan, Yan, Xing Zhi Wu, Chang Zhi Liu and Yu Ming Gu (1960b) A study of human skeletons from Banpo, Xian, Shaanxi. Archaeology (Kao-gu) 9:36-47.

Yang, Xi Mei (1969) A preliminary report of human crania excavated from Hou-chia-chuang and other Shang dynasty sites at Anyang, Henan, North China. Annual Bulletin of the China Council for East Asian Studies 5(1):1-13 (in Chinese).

Yang, Xi Mei (1985) Research on the Skeletons From the Sacrificial Tombs of Shang Dynasty in Anyang, Henan. In Yang, X.M. (ed.): Contributions to the Study on Human Skulls From the Shang Sites at Anyang. Beijing: Cultural Relics Press, pp. 21-44 (in Chinese).

Yang, Yu Tian, Jin Zhong Zhong and Ru Lin Dang (1987) The analysis of modern human skulls from Xian. Acta Anthropologica Sinica 6(3):222-226 (in Chinese).

Yu, Fu Wei and Wan Song Ye (1986) Agricultural archaeology in Luoyang, Henan. Agricultural Archaeology 11(1):101-111 (in Chinese).

Zang, Zhen Hua (1985) A Study of Incisors of the Shang Skeletons From Anyang, Henan. In Yang, X.M. (ed.): Contributions to the Study on Human Skulls From the Shang Sites at Anyang. Beijing: Cultural Relics Press, pp. 195-209 (in Chinese).

Zhang, Hai Guo (1988) Distribution of dermatoglyphic parameters in fifty-two Chinese populations. Acta Anthropologica Sinica 7:39-45 (in Chinese).

Zhang, Shi Cai, Ning Chen, Shu Tu, Li Jing Cheng and Rui Qing Sun (1985) Cusp numbers and groove patterns on the mandibular molars. Journal of Stomology 5:25-27 (in Chinese).

Zhang, Ying Yun, Ling Hong Wang and Xing Ru Dong (1977) The human skulls from Zhenpiyan Neolithic site at Guilin, Guangxi. Vertebrata Palasiatica 15(1):4-13 (in Chinese).

Zhang, Zhen Biao (1981) On the geographical distribution of physical features of the Neolithic population in China. Vertebrata Palasiatica 19:87-97 (in Chinese).

Zhang, Zhen Biao (1988) An analysis of the physical characteristics of modern Chinese. Acta Anthropologica Sinica 7:314-23 (in Chinese).

Zhang, Zhen Biao (1993) Morphological variation of dentition in two ancient inhabitants, China. Acta Anthropologica Sinica 12(2):103-12 (in Chinese).

Zhang, Zhen Biao and Shan Cai Wang (1992) The study of human skeletons from the Bronze-Age tombs in Changyang, Hubei. Acta Anthropologica Sinica 11(3):230-40 (in Chinese).

Zhang, Zhen Biao, Lin Hong Wang and Lian Oyang (1982) Physical patterns of Neolithic skulls in China in view of cluster analysis. Verteberata Palasiatica 20:72-78 (in Chinese).

Zhao, T. and T.D. Lee (1989) Gm and Km allotypes in 74 Chinese populations: A hypothesis of the origin of the Chinese nation. Human Genetics 83:101-10.

Zhao, Wen Yi (1982) Xian Banpo. Beijing: Cultural Relics Press (in Chinese).