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HEGELIAN LOGIC AND THE HARAPPAN CIVILIZATION:
AN INVESTIGATION OF HARAPPAN BIOLOGICAL AFFINITIES
IN LIGHT OF RECENT BIOLOGICAL
AND ARCHAEOLOGICAL RESEARCH

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INTRODUCTION

Norwood Russell HANSON (1969; 1972) states that human perception is a case of seeing 'is' as seeing 'as'. Humans make sense of the blurring, buzzing outside world by identifying causal chains between specific perceptions (HANSON 1955). In no area of human inquiry is this process of identification more rampant than in historical studies (COLLINGWOOD 1965). The overall pattern of these chains of explanation are known as a paradigm (KUHN 1962), and interpretation of specific historical events proceed within that paradigm until enough anomalous features accumulate to render a given paradigm invalid. It is this process of paradigm replacement that Hegel described in his famous dictum of scientific development as thesis, antithesis, synthesis.

Attempts to understand events and forces that led to the rise and fall of the Harappan Civilization provide a clear illustration of these paradigmatic processes. The rise of the Harappan Civilization was originally explained by MARSHALL (1931) as an indigenous development within the Indus Valley. However, later scholars steeped in the prevailing paradigm of that time developed the *thesis* that the rise of the Harappan Civilization was the product of 'stimulus diffusion', or actual migration from the West (GADD 1932; GORDON 1947; 1958; HEINE-GELDERN 1956; MACKEY 1938; PIGGOTT 1952; WHEELER 1968). Numerous correspondences in items of material culture were cited as evidence of contact between the Indus Valley and Mesopotamia.

This view of the Harappan Civilization, which we will refer to as the *thesis* model hinges on assumptions of cultural intransience, and a lack of variation or *in situ* dynamism. With such a view of cultural intransience, these scholars interpreted the demise of the Harappan Civilization to be the product of outside forces, specifically warlike Aryan invaders (CHILDE 1957; GORDON 1958; PIGGOTT 1952; WHEELER 1968). This model of cultural intransience was expressed in biological research as racial typology (fig. 1). Early

Mendelian genetics did not allow for variation. Mendel's pea plants possessed white flowers or red flowers. Cross-breeding between these plants continued to result in plants that featured either white or red flowers. Applied to past populations, *thesis* biologists described numerous pure races, each of which possessed certain hallmark features that identified them as members of one race or another. Studies of skeletal remains from Harappa led to claims that two, three, and even four races were present. Any variation from these idealized types was explained as the result of admixture between pure races (GUHA & BASU 1938; GUPTA, DUTTA & BASU 1962; KROGMAN & SASSMAN 1943; KUMAR 1971; 1973; SARKAR 1954; SEWELL & GUHA 1931).

Numerous problems and conflicting interpretations threw the 'migrationist' school of archaeological interpretation into disarray. Similarly, confusing typologies and unusual similarities in cranial series over vast distances led to serious problems in racial typological interpretations of past populations. In response to these accumulating anomalies to the *thesis* paradigm, new models of archaeological and biological interpretation began to develop after 1960. GHOSI's (1965) argument for ceramic continuity between pre-Harappan times and the Mature Harappan Period was followed by the 'Indigenous Place', 'Three Influences', and the 'Early Harappan Phase' theories of DALES (1965), FAIRSERVIS (1975), and MUGHAL (1970).

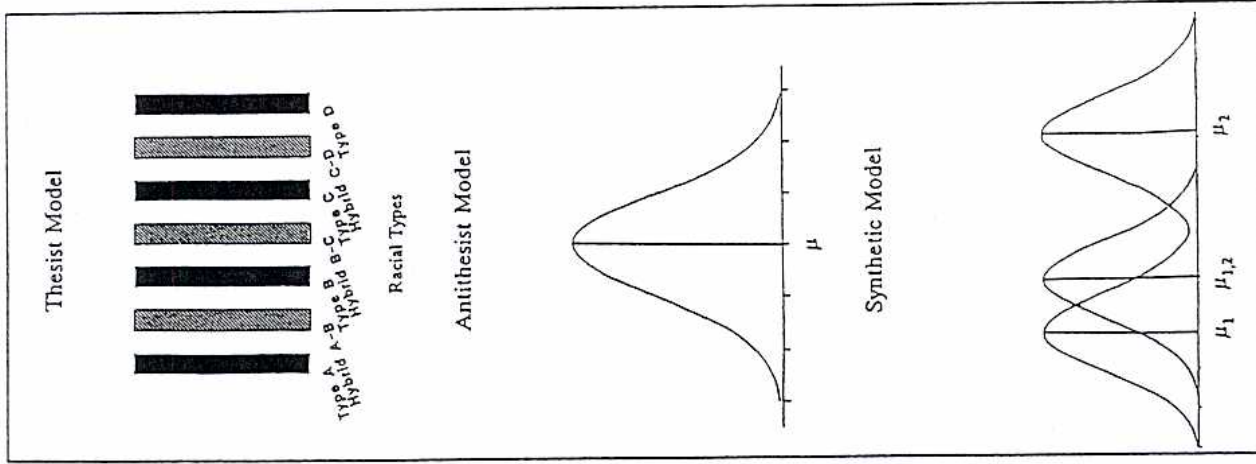


fig. 1 Three Views of Biological Variation

Further archaeological investigations within the Indus Valley, Afghanistan, and Iran led many scholars to support a model of indigenous developed. Continued investigation of new sites and re-examination of previously excavated sites brought additional support for a new paradigm of interpretation predicated on internal dynamism. This paradigm interpreted the Harappan Civilization as a product of indigenous development within the Indus Valley from pre-Harappan cultures (ALLCHIN & ALLCHIN 1968; 1982; JARRIGE 1982; JARRIGE & LECHÉVALLIER 1979; JARRIGE & MEADOW 1980; MUGHAL 1970; 1990).

This view of the Harappan Civilization, which we will refer to as the *antithesis model*, emphasizes localized continuity over time and *in situ* dynamism. Such a view of cultural dynamism led these scholars to interpret the demise of the Harappan Civilization to be the product of such internal forces as ecological change (DALES 1966; KENOYER 1988; LAMBRICK 1967; MISRA 1984; RAIKES 1964; 1965) and internal degeneration (FAIRSERVIS 1975). No longer were outside forces necessary to explain the rise or fall of the Harappan Civilization. Biologically, this paradigm shift to the *antithesis* model was expressed as a 'new understanding of biological variation'. Post-Mendelian genetic studies demonstrated that few biologic variations are of an all or nothing type (fig. 1). Most polymorphic features, such as stature, are controlled by many genes and exhibit continuous variation. In a population, most individuals exhibit these features near some mean frequency for that population, and few express extreme conditions. These advances demonstrated the applicability of the normal curve for genetics. No longer was variation viewed as error, or as evidence of admixture between pure racial types. In their zeal to refute racial typology, biological *antithesis* reified the normal curve. All differences in time and space were explained as a consequence of such internal forces as population size, founder effects, and genetic drift. This view led to interpretations that called for sweeping claims of localized biological continuity over time at Harappa (DUTTA 1972; 1975; 1983) and even across South Asia as a whole (KENNEDY *et al.* 1984).

Lately, recent excavations in Iran, Afghanistan, and western Pakistan have suggested to some archaeologists that the rise of the Harappan Civilization may not be solely a product of localized indigenous development (BEALE 1973; BISCIONE 1983; KOHL 1978; 1979; LAMBERG-KARLOVSKY 1972; 1978; LAMBERG-KARLOVSKY & TOSI 1973; SANTIONI 1984; TOSI 1979). Lamberg-Karlovsky and others maintain that prior to the rise of the Harappan Civilization, the Indus Valley was part of an 'early urban interactive sphere' centred outside the Indus Valley on traders of the Iranian Plateau. They suggest that participation of pre-Harappan Indus Valley populations in this 'interactive sphere' may have led to considerable interaction between peoples of the Indus Valley and the Iranian Plateau. This view of the Harappan Civilization, which we will refer to as the *synthetic* model, calls for localized continuity and development coupled with pulses of external input. Biologically, the *synthetic*

model derives from recent developments in quantitative genetics and multivariate statistical theory (fig. 1). Internal forces such as genetic drift will prevent a population from remaining in a 'steady state' over time. Pulses of gene flow from outside the population will result in shifts of mean gene frequencies in various directions depending on the relative frequencies of those genes in the two populations. Multivariate statistical analysis permits examination of the covariance of many genetic systems at one time and provides the greatest insight into human genetic variation (BOWCOCK *et al.* 1991; CAVALLI-SFORZA 1991; CAVALLI-SFORZA *et al.* 1988). The covariance of many genetic systems results in a genetic profile unique to each population (FALCONER 1981). The statistical possibility that two populations share similar quantitative genetic profiles without actual genetic exchange is effectively zero.

This model differs from the *thesis* model in two ways: All change is not interpreted as a direct consequence of external forces, and pulses of change from outside do not necessarily involve massive population movements and replacements. The *synthetic* model differs from the *antithesis* model by suggesting that indigenous dynamism is not the sole source of cultural change. Prehistoric cultures and populations are not interpreted as entities in 'splendid isolation' from all other groups, but emphasizes periodic and varying directions of interaction between them.

Archaeological attempts to resolve questions concerning rise and fall of the Harappan Civilization have been plagued by problems in dating, inaccessibility of key research areas, and differing interpretations of artifact assemblages. Perhaps one of the most difficult problems to address from archaeological data are the relative roles played by actual contact, stimulus diffusion, and independent invention. Recent excavations at Cemetery R37 by the University of California Expedition to Pakistan allow a unique opportunity to examine these questions from the perspective of skeletal biology. For unlike material cultural items, genetically controlled features cannot be transferred verbally, or inherited by others not in actual contact with the reference population.

Biological data may be used to test expectations of the *thesis* and *antithesis* models. The biological expectations of the *thesis* model are two. First, strong discontinuities in the biological history of the Indus Valley should occur immediately before and after the Harappan Civilization, reflecting the intrusive nature of this civilization. Second, Mature Phase Harappans should possess closest biological affinities to populations from Mesopotamia. Biological expectations of the *antithesis* model are also two. Mature Phase Harappans should reflect a history of biological continuity within the Indus Valley throughout the prehistoric period, and sites closest in geographic distance and age should be most similar to one another.

MATERIALS AND METHODS

Originally discovered by SHASTRI (1965) in 1937, Cemetery R37 is located at the southern edge of the site of Harappa and represents one of the two major cemeteries known at this site. Previous investigations of these cemeteries by WHEELER (1947; 1968), VATS (1940), and MUGHAL (1968) have established that Cemetery R37 belongs to the Mature Phase of the Harappan Civilization while Cemetery H appears to be late-Harappan. Excavations at Cemetery R37 by the University of California Expedition to Pakistan resulted in the recovery of more than 90 individuals (Table 1: R37C). This number compares favourably with the 106 reported by DUTTA (1983) from previous excavations (R37A). Unfortunately, many of these individuals are extremely fragmentary. When well preserved individuals are used as the basis of comparison, 33 individuals were recovered in 1987 and 1988 and 34 individuals were recovered from previous excavations. Thus, recent excavations at Cemetery R37 have resulted in a doubling of the skeletal information available for the mature phase inhabitants of Harappa.

TABLE 1
Skeletal Sample Sizes from Cemetery R37 at Harappa

SAMPLE	MALES	FEMALES	UNKNOWN	TOTAL
R37A	38	55	13	106
R37C	19	29	42	90
TOTAL	57	84	55	196

Twenty morphological features of the permanent teeth were assessed for 55 tooth-trait combinations by Lukacs in accordance with standards established for the Arizona State University Dental Anthropology System (TURNER *et al.* 1991). Frequencies of dental traits were calculated for each grade of expression according to the individual count method of SCOTT (1973; 1977; 1980) and trait expression was dichotomized into presence/absence only for comparison with other South Asian dental series (Table 2). Only tooth-trait combinations scored in all series were considered, and if a specific trait was completely absent in more than half of the series it was eliminated from consideration. These criteria resulted in a reduction of dental traits included in the comparative analysis to 10 traits scored as 16 tooth-trait combinations. Trait frequencies were arcsine transformed according to the formula recommended by GREEN and SUCHEY (1976) to stabilize sample variance.

Twenty-seven non-metric cranial traits were scored for adult individuals by Hemphill according to the method of BERRY and BERRY (1967). Traits were scored by side, and

TABLE 2
Dental Non-metric Trait Sample Sizes and Sources

SAMPLE	ABB.	DATE	N _{max}	SOURCE
Harappa	IAR	2300-1700 B.C.	33	This Report
Chalcolithic Mehrgarh	CHMRG	4500 B.C.	25	LUKACS & HEMPHILL (1991)
Neolithic Mehrgarh	NeoMRG	6000 B.C.	49	LUKACS (1988)
Inamgaon	INM	1600-700 B.C.	41	LUKACS (1985)
Mahadaha	MDH	8000 B.C.	11	LUKACS & HEMPHILL (1992)
Timargarha	TMG	1400-850 B.C.	21	LUKACS (1983)
Sarai Khola	SKII	200-100 B.C.	25	LUKACS (1983)

only full expressions were considered positive manifestations. The frequency of cranial non-metric traits in the Cemetery R37 sample were compared with ten other samples from South Asia and the Near East (Table 3). Only those samples scored by other workers with the method of BERRY and BERRY (1967) were accepted. Each cranial trait had to be considered in every sample in order to be included in the comparative analysis. This resulted in a reduction in the number of cranial non-metric traits to 18.

Contingency chi-square statistics were calculated to determine whether these non-metric dental and cranial traits detect significant heterogeneity in specific trait frequencies across all samples. If the number of significant differences exceeded the number of differences expected by chance alone, these traits were accepted as providing adequate data for determining patterns of relative similarity. Affinities between samples were assessed by two different statistical methods. In the first method, transformed trait frequencies were used as input for cluster analysis and results were represented as dendrograms constructed in euclidean space with Ward's minimum variance technique (WARD 1963). In the second method, transformed trait frequencies were submitted to principal components analysis.

TABLE 3
Cranial Non-metric Trait Sample Sizes and Sources

SAMPLE	ABB.	DATE	N _{max}	SOURCES
Harappa	IAR	2300-1700 B.C.	24	This Report
Egyptian	EPT	4000-0 B.C.	250	BERRY & BERRY (1967)
Ancient Palestinian	APAL	700 B.C.	54	BERRY & BERRY (1967)
Modern Palestinian	MPAL	Modern	18	BERRY & BERRY (1967)
Punjabi	PUN	Modern	53	BERRY & BERRY (1967)
Burmese	BUR	Modern	51	BERRY & BERRY (1967)
Mahadaha	MDH	8000 B.C.	11	This Report
Lidar	LDR	2300-2000 B.C.	25	KLUG & WITTWER-BAKOHEN (1985)
Kamid el-Loz	KEI	500 B.C.	47	KLUG & WITTWER-BAKOHEN (1985)
Sarai Khola	SKII	200-100 B.C.	26	KLUG & WITTWER-BAKOHEN (1985)
Bedouin	BED	Modern	35	HENKE & DISI (1981)

Arcsine transformed trait frequencies were standardized to have a zero mean and unit variance prior to submission to principal components analysis. Unrotated principle components were used since varimax rotation (KAISER 1958) served to reduce the percentage of the total variance explained by the first three principal components and offered no improvement in interpreting the patterning of component loadings. Factor score coefficients (eigenvalue coefficients) for each variable were multiplied by the standardized arcsine transformed frequency for each sample. These values were summed for each group according to each of the first three principal components. The resulting scores were plotted into three dimensions to illustrate the position of each sample in multicomponent space.

All adult crania recently excavated at Cemetery R37 were assessed for 30 metric variables by KENNEDY. All measurements have been standardized by the Biometrika school and by MARTIN and SALLER (1957). Only those variables for which data is available for either males or females in each sample were accepted. This reduced the number of variables considered to 14. Harappans are placed in South Asian and regional perspective by comparing them with 16 other cranial series from South Asia, Egypt, Anatolia, Mesopotamia, and the Iranian Plateau (Table 4). Samples were divided by sex and mean values obtained. To control for different sex ratios within each sample, group values were calculated for each variable as the average between male and female means. These values were submitted to cluster analysis and to principal components analysis.

TABLE 4
Cranimetric Sample Sizes and Sources

SAMPLE	ABB.	DATE	N _{max}	SOURCE
Harappa: Cemetery R37A	R37A	2300-1700 B.C.	34	GUPTA <i>et al.</i> (1962)
Harappa: Cemetery R37C	R37C	2300-1700 B.C.	30	This Report
Harappa: Cemetery H (Jar)	H1(JAR)	Post-Harappan	15	GUPTA <i>et al.</i> (1962)
Harappa: Cemetery H (Open)	H2(OPEN)	Post-Harappan	13	GUPTA <i>et al.</i> (1962)
Çatal Hüyük	CHY	5000-64 B.C.	12	KROGMAN (1949)
Tell al-Judaidah	TAJ	5000-64 B.C.	19	KROGMAN (1949)
Kish	KISH	2900-2800 B.C.	27	BUXTON & RICE (1931)
Tepe Hissar 2	TH2	3500-3000 B.C.	16	KROGMAN (1940)
Tepe Hissar 3	TH3	3000-2000 B.C.	138	KROGMAN (1940)
Naqada	NAQ	7000-5000 B.C.	407	FAWCETT & LEE (1901)
Abydos	ABY	1st Dynasty	47	MORANT (1925)
Badaria	BAD	Predynastic	58	STOUSSIGER (1927)
Nepalce	NEP	Modern	56	MORANT (1924)
Tibetans	TIB	Modern	25	MORANT (1924)
Sediment	SED	9th Dynasty	70	WOO (1930)
Mohenjodaro	MHD	2300-1700 B.C.	16	SEWELL & GUHA (1931); GUHA & BASU (1938)
Timargarha	TMG	1400-800 B.C.	20	BIERNHARD (1967)
Veddahs	VED	Modern	62	OSMAN HILL (1941)

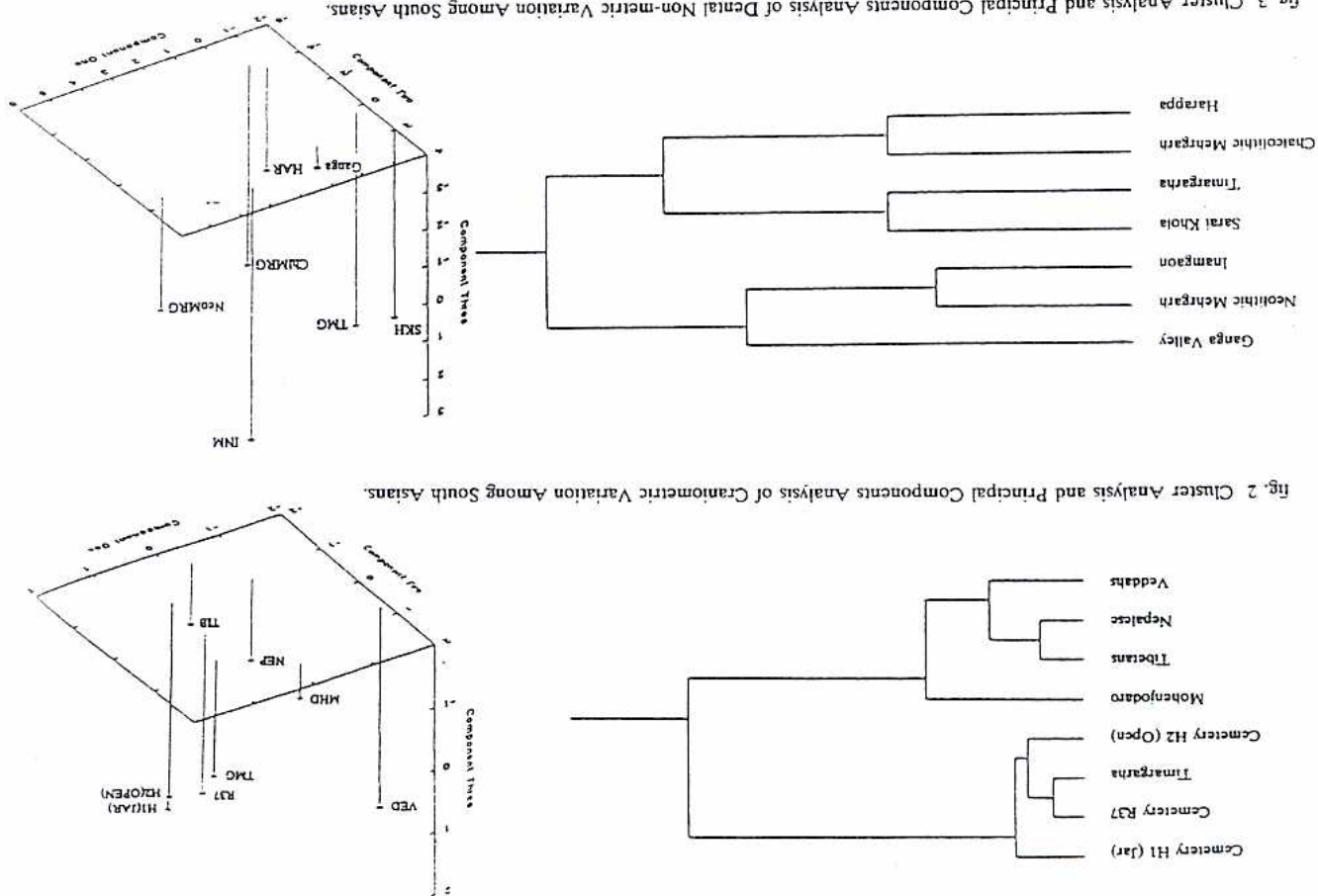


Fig. 2 Cluster Analysis and Principal Components Analysis of Craniometric Variation Among South Asians.

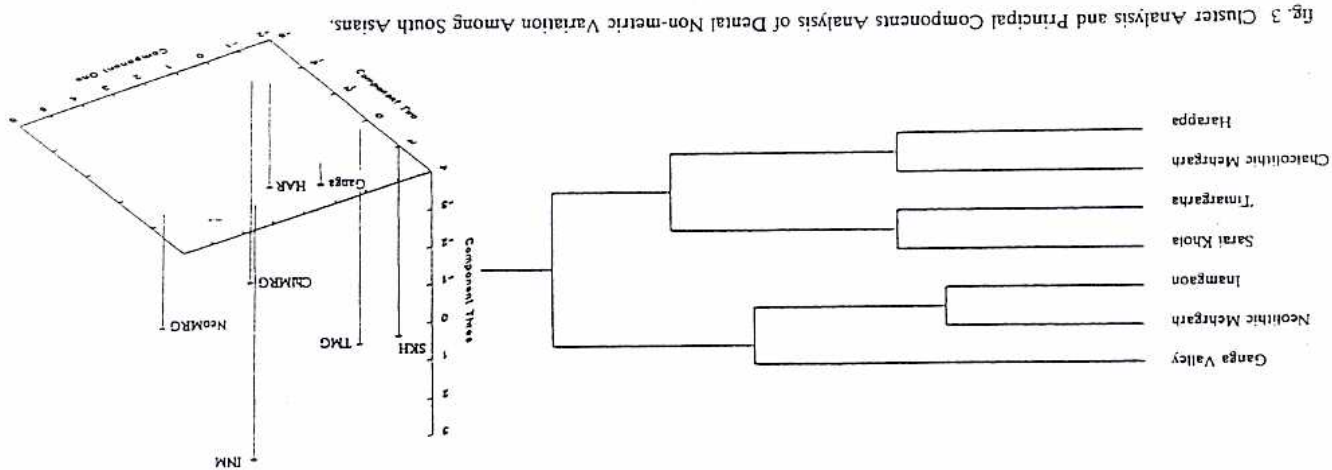


Fig. 3 Cluster Analysis and Principal Components Analysis of Dental Non-metric Variation Among South Asians.

RESULTS

The results to be presented here are in two phases. In the first phase, craniometric and dental non-metric features are used to examine variation within South Asia for evidence of biological continuity or discontinuity within the Indus Valley across the prehistoric era. In the second phase, cranial non-metric and metric features are used to assess biological relationships of Indus Valley groups to non-Indus Valley groups.

Analysis of variance of craniometric variation indicates that with 12 and 14 significant differences among females and males respectively, these 14 variables provide adequate data for distinguishing between South Asian cranial samples. Cluster analysis indicates that South Asian samples fall into two main groups (fig. 2). The first group includes all northern Pakistani sites, while the second includes Tibetans, Nepalese, Veddas, and Mohenjodaro. This represents a nearly complete division of samples between those of the Indus Valley, and those from other parts of South Asia. Mohenjodaro is the sole exception to this division. Individuals from the mature phase cemetery at Harappa possess closest affinities to post-Harappan Timargarha and to earth (open) burials at Cemetery H (H2 Open). Jar burials at Cemetery H (H1 Jar) bear only a peripheral relationship to these three samples.

Principal components analysis yields three components that combine to explain 87.2% of the total variance. Three dimensional ordination of principal component scores (fig. 2) confirms the nearly complete division between Indus Valley samples (stars) and samples from other parts of South Asia (circles). With the sole exception of Mohenjodaro, Indus Valley samples stand apart from other South Asian sites. In contrast to cluster analysis, principal components analysis suggests that mature phase individuals from Cemetery R37 bear slightly closer affinity to Cemetery H earth burials (H2 Open) than to individuals from Timargarha. Component two indicates that individuals from jar burials at Cemetery H (H1 Jar) and individuals from Mohenjodaro are only peripherally associated with the other Pakistani sites, and are clearly very different from one another. Addition of component three emphasizes the similarities among all northern Indus Valley samples and their separation from the only southern Indus Valley sample (Mohenjodaro).

Contingency chi-square analysis of dental trait frequencies indicates that 5 of 16 traits reflect a significant degree of heterogeneity. Since this is nearly three times the number of significant differences expected from chance, these dental non-metric traits may be accepted as adequate data for identifying patterns of biological affinity among these South Asian dental series. Two main groups of South Asians are identified by cluster analysis (fig. 3). The first group includes mesolithic Ganga Valley, neolithic Mehrgarh, and Late Bronze Age Inamgaon. The second group includes Sarai Khola, Timargarha, chalcolithic Mehrgarh, and the Harappan phase sample from Cemetery R37 at Harappa. Two important points may be noted from figure 3. First, the two samples from Mehrgarh possess widely

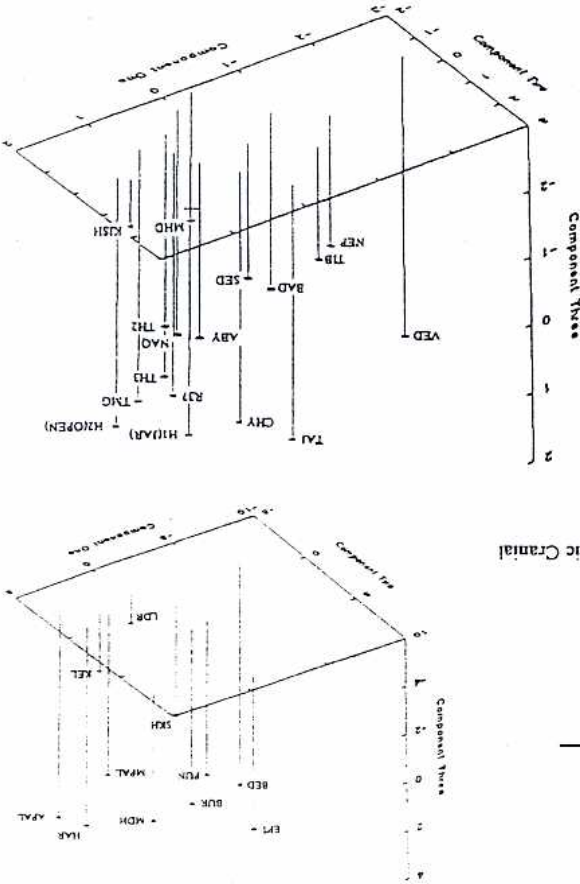


Fig. 4 Cluster Analysis and Principal Components Analysis of Non-metric Cranial Variation Among Indus Valley and Non-Indus Valley Groups.

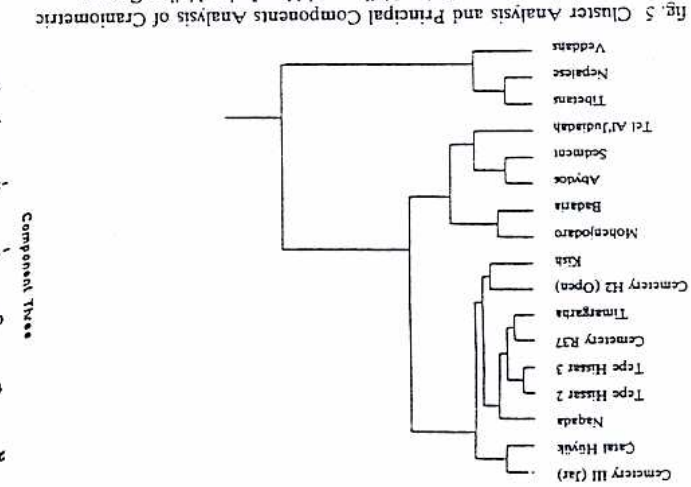


Fig. 5 Cluster Analysis and Principal Components Analysis of Craniometric Variation Among Indus Valley and Non-Indus Valley Groups.

different patterns of biological affinity, with neolithic individuals as members of group one and chalcolithic individuals as members of group two. Second, there is a nearly complete division of sites between those from peninsular India (group one), and those from the Indus Valley (group two). Neolithic inhabitants of Mehrgarh as members of group one represent the sole exception to this division.

Principal components analysis results in three components that combine to explain 82.3% of the total variance. Ordination of group component scores (fig. 3) provide strong confirmation of results obtained from cluster analysis. That is, mature phase individuals from Harappa (HAR) possess closest affinities to the chalcolithic inhabitants of Mehrgarh. The two post-Harappan Northern Pakistani samples from Sarai Khola and Timargarha bear closest affinities to one another, and the neolithic inhabitants of Mehrgarh are most similar to the Late Bronze Age sample from Inamgaon. Mesolithic Ganga Valley inhabitants represent an isolate that possesses no close affinities to any of the other samples.

In the second phase of our analysis, biological relationships of Indus Valley groups to non-Indus Valley groups is assessed. Non-metric cranial variation of mature phase individuals from Harappa is contrasted against ten samples from Egypt, the Near East, and South Asia. Contingency chi-square analysis indicates that 11 of 18 traits reflect a significant degree of heterogeneity. This number is greater than 12 times that expected by chance, therefore these traits may be used to assess patterns of biological affinity.

Cluster analysis indicates that all South Asian samples do not cluster together. In fact, two major groups may be identified (fig. 4). The first group includes the mature phase individuals from Harappa and all modern and ancient Near Eastern samples, except Jordanian Bedouins. The second group includes all South Asian samples (except Harappans from Cemetry R37), modern Burmese, and ancient Egyptians. What is clear from figure 4 is that the mature phase individuals from Harappa represent a South Asian sample that possesses a very different set of phenetic relationships than those possessed by other prehistoric and modern South Asians.

Principal components analysis results in three components that account for 69.2% of the total variance. Ordination of group component scores (fig. 4) confirm results obtained by cluster analysis. Harappans from Cemetry R37 and the two Palestinian samples form a group distinct from all other samples. The two Anatolian sites, Kamid el-Loz and Lidar, form a second group, and modern Punjabis, Burmese, and the mesolithic inhabitants of Mahadaha form a third group. Post-Harappan Sarai Khola is only peripherally associated with these latter samples. Ancient Egyptians and Jordanian Bedouins possess no close phenetic associations with any of these Near East and South Asian samples.

Cranio-metric variation among nine prehistoric samples from Egypt, Anatolia, Mesopotamia, and the Iranian Plateau were contrasted with eight South Asian samples to provide a second examination of population relationships from a regional perspective.

Samples were divided by sex and the adequacy of these variables for drawing distinctions across all samples was tested with analysis of variance. Since all 14 variables are significantly different by sex across these groups, these variables may be used to examine biological affinities.

Cluster analysis identifies three main groups (fig. 5). Tibetans, Nepalese, and Veddhals share close affinities to one another and are quite distinct from all other samples. The rest of the samples fall into two groups. The first is composed of nine samples and includes all prehistoric Pakistani sites except Mohenjodaro, the two samples from Tepe Hissar, and samples from Çatal Hüyük and Kish. The second group is composed of five samples and includes all Egyptian sites, Tel al'Judaidah, and Mohenjodaro. Mature phase individuals from Harappa bear closest affinities to Timargarha, followed by the two samples from Tepe Hissar.

Principal components analysis yields three components that combine to explain 67.8% of the total variance. Ordination of component scores into three dimensions is presented in figure 5. Sites from the Indus Valley are represented by stars, other South Asian samples by squares, Egyptian sites by circles, Anatolian Plateau sites by triangles, and Iranian Plateau sites by pentagons. High scores along component one separate all Indus Valley sites, except Mohenjodaro, from all other samples, except Abydos, Kish, and the two samples from Tepe Hissar. Component two separates Anatolian Plateau sites with high scores, and samples from Naqada and Mohenjodaro with low scores, from all other samples. While ordination of the first two components suggests that Harappans from Cemetery R37 possess equally close affinities to Abydos and Tepe Hissar 3 as to Timargarha, addition of the third component reveals that affinities between Cemetery R37 and Abydos are not close, while affinities to Timargarha are slightly closer than those with Tepe Hissar 3. Located in the centre foreground, Mohenjodaro is strongly separated from all other Indus Valley samples, and possesses no close affinities to any other samples.

DISCUSSION

We believe that the *thesis* and *antithesis* models are too draconian. The *thesis* model is based on all or nothing changes reflective of internal intransience and population replacement. Conversely, the *antithesis* model ascribes all genetic change to internal factors and denies any external influence on local gene pools in the form of gene flow. But human populations are dynamic. Their relationships with other human groups are conditioned not only by technological developments, but also by transitory economic and political factors.

Our *synthetic* model suggests that the biological history of Indus Valley populations was

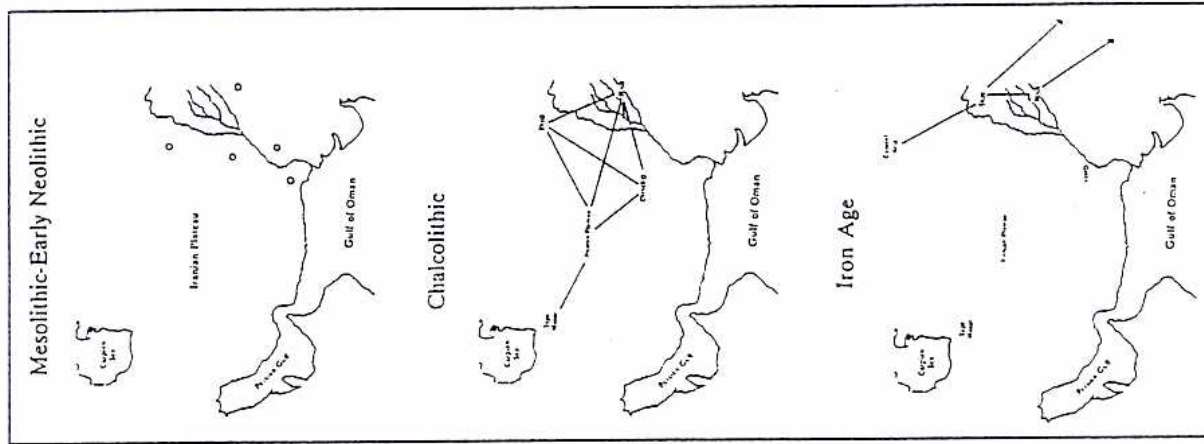


fig. 6 Patterns of Biological Change at Different Periods of Indus Valley Prehistory

not the series of decimations and replacements called for by the *thesis*, nor the series of 'steady states' appealed to by the *antithesis*. We propose that pre-chalcolithic groups represent a series of isolated populations, in which genetic change closely followed the 'steady state' model of the *antithesis* (fig. 6). However, with development of agriculture and increased sedentism, acquisition of material goods increased and intensified. Trade networks developed to procure these desired commodities and possession of these items provided the main-spring for differentiation in social status. Such frequently used trade routes provided avenues for contact and gene flow in specific and habitual directions among neolithic groups.

Beginning first as a trickle, but ever increasing over time, these avenues of exchange began to exert an influence over local gene pools. We propose that mesolithic Ganga Valley and neolithic Mehrgarh represent the isolated condition prior to this effect. The dramatic difference in biological affinities between inhabitants of chalcolithic and neolithic Mehrgarh represents a disruptive event consistent with a model of population replacement. By contrast, similarities between chalcolithic Mehrgarh, mature phase Harappans and post-Harappan Timargarha suggest continuous change from the early to late chalcolithic period produced by ever increasing participation in long distance trade (fig. 6). Affinities between Harappans and post-Harappan Timargarha with the inhabitants of Tepe Hissar 3 suggest that an

important influence in this change was sustained interaction and gene flow between the Indus Valley and the Iranian Plateau.

The peripheral association of Early Iron Age Sarai Khola to Late Bronze Age Timargarha, coupled with strong differences from earlier Indus Valley groups suggests a second disruptive event, but an event that did not entail replacement (fig. 6). Rather, the pattern of relationships possessed by Sarai Khola are consistent with those expected when new genes are gradually introduced and overlaid upon a pre-existing substrate shared by Timargarha, Harappa, and chalcolithic Mehrgarh. This would suggest that during the latter half of the 2nd millennium B.C. gene flow occurred from outside the Indus Valley, but the source of these genes was different from that which occurred in the earlier chalcolithic period.

This model of genetic affinities within the Indus Valley and with non-Indus Valley groups is consistent with several lines of evidence from linguistics and archaeology. Glotto-chronological studies by GARDENER (1980) indicate that Dravidian languages were introduced into South Asia around 4000 B.C. Examination of phonological shifts present in the vocabulary of the *Rig Veda* suggests that not only were Dravidian speakers present at the time of composition of these texts, but a yet unknown language that dominates terms for flora and fauna indigenous to South Asia was also present (FAIRSERVIS & SOUTHWORTH 1989; SOUTHWORTH 1979). This Dravidian incursion into South Asia accords reasonably well with the sharp break between neolithic and chalcolithic Mehrgarh. It may be that the neolithic inhabitants of Mehrgarh, and perhaps those of mesolithic Ganga Valley and Late Bronze Age Inamgaon are the biological reflections of this unknown South Asian linguistic substrate. Although this biological evidence of a strong discontinuity at Mehrgarh is at odds with JARRIGE's (1985) assertion for continuity of material culture, it is highly consistent with MUCHHAL's (1990) recent claim of a long standing pre-Harappan continuity within the Indus Valley that begins with the strong differences between neolithic and chalcolithic levels at Mehrgarh.

Close affinities between chalcolithic Mehrgarh, Harappans, and post-Harappan Timargarha may be reflective of the genetic shifts that accompanied introduction of Dravidian languages into South Asia. That the inhabitants of Harappa were Dravidian speakers has been argued for many years on the basis of the Harappan script by PARPOLA (1984a; 1984b; 1986) and most recently by FAIRSERVIS and SOUTHWORTH (1989). Indeed, comparative linguistic studies by MACALPIN (1974; 1975; 1979; 1981) strongly suggest a close tie between proto-Elamitic and proto-Dravidian and the source of these linguistic developments occurs on the Iranian Plateau between Harappa and Tepe Hissar. Coupled with their differences from the earlier neolithic Mehrgarh sample and from Early Iron Age individuals from Sarai Khola, this pattern of biological relationships lends support to LAMBERG-KARLOVSKY's (1978) and KOHL's (1978; 1979) 'early interactive sphere' of trade

and communication between the Indus Valley and the Iranian Plateau and suggests that this interactive sphere was already in existence by the 4th millennium B.C. With closest biological affinities outside the Indus Valley to the inhabitants of Tepe Hissar 3, these biological data suggest that gene flow accompanied economic interaction between Indus Valley and Iranian Plateau peoples.

Sarai Khola appears somewhat distinct from all other Indus Valley groups, but possesses closest phenetic affinities to Timargarha. Cranial non-metric traits indicate that the inhabitants of Sarai Khola possess closer affinities to modern Punjabis than to Harappans. This suite of biological affinities, coupled with changes in material culture associated with the introduction of iron, may signal the introduction of new genes into South Asia: genes that are still strongly represented among modern Punjabis. This shift accords well with linguistic evidence for introduction of Indo-European languages into South Asia at some point during the 1st millennium B.C., and is in agreement with archaeological evidence of new cultural patterns brought into the Indus Valley with the Gandharan Grave complex at Timargarha.

CONCLUSIONS

The *thesisist* model is not supported. Harappans do not represent a unique population within the Indus Valley, but share close affinities with the early chalcolithic inhabitants of Mehrgarh, with the late-Harappan inhabitants of Cemetery H, and with post-Harappan Timargarha. While population replacements may have taken place at various times, such as between neolithic and chalcolithic occupations at Mehrgarh, these appear to be isolated events in the biological history of the Indus Valley.

The *antithesisist* model is also not supported. Indus Valley biological history is not one of uninterrupted continuity, in which biologic relationships are determined solely by time and by space. This continuity is refuted by strong separation between neolithic and chalcolithic inhabitants of Mehrgarh, close affinities between neolithic Mehrgarh and Late Bronze Age Inamgaon, and by close affinities among northern Pakistani samples and non-Indus Valley Tepe Hissar 3.

The *synthetic* model presented here suggests that the biological history of the Indus Valley is best seen as an amalgamation of these two paradigms. Biologic affinities among Indus Valley inhabitants reflect long periods of *in situ* continuity coupled with pulses of genetic input from outside the Indus Valley. We suggest that these latter pulses of change were conditioned by habitual and frequent avenues of trade, the stability of which may have been cemented by marriage alliances. This exchange began in the neolithic, intensified during the chalcolithic, and was primarily oriented between the Indus Valley and the Iranian Plateau. A secondary network of exchange based on seaborne trade cannot be ruled

out at this time. During the 1st millennium B.C. the orientation of these trade routes appears to have shifted, leading to gradual introduction of new genes into the Indus Valley. The orientation of this latter trade network is as yet unknown.

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