THE ORGANISATION OF LITHIC TECHNOLOGY IN THE MIDDLE AND EARLY UPPER PALAEOLITHIC INDUSTRIES AT THE HAUA FTEAH, LIBYA

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Preface

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text. This dissertation does not exceed 80,000 words as required by the faculty of Archaeology and Anthropology and as outlined in the *Memorandum to Graduate Students*.

Dedication

This dissertation is dedicated to my father, Dr David Moyer, who passed away during its completion. Many of the ideas that follow are inspired by his example. He was an anthropologist by profession, but a polymath by disposition, he explored human knowledge in the broadest possible terms – from the scholarly and literary to the technical and practical. He taught me the importance of kinship in both the personal and academic sense. This dissertation is not complete because it lacks the benefit of his comments, insights and criticisms.

Acknowledgements

I would like to thank my twin brother Ian who, from the beginning has provided a sounding board for my ideas. My mother painstakingly proofread several drafts. My son Bennett provided a case study for my ideas on child-development and inspired this interest. If it were not for my wife Ruth, I would not have had the support and strength to finish.

I would also like to thank another family, those friends and colleagues that I met at Cambridge and Corpus Christi College. Special thanks must go to my office mates and fellow co-conspirators Laura Basell, Chantal Conneller, Carolyn Szmidt and Mark White; Juliet Foster at Corpus was a good friend who, incidentally, introduced me to the ideas of social psychology. The staff and fellows of Corpus Christi understood the difficulties that I faced these last few years and provided support, financial and otherwise. Paul Mellars was an understanding, supportive supervisor and provided sound professional and academic advice.

Elsewhere in the world, Harold Dibble and Shannon McPherron taught me lithic analysis and Nicolas Rolland introduced me to the Palaeolithic.

Finally, I would like to acknowledge the financial assistance of the Society for Libyan Studies, the Social Sciences and Humanities Research Council of Canada, Corpus Christi College, the Cambridge Commonwealth Trust and the Overseas Research Students Awards Scheme.

Summary

The Organisation of Lithic Technology in the Middle and Early Upper Palaeolithic Industries at the Haua Fteah, Libya

Colin Campbell Moyer

The site of the Haua Fteah is located near the slopes of the Gebel el Akhdar mountains near the Mediterranean coast in Libya. Three cultural periods are examined, the Pre-Aurignacian, the Middle Palaeolithic and the Early Dabban. The dating for the site is controversial, however, the Pre-Aurignacian appears to date from ca. 195kya, the Middle Palaeolithic from 130kya – 42kya and the Early Dabban from 42kya – 30kya. Non-lithic evidence suggests that the Early Dabban is an Upper Palaeolithic industry that exhibits evidence of modern behaviour. There appear to be no Aterian affinities at the site.

Based on a statistical analysis of the debitage at the site, a number of conclusions are reached. Three conceptual modes – complexity, shape and efficiency – explain the bulk of the differences between three techno-chronological categories (flake blades, Levallois flakes and blades). Unlike the previous periods, the Early Dabban shows an integration of these conceptual modes in a single, numerically abundant technology (blades). In terms of tool production, the Early Dabban shows an organised, integrated strategy that is largely missing in the preceding periods: blank selection and/or intentional production of blades are important aspects of tool design. Despite some evidence of cumulative change in the previous periods, the changes in the Early Dabban signify a much larger and important shift: the different aspects of tool production become integrated and organised. This indicates extensive changes in human behaviour and capabilities.

Based on evidence from the site, Palaeolithic archaeology, primate behaviour and modern ethnography, a genetically based cognitive shift is rejected as a plausible explanation for this transition. Changes in human social organisation, specifically the emergence of a kin-ordered mode of production, are seen as a more plausible explanation for the changes that occur at the Middle to Upper Palaeolithic transition

at the Haua Fteah and elsewhere. Cognitive redistribution across kinship networks creates the possibility of exponential increases in the complexity of behaviour and cognition.

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Introduction

> It was taken up by ethnologists of the Elliot Smith and Perry school to construct a theory, which, although questionable, clearly reveals, beyond the arbitrary detail of the historical outline, the profound contrast between two levels of human culture, and the revolutionary character of the Neolithic transformation. With his probable knowledge of language, his lithic industries and funeral rites, Neanderthal man cannot be regarded as living in a state of nature. His cultural level, however, place him in a marked contrast with his Neolithic successors as, in another way, writers of the seventeenth century are to be distinguished from writers of the eighteenth. Above all, it is beginning to emerge that this distinction between nature and society, while of no acceptable historical significance, does contain a logic, fully justifying its use by modern sociology as a methodological tool (Lévi-Strauss 1969 [1949]: 1).

While upholding the distinction, Lévi-Strauss argues that no empirical or historical analysis "can determine the point of transition between natural and cultural facts" (1969: 8). One of the principal aims of Palaeolithic archaeology in recent years, however has been to unearth this transition and explain, using empirical analysis, how it occurred. One of Lévi-Strauss' assertion is true; archaeology will never provide a definitive solution to this puzzle.

New research argues for the existence of culture in other species while genetic research seeks to reduce human behaviour and culture to biochemical impulses. Either culture exists, but is no longer exclusive to humans or it is reducible to *nature*. While Lévi-Strauss is right on one count, he is wrong on the other; the distinction between nature and culture no longer has methodological validity. Lévi-Strauss ignored his intellectual predecessor. Mauss argued that human behaviour, especially technology, must be understood from a simultaneous triple perspective: physical, psychological and sociological.

This study of the archaeology of the Palaeolithic at the Haua Fteah is divided into two halves. The first looks at the lithic industries of the Haua Fteah after discussing the chronology of the site and regional affnities. The empirical analysis fully supports the view that there was an important transition in the organisation of lithic technology at the time of the Early Upper Palaeolithic. This transition resulted in what is recognisable as *modern* human behaviour. The second half tries to explain what led to this transition. The starting point of the second half is a critique of a cognitive explanation for this transition. In response to the problems raised, an alternative explanation of the Middle too Upper Palaeolithic transition is put forward, one that endeavours to incorporate a triple perspective. The explanation emphasises the strong relationship between social organisation, behaviour and cognition.

The goal in this analysis is to provide a plausible and parsimonious explanation for the changes observed in the lithic industries of the Middle and Early Upper Palaeolithic at the Haua Fteah in Libya.

I. Site Chronology and Regional Comparisons

Recent research, especially on chronology of the site and its relationship to other sites in the vicinity, is crucial in placing the current study in context. Discussed in this chapter are the location and excavation of the site, its chronology and climatic sequence, the classification of the hominid remains found at the Haua Fteah and finally, a brief assessment of the Middle and Early Upper Palaeolithic assemblages and their regional affinities.

SITE LOCATION AND EXCAVATION TECHNIQUES

The location of the site and the excavation techniques that McBurney (1967) used are somewhat vague in *The Haua Fteah (Cyrenaica) and the Stone Age of the South-east Mediterranean*. The site is located 8 km east of Apollonia (Marsa Sousa) and is only a short distance from the coast (approx. 1 km). The location of the site and an indication of the surrounding topography is given in Figure I.1 (based on the 1941 British Military map and after McBurney 1967: Figure II.8). The excavated portion of the site is in a large natural cave, the entrance of which faces north toward the Mediterranean Sea. The mouth of the cave itself is approximately 20 m high and 80 m wide. The site is on the northern slope leading toward the Gebel el Akhdar, or "Green Mountain," which comprises a fertile region of Mediterranean vegetation between the coast and the Libyan Desert (see Figure I.1 and Figure I.2; McBurney & Hey 1955: 6). This fertile region is bounded by arid lands on three sides and is isolated from regions such as the Maghreb to the west and the Nile Valley to the east. Presently the rainfall in this region is between 200 and 550 mm per year, whereas the coastal regions to the east and west have annual accumulations of around 150 mm and as low as 100 mm (McBurney & Hey 1955: 5). The relatively high rainfall on the Gebel el Akhdar is due to the combination of elevated landscape and proximity to the Mediterranean Sea. Along the North African coast, the region around the Gebel el Akhdar is a geographical and climatic isolate, different from both the Maghreb and the Nile Valley. Much of this is due to the fact that the Gebel el Akhdar is "the only large area of high ground in the whole of the 2500 km of flat coastline between Homs, in Tripolitania, and Mount Carmel in Palestine" (McBurney & Hey 1955: 8). The Green Mountain reaches heights of over 800 m, with the highest points being within 50 km of the coast. It covers a much smaller area, however, than do the Atlas Mountains to the west.

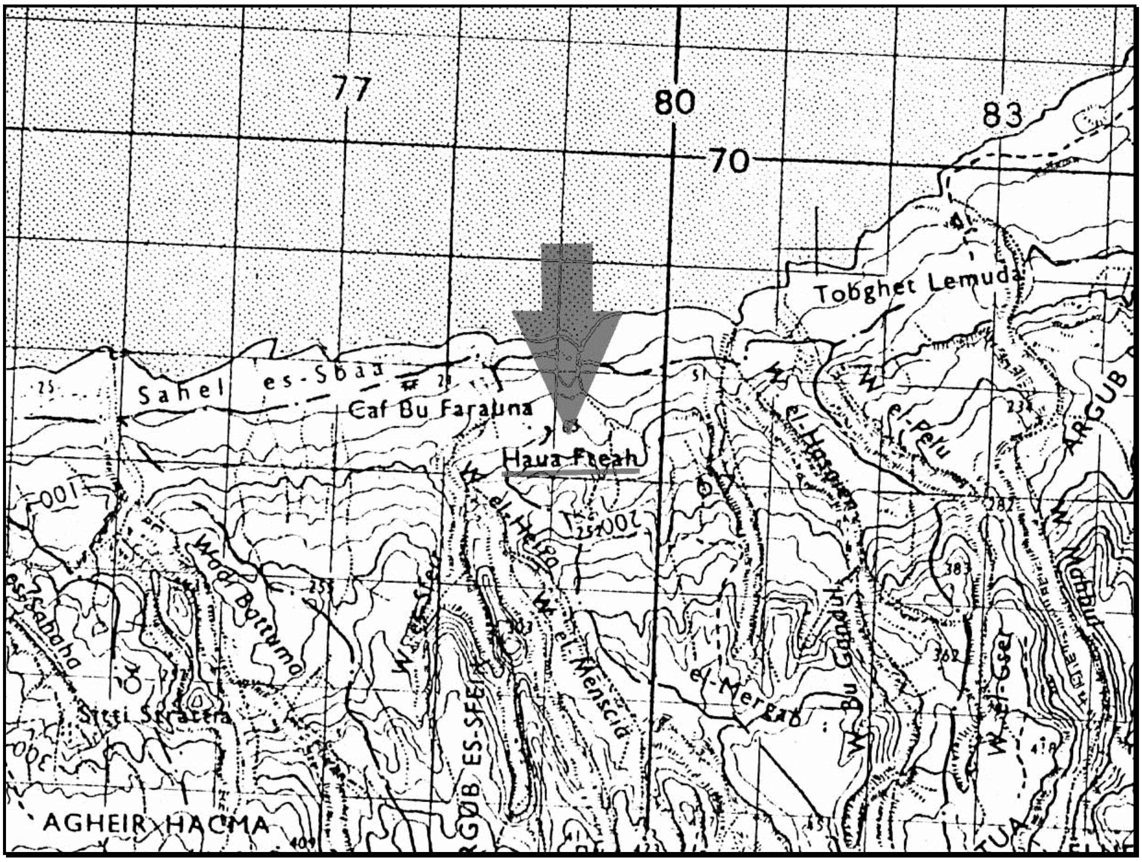

Figure I.1. Map of Immediate Region Surrounding the
Haua Fteah.

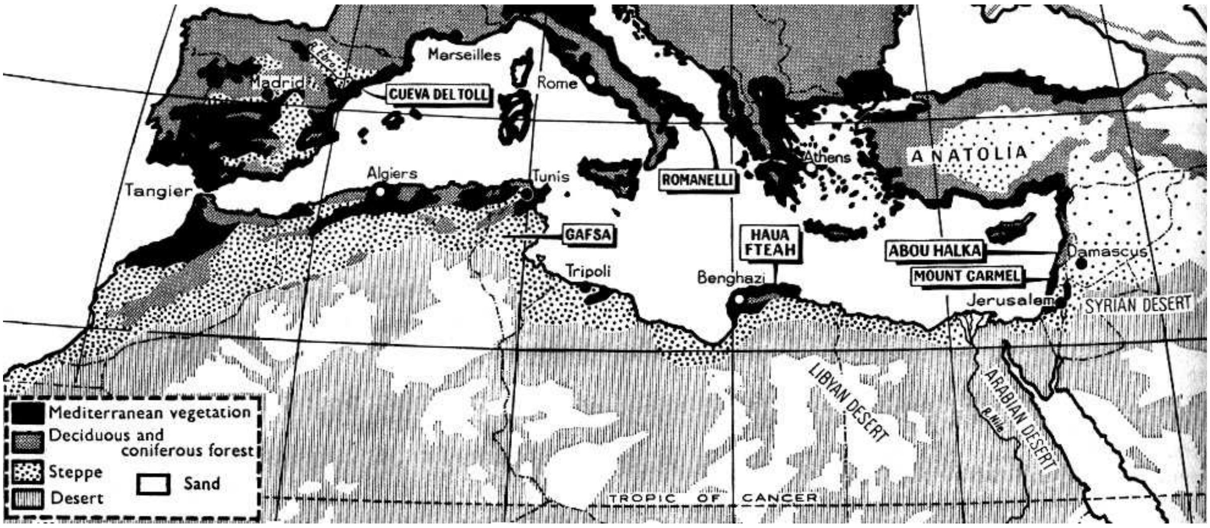

Figure I.2. Map of Cyrenaica and Vegetation Zones (after McBurney 1967: Figure II.3).

From the Mediterranean coast southwards there are two successive escarpments, one very close to the sea, broken by the gorges of several wadis (intermittent streams or rivers; see Figure I.1), and the second approximately 10 km from the coast. These escarpments are composed of "hard, even-bedded limestones, often containing bands of flint" (McBurney & Hey 1955: 19). The limestone escarpments presumably provided an abundant local source of flint, although McBurney does not discuss raw material sources in his 1967 monograph.

The Haua Fteah is near the foot of the first escarpment and overlooks a terrace at an elevation of approximately 60 m (200 ft) formed by one of six successive ancient shorelines (Anketell 1989: 17; McBurney 1967: 3). The cave is formed from a "rounded vertical dissolution-shaft of great size and presumably corresponding depth formed by a wide overhanging lip" (McBurney 1967: 3). It is eroded into "nummulitic limestone of Tertiary age" (McBurney 1967: 1). The process of sedimentation was, according to McBurney (1967: 3):

> ...initiated by slope downwash in the open area (supplemented perhaps, especially in the past, by some degree of eolian deposition due to the prevailing on-shore wind), and thence spread out and carried into the interior by the winter rains... This in turn might serve to explain the remarkably even surface, which seems to have been a constant feature from antiquity, to judge from the extraordinarily regular horizontal stratigraphy seen in the sections.

The stratigraphy at the site shows a relatively stable process of sedimentation with few post-depositional disturbances in the Palaeolithic levels (see McBurney 1967: Figures I.3-I.9, plates III.1-III.2).

The excavation of the site took place in three seasons, 1951, 1952 and 1955, using what appears to be a combination of arbitrary spits and natural stratigraphy. The stratigraphic diagrams of the site (McBurney 1967: Figures I.7 to I.9; see Figure I.3 to Figure I.7) show varying depths for the spits and the artefacts were divided or combined into "cultural" layers corresponding to the natural stratigraphy.[1] Sieving of materials was carried out at the site (see McBurney 1967: plates I.3 - I.5). As MacDonald states, however, "exact specification of the mesh size is neither apparent in McBurney's (1967) site monograph or in his notes" (1997: 84). The bulk of the site was excavated to an area of 20 x 15 ft (6.1 x 4.6 m) down to 25 ft (7.6 m). In 1955 a deep sounding was made in the centre of this and the top 7 ft (2.1 m) were excavated to an area approximately 30 x 35 ft (9.1 x 10.7 m). The sounding went to a depth of 42.5 ft (13.0 m), and was 5 ft x 8 ft (1.5 x 2.4 m) in plan.

The current analysis is concerned with the levels at the site from the base of the deep sounding up to and including the Early Dabban (i.e., up to level XXe). McBurney's (1967) cultural designations of Pre-Aurignacian, Middle Palaeolithic and Early Dabban are used. The forthcoming chapters describe the differences between the Initial Upper Palaeolithic (Early Dabban) industries and those that preceded them.

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[1] The following discussion of level attribution suggests that stratigraphic determinations were done at least in part in the field (McBurney 1967: 146 contra Klein & Scott 1986: 517): "Owing to the extreme complexities of the interlocking sub-layers at this point, it proved impossible to unravel the sequence with even moderate confidence until the vertical faces of 1955 were exposed; only then was it possible to restrict the vertical extension of the spits satisfactorily to individual sub-layers and their interfaces."

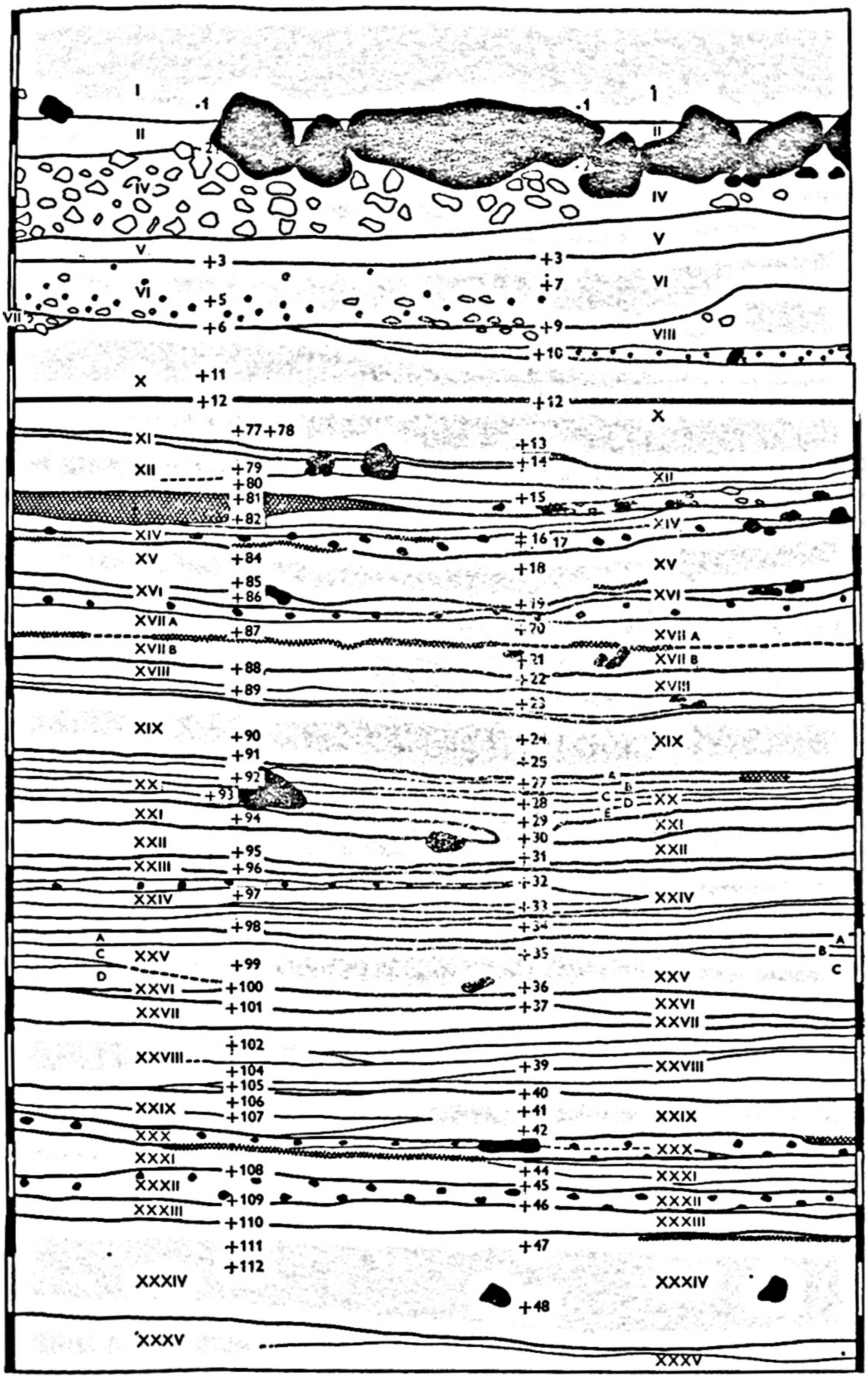


Figure I.3. Diagram of West Face (1955 excavation) Showing Level and Spit Designations in Relation to Site Stratigraphy (after McBurney 1967: Figure I.7).

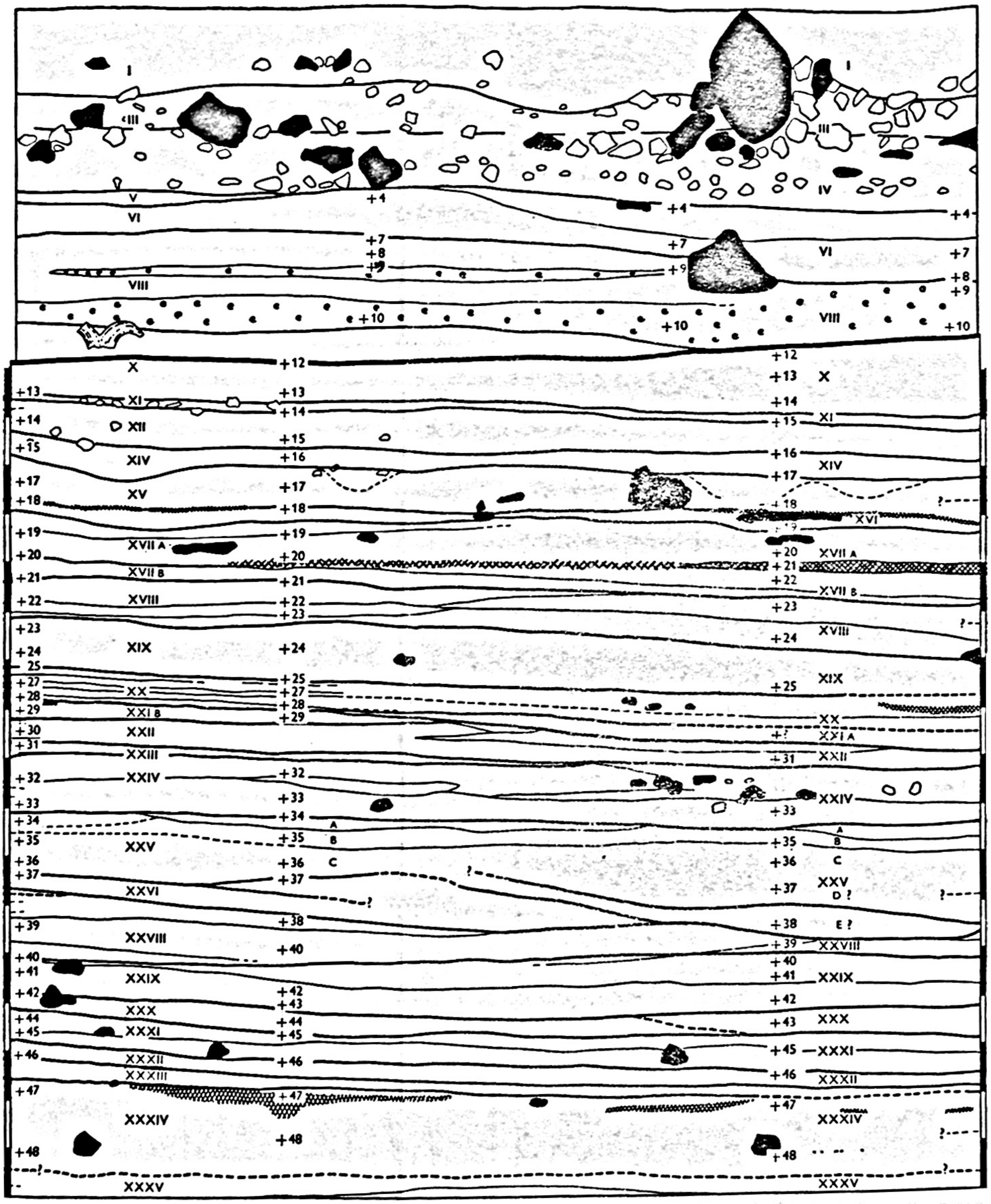


Figure I.4. Diagram of North Face (1955 excavation) Showing Level and Spit Designations in Relation to Site Stratigraphy (after McBurney 1967: Figure I.7).

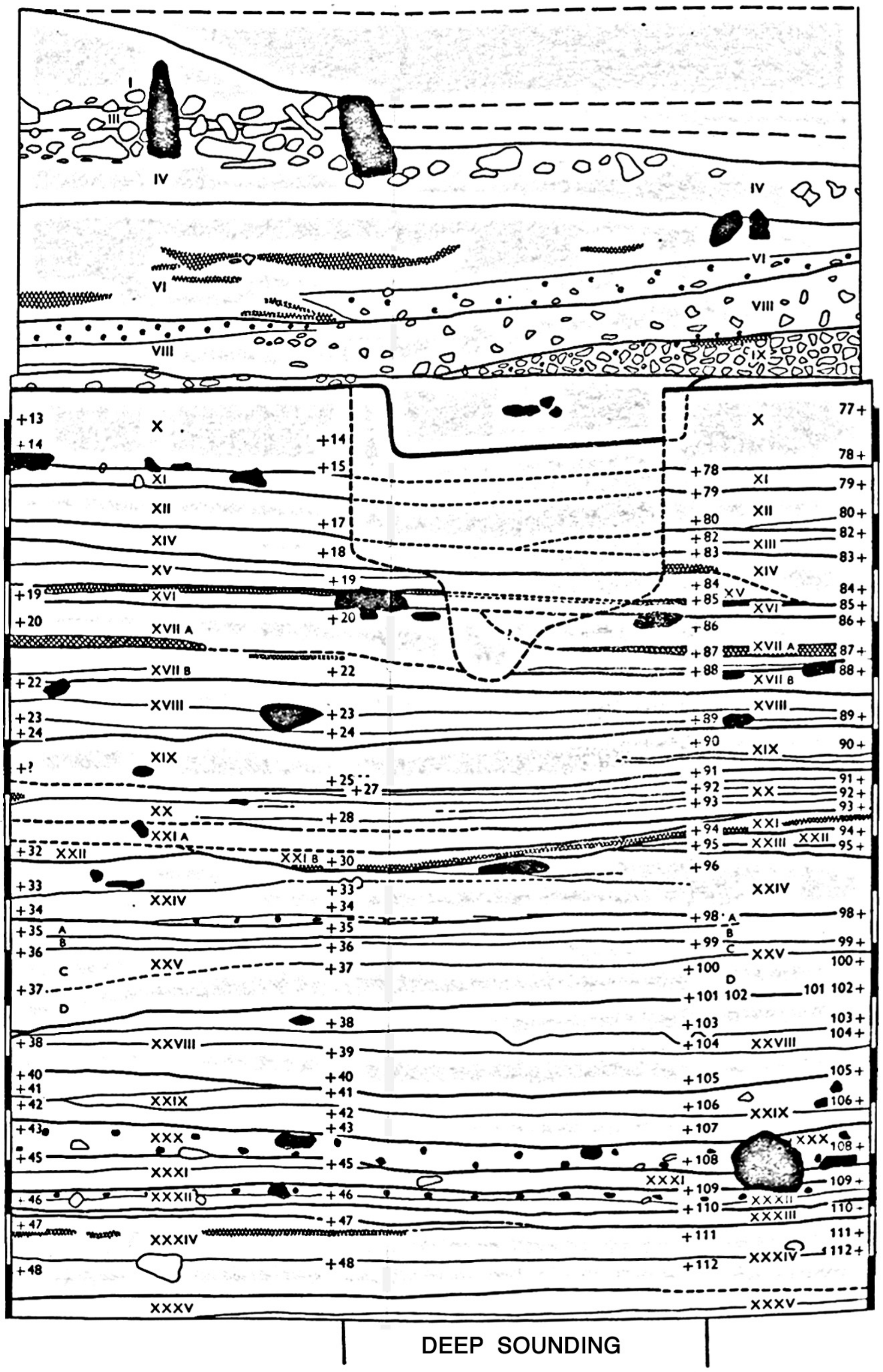


Figure I.5. Diagram of East Face (1955 excavation) Showing Level and Spit Designations in Relation to Site Stratigraphy (after McBurney 1967: Figure I.7).

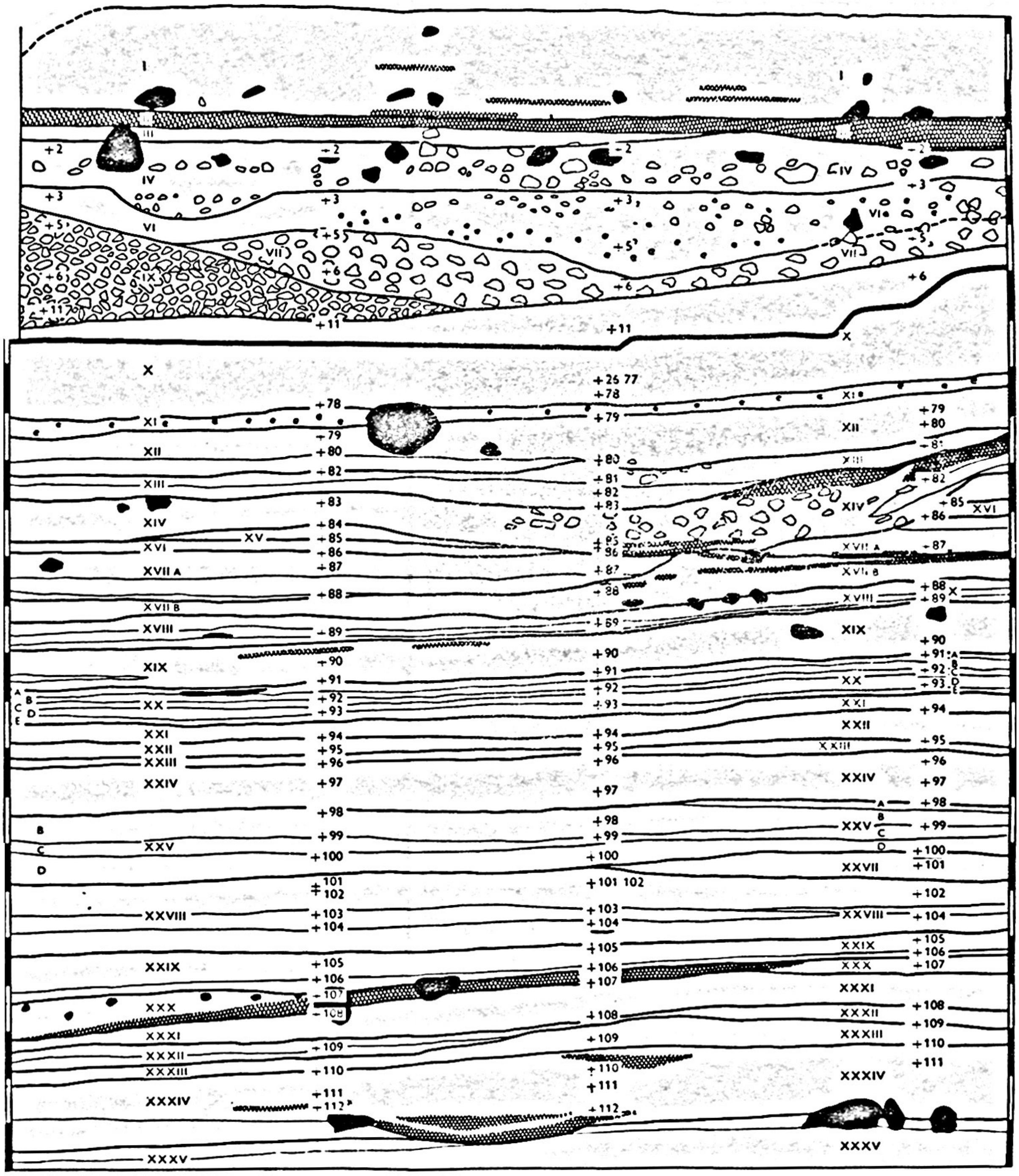


Figure I.6. Diagram of South Face (1955 excavation) Showing Level and Spit Designations in Relation to Site Stratigraphy (after McBurney 1967: Figure I.7).

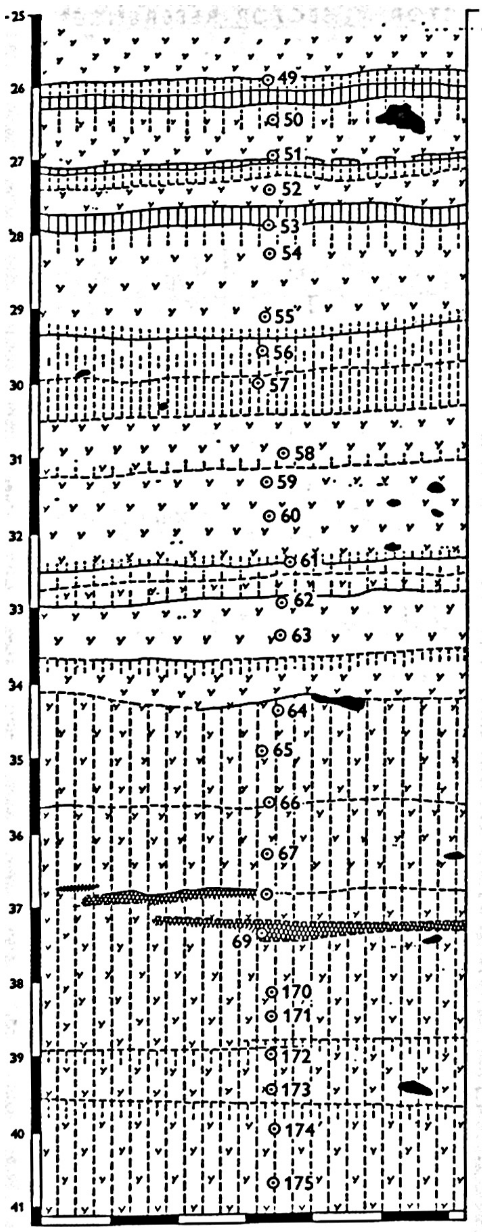


Figure I.7. Diagram of East Face of the Deep Sounding (1955 excavation) Showing Level and Spit Designations in Relation to Site Stratigraphy (after McBurney 1967: Figure I.7).

CHRONOLOGY AND PALAEO-ENVIRONMENT

For its time, one of the best-researched features of McBurney's (1967) monograph was the discussion of the chronology of the site. The original chronology was established using radiocarbon dating, faunal analysis and granulometric analysis. It was also one of the first archaeological applications of oxygen isotope analysis.

RADIOCARBON DATING

The radiocarbon dates were calculated using early methods, which were more prone to error than modern ^{14}C methods. Recently, various means have been used to recalibrate radiocarbon dates before 15 kya using records of variation in the earth's geomagnetic intensity, which has an effect on ^{14}C ratios in the atmosphere (van Andel 1998). Following van Andel (1998: 32), approximate calibrated dates are given in Table I.1. based on the dates provided by McBurney (1967: 71).

Table I.1. Calibrated ^{14}C Dates.

Layer (Culture)	Uncalibrated dates (BP)	Calibrated date (BP)
VI (Neolithic)	4,860 ± 97	≈ 5,500
VI (Neolithic)	5,800 ± 108	≈ 6,400
VIII (Neolithic)	6,370 ± 103	≈ 7,000
VIII (Neolithic)	6,800 ± 350	≈ 7,400
X (Libyco-Capsian)	7,000 ± 110	≈ 7,600
X (Libyco-Capsian)	7,300 ± 300	≈ 7,900
X (Libyco-Capsian)	8,400 ± 150	≈ 9,200
XI/XII (Eastern Oranian)	10,600 ± 300	≈ 11,800
XIV (Eastern Oranian)	12,300 ± 350	≈ 13,800
XIV (Eastern Oranian)	12,580 ± 172	≈ 14,000
XIV/XV (Eastern Oranian)	12,750 ± 173	≈ 14,250
XVIII (Late Dabban)	16,070 ± 100	≈ 18,500
XVIII (Late Dabban)	18,620 ± 150	≈ 21,800
XX/XXII (Early/Late Dabban transition)	28,500 ± 800	≈ 31,500
XX (Early/Late Dabban transition)	33,100 ± 400	≈ 36,000
XXVIII (Middle Palaeolithic)	> 35,950	≥ 38,500
XXVIII (Middle Palaeolithic)	43,400 ± 1,300	≥ 44,000
XXXIII (Middle Palaeolithic)	47,000 ± 3,200	≥ 47,000

‡ Problematic date.

Dates preceding 25 kya have high error margins and other comparative dating methods show that ^{14}C methods may underestimate age more than is shown in Table I.1 (see Taylor, Stuiver & Reimer 1996: Fig. 2). The timing of the Early Dabban industries is important because, based on these early ^{14}C dates, it is considered to be one of the world's first "true" blade industries (i.e., small punch or soft hammer platforms). One of the problems with the dates from layer XX is that this level is subdivided into several sub-layers. Layer XXe is designated as Early Dabban and Layers XXa-d are designated as Late Dabban. The ^{14}C dates given in McBurney's text (1967) are not assigned to these sub-units or to spit designations. Thus their relationship to the timing of the Early Dabban industries is unclear; the dates may belong to either the Early or Late Dabban. A sound assumption, however, is that the Early Dabban *ends* by ca. 30 kya if not before that time. A single ^{14}C date from Hagfet ed Dabba gives a date of 40,500 (≈ 42,500 calibrated) BP for the Late Dabban; however, McBurney admits that this date may be problematic (1967: 71, 169; Klein & Scott 1986: 535). Based on the ^{14}C measurements and environmental correlations, McBurney (1967: 170) estimated the start of the Dabban to be around 40 kya based on an uncalibrated ^{14}C time-scale or 42 kya in calendar years.

SEDIMENTARY ANALYSIS

The Middle Palaeolithic dates are beyond the practical limits of ^{14}C measurement. For this reason, the original climatic reconstructions, based on faunal analysis, granulometry and oxygen isotope analysis, provide the best framework to reinterpret the early chronology at the site. The granulometric analysis of the site (Sampson 1967) showed a number of defined climatic episodes. The relative proportions of debris and silt were plotted, with higher proportions of coarse debris (> 3.353 mm) interpreted as the result of frost action and corresponding to cold climates (Sampson 1967: 51). This suggested a sequence of four general climatic periods, with a possible subdivision of one.

Recent research, however, has called into question the attribution of coarse debris to frost action and thus the inferred correlation with cold climates. Woodward and Goldberg (2001) point out that, although frost action does produce coarse debris in some instances, other geomorphological processes such as dissolution, seismic activity and hydration shattering cannot be ruled out. Woodward and Goldberg (2001) emphasize the adoption of micromorphological techniques and the palaeoenvironmental significance of the fine sediment fraction in rockshelter sites instead of analyses of the coarse sediment fraction. Such a study is beyond the scope of the current work; however, some inferences can be made from Sampson's data based on the proportion of silt in the site.

Woodward and Goldberg (2001: 327) state that:

> …the two main characteristics of a rockshelter or cave site which control its usefulness as an archive of environmental change are the temporal resolution of the sedimentary record and the environmental sensitivity of the site. Many rockshelters and caves can be described as either Active Karst Settings (AKS) or Passive Karst Settings (PKS) and site type is an important influence on climatic sensitivity with a direct influence upon the usefulness of the sedimentary sequence as a proxy record of climate change… The most favorable sites for detailed paleoclimatic reconstruction appear to be in active karst settings…

The limits of ^{14}C dating restrict our ability to reconstruct the palaeoclimate prior to ca. 25 kya at the Haua Fteah. One of the advantages of the Haua Fteah sequence, however, is that it has a very long stratigraphic sequence. Sedimentary samples from the well-dated ^{14}C sequence can be used to test assumptions about the climatic sensitivity of the sedimentary record, which could in turn be used to interpret the samples from earlier periods. Such a method would use inferences specific to the site, rather than generalized assumptions.

The second characteristic of a rockshelter or cave that affects its usefulness in reconstructing palaeoclimates is whether it is an active (humid) or a passive (dry) karst system. Woodward and Goldberg (2001: 333) produce a table comparing these types of system that has been summarised below (Table I.2):

Table I.2. Comparison of Characteristics of Active and Passive Karst Systems (after Woodward & Goldberg 2001: 333).

Active Karst Setting (Humid)	Passive Karst Setting (Dry)
▪ Linked to an internal cavern or conduit system	▪ No significant links with an internal conduit system
▪ Dripping vadose waters	▪ Dry site without flowing or dripping water
▪ Seasonal water flows and ponding	▪ Limited or no inwashing of sediments via karstic cavities
▪ Precipitation of calcite and other minerals	▪ Highly localised or no chemical precipitation
▪ Inwashing of fine sediments via conduits in the host bedrock	▪ Import of fine sediments through the shelter opening may be dominant
▪ Development of vegetation within the site	▪ Limited vegetation growth in the site
▪ Mineralization of macroscopic plant remains	▪ Desiccation of macroscopic plant remains
▪ Strong chemical diagenesis and mineral alteration	▪ Limited chemical diagenesis and mineral alteration
▪ Humidity may encourage host rock breakdown by frost action	▪ Limited host rock weathering by solution
▪ Evidence of erosion and sediment removal by invasive karst waters	▪ Subaerial processes are dominant
▪ Range of hydrological pathways	

A number of features of the Haua Fteah indicate that it is an active karst setting. McBurney (1967: 3) states that

> In general morphology the cave had obvious affinities with the *doline* of the karstic limestone regions north of the Mediteranean; that is to say it is essentially a rounded vertical dissolution-shaft of great size and presumably corresponding depth…

The following points further indicate that the Haua Fteah has elements of an active karst system:

- Similar local sites are filled with standing fresh water (McBurney 1967: 3);
- Fig I.1 and Plates I.1 to I.5 (McBurney 1967) indicate vegetation in the cave;
- Fig I.1 (McBurney 1967) indicates the presence of dripping water;
- Artefacts from some layers (e.g., layer XX in the Early Dabban) indicate heavy patination and chemical alteration; and
- There is poor bone preservation in several layers (Klein & Scott 1986: 537).

In order to determine the usefulness of Sampson's granulometric data, the proportions of silt were compared to data on pluvial periods in the Mediterranean

Sea. A hypothesis that increased pluvial periods in the Mediterranean region would result in higher proportions of silt (particles smaller than 0.5 mm) in certain layers will be examined using the available data. This hypothesis is based on the examples of geomorphological processes associated with fine sediment deposition given by Woodward and Goldberg (2001: 339; see Table III). Infiltration, colluvial and fluvial processes suggest that an increase in pluvial activity in the region would result in a higher relative proportion of fine sediment deposition (e.g., silt). A graph of relative proportions of silt has been redrawn from the original data in McBurney's Table III.2 (1967). Figure I.8 shows the relative proportions of silt (< 0.5 mm; in white) in relation to fine (0.5 to 1.003mm; in grey) and coarse grit (1.003 to 2.057 mm in black) by layer sampled using the data supplied by McBurney (1967: Table III.2). Coarse sediments greater than 2.057 mm were not considered here because of the problems associated with coarse debris discussed above. Woodward and Goldberg (2001: 339) do not consider coarse sediments (> 2 mm) in their discussion of fine sediment deposition.

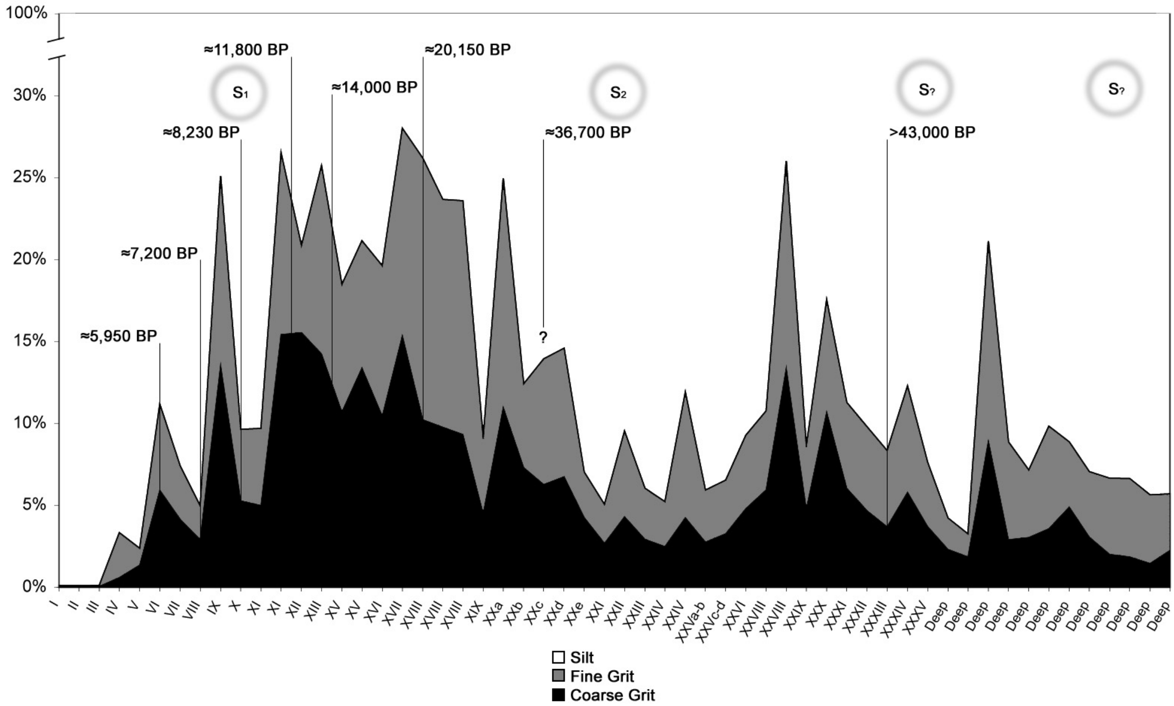


Figure I.8. Granulometric Analysis of Small Particle Proportions with Approximate Calibrated ^{14}C Dates and Approximate Sapropel Dates (recalculated based on McBurney 1967: Table III.2; silt ≤ 0.5mm, 0.5mm < fine grain ≤ 1.003 mm, 1.003 mm < coarse grit ≤ 2.057 mm).

Figure I.8 indicates calibrated ^{14}C dates by layer (see Table I.1; when layers had multiple dates these were averaged). In addition to ^{14}C dates, Figure I.8 shows the approximate dates of sapropel formation in the Mediterranean Sea (S_x). Sapropels are dark layers of carbon rich organic matter found at the bottom of water bodies and indicate increased organic production in the marine environment in the past. Sapropels have been recorded since 1947 in cores taken from the floor of the Mediterranean Sea (Cramp & O'Sullivan 1999). Fifty years of research on a series of dated cores has produced a chronological sequence of 12 sapropels in the Mediterranean dating from ca. 8 kya (S_1) to ca. 461 kya (S_{12}). Sapropel dates are given in Table I.3 (dates and comments based on Cramp & O'Sullivan 1999 and Kallel, Duplessy, Labeyrie, Fontugne, Paterne & Montacer 2000; S_9 to S_{12} are thin and extensively bioturbated according to Cramp & O'Sullivan 1999: 19 and are not included).

Table I.3. Dates, Notes and Oxygen Isotope Stages (OIS) stages of Mediterranian Sapropel Formation (based on Cramp & O'Sullivan 1999 and Kallel *et al.* 2000).

Sapropel	Date (kya)	Notes	OIS
S_1	ca. 8.2 ± 2.3	Average of ^{14}C dates	1
S_2	Between 23 and 52	Not always present in cores and not a large event	3
S_3	ca. 80	^{14}C outlier at ca. 39kya – probably much earlier	5a
S_4	ca. 100		5c
S_5	ca. 125		5e
S_6	ca. 170	Deposited in a cold climate	6
S_7	ca. 195	Deposited in a warm phase of OIS 7	7a
S_8	ca. 217	Cooler climate than S_7	7d

The relationship between sapropels and site formation processes at the Haua Fteah depends on the interpretation of sapropel formation processes. Kallel *et al*. (2000: 45) demonstrate that sapropel formation events correspond with a decrease in salinity in the Mediterranean and therefore a change in the freshwater budget of the Mediterranean. The pertinent question is where the freshwater came from. A number of hypotheses have been put forward as to what may have caused the changes in the salinity of the Mediterranean Sea. They include increased input of glacial meltwater, large-scale fluvial inputs (such as from the Nile), or increased pluvial activity over the Mediterranean and surrounding regions (Cramp & O'Sullivan 1999; Kallel *et al*. 2000). According to Kallel *et al.,* the dating of the sapropels, comparisons with sea surface temperature records and $\delta^{18}O$ variations indicate that sapropels were formed when "precipitation plus runoff were high and nearly equilibrated or superseded evaporation, so that the Mediterranean Sea was no longer a concentration basin" (2000: 56). They conclude that during the periods of sapropel formation the Mediterranean basin exhibited monsoon-like atmospheric circulation (2000: 55).

The geographical position of the site near the shore of the Mediterranean Sea and at the foot of the Gebel el Akhdar, in conjunction with the interpretation that it is part of an active karst system, suggests that its sedimentary record was sensitive to increased rainfall in the Mediterranean. Based on the observations of fine sediment deposition (Woodward & Goldberg 2001) and the studies of sapropel formation (Kallel *et al.* 2000), periods of sapropel formation should correlate with layers containing relatively high proportions of silt at the Haua Fteah. In Figure I.8, sapropels S_1 and S_2 have been plotted in relation to the ^{14}C dates at the Haua Fteah. The date for S_1 corresponds with the date of layer X, which shows a high relative proportion of silt as predicted. S_2, although ephemeral and less well dated, corresponds to levels attributed to OIS 3. These levels indicate a relatively high proportion of silt. Furthermore, the dates from the dry glacial OIS 2 show relatively lower proportions of silt. The data from the dated sequence indicates that the relative proportion of silt provides a proxy indicator of increased rainfall in the region of the Haua Fteah.

The well occupied layers from the Middle Palaeolithic (top of the deep sounding to level XXXI; see Table II.1) and the Pre-Aurignacian (toward the bottom of the deep sounding; see Table II.1 and Figure I.7) occur in periods with relatively high proportions of silt and low proportions of fine and coarse grit. According to the hypothesis, these would be in periods of relatively high pluvial activity. It is important to point out that although the proportion of silt can indicate pluvial activity, Figure I.8 should not be read as an approximate timeline because a continuous rate of sediment deposition cannot be assumed and there may be gaps in the sequence due to erosion or other geophysical processes. The densely occupied parts of the Middle Palaeolithic and the Pre-Aurignacian sequence at the Haua Fteah likely occurred during one of the sapropel events S_3 to S_8 or OIS 5a, 5c, 5e, 6, 7a or 7d (see Table I.3).

Nearby regions such as the Egyptian Western Desert and the Fezzan in southwest Libya provide evidence to support the notion that the monsoon-like conditions applied to inland regions of North Africa. Churcher, Kleindienst and Schwarcz (1999) found faunal remains and evidence of human occupation in association with extensive lakes on the margin of the Libyan Escarpment in OIS 7 (ca. 200 kya and corresponding to sapropel S_7). Crombie, Arvidson, Sturchio, El Alfy & Abu Zeid (1997) analysed dates from travertine deposits in the Egyptian Western Desert. The travertine deposits were produced during pluvial episodes and had dates of ca. 70, 100-110, 120, 160, 190 and 220 kya (see Crombie *et al*. 1997: Table 1, 351); these dates broadly correspond to sapropels S_3, S_4, S_5, S_6 and S_7 (OIS 5a, 5c, 5e, 6 & 7a; see Table I.3). A wet climate in OIS 5a (S_3) is supported by the discovery of a substantial palaeolake dating to 85 kya (U/Th) in the Fezzan region in southwest Libya, now part of the Sahara (Fezzan Project Geomorphology Page: http://www.cru.uea.ac.uk/~e118/Fezzan/fezzan_geomorph.html).

OXYGEN ISOTOPE ANALYSIS

The $^{18}O/^{16}O$ isotope ratios in marine shells from several Palaeolithic layers at the Haua Fteah were analysed to calculate palaeo-temperatures. These were compared with modern populations of the same types of shells (*Patella* and *Trochus*) and with the isotopic sequences from dated deep-sea cores. The shells from the deep sounding (spits 55-50, 55-171, 55-172, 55-175) all show "temperature ranges and temperature averages respectively of fully interglacial character" (McBurney 1967: 56-58). Spit 55-50 is allocated to the Middle Palaeolithic (Top Deep) and is contiguous with the densely occupied layers of the Middle Palaeolithic. A later Middle Palaeolithic layer (XXVIII) yielded a range of temperatures overall suggestive of a glacial environment. Two Dabban readings (XX and XXII) showed cooler environments with XXII being slightly warmer. The readings for the densely occupied layers of the Pre-Aurignacian (55-171, 55-172 and 55-175 see Table II.1) and the Middle Palaeolithic (55-50) suggest warm climates. These layers correspond to periods with relatively high proportions of silt. Layer XXVIII had relatively low proportions of silt, which is characteristic of a dry, glacial period. The

Dabban readings for layer XX also correspond to relatively low proportions of silt. Layer XXII showed intermediate proportions. The isotopic analysis, therefore, supports the findings of the analysis of the silt.

Based on his data, McBurney (1967: 325) constructed five episodes, each corresponding to an OIS as formulated by Emiliani (who conducted the isotopic analysis on the Haua Fteah shells; McBurney 1967). These stages and their corresponding levels are presented in Table I.4.

Table I.4. Isotopic Stages, Cultural and Stratigraphic Associations, and Dates Based on McBurney 1967.

OIS	Layers	Culture type(s)	Proposed dates (McBurney 1967: 325)
1	I-XI	Historic, Neolithic, Libyco-Capsian, Eastern Oranian	present -10 kya
2	XII-XX	Eastern Oranian, Late/Early Dabban	10 kya - 33 kya
3	XXI-XXVIII	Early Dabban, Middle Palaeolithic	33 kya - 45 kya
4	XXIX-XXXI	Middle Palaeolithic	45 kya - ?
5	XXXII-deep sounding	Middle Palaeolithic, Pre-Aurignacian	80 kya - 100 kya

Since this sequence was proposed, the palaeoclimatic record has been studied more thoroughly and the dating of the isotopic sequence has been revised. Importantly, OIS 5 was subdivided and dated earlier with the advent of refined absolute dating techniques and the detailed climatic sequences produced from the ice cores (see Figure I.9). The Last Interglacial is now considered to extend from 130 to 117 kya and is confined to OIS 5e.

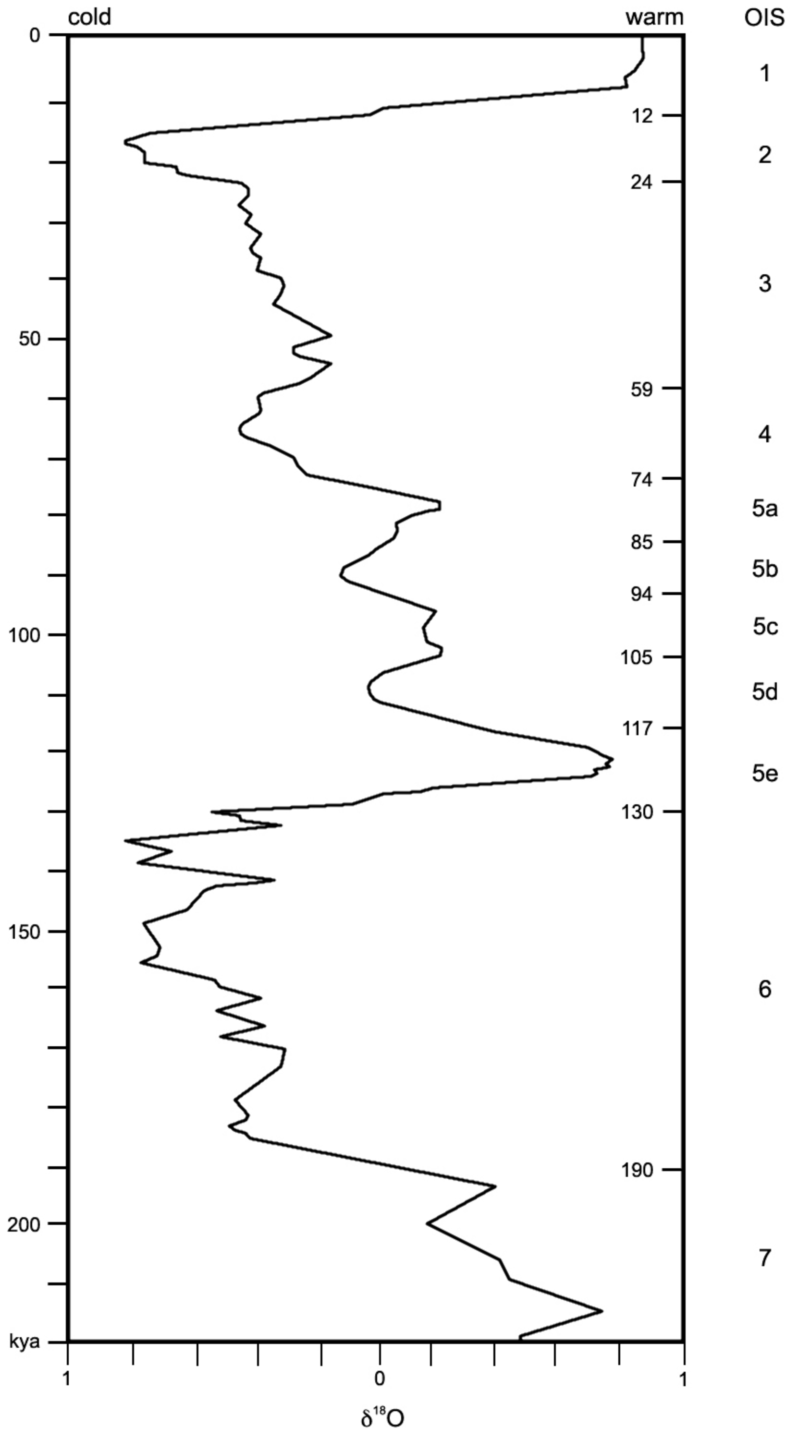


Figure I.9. Oxygen Isotope Curve (after van Andel & Tzedakis 1996: Figure 1).

In terms of sediments and isotopic evidence it is likely that the artefact-rich layers of the deep sounding were deposited during a wet interglacial period. The temperatures implied by the granulometric and isotopic analyses of the marine shells indicate a fully interglacial climate comparable to or warmer than Holocene levels for spits 55-171, 55-172 and 55-175 (toward the bottom of the Pre-Aurignacian sequence), all of which were relatively intensely occupied. The inferred climates were never reached between then and the Holocene (OIS 1). Given possible associations with the Levantine Pre-Aurignacian (see below), these layers at the Haua Fteah may occur during the interglacial environments of OIS 7 or possibly later in OIS 5e. There appears to have been a dry, possibly glacial, phase between the Pre-Aurignacian and Middle Palaeolithic levels of the deep sounding. The temperature range of the Pre-Aurignacian rules out an association with sapropel S_6 because this occurred during the glacial phase of OIS 6. Sapropels S_5 and S_7 (occurring in OIS stages 5e and 7a respectively) appear to be the best correlates as they occur in fully interglacial conditions. This would date the Pre-Aurignacian to either ca. 125 kya or ca. 195 kya, most likely the latter (see below).

On the basis of the granulometric and isotopic evidence from spit 55-50, the densely occupied levels of the Middle Palaeolithic occur during a wet, fully interglacial phase. The most likely attribution is therefore with S_5 (OIS 5e). Stages 5c and 5a cannot be ruled out, however, because they are associated with sapropel formations and warmer climatic conditions (see Table I.3 and Figure I.9).

What occurs between OIS 5e and the glacial maximum of OIS 2 is less clear. This is due to the fact that the isotopic record shows many more oscillations in climate than previously thought (van Andel & Tzedakis 1996). Based on the radiocarbon dates that can be interpreted with confidence, the Early Dabban must have come to an *end* well before the onset of OIS 2. Based on McBurney's inferences, the Dabban started at around 42 kya (40 kya in ^{14}C years). This would place it in the middle of OIS 3. The start of the Dabban (layer XXV), according to granulometry, was in a relatively wet phase (see Figure I.8). The Early to Late Dabban transition (on the basis of granulometry and isotopic temperature) was cooler and drier with an isotopic temperature range of approximately 9 - 21°C (from *Trochus* shells; McBurney 1967: Figure III.5). The modern temperature range is between 16 and 27°C for the same type of shell in nearby coastal waters. The Early Dabban either occurs within the warmer first half of OIS 3 or in a warm oscillation. The relatively warm phase in which the Dabban began may be as early as one of the warmer peaks around 50 kya (see Figure I.9). The entire Dabban sequence (Early to Late) shows an overall decrease in silt leading to dates within OIS 2 at the end of the Late Dabban (see Figure I.8 and Figure I.9). This sequence also shows considerable oscillations in proportions of silt. This corresponds with the gradual decline in temperatures in OIS 3, leading to the last glacial maximum in OIS 2. The majority of the Early Dabban cultural remains occur between layers XX and XXII (see Table II.1), in a cooling phase.

The Early Dabban and late Middle Palaeolithic are preceded by a dry phase (according to granulometry) in the Middle Palaeolithic (layers XXVIII-XXXI), corresponding to lower proportions of silt. These stages likely belong to OIS 4, 5b or 5d. The most intensively occupied portion of the Middle Palaeolithic, however, occurs before this stage. Some studies suggest that the Middle Palaeolithic in the Sahara, to which the Haua Fteah material shows affinities (see below), is restricted to pre-70 kya owing to hyperaridity in this region (MacDonald 1997; Wendorf & Schild 1992). The cold phase of OIS 4 (74 - 59 kya) is generally associated with much lower levels of precipitation and this area, despite being on the Mediterranean coast, is likely to have only been ephemerally, if at all, occupied at this time. Based on this, the majority of the Middle Palaeolithic sequence likely occurs during OIS 5a-e with limited, if any, occupation during OIS 4.

The latest layers of the Middle Palaeolithic appear to belong to early OIS 3. Of the 9 tools in XXV-XXVII 4 are points, perhaps representing a different, late Middle Palaeolithic, culture phase. In XXVII-XXVIII, there were 3 points among 7 tools. The only other points in the Middle Palaeolithic occur in the abundant layers below XXXI in considerably lower proportions. Given the low number of artefacts in these layers and the typical nature of these points (i.e., Mousterian points), no reliable cultural associations can be attempted because there may be other explanations for the differences in these more ephemeral layers (e.g., occupation vs. hunting). Layer XXV was subdivided and had Early Dabban materials in its later portions, suggesting relatively similar times. As stated above, layer XXV showed a relatively wet climate and may correspond to the onset of OIS 3, and was preceded by a cold phase. Layers XXVIII-XXXI have some of the lowest densities of artefacts in the Middle Palaeolithic sequence (McBurney 1967: 119-121). This strengthens the notion that the Early Dabban began in OIS 3, and was likely preceded by a brief, late Middle Palaeolithic occupation in OIS 3. The majority of the Middle Palaeolithic material comes from levels XXXII - XXXV and contains intermediate proportions of silt (≈ 75-85%), whereas the deep sounding contains higher proportions of silt (≈ 75-95%). The abundant Middle Palaeolithic levels appear to belong to one of the wet phases in OIS 5, probably 5e.

Between the abundant Pre-Aurignacian and Middle Palaeolithic levels, there are several spits of artefactually sterile sediments. These spits (55-61 to 55-67) comprise over 3 ft (0.9 m) of sediment. There is a small amount of material in spits 55-58 to 55-60: 9 flakes, 2 tools and 4 cores. These materials are insufficient for cultural comparisons, but contain a point fragment and a resharpening flake, which may indicate bifacial manufacture and a lack of hard-hammer blades. McBurney's contention that some of the items were coarse bifaces (1967: 89) is wishful thinking; they resemble crude, shapeless cores. They may be either Pre-Aurignacian or Middle Palaeolithic, but for the purposes of analysis were classified as Pre-Aurignacian. Following these ephemeral deposits is another series of sterile spits (55-51 to 55-57), again reaching over 3 ft (0.9 m) in depth. These gaps in the record suggest periods without occupation, potentially one or both of the cooler periods of OIS 5d, 5b or 6. Stage 5d showed arid conditions in Africa that may have resulted in a hiatus in occupation in the Sahara (Adams: http://members.cox.net/quaternary/nercAFRICA.html).

FAUNAL INDICATORS

A number of faunal indicators support the chronological information presented above. However, as Klein and Scott note (1986: 537):

> Interpretation of the Haua Fteah fauna is hampered by the comminuted condition of the bones from the pre-Neolithic units and also by the relatively small number of identifiable bones from the Pre-Aurignacian, Mousterian, and Dabban units.

The sizeable presence of marine shellfish in the Pre-Aurignacian levels (Klein & Scott 1986: 520; McBurney 1967: 99) suggests that sea levels were similar to, or higher than, modern levels and that the shells were transported to the site and utilised as human food resources. The African elephant, which only occurs in the Pre-Aurignacian and in the late Eastern Oranian (Ibero-Maurusian), and other sub-Saharan species suggest that the Sahara might have been crossed (Klein & Scott 1986: Table 2; 524). The Pre-Aurignacian and Eastern Oranian both occur in relatively wet periods in the isotopic sequence. In addition, the avifauna from the Pre-Aurignacian "contain no specialized arid taxa... and single elements attributable to a large duck (*Anas* sp.) and the Wood Pigeon" (MacDonald 1997: 89). These birds imply a freshwater and woodland adaptation, respectively. MacDonald concludes that the Pre-Aurignacian environment most likely pertains to the wet parts of OIS 5e or late OIS 6 (1997: 91). Given the humid interpretation of the granulometry, however, OIS 7 should also be considered.

The Middle Palaeolithic period should be divided into two or three periods, although the bulk of the lithic material comes from the earliest period. The bird remains in the early Middle Palaeolithic period are more numerous and indicate the presence of woodland and freshwater habitats (MacDonald 1997: 88). MacDonald suggests that the Early Mousterian belongs to the "North African wet phase of Stage 5a" (MacDonald 1997: 91). Mammalian fauna indicate the persistence of some sub-Saharan species and a higher proportion of bovine bones also points toward a moist climate (Klein & Scott 1986: 536). The majority of the Middle Palaeolithic finds could be attributed to any of the wet phases of OIS 5 and the corresponding pluvial episode.

The later Middle Palaeolithic contains relatively little in the way of faunal material. MacDonald, however, notes in layers XXVIII/XXIX the presence of a European snake eagle, indicative of habitats "ranging from the fringes of true deserts to open woodland" (1997: 88). An arid environment would fit with the occurrence of these levels occurring at the OIS 3/4 boundary. For the bulk of their comparisons, Klein and Scott combine the Middle Palaeolithic levels because of small sample sizes; therefore, their interpretations of the climate based on fauna are unclear.

The final layers of the Middle Palaeolithic appear to occur at the beginning of OIS 3. The Early Dabban replaces the Middle Palaeolithic sometime in the first half of OIS 3. Avifauna from this period are rare and for the entire Dabban sequence suggest open country habitats (MacDonald 1997: 88). The higher proportion of Barbary sheep compared to bovines suggests a drier climate than the preceding Middle Palaeolithic occupation layers (Klein & Scott 1986: 536). It is important to note that although the Dabban likely begins in this warmer phase of OIS 3, the abundant lithic and presumably faunal material comes from the last few layers in the Early Dabban when the climate appears to be deteriorating.

Finally, another important factor is the presence of Kirchberg's rhinoceros bones in the Dabban, Middle Palaeolithic and Pre-Aurignacian layers. This species is a "Eurasiatic immigrant that first arrived in northern Africa in the late middle or early late Quaternary, between perhaps 250,000 and 130,000 bp" (Klein & Scott 1986: 538). It does not occur in the sequence from the last glaciation onwards, suggesting greater biogeoclimatic affinities to the Levant throughout the Palaeolithic sequence than at present. These links were of great significance for human occupation when the Sahara prevented direct population movements from tropical and temperate southern Africa.

PALAEO-ENVIRONMENT

Certain aspects of the palaeo-environment (temperature and humidity) are discussed above. Their implications in terms of palaeoclimate are important for putting the site in a regional perspective. The most important feature of this region is the Sahara and connected desert systems, which essentially surround the site today and provide a major barrier between the Mediterranean coast and the tropical and savannah regions of sub-Saharan Africa. During arid periods few routes were available to cross the Sahara (possibilities existed along the Nile, although the majority of Middle Palaeolithic Nile Valley sites are in Upper Egypt and the Sudan; see Wendorf & Schild 1992: Fig. 1). Contrary to McBurney's assumptions, cold, glacial climates were affected by periods of hyperaridity when the Sahara would have been largely uninhabitable.

Although data from pollen records is limited in Africa for the period before the last glaciation, a number of inferences can be made about the vegetation in the preceding periods. Adams (http://members.cox.net/quaternary/nercAFRICA.html) compiled a number of sources of data and produced a climatic sequence for Africa in the last 150 kya. During OIS 5e (Adams: http://members.cox.net/quaternary/nercAFRICA.html):

> Rainforest occupied a far greater area than at present, and rainfall was generally higher over North Africa. Data are sparse, mainly coming from long cores recording pollen and dust flux off the west coast of Africa. From these indicators, it seems that the situation generally resembled that of the early Holocene, around 8,000 14C y.a.

During this period and the early Holocene, many of the deserts of Africa were covered with vegetation. Early Holocene vegetation, as presented in Figure I.10, indicates what the climate in North Africa might have been like at the time of the Pre-Aurignacian. During this period the sea level was higher than it is today by approximately 2 to 12 m (van Andel & Tzedakis 1996: 487). The climate based on the preceding evidence was likely similar in OIS 7, which was wet and fully interglacial.

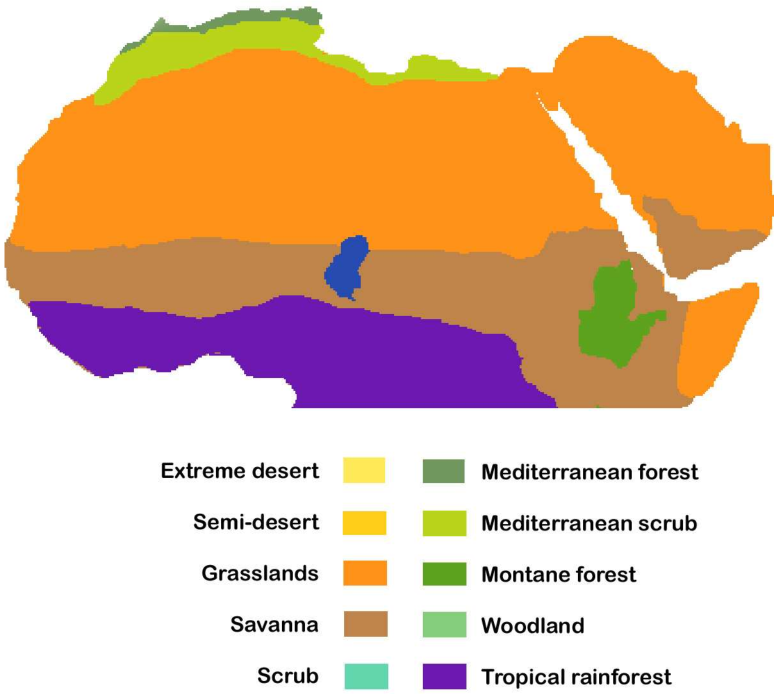


Figure I.10. North Africa during the Early Holocene
(similar to OIS 5e and 7; after Adams:
http://members.cox.net/quaternary/nercAFRICA.html).

Van Andel & Tzedakis state "OIS 5a-d conditions in northern Africa are documented only for the northwest... elsewhere the chronology is too insecure;" in the northwest, the Mediterranean forests were impoverished even in OIS 5a and 5c (1996: 491). The climate was warmer and wetter than in glacial times, but the extent of the vegetation and climate is less clear. The sea levels in these periods were around 20 m below modern levels, although slightly lower in 5a (van Andel & Tzedakis 1996: 490-491). The climate in OIS 4 was cold and dry and, according to Adams, "Vegetation conditions seem to have been much as they were at the Last Glacial Maximum ... with greater-than-present desert extent in North Africa" (Adams: http://members.cox.net/quaternary/nercAFRICA.html). The glacial maximum from OIS 2 is shown for comparative purposes in Figure I.11. Sea levels were approximately 75 m below modern levels (van Andel & Tzedakis 1996: 493).

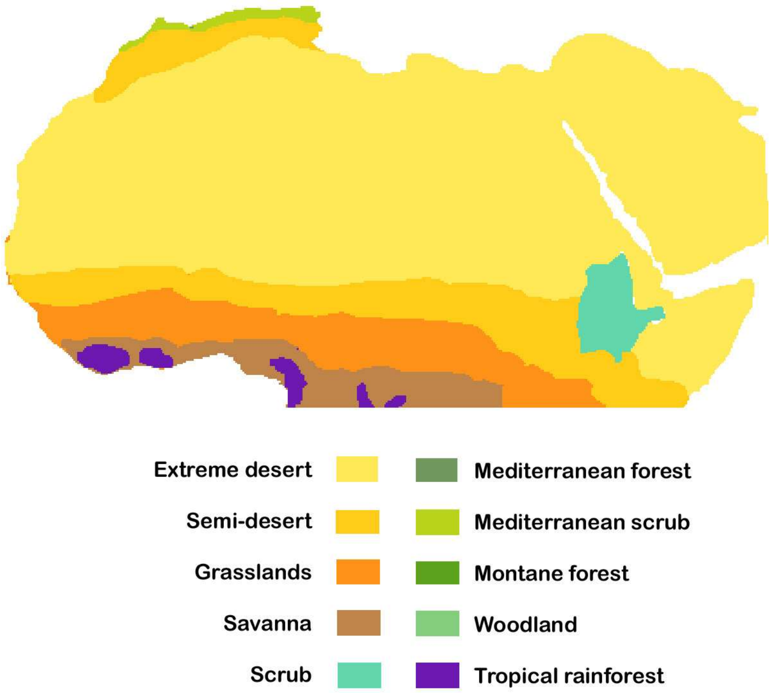


Figure I.11. North Africa during the Last Glacial Maximum
(similar to OIS 4; after Adams:
http://members.cox.net/quaternary/nercAFRICA.html).

The climate of OIS 3 is more difficult to describe in detail. One of the essential features of this period is an unstable climate. There were between 15 and 20 "sharp climatic events, as much as 7℃ warmer than the bri ef intervening cold spells" (van Andel 1998: 26). The cold periods were much more brief (100-1000 years) than the warmer spells, which lasted between one and three millennia. In France the differences in climate in these periods were great, with warm periods reaching near modern temperatures and levels of rainfall, and the cold periods having mean annual temperatures dropping to near 0℃ (van Andel 1998: 28). As indicated, temperatures were warmer at the start of OIS 3 and then decreased overall (despite fluctuations) over the next 32 ky. This was due largely to changes in the amount of glacial ice, which had an overall effect on sea levels (– 50 m at the onset to – 80 m towards the end; van Andel & Tzedakis 1996: 493).

In terms of vegetation in OIS 3, the region of Cyrenaica was more arid than in modern times and less vegetated, even in the warmer periods. Semi-desert vegetation predominated in north-western Africa and much of south-eastern Africa was predominantly desert. There was, however "an arid grass and *Artemisia* steppe [which] marked the Mediterranean coastal zone where the woodland had withdrawn to a narrow strip in the Atlas Mountains" (van Andel & Tzedakis 1996: 495). In the Levant, however, there were areas of evergreen woodland. The Levant and Cyrenaica likely were linked by a coastal strip of vegetation that was wider than modern levels due to the lower sea levels. During the alternating environments of OIS 3, however, there is evidence of periods of increased rainfall as demonstrated by the sapropel data (S_2 above).

The faunal and vegetation populations of Cyrenaica were likely derived from the larger surrounding areas, which are now the Sahara, the Atlas Mountains and the Levant. The influence of these regions varied significantly depending on the climates. The extent of the Sahara had an important limiting effect on human occupation in North Africa. In the Pre-Aurignacian and the Middle Palaeolithic, significant occupation was restricted to relatively warm and wet phases. Ephemeral occupations appear to have occurred in drier phases. The Early Dabban, on the other hand, differs from this trend, with more intensive occupations in relatively arid and fluctuating climates (mid OIS 3).

HOMINID REMAINS

Two hominid mandible fragments were discovered in spits 55-110 and 52-32. Both corresponded to level XXXIII in the most intensively occupied Early Middle

Palaeolithic levels (McBurney 1967: 117). Trevor and Wells (1953: 83-84, cited in McBurney 1967: 117) compared the first fragment (spit 52-32) with specimens from Tabun and Skhul, concluding that it was most closely related to Individual I from Tabun C (i.e., west Asian Neanderthal).

After the discovery of the second mandible fragment, Tobias characterised both in detail. The larger mandible fragment contained two molars (M_2, M_3) and an intact left ramus belonging to a young (possibly female) adult. The second, smaller fragment contained little more than the left ramus, half of the M_2 socket and an unerupted M_3, thus belonging to a juvenile (12 - 14 y; Tobias 1967). The specimens clearly belonged to two separate individuals from the same occupation episode.

Based on detailed measurements of both fragments and a larger comparative sample, Tobias states that "there are resemblances between Haua Fteah and the south-west Asian populations, on the one hand, and both earlier and later African hominids, on the other" - traits marking them as an "advanced Neanderthaloid population" (1967: 349). The mandibles contain a combination of archaic and modern traits, e.g., the rami of the Haua Fteah specimens share features with Tabun and Shanidar Neanderthals on the one hand and on the other with non-Neanderthal specimens such as those from Skhul and Ksar ‘Akil (Tobias 1967: 342). Additionally, one Haua Fteah mandible has large teeth, but lacks a retromolar space (shared with earlier African specimens and modern humans; Tobias 1967: 347). These features are similar to the more complete Jebel Irhoud 3 mandible described by Hublin (2001: 113). Tobias attributes the Haua Fteah specimens to *Homo sapiens rhodesiensis* among which he includes a wide range of hominids including the Middle Pleistocene northwest African hominids and “the early Upper Pleistocene hominid remains which have been described as a primitive variant of Neanderthal man” (1967: 349). He includes Jebel Irhoud in the latter group. Tobias finally suggests that *Homo sapiens rhodesiensis* has affinities to and roots in sub-Saharan African specimens.

Despite the fragmentary nature of the Haua Fteah hominid specimens, the most obvious analogues are the Jebel Irhoud hominids, which share morphological features, are from North Africa and are associated with a similar Levallois based technology lacking Aterian affinities (Hublin 1992: 186; see below). Hublin (1992: 186; 2001: 115) presents a number of lines of evidence to date the Jebel Irhoud specimen at the OIS 5e – OIS 6 boundary, ca. 130 kya and argues that the occupants of the Jebel Irhoud cave should be classified as *Homo sapiens sensu stricto* ('early modern humans').

These African specimens containing a mix of archaic and modern features have been attributed to a number of taxa including *Homo heidelbergensis, H. rhodesiensis, H. sapiens* and more recently *H. helmei*. A number of competing theories exist as to where to place this broad collection of transitional specimens and how they relate to other taxa. Some consider *H. heidelbergensis* to be ancestral to both *H. sapiens* and *H. neanderthalensis* (as discussed in Hublin 2001: 115; see his Figure 8.10a). Presuming the taxonomic identity of the Haua Fteah and Jebel Irhoud specimens, this would place them in the early modern *H. sapiens* taxon, possibly after a hypothetical speciation event.

Another possible association emerges if one considers the taxon *H. rhodesiensis*, on which there are two views. One view distinguishes *H. rhodesiensis* from *H. heidelbergensis*, with the latter belonging to a European/Eurasian clade and the former restricted to Africa (Howell 1999). Another view sees *H. rhodesiensis* as being directly ancestral to both *H. sapiens* and *H. neanderthalensis*, but with *H. rhodesiensis* persisting and evolving in Africa (see figure 8.10b in Hublin 2001). If one accepts *H. rhodesiensis* as a taxon, as Hublin (2001: 116) states, "the question remains whether the distinction between *Homo rhodesiensis* and *Homo sapiens* results from a speciation event or if once again we are dealing with grades" (the same could be asked with regard to the *H. heidelbergensis* as common ancestor theory). As discussed previously, if a speciation event occurred the implications for the Haua Fteah would be similar. If the relationship between taxa was gradual, then the Haua Fteah hominids would be emergent from *H. rhodesiensis* (or *H. heidelbergensis*) toward *H. sapiens sapiens*.

Recently Foley and Lahr (1997; Lahr & Foley 2001) have proposed the "mode 3 hypothesis" to explain the origin and dispersal of modern humans from Africa and the relationship of Neanderthals to humans. In this model Foley and Lahr (1997) seek to use changes in and dispersals of stone tool technology to explain phylogenetic relationships in hominid evolution. The argument for using such an approach is the assumption that biological changes are the consequence of behavioural changes. In other words, behavioural changes precede biological ones (see Bateson 1988 and Chapter VI below). Alternatively, from a neo-Darwinian perspective, a change in technology confers an adaptive advantage to the biological population adopting it.

Foley and Lahr (1997) argue that there is a weak relationship between the origins and dispersal of modern humans, and Upper Palaeolithic technology. There are several problems with linking Upper Palaeolithic (Mode 4/5) technologies (following Clark 1977) with a recently evolved dispersing modern population with new genetically encoded cognitive powers (as argued by Klein 1995 and Mithen 1996, among others). One is that 'Upper Palaeolithic' technology is a regional phenomenon (Lahr & Foley 2001; Foley & Lahr 1997: Figure 4G). Straus (1995: 7) points out that in Europe, even among anatomically modern humans:

> …the classic characteristics of 'The Upper Palaeolithic' did not all erupt full-blown on the whole European scene at c. 40 kya. Rather, they developed over 30 ky, probably as responses to major shifts in physical, demographic, and social environments and resources.

Another problem lies with the assumptions underlying a late cognitive shift and the lack of archaeological evidence for a bottleneck population and its corresponding technologies (see Chapter V below). Finally, as McBrearty and Brooks (2000) and others stress, elements of the Upper Palaeolithic technological package emerge in Middle Stone Age/Middle Palaeolithic contexts in Africa and elsewhere. Caution should be used when the morphological definition of blades is used as evidence of complex behaviour (see Chapter III below).

The Mode 3 hypothesis of Foley and Lahr argues that a major evolutionary change coincided with the emergence of Mode 3 (prepared core) technologies such as the Levallois technique (see Clark 1977). In this model, *Homo helmei* evolved from *H. heidelbergensis* and both *H. sapiens* and *H. neanderthalensis* evolved from *H. helmei*. The model of *H. helmei* as a more recent common ancestor explains the occurrence of shared biological features (such as large cranial capacity) and behavioural features (prepared core technology) among Neanderthals and contemporaneous *H. sapiens*. Multiple dispersals from Africa are needed to explain this model, e.g., there would need to be separate migrations of *H. erectus/ergaster,* *H. heidelbergensis, H. helmei/neanderthalensis* and finally *H. sapiens* into Eurasia (Lahr & Foley 2001: 28-29). Neanderthals and modern humans would have been separated geographically shortly after *H. helmei* separated from *H. heidelbergensis* and evolved independently but with a common cognitive substrate. A number of criticisms can be made of this model. Most notably, the fossil evidence from Europe indicates "a high degree of endemicity" (Hublin 2001: 118), which undermines the argument for a relatively recent *H. helmei/neanderthalensis* migration into Europe.

In terms of the Haua Fteah & Jebel Irhoud specimens, following the Mode 3/*H. helmei* model, these specimens would be late *H. helmei* or early *H. sapiens* according to their dates and technological associations. McBrearty and Brooks (2000: 480) group both sets of specimens together under *H. helmei*, which they discuss:

> *H. helmei* is a somewhat problematic taxon, as there is as yet no formal diagnosis for the species and its unique autapomorphies are not defined. Like all species… *H. helmei* may be expected to exhibit a mix of primitive and derived features, and the specimens attributed here to *Homo helmei* share characteristics with both *H. sapiens* and Group 1 hominids [*H. rhodesiensis/heidelbergensis*].

All of these models, together with the lack of Neanderthal features, suggest a sub-Saharan African origin of the Middle Palaeolithic hominids at the Haua Fteah. The movement (if that is an appropriate term for something taking thousands of years) into North Africa from sub-Saharan Africa likely occurred during a wet interglacial phase when the Sahara was habitable, even if it was a coastal migration (in glacial times parts of the Atlantic and Mediterranean coasts of North Africa would have been extreme desert and would not have had sufficient biomass to sustain a significant hominid population; see Figure I.11). Given the dates for the Jebel Irhoud specimen this migration could have occurred during late OIS 7 or 5e. Each option is assessed.

1. *OIS 7:* Following Hublin's analysis, the Irhoud specimen is essentially modern (or late H. helmei/ early H. sapiens) and would have survived in Morocco during a long glaciation in OIS 6 and evolved from a local population if its origin was from an OIS 7 or earlier migration. The most recent Northwest African hominid known prior to the Irhoud specimen is from Kebibat in

Morocco and is dated from 250 to 350 kya in the Middle Pleistocene (Hublin 2001). The Kebibat specimen is very fragmentary, but exhibits robusticity and several primitive retentions, thus likely belonging to an earlier grade or species. If an independent evolution occurred, the similar taxonomic similarities of the Jebel Irhoud and Haua Fteah specimens with broadly contemporaneous East and South African specimens (e.g., from Omo-Kibish or Border cave) would need to be explained.

2. *OIS 5e:* An early OIS 5e/late OIS 6 expansion into North Africa is more plausible given the distribution of early modern human specimens in sub-Saharan Africa. Given the broad similarities in technology and in hominid morphology, a date of OIS 5e for the Haua Fteah hominids and the intensive occupation layers of the Middle Palaeoltihic is more realistic.

The Pre-Aurignacian and Early Dabban levels did not yield hominid remains and thus the taxa of the populations that left their tools behind can only be inferred. The Early Dabban is presumed to be the product of fully modern humans because of its similarity to contemporaneous transitional industries in the Levant.

The association of the Pre-Aurignacian at the Haua Fteah with similar industries in the Levant (see below) raises the possibility of a relationship to the Zuttiyeh hominids (associated with Acheulo-Jabrudian industries; see below) dated to OIS 6 - 8; Bar-Yosef 1992: 194; Zeitoun 2001: 521). The taxonomy of the Zuttiyeh hominid has been widely debated (Zeitoun 2001: 521):

> Zuttiyeh a d'abord été considéré comme un néandertalien, puis comme un Homo sapiens archaïque et, plus précisément, comme un prédécesseur des protocromagnoïdes, soit un précurseur moderne qui fut temporairement remplacé dans cette région par des néandertaliens venus du nord. Mais Bräuer le considère comme un néandertalien jusqu'en 1989, lorsqu'il admet l'hypothèse de comme étant plus probable. Des études métriques et phénétiques ne le distinguent, ni des néandertaliens du Moyen-Orient, ni des hommes modernes. D'autres le rapprochent de la série chinoise de Zhoukoudian.

Zeitoun's cladistic analysis finds the closest relationships of the Zuttiyeh specimen with Skhul V and modern humans, however the sample contained no African specimens from the *H. helmei* group (comparing McBrearty & Brooks 2000: 485 with Zeitoun 2001:523). The presence of Levallois technology in the Haua Fteah's Pre-Aurignacian and the inferred dates would place its producers in the *H. helmei* group following Foley and Lahr's reasoning.

REGIONAL AFFINITIES

A cluster of adjacent stratigraphic layers with intense occupation dominates each of the three cultural phases analysed. Between each of these occupation periods are gaps with either very low proportions of artefacts or culturally sterile deposits. The regional affinities of the intensely occupied periods will be compared.

PRE-AURIGNACIAN

McBurney dubbed the cultural materials from the deep sounding *Pre-Aurignacian* after a similar industry in the Levant (1967: 97). At the site of Jabrud I in northern Syria, Rust described an industry that contained relatively large blades from prismatic cores and a high proportion of burins, and was inter-stratified with the Jabrudian, an industry with thick scrapers (Jelinek 1994: 154-155). The Pre-Aurignacian was at first considered a precursor to the European Aurignacian because of the combination of blades and Upper Palaeolithic tool types. Garrod adopted Rust's usage at Tabun (layer Eb) and differentiated it from the Amudian (named after Wadi Amud, the location of the site of Zuttiyeh), an early blade industry dominated by backed elements (Jelinek 1994). Both of these industries are now subsumed under the broader Mugharan tradition, which also includes the Acheulo-Jabrudian and Jabrudian traditions (Jelinek 1994).

Following a re-examination of the material at the site, the term Pre-Aurignacian remains appropriate. Over one third of the tools in the deep sounding are burins (34% of the retouched tools), and large platform hard hammer blades (7% of the debitage) and prismatic cores (13% of the cores) are both present and numerically dominant. Backed elements occur but there are only three backed pieces (6% of the tools). The second most abundant tool type is the sidescraper (28% of the tools). Contrary to McBurney's analysis, some Levallois flakes (6% of the blanks) were noted in these levels, including some very typical examples. Although no clear examples of Levallois cores were found, 9% of the cores were discoid, suggesting a ‘Mousterian’ influence. Many have argued that disc cores represent exhausted Levallois cores (Mellars 1996b: 72). McBurney's definition of Levallois flakes was more restrictive than many (e.g., Bordes 1961); he only included those flakes with facetted platforms (McBurney 1967: 77). Despite the use of this restricted definition, however, he found three Levallois flakes in these early levels. Tools were made on normal debitage, Levallois flakes and hard blades with no apparent preference in blank form (see Chapter IV).

With regard to possible North African affinities, there are blades in van Peer’s N group of the Middle Palaeolithic in the Lower Nile Valley (ca. 140-70 kya; van Peer 1998: 119) but Nubian-style Levallois points dominate there. Elongated Levallois "blades" occur in the Lower Nile Valley (van Peer 1998: 130). The early Haua Fteah industries differ in that Levallois points are very rare (1.6% of the blanks), they are not Nubian style, and the blades are predominantly made on crude prismatic cores. Small proportions of elongated Levallois flakes occur (1.6% of the debitage). The majority of the Levallois flakes at the site are neither pointed nor elongated.

The bottom of the deep sounding at the Haua Fteah is most comparable with the Pre-Aurignacian tradition in the Levant because of the combination of large prismatic cores and a high proportion of burins. A small triangular biface was also found in these layers, suggesting possible affinities to the Acheulo-Jabrudian. The equivalent levels at Tabun are dated earlier than OIS 5e. Dates for Tabun E remain controversial, however, with different proposed chronologies using experimental dating techniques. Recent thermoluminescence (TL) dates on burnt flint from Jelinek's excavations at Tabun indicate that the sequence of deposits in layers Ed to D were made between ca. 330 and 210 kya, placing the transition from the Mugharan to the Middle Palaeolithic at 200 kya (Mercier et al. 1995). These dates make up the *early chronology* (Porat, Chazan, Schwarcz & Horwitz 2002), whereas the *younger chronology* places late Acheulian and Acheulo-Jabrudian sites at ca. 200 kya using electron spin resonance (ESR) and TL dates (Porat, Zhou, Chazan, Noy & Horwitz 1999). This would place the Middle Palaeolithic later. Both chronologies, however, place the Pre-Aurignacian industries of the Levant in OIS 7.

The most obvious cultural analogue for the Pre-Aurignacian occurs in OIS 7. Three chronological interpretations for the Libyan Pre-Aurignacian exist.

1. The materials from the deep sounding represent a late, regional variant of the Levantine Pre-Aurignacian in North Africa during OIS 5e. This alternative is perhaps the least probable, due to the large time gap of OIS 6. The Pre-Aurignacian is unlikely to have survived unnoticed in the archaeological record for 50 ky only to re-emerge in North Africa following an arid glacial event.
2. The material from the deep sounding is an independent regional blade and burin tradition dating to 5e. This possibility gains credibility from the numerous early large blade traditions that have emerged independently in parts of Africa and Europe, only to be replaced later by Levallois based technology. The co-presence of Levallois and large, hard hammer blade technology suggests that this technology belongs to the Middle Palaeolithic.
3. The materials from the deep sounding are older than previously thought, dating from the interglacial climates of OIS 7. This theory has merit because the dating of the sequence at the Haua Fteah before 42 kya is based entirely on climatic and faunal associations rather than absolute dating. During the entire sequence at the site before the last glacial, the presence of Eurasian fauna (e.g., Kirchberg's rhinoceros) suggests important faunal movements between the Levant and Cyrenaica, which would have affected hominid movements in the region. In this sense, during the Palaeolithic the Haua Fteah should be considered a part of the Eastern Mediterranean as much as it is a part of Africa. The association with a wet, fully interglacial climate, the presence of Eurasian fauna and a nearby technologically similar industry from OIS 7 makes this the most plausible interpetation.

Finally, despite being an early burin and blade industry, the lithic material from the deep sounding also has unique features, such as the presence of Levallois materials. This suggests that if it is related to the Pre-Aurignacian (which is traditionally placed in the Lower Palaeolithic in the Levant), it is transitional to the Middle Palaeolithic due to the presence of Levallois flaking. Mode 3 industries appear between 400 kya and 250 kya in Africa (Lahr & Foley 2001:26) and early Levallois industries are found in OIS 7 in North Africa.

Non-Lithic Material

In addition to the lithic material in the Pre-Aurignacian levels, a number of non-lithic artefacts require attention. The first are the numerous marine shells mentioned above. These appear to have been deliberately transported to the site because they are found in large quantities in the occupied spits in the deep sounding. As McBrearty and Brooks (2000: 512) point out, molluscs appear at several coastal Middle Stone Age (MSA) sites in Algeria and Morocco. Early examples (ca. 125 kya) of invertebrate food consumption are found in East Africa and broadly contemporaneous examples also exist in Mediterranean Europe and Southern Africa (McBrearty & Brooks 2000: 512-3). The collection and consumption of marine shellfish is a non-complex behaviour. It is a direct archaeological indicator, however, that food foraging played an important role alongside hunting and/or scavenging strategies in the early Middle Palaeolithic. Diet was likely more varied than the archaeological remains of the Middle Palaeolithic suggest.

From spit 55-64 McBurney draws attention to "a remarkable bone object most plausibly explained as a fragment of a vertical 'flute' or multiple pitch whistle" (1967: 90, Plate IV.4). This artefact is easily dismissed as being of natural origin for two reasons: 1) there is no other indication of human activity in this spit; and 2) the item in question only has a single circular hole. Recent research into more plausible looking flutes has shown that a combination of carnivore activity and post depositional processes can produce circular holes in the sides of bone shafts (Chase and Nowell 1998; d'Errico, Zilhao & Pelegrin 1998). More importantly, the lack of associated cultural remains makes a strong case against this being a flute.

Finally, there are two scored limestone slabs from spits 55-170 and 55-172 (McBurney 1967: 86, 88, Plates IV.1-IV.3; Figure I.12). Both of these artefacts come from spits with abundant cultural remains. Although the function of these limestone blocks is unclear, they are clearly the result of hominid activity. Figure I.12 shows the irregular and apparently random scar patterns on a portion of one of the limestone slabs. McBurney described the nature of the scars in three categories as follows (1967: 88):

(1) relatively shallow and wide grooves with well marked subsidiary scratches, (2) deeper but still flat-bottomed grooves of the same nature, (3) grooves with asymmetrical 'V'-shaped section in which there is apparently a tendency for the traces of subsidiary scratches to appear on the more nearly horizontal wall.

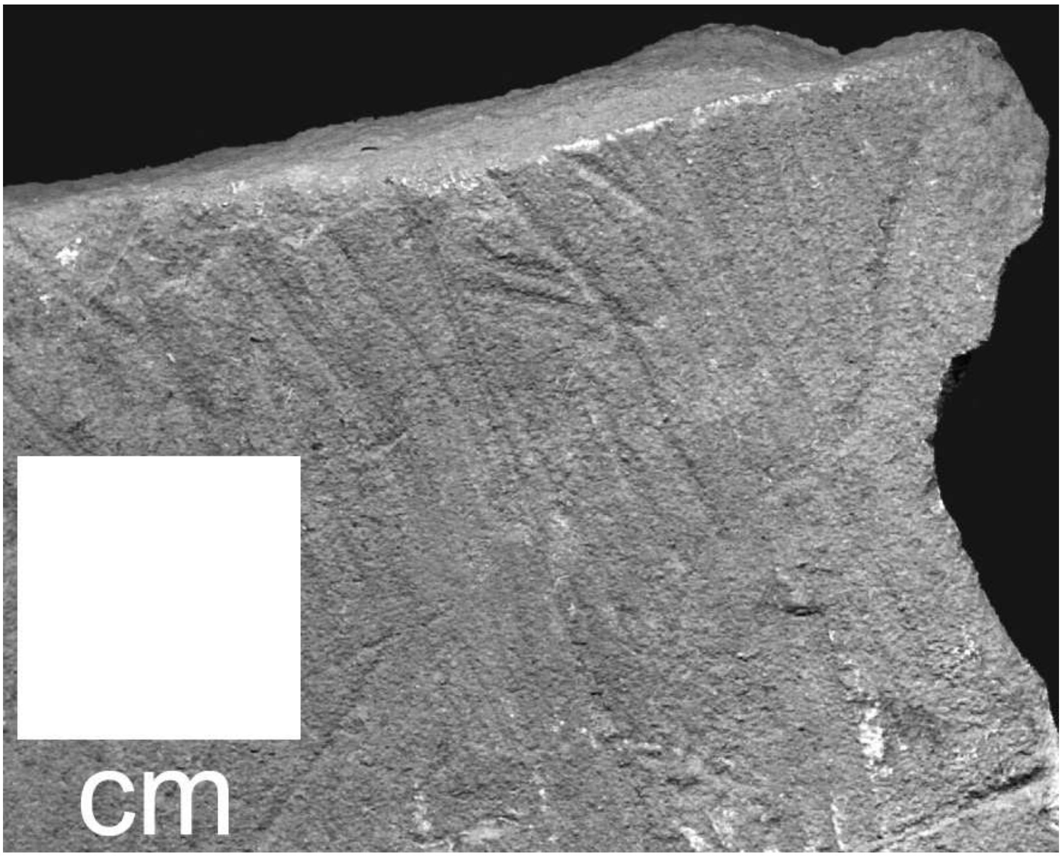


Figure I.12. Scored Limestone Fragment from Spit 55-170.

McBurney thought these scars were made by burins. Recent work on the Berekhat Ram figurine shows experimental cross sections of cuts made by various types of retouched implement (d'Errico & Nowell 2000). The characterisations made by McBurney as well as direct (macroscopic) observation suggest that retouched implements were used and that the shallow and wide grooves were likely made by burin tips, retouched points or pointed blanks (following d'Errico & Nowell 2000: Figs. 14 and 15). The asymmetrical grooves, however, may indicate sidescrapers because the cross sections of these produce similar scars. Given the high proportion of burins and scrapers in the lithic industry in these levels, this is the most likely interpretation. The purpose of these scratches is likely functional because they are positioned in a random manner. McBurney's interpretation of these grooves as having been made in the process of cutting hide or bark (or other faunal or floral remains) is probable. Numerous intentionally incised objects occur throughout Lower and Middle Palaeolithic contexts; few, if any, appear to represent symbolic behaviour (Chase & Dibble 1987). The random nature of the incisions suggests that these slabs are ancient work surfaces.

MIDDLE PALAEOLITHIC

The nature of the abundantly occupied Middle Palaeolithic levels will be discussed. The most important question regarding the affinities of these layers is whether or not they can be attributed to the Aterian industries of Northern Africa. Layers XXXI-XXXV and the very top of the deep sounding have the largest proportions of tools. Some authors have characterised the Middle Paleolithic levels at the Haua Fteah as Aterian (e.g. Klein & Scott 1986; Wendorf, Close & Schild 1994) on the basis of the presence of bifacial foliates and crude tanged or pedunculated pieces (Wendorf et al. 1994: 118). Wendorf et al. further claim that all of the Middle Palaeolithic industries outside of Egypt in North Africa are Aterian (1994: 119). Wendorf & Schild (1992: 49) raise a legitimate question, often asked about industries defined by type fossils: How many Aterian tools have to be present for the assemblage to be Aterian? Although the Aterian is indeed more abundant in North Africa than the Mousterian, there are some important patterns to Middle Palaeolithic site distribution. Van Peer (1991: 112) points out that

> ... to the west of Egypt, the presence of two Middle Palaeolithic industrial complexes is generally acknowledged. On the one hand, there is the Mousterian, which seems to be confined almost exclusively to the coastal areas from Libya to the Atlantic ocean.... Aterian sites are numerous. Their distribution ranges from the Atlantic Coast to the Egyptian Sahara and from the southern borders of the Sahara to the Mediterranean Coast.

If the Middle Palaeolithic (or Mousterian) of Northern Africa were simply Aterian assemblages without Aterian tools, one would expect the distribution of these sites to be essentially random, i.e., not having geographical or chronological patterning. The geographical and temporal relationship between these industries suggests that they represent different behavioural entities warranting separate taxonomic treatment.

The relationship of the Aterian to the Mousterian is problematic in terms of chronology and lithic style. Most people believe that the Aterian is relatively late and emerges from a preceding Mousterian (or generalised Middle Palaeolithic) tradition (van Peer 1991: 112). Others point to the antiquity of the Aterian, asserting that it predates and is interstratified with the Middle Palaeolithic. Wendorf & Schild (1992: 50) use the material from the Haua Fteah to support the contention that the Aterian precedes Middle Palaeolithic horizons:

> Rare Aterian pieces occur in the earliest Middle Palaeolithic horizons (Layer XXXV)... Aterian types are more frequent slightly higher in the sequence but they disappear in the upper Middle Palaeolithic horizons (layers XXVII-XXV and lower half of XXV)...

In addition to tanged pieces and bifacial foliates, the Aterian is thought to have higher proportions of Levallois and generally more elongated pieces. The material from the Haua Fteah is thus the cornerstone of the argument that outside of Egypt the entire Middle Palaeolithic is Aterian (Wendorf et al. 1994).

The chronology of the Aterian is poorly understood. However, recent dates from the Libyan Sahara have been conducted using TL and optically stimulated luminescence (OSL) dating methods (Cremaschi, di Lernia & Garcea 1998). Four dates were produced from the site of Uan Afuda (2 TL and 2 OSL) and one date from Uan Tabu (OSL). Both sites are in the southwest corner of Libya in the Fezzan region. The sample from Uan Tabu came from sands in a stratigraphic unit containing undisputed tanged points, which dated to 61 kya (± 10 ky; Cremaschi et al. 1998: 275). The lithic material from Uan Afuda was sparse and did not contain diagnostic Aterian tools, but was dated to a similar time period (dates ranging from 69 kya to 73 kya; Cremaschi et al. 1998: 275). The layers at Uan Afuda and Uan Tabu were considered to be contemporaneous because of similarities in stratigraphy and the technology of the non-tanged pieces. The oldest sample from the sequence at Uan Afuda was approximately 90 kya, but came from sands beneath the lithic material (Cremaschi et al. 1998: 272). The time range was thus approximately between 69 and 90 kya for the lithic material at Uan Afuda. The earliest reported dates for the Aterian in the Libyan Desert, curiously enough, come from stratigraphic units lacking

Aterian type fossils. Therefore, the earliest acceptable absolute dates for the Aterian are ca. 61 kya or late OIS 4.

The relationship between the Saharan Aterian and the Aterian from the Maghreb is also problematic. New absolute dates from Morocco, however, suggest that the Aterian occurs earlier in that region than previous radiocarbon chronologies suggested. Wrinn and Rink (2003: 130) date the Aterian at the site of Mugharet el `Aliya between 35 and 60 kya using ESR dates from ungulate tooth enamel. The Aterian chronology from this site stretches from late OIS 4 to the middle of OIS 3. Wrinn and Rink (2003) suggest a possible Saharan origin for the Aterian and migration into Morocco. The relatively early dates for the Aterian in the Sahara support this.

Consideration of the early layers at the Haua Fteah thus remains central to the question of the origins and dispersal of the Aterian. If the proposed chronology (OIS 5e) is correct and if the early Middle Palaeolithic layers at the Haua Fteah do contain Aterian implements, these would be the earliest known occurrences of the Aterian. Furthermore, as Wendorf et al. (1994) suggest, this would also be the only known occurrence of the Aterian stratigraphically preceding more typical Middle Palaeolithic industries. Given the high numbers of tools in the early layers (over 100 complete tools), one would expect that if these assemblages were indeed Aterian, type fossils such as tanged pieces and bifacial foliates would be present in significant numbers. There are no unequivocal tanged pieces at the site. Of seven possible tanged pieces in layers XXXIV and XXXV McBurney states that "none of these affords more than a suspicion of this highly distinctive device" and that "the attribution of possible traces of Aterian elements in the tradition of this settlement must accordingly remain an open question" (1967: 113). Other candidates (2 pieces) in layers XXXI and XXXII are described in equally equivocal terms: "It could very well be a true Aterian piece, but the work is just not sufficiently characteristic to be absolutely conclusive" (1967: 119). In fact, the most convincing examples of tangs at the site appear to be convergent notches on the proximate end or upside down Tayac points. Notches and denticulates make up the largest number of tools in the Middle Palaeolithic levels (over 30%). The small number of possible tangs can easily be explained by the random distribution of notches along the periphery of the pieces. None of the pieces McBurney identifies as being possibly tanged show complex retouch in the tangs.

The other type fossil of the Aterian is the bifacial foliate. Bifacial foliates are "generally distinguished from bifaces by their small size and leaf shape, though an explicit distinction between bifacial foliates and other bifaces is not possible" (Debénath & Dibble 1994: 119). At the Haua Fteah, there are six bifacially worked specimens (5 complete and 1 fragment) from layer XXXIV/XXXV. Of the complete pieces, the lengths range from 5 to 11 cm. Four of these have an essentially cordiform shape (average planform = 0.35; range 0.27-0.49), one being relatively thick and thus amygdaloid. The fifth is relatively thin, small and elongated, but only partially bifacially worked. In short, none of the bifacially worked pieces appear to be similar to Aterian bifacial foliates, which are generally relatively elongated, thin and truly leaf shaped. Two bifacial foliates from the Libyan Sahara have elongation measures (width/length) of 0.41 and 0.33 (based on Cremaschi et al. 1998: Fig. 8), whereas the bifaces from the Haua Fteah range from 0.57 to 0.92 and have a mean elongation of 0.73. Technologically, the Middle Palaeolithic is dominated by relatively broad flakes (elongation = 0.64) and radially and sub-radially prepared flakes. Typical examples of bifacial foliates from Morocco are compared to two purported bifaces from the Haua Fteah in Figure I.13.

Figure I.13. Comparison of Purported Bifacial Foliates from the Haua Fteah from layer XXXIV (1 and 2) with Aterian *Pointes foliacées* from El `Aliya Cave, Morocco (after Bouzouggar, Kozlowski & Otte 2002: Figure 18).

The predominance of radially prepared Levallois flakes and the lack of diagnostic Aterian elements suggests that the early Middle Palaeolithic levels at the Haua Fteah belong to the non-Aterian Middle Palaeolithic of coastal North Africa (van Peer's North African Mousterian). In van Peer's analysis of four assemblages of this type he states that they are dominated by classical (i.e., centripetal or radial preparation) Levallois flakes and have elongation ratios ranging from 0.63 to 0.72, and a mean elongation of 0.67 (all measures based on van Peer 1991: Table 5). The mean elongation for the Levallois flakes at the Haua Fteah is 0.65 and thus in the same range. The Levallois flakes from the Aterian, however, are similar in terms of mean elongation and are predominantly of classical Levallois technology. The Aterian Levallois does differ from the North African Mousterian in terms of the total number of scars per flake. The mean number of total scars in the Levallois flakes from North African Mousterian assemblages ranges from 5.67 to 6.68 (mean = 6.25), whereas the Aterian Levallois flakes have mean total scars ranging from 6.90 to 9.17 (mean = 7.93). The mean number of scars for the Haua Fteah is 6.78 and although it is between the two ranges it is much closer to the mean for the North African Mousterian. The other sites from this category in van Peer's (1991) analysis include Hajj Creiiem on coastal Libya and Jebel Irhoud in Morocco.

The time period for these early layers, their coastal location, the lack of diagnostic Aterian tools and the general similarities in Levallois technology all suggest that the Middle Palaeolithic of the Haua Fteah is not part of the Aterian, but comparable to van Peer's North African Mousterian. Debénath, Raynal, Roche, Texier & Ferembach (1986: 235) state of the supposed Aterian layers at the Haua Fteah: "…les caractères atériens de l'industrie considérée sont pour le moins peu évidents." The presence of bifaces suggests that these early layers may in fact be much earlier than OIS 5a - the cordiform bifaces may represent a late Acheulian influence. This is compatible with the very early chronology suggested for the Pre-Aurignacian above. Levallois flakes and bifaces coexist (Jelinek 1994) in some early Middle Palaeolithic industries in the Levant such as Tabun layers C and D. These bifacial elements, however, are relatively small and some are very well made by Acheulian standards (see McBurney 1967: Fig. V.5). An alternate explanation is that an early bifacial element in North Africa may have been a precursor to the bifacial foliates of the Aterian. The Jebel Irhoud industry associated with human remains and van Peer's North African Mousterian is dated to ca. OIS 5e or 6 (Hublin 1992: 187).

The later layers are relatively impoverished and sweeping comparisons should not be made. As Wendorf & Schild state (1992), these layers lack clear Aterian affinities. Given the time periods proposed and the low number of implements, however, the possibility of them being Aterian although lacking diagnostic Aterian implements is much more likely than in the early Middle Palaeolithic levels. Further west in Libya, at Wadi Gan in Tripolitania, numerous points without tangs coexist with typical Aterian points (McBurney & Hey 1955: 225-229). This also fits well with the recent Aterian dates of Wrinn and Rink (2003).

Non-Lithic Material

The poor bone preservation in the Palaeolithic layers at the Haua Fteah is unfortunate. The most important non-lithic remains from the Middle Palaeolithic are the hominid remains discussed above. The morphological similarities to the Jebel Irhoud remains, coupled with the similarities in industrial complex, suggest an association between *H. helmei* and a non-Aterian North African industry at a relatively early date. The other piece of non-lithic evidence of note is the presence of hearths both near the bottom of the sequence (layers XXXV/XXXIV) and further up in layer XXX. This suggests that the site may have been used for habitation.

EARLY DABBAN

The Early Dabban is relatively unambiguous to interpret. It is better dated than the previous cultures and contains a diagnostic tool type, the chamfered piece (*chanfrein* or simply *chamfer*). The chamfered piece was originally considered to be a transverse burin, but does not appear to be made using a burin blow technique (Azoury 1986: 47). Furthermore, the functional edge produced by a chamfer blow differs from the burin. Chamfered blades produce a sharp bevelled edge, normally at the distal end of the tool, which can easily be rejuvenated by subsequent chamfer blows. This tool occurs at a relatively small number of Eastern Mediterranean sites in Lebanon, Cyrenaica and Turkey. All of the sites occur near the modern coastline. Apart from the Libyan site of Hagfet ed Dabba, the nearest sites from this time period containing this tool type are Abu Halka, Abri Antelias and Ksar 'Akil in Lebanon, all within 60 km of each other (Bar-Yosef 1994: 242). These tools occur in transitional Middle to Upper Palaeolithic assemblages. The site of Ksar 'Akil shows a transition from a unipolar Levallois technique to a unipolar blade core. At the transitional assemblages of Boker Tachtit (Israel), however, the transition is from a bipolar Levallois to a bipolar blade technique and chamfered pieces are lacking (Bar Yosef 1994). Recently a chamfered piece was found at an early Upper Palaeolithic site in coastal southern Turkey (Kuhn, Stiner & Gulec 1999). The type fossils of other transitional sites, such as Emireh points at Boker Tachtit, are missing from the Haua Fteah. Kuhn et al. (1999) introduce the term *Initial Upper Palaeolithic* for these early and transitional sites in the Eastern Mediterranean, but do not discuss the occurrence of this diagnostic tool at the Haua Fteah and Hagfet ed Dabba.

Importantly, all of these Initial Upper Palaeolithic sites containing chamfered blades occur relatively close to the modern shoreline.

Significant evidence of a direct transition from the Middle to Upper Palaeolithic is not found at the Haua Fteah, mainly because of the small number of artefacts at the transition from the Middle Palaeolithic to Early Dabban layers. The transition occurs at various sub-levels of layer XXV. There is some limited evidence of possible mixing at this interface. McBurney dismisses Levalloiso-Mousterian influences in the Dabban (1967: 125), but the current analysis shows a Levallois presence in several Early Dabban levels, including several cores and flakes at the Early/Late Dabban transition, where the assemblages are rich and less prone to accidental mixing. As in the case of the Levallois presence in the Pre-Aurignacian, these have been underreported due to McBurney's strict definition of Levallois. The Levallois flakes in the Dabban layers are almost exclusively sub-radial or radial in preparation and there are only two Levallois points and two Levallois point cores.

Chamfered pieces are absent from the earliest levels and occur only from layer XXII onward. Blades, endscrapers and backed knives do occur in the earliest levels and are technologically and typologically Upper Palaeolithic. The low numbers of tools and flakes in the late Middle Palaeolithic layers and the Earliest Dabban layers unfortunately preclude any detailed discussion of the possibility of a transitional assemblage at the site. The low numbers of artefacts suggest that the evidence for this transition occurred elsewhere. The earliest levels of the Dabban (XXV to XXIV) contain small, elongated blades and one Levallois flake. The rapid introduction of an Upper Palaeolithic true blade industry, without any direct technological precedents, further suggests that this technology was introduced rather than being indigenous to the site.

As Kuhn et al. (1999) state, one of the important features of the Initial Upper Palaeolithic is regional diversity in tool manufacture. Despite the shared characteristics of chamfered blades, Levallois points were common at Ksar 'Akil in the layers with chamfered blades, but are relatively rare at the Haua Fteah. Chamfered blades dominate the assemblages (55% of all tools in layer XXIII; Azoury 1986: 47) at Ksar 'Akil, but never account for more than 15% of any level at the Haua Fteah. Despite certain features common to Initial Upper Palaeolithic assemblages (e.g., true blades, backed knives and their geographic location), regional traditions tend to emerge simultaneously.

The timing of the Initial Upper Palaeolithic in this region is also broadly similar to and compatible with the early chronology set forth for the Early Dabban above. The earliest Upper Palaeolithic is generally accepted to have begun somewhere between 45 and 50 kya, with early dates from Boker Tachtit (ca. 47 kya, Marks 1983: 67 and ca. 50 kya, Mellars & Tixier 1989: 767). The proposed dates for the Early Dabban (between 50 kya and 42 kya) are similar to other dates for the Initial Upper Palaeolithic in the Eastern Mediterranean.

Non-Lithic Material

The site of Hagfet ed Dabba, the type site for the Dabban 35 miles (56 km) to the south-west of the Haua Fteah, provides supporting evidence that the Dabban shows "modern" behaviour. A number of worked bone tools were discovered at the site, compensating for the poor bone preservation at the Haua Fteah. Based on technological and typological comparisons, McBurney believed that the entire sequence at Hagfet ed Dabba was contemporaneous with layer XX as a whole at the Haua Fteah and crossed the Early to Late Dabban transition (McBurney 1967: 168). In the Late Dabban (beginning with layer XXa-d at the Haua Fteah), chamfered blades almost completely disappear and scrapers become more common than burins and backed blades. At Hagfet ed Dabba, Layers VII to IV are Early Dabban and III to II are Late Dabban. Although it may be problematic, a date of 42 kya (calibrated, see above) was made for layer III at Hagfet ed Dabba. Two bird ulnas from the Early Dabban are "severed with a clean grooved cut" and in the Late Dabban a bird bone is "worked into an awl or bodkin point by grinding" (McBurney & Hey 1955: 210). The most important bone artefact has a worked criss-cross pattern and although fragmentary is clearly non-random and arguably symbolic. Unfortunately McBurney & Hey do not state which layer this piece comes from. The inventory sheets at the end of the monograph show that level XX/XXI in the early Dabban contains eight decorated ostrich egg shells but no comment on this or on the significance of the worked bone at ed Dabba is made in either monograph. Both of these imply that the Early Dabban, by conventional definitions (e.g., as listed in McBrearty & Brooks 2000), exhibits several hallmarks of modern human behaviour, which occurs in the deteriorating climate of OIS 3. Unlike previous culture periods, the site did not appear to be abandoned during worsening glacial climates. There appears to be a different response to these climatic differences in the Upper Palaeolithic.

SUMMARY

Table I.5 summarises the chronological evidence available for the three cultural periods analysed at the Haua Fteah. Based on multiple lines of evidence, the Early Dabban likely dates to ca. 42 kya, the Middle Palaeolithic most likely dates from OIS 5e and the Pre-Aurignacian from OIS 7.

Table I.5. Summary of Chronological Evidence.

Cultural Designation	^{14}C	Sediments	Isotopes	Fauna	Cultural & Hominid Remains
Early Dabban	ca. 42,500 ya	Cooling with intermediate pluvial activity	Cooler and drier than now	Drier than Middle Palaeolithic	50 – 30 kya
Middle Palaeolithic	≥38,500 ya	Wet OIS 5a, 5c or 5e	Interglacial	Wet interglacial (OIS5a/c/e)	OIS 5e or 6
Pre-Aurignacian	n/a	Wet OIS 7 or 5e	Fully Interglacial	Wet fully interglacial (OIS 5e/7)	OIS 7

The Haua Fteah site is located in a unique environment on the Mediterranean coast. Climatic, faunal and archaeological evidence show the importance of Eurasian as well as African influences throughout the Middle and Early Upper Palaeolithic. McBurney (1967) noted Levantine influences in his original analysis and subsequent re-examination does not contest this.

The presence of Eurasian fauna in particular strengthens the probability of such links before the Last Glacial maximum. Affinities with coastal sites on the southeastern Mediterranean coast suggest that the Mediterranean Sea is a potentially more important geographical predictor of archaeological industries than the modern political designations of Asia, Africa or even Europe. Regionalism in archaeology remains a barrier to understanding the emergence of modern human behaviour. Such provincialism is perpetuated by studies such as that of McBrearty and Brooks (2000), who insist on using sub-Saharan African terminologies to explain North Africa. In the past, especially in arid times, the Sahara was as much, or potentially more, of a barrier to population movement as the Mediterranean Sea.

Two important points that have a bearing on explaining the cultural differences at the Haua Fteah need to be made concerning this site.

1. Prior to the Early Dabban the site appears to have been occupied in relatively warm, wet periods with ephemeral occupation or abandonment in cold arid times. In the Early Dabban, the site appears to be more intensely occupied in an unstable, deteriorating climate.
2. Despite the presence of morphological blades, the Pre-Aurignacian at the Haua Fteah shows no clear evidence of complex behaviour in terms of climatic occupation or in its lithic industries. The Pre-Aurignacian is likely much older than previously thought and may occur at the Lower to Middle Palaeolithic transition.

II. Multivariate Analyses of the Debitage from the Haua Fteah

The objective of the analysis of the lithic debitage from the Haua Fteah is to describe the nature of the differences between the three earliest *culture* types as defined by McBurney (1967). Due to the small number of artefacts in several levels in this sequence (see Table II.1), the analysis is restricted to examining the differences between the Pre-Aurignacian, Middle Palaeolithic and Early Dabban culture periods as categories. The categories used by McBurney were retained for the purposes of analysis to increase the sample sizes for each period, despite the differences between some layers. As discussed above, each culture period was dominated by a group of adjacent layers with abundant remains. The study focuses primarily on the comparison of metrical traits relating to the production of flake blanks. This technological component is also discussed in relation to the cores from which the flakes were removed.

An exploratory multivariate analysis was required in order to understand the nature of the technology and morphology of the debitage at the Haua Fteah. Many qualitative and quantitative approaches can be used in lithic analysis. In recent years the qualitative approach has come to the fore with refitting studies and the *chaîne opératoire* approach. One of the most difficult aspects of qualitative approaches is that they do not lend themselves to making extensive comparisons either within sites or across regions. Many studies are limited to a non-random selection of cores and their associated debitage. Conversely, most quantitative approaches involve hypothesis testing using a small number of variables to answer specific questions such as the nature and extent of lithic reduction, and morphological variation between assemblages. Although much more amenable to large-scale comparisons, these tests are often selective and lack a richness of information.

The current study of the debitage at the Haua Fteah involves a two-step approach. First, patterns in the data are explored using a large number of variables simultaneously. These variables cover a wide range of attributes including not only the standard metrical ones (length, width, etc.) but also several ordinal scales. These encapsulate some of the information that has become relevant in light of recent qualitative studies (e.g., the nature of preparatory removals in the production of a flake). Using multivariate statistics, these variables are broken down into a small number of meaningful units of analysis that explain the bulk of the differences between individual flakes and predefined categories.

Following this, a number of temporal and technological categories are presented and verified using discriminant analysis. These include the dominant technologies of each time period as well as the normal debitage. In the following chapter, the nature of the differences between these categories will be discussed with the aim of understanding the nature of change in the Palaeolithic levels of the Haua Fteah.

THE SAMPLE

Due to the large number of variables, differences in assemblage size, apparent gaps in the record, and the relatively large proportion of unretouched pieces, a sampling procedure was used for some levels. When the assemblage size was large, a sample of the total unretouched debitage was taken. The Pre-Aurignacian levels (defined as individual spits, following McBurney 1967) with unretouched flakes exceeding 50 pieces were sampled to approximately 50 and the Middle Palaeolithic and Early Dabban levels (combining multiple spits) exceeding 100 flakes were sampled to approximately 100. During analysis, some of the original sample was reclassified as broken pieces or as tools, resulting in variations in the sample size. The smaller sample for the Pre-Aurignacian levels was used because there were no level designations other than spits, the size of each assemblage was not as large, and there were more levels. Only complete flakes and cores were measured. To give an idea of the relative assemblage sizes, Table II.1 shows the total number of unretouched flakes, i.e., complete flakes + proximal flakes (a crude measure of the original number of flakes), and the number of flakes analysed for each level. In addition, an estimate of the total number of tools was made using the minimum number of tools (MNT) measure (Shott 2000), which is simply the sum of the complete tools and the highest proportion of the different fragment types (i.e., proximal, medial, or fragment by data class). All pieces smaller than 20 mm were not included in the analysis.

Table II.1. Artefact Counts by Level.

Level	Complete flakes	Proximal flakes	Flakes total	Analysed flakes	MNT	Complete tools	Cores
XXe (spit 55-93)	151	247	398	100	54	22	21
XX/XXI interface	517	571	1088	102	140	76	60
XXI/XXII	42	44	86	42	22	12	5
XXII	52	49	101	52	19	10	8
XXII-XXIV	15	5	20	15	5	2	1
XXIV	12	6	18	12	8	5	1
XXIV/XXV	2	1	3	2	4	2	0
XXVa-b	2	2	4	2	2	0	0
XXVc-d	8	7	15	8	6	3	0
Early Dabban	801	932	1733	335	260	132	96
XXV-XXVII	3	5	8	3	9	6	3
XXVII/XXVIII	8	8	16	8	7	4	2
XXIX-XXXI	5	9	14	5	5	1	2
XXXI/XXXII	37	58	95	37	9	3	3
XXXII/XXXIII	1602	663	2265	97	77	54	72
XXXIV/XXXV	534	512	1046	102	116	72	22
Top deep (spits 55-50/49)	16	25	41	16	11	5	1
Middle Palaeolithic	2205	1280	3485	268	234	145	105
55-58	0	0	0	0	0	0	1
55-59	3	6	9	3	1	0	1
55-60	0	0	0	0	1	1	2
55-68	0	5	5	0	0	0	1
55-69	4	55	59	4	2	1	0
55-170	108	132	240	52	8	5	4
55-171	252	123	375	60	14	11	4
55-172	204	45	249	66	15	8	5
55-173	110	67	177	53	9	8	4
55-174	161	8	169	50	18	13	4
55-175	19	22	41	19	3	3	2
55-176	56	0	56	56	3	3	0
55-178	1	0	1	1	0	0	0
Pre-Aurignacian	918	463	1381	364	74	53	28

THE VARIABLES

The variables used to describe the debitage can be divided into a number of subgroups. The first group of variables are essentially descriptive and include both nominal and ordinal data. As many of the descriptive categories as possible were put into ranked categories in order to be used in the following statistical analyses. Culture and technology were combined to create the techno-chronological categories that are tested below. The remaining categorical variables were all ordinal variables and were incorporated into the statistical analysis.

Table II.2. Descriptive (Categorical) Variables.

Variable	Description/ Categories
Culture	Pre-Aurignacian / Middle Palaeolithic/ Early Dabban
Technology	E.g., flake blade/Levallois/blade/normal
Amount of cortex	0%/1-10%/11-50%/51-90%/91-100%
Axis of the piece	0°/30°/60°/90°
Dorsal scar orientation	0-10 (ranked from unipolar = 1 to radial = 10)
Platform facets	0 = cortical/1 = plain or punctiform /2 = dihedral/ 3 = facetted/4 = chapeau de gendarme

The second group of variables are those that were measured on the debitage. These include mainly linear measurements (in millimetres), but also other measurements such as platform angle and the number of dorsal scars.

Table II.3. Measured (Continuous) Variables.

Variable	Description
Dorsal scars	The number of unambiguous dorsal scars (i.e., not retouch)
Exterior platform angle	The angle between the platform at the point of percussion and the dorsal surface
Length (axis)	The length along the longest, essentially symmetrical axis
Length (base to max. width)	The distance between the platform and the point of maximum width along the axis of the piece
Length (box)	The length of the smallest box oriented along the axis of percussion
Length (Jelinek)	The length of the piece from the point of percussion to the point furthest away from it on the flake (the length used by Jelinek, Dibble, and others, Debénath and Dibble 1994)
Platform thickness	The thickness of the platform at the point of percussion (if possible)
Platform width	The width of the platform perpendicular to the thickness
Sharpest length	The length of the longest sharp continuous edge that can be measured linearly
Thickness (axis)	The thickest point along the axis of the piece
Thickness (Jelinek)	The thickness at the intersection of the length and width lines
Thickness (max)	The maximum point of thickness
Weight	In grams
Width (axis)	The maximum thickness of the piece perpendicular to the length axis
Width (box)	The width of the smallest box enclosing the piece perpendicular to the axis of percussion
Width (distal)	The width of the piece at 1/4 of its length along the longest axis from the distal end
Width (Jelinek)	The width of the piece at the midpoint of and perpendicular to the Jelinek length

Width (middle)	The width of the piece at 1/2 of its length along the longest axis
Width (proximal)	The width of the piece at 1/4 of its length along the longest axis from the proximal end

A number of different length and width measurements were taken in order to determine comparisons between the different types of measurements (Debénath and Dibble 1994). Many studies do not describe in accurate detail what types of measurements were taken. Furthermore, both the box and Jelinek methods require an intact platform, which may not be possible due to minor post-depositional or other forms of damage. Each of the types of measurements measures a different thing. The measurements along and perpendicular to the axis (hereafter = axis) measure the morphology of the piece without regard to the dynamics of flaking. Both the box and the Jelinek measurements, however, do refer to the flaking. The box measurement is strictly aligned with the axis of percussion, whereas the Jelinek length measurement measures how far the force of the percussion spreads from the point of the impact. The differences between these measurements are shown in Figure II.1. The various width measurements at intervals along the axis (1/4, 1/2, etc.) were used in ratios and are derived from the biface measurements of Roe (1964) and Bordes (1961).

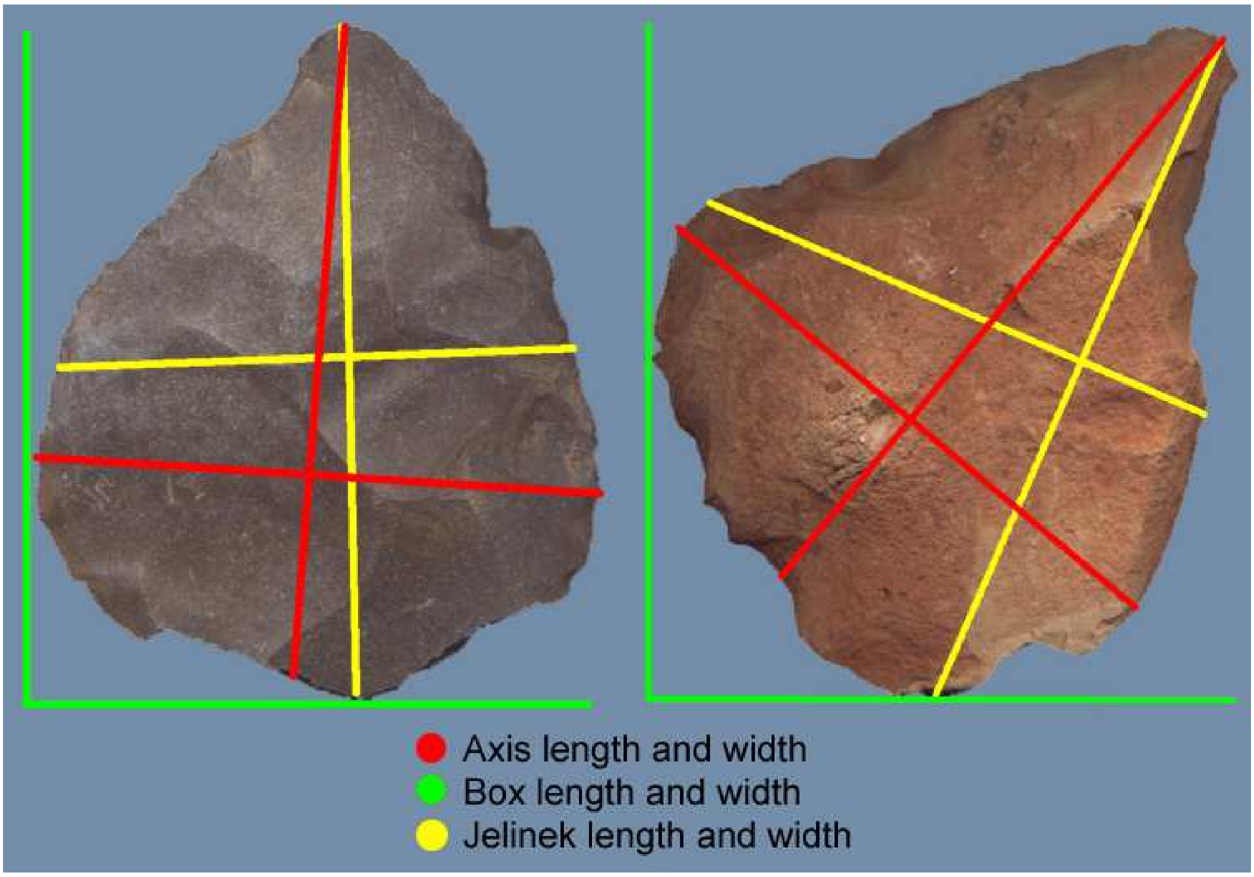


Figure II.1. Differences in Length and Width Measurements.

The final grouping of variables was calculated using a mathematical combination of the measured variables. They include many standard ratios in the literature (e.g., Bordes 1961, Roe 1964) and relate to the morphology of the piece.

Table II.4. Mathematical and Combination Variables.

Variable	Description
Elongation (axis)	Width/length (axis)
Elongation (axis)/elongation (box)	Elongation (axis)/(box); ratio to see to what extent these elongation measurements deviate
Elongation (box)	Width/length (box)
Elongation (Jelinek)	Width/length (Jelinek)
Length/weight	Length (axis)/ weight
Planform	Length base to max width/length (axis)
Platform area	Platform thickness x width
Pointedness	Width (distal)/width(proximal); the ratio of the tip to the base (for flakes ≥ 40 mm)
Refinement	Thickness (max)/width (max)
Scars/surface area	Number of dorsal scars/the surface area (see below)
Sharp/length (axis)	Sharpest length/length (axis); the proportion of the longitudinal axis that is sharp
Sharp/weight	The amount of cutting edge/gram
Surface area	If length ≥ 40 mm = the average of the distal middle and

	proximal width x length (axis). If < 40 mm = length (axis) x width
Thickness (axis)/thickness (max)	Measures the extent to which the thickness along the axis of the piece deviates from the maximum
Thickness (Jelinek)/thickness (max)	Measures the extent to which the Jelinek thickness deviates from the maximum
Uniformity	The sum of the difference between the distal, middle and proximal widths from the width along the axis/width axis (for flakes ≥ 40 mm)

The planform, pointedness, and refinement measurements are based on biface morphology ratios of Bordes and Roe. The elongation measurements were taken so that the ratio would be less than 1, that is, so that it was more amenable to data transformations (rather than length/width). Morphologically, if the elongation value is less than 0.5, the piece is a blade (i.e., it is twice as long as it is wide). However, in the case of box elongation, it is possible that the elongation is greater than 1. This would be a broad flake. As shown above, these different ratios measure different things. The comparison of the box and axis of elongation shows whether the axis of the piece is oriented with the axis of percussion. They will be the same or similar if the value is close to 1 (as would be the case for the flake on the left side of Figure II.1). The uniformity measurement is standardised by the width of the axis so that the deviations are relative to the width, making comparable ratios regardless of the dimensions of the piece.

Because many statistical analyses assume normal distributions for the variables used, a number of data transformations were employed. The purpose of these transformations is to convert the data from skewed or other non-normal distributions to those that best approach a normal (bell-curve) distribution. For each variable, the distribution was plotted and the best method of transformation was selected. In practice, this meant that log transformations, $z = \log(x)$, were often used for measured data such as length, width and weight, because in most cases these had a bias toward smaller numbers. In one case the exponential (exp) transformation, $z = 10^x$, was used. In the case of ratios the arcsine (asin) transformation, $z = \sin^{-1}\left(\sqrt{x}\right)$, was often used, because this is particularly suited to proportions (i.e., between 0 and 1; for a discussion of transformations see Baxter 1994: 45-46).

STATISTICAL ANALYSIS

The statistical approach taken in this chapter is exploratory and relies upon multivariate statistical approaches. The chronological element in this analysis is supplied by McBurney's classification of the assemblages into cultural groups, levels and their stratigraphic position. The primary chronological component will be a comparison of Pre-Aurignacian, Middle Palaeolithic and Early Dabban as inclusive categories. In addition, in the Early Dabban and Middle Palaeolithic levels, the bulk of the material was confined to a small number of adjacent assemblages with reasonable sample sizes. In addition to the chronological element, there are different technologies at the site. A combination of temporal and technological categories will be used to divide the data into useful categories. Some arbitrariness results from this method; however, the findings of the analysis, being exploratory and suggestive, do not suffer greatly from this. The categories will be tested to see if they are sufficiently homogenous as units of analysis.

TECHNOLOGY OF UNRETOUCHED FLAKES

The primary goal of the analysis is to describe how the flaking technologies (including flake-based tools) change through time. The first task in the analysis is to reduce a large amount of measured data to a smaller, conceptually coherent summary of that data, which can then be used to compare and contrast different categories of the data (see Baxter 1994). It was decided at the outset to use a large set of variables to measure the debitage so as not to be prejudiced by other analyses. The variables for comparisons in the subsequent chapter were not selected out of received wisdom; they were chosen because they explain as much of the variation in the sample as possible (using factor analysis) but also best account for the differences between the defined techno-chronological groups (using analysis of variance).

PRINCIPAL COMPONENTS AND FACTOR ANALYSIS

Factor analysis, or more precisely principal components analysis using rotation, accomplished the first task. The mathematical details of principal components analysis and factor analysis are too complex and detailed to discuss thoroughly; however, a brief summary of the basic ideas will aid in understanding the results.

The purpose of principal components analysis is to produce a relatively small number of uncorrelated linear equations, which summarise most of the relevant information in the original variables (Dunteman 1989: 10). These mathematical equations are derived using the correlations or covariations between the original variables. Initially the computer software creates as many linear equations as there are variables. The first linear equation calculated contains the largest proportion of variance in the sample. The next equation contains the next largest proportion of variance, but is uncorrelated with the previous equation. This process is repeated until there are as many equations as variables. Following this, a selection of the number of equations to retain is made. One can either choose the number of factors to retain, or make a selection of factors based on the amount of variance with which each factor is associated (its eigenvalue).

For each equation, each variable has a constant that weights its value in the equation. Based on this, the correlation coefficient between the variable and the equation can be calculated. These *loadings* provide a measure of the relative importance of each variable in each principal component (or factor). The amount of variance that the equation explains can also be expressed as a percentage of the total variance in the sample. Each equation extracted thus explains which variables contribute to that component or factor and the relative importance of the factor in explaining the overall variance. Variables that are strongly correlated with the same component are said to co-vary together or relate to the patterns in the data in a similar manner.

In addition, *principal components scores* for each case (artefacts in this instance) are calculated. They are simply the product of the equation described. This is important for comparing the cases (or categories of cases) in the data.

Principal components analysis can be used for the following tasks:

1) to reduce a large number of variables into a smaller set of variables;
2) to examine the relationships between the variables and how important they are in the structuring of the data; and

3) to examine the relationships between cases using a large number of variables simultaneously.

Once extracted, however, certain mathematical conditions of the original extraction can cause problems in interpretation, e.g., some variables may be correlated with more than one equation or the loadings may not be significantly high. In order to facilitate interpretation, the linear equations are rotated in *n* dimensional space away from the statistically optimal conditions of the initial calculations. This has the effect of making the loadings either large or small. Different methods of rotation can simplify the factors in different ways (Kinnear & Gray 2000). Varimax rotation does this by reducing the number of variables with high loadings on each factor. Quartimax rotation does this by reducing the number of factors with which each variable has high loadings. Other methods exist including Equamax, a combination of Varimax and Quartimax rotation. Rotation normally takes place only on the variables that are retained.

In addition to principal components analysis, several alternative methods of extracting the initial factors can be used. All of these methods generally fall under the banner of *factor analysis*; however, several authors consider principal components analysis to be distinct from factor analysis (Baxter 1994).

First Factor Analysis

Two factor analyses were conducted. In the first factor analysis, 39 continuous and ordinal variables were used from all complete unretouched flakes and flake-based tools. The variables included all of the various metrical attributes, all of the ratios used, and various technological attributes. Principal components analysis was the extraction method and Equamax rotation was used. Based on the proportion of variance that each equation represented, 10 components were chosen (eigenvalue ≥ 1 or approximately 2.5% of the variance). Together the first ten components account for 89% of the total variance in the sample (Table II.5).

Table II.5: Proportion of Variance by Factor.

Factor (component)	Percent of variance	Cumulative percent of variance
1	12.7	12.7
2	12.5	25.2
3	11.8	37.0

4	9.6	46.6
5	8.9	55.5
6	8.5	64.1
7	7.7	71.8
8	5.9	77.7
9	6.9	83.6
10	5.6	89.2

The first factor, accounting for approximately 13% of the variance, included two of the elongation measurements (axis and Jelinek) and several width measurements. Both elongation measurements had the highest loadings on this component (loadings less than .5 are not shown). The best interpretation for this factor would be that, given this set of variables, elongation accounted for the largest proportion of variation in the sample. Width is obviously an important component of elongation (= width/length) and is related to the entire data set in a similar way. Both elongation and width variables were positively correlated with this factor.

Table II.6. Factor Analysis 1 Loadings.

Variable/factor	1	2	3	4	5	6	7	8	9	10
Asin elongation (axis)	.831									
Asin elongation (Jelinek)	.757									
Log width (axis)	.664									
Log width (middle)	.649									
Log width (Jelinek)	.647									
Log width (proximal)	.642									
Log width (distal)	.629									
Log thickness (max)		.861								
Log thickness (axis)		.799								
Log refinement		.767								
Log thickness (Jelinek)		.745								
Log sharp/weight		-.647								
Log length/weight		-.628								
Log weight		.600								
Log sharpest length			.941							
Log length (Jelinek)			.787							
Log length (axis)			.784							
Log length (box)			.734							
Asin sharp/length (axis)			.670							
Log surface area			.539							
Log platform area				.864						
Log platform thickness				.814						
Log platform width				.788						
Exterior platform angle				-.644						
Axis of the piece					.900					
Asin elongation (axis)/elongation (box)					-.854					
Log elongation (box)					.816					
Log width (box)					.607					
Platform facets						.731				
Length (base to max width)							.924			
Asin planform							.871			
Asin uniformity								.836		
Asin pointedness								-.832		
Dorsal scars									.834	
Log scars/surface area									.713	
Amount of cortex									-.678	
Dorsal scar orientation									.636	
Asin thickness Jelinex/axis										.841
Exp thickness axis/max										.745

The second factor, also accounting for approximately 13% of the variance, included measurements for thickness, refinement (thickness/width), longest sharp edge/weight, length/weight and weight. All of these variables suggest the volume of the piece, and although weight does not have the highest loading on this factor, it is the most meaningful interpretation for this variable. This factor also suggests economy or efficiency in lithic production as length/weight and sharpness/weight are included. This also suggests that, because they are inversely correlated, low weight is correlated with this efficiency. The ratios sharpness/weight and length/weight have negative loadings because they are inversely correlated with weight.

The third factor, accounting for 12% of the variance, included various length and surface area measurements. Length is the dominant feature recorded in this variable. Included in this variable, however, were the sharpest length and the sharpest length/length, which is generally correlated with the length of the piece. This factor should be interpreted as length and the amount of sharp edge on the piece, because they are both positively correlated with this factor.

The fourth factor, representing about 10% of the variance, showed high loadings for variables associated with platform measurements. Platform area has the highest loading followed by platform thickness and width. Platform angle is inversely correlated with this factor; thus a high platform angle is correlated with a small platform area and vice versa. This factor should be thought of as representing platform size and potentially could indicate the flake striking technology employed. Large platforms tend to be associated with hard hammer platforms.

The fifth factor in this analysis, representing 9% of the sample variance, is best interpreted as the tilt of the piece, i.e., the angle differentiating the axis of the piece from the axis of flaking. The absolute value of this axis has the highest loading on this variable. The remaining values relate to the box elongation and box width measurements. The box measurement used was the length and width of the smallest rectangle in which the flake fits, with the length of the box parallel to the axis of flaking. In the case of the flake on the right of Figure II.1, the different length and width measurements differ because of the tilt, or axis of the piece. In the cases of broad or tilted pieces the box elongation (width/length) can be greater than 1. When the axis of flaking is in line with the axis of the piece, there should be few differences between the measurements. The box width, box elongation and the ratio between box and axis elongation are sensitive to the tilt of the piece, whereas the other width and elongation measures are not (by definition in the case of the axis measures) or less so (in the case of Jelinek measures). This factor thus indicates the role of the axis of the piece and potentially precision in the application of force, i.e., how well the axis of the piece aligns with the percussion forces.

Factor 6 only has significant loadings for the number of platform facets, with a loading of 0.731. This factor simply signifies the amount of platform preparation before flake removal. This factor accounts for 8.5% of the variance.

Factor 7, accounting for approximately 8% of the variance, has a loading of .924 for the length from base to maximum width and a loading of .871 for (asin) planform (length from base to max width/length). This variable can simply be interpreted as the planform of the piece. This variable is important in biface shape definitions (Roe 1964; Bordes 1961).

The eighth factor has high loadings for (asin) pointedness (distal width/proximal width; .836) and (asin) uniformity (the difference between the max width and the 1/4, 1/2 and 3/4 widths divided by the max width; -.832) and accounts for approximately 6% of the variance. This can be interpreted as the uniformity of the width of the piece.

The ninth factor (6% of the variation) has high loadings for the number of dorsal scars on the piece, the number of dorsal scars/surface area, the amount of cortex and the dorsal scar orientation. The last variable is a 10-point rank scale of dorsal scar orientation where 1 = unipolar and 10 = fully radial preparation of the flake. All of these variables indicate the complexity of core preparation before flake removal. This factor indicates the degree of predetermination of the flake.

The final factor selected relates to the relative location of the maximum thickness of the piece and accounts for 6% of the variation. The (asin) maximum thickness along the axis/maximum thickness (.841) and the (exp) Jelinek thickness/maximum thickness (.745) had the highest loadings.

The results of this factor analysis are summarized in Table II.7. The factor analysis also points to a number of further observations. One is that there is meaningful patterning in the data and the factors all point to conceptually parsimonious interpretations. However, the number of factors (likely a product of the large number of variables in the analysis) was high and several factors had large numbers of variables correlated to them. This suggests that much of the data present in the sample could be explained by a much smaller number of variables.

Table II.7. Factor Analysis 1 Summary.

Factor	Interpretation	% Variance
1	Elongation	12.7
2	Volume/efficiency	12.5
3	Length/efficiency	11.8
4	Platform size	9.6
5	Axis of piece/precision	8.9
6	Platform preparation	8.5
7	Planform	7.7
8	Uniformity	5.9
9	Core preparation	6.9
10	Thickness location	5.6

Second Factor Analysis

The second analysis excluded many of the primary measurement variables (such as length/width/thickness) because they were significantly correlated with a number of the ratios and with weight (which was retained). In this analysis, 20 variables were used and 6 factors were extracted using the same methodology as in the first analysis.

Table II.8. Factor Analysis 2 Loadings.

Variable/factor	1	2	3	4	5	6
Log weight	.968					
Log length/weight	-.955					
Log surface area	.880					
Log sharp/weight	-.849					
Log platform area	.780					
Log refinement		-.821				
Asin elongation (axis)		.785				
Asin elongation (Jelinek)		.706				
Platform facets						
Axis of the piece			.905			
Asin elongation (axis)/elongation (box)			-.845			
Log elongation (box)			.809			

Dorsal scars				.796		
Dorsal scar orientation				.677		
Amount of cortex				-.652		
Exterior platform angle				.582		
Asin pointedness					.877	
Asin uniformity					-.838	
Asin planform					.557	
Asin sharp/length (axis)						-.861

In the second analysis, many of the same interpretations as those reached in the first can be made; however, there are fewer factors. The first factor in this analysis corresponds to the second in the previous analysis and can be interpreted as volume and efficiency. The second factor shares with the first in the preceding analysis the interpretation of elongation. The third can be explained as the axis of the piece and the fourth as core preparation. The fifth factor combines the seventh and eighth factors in the first analysis and can be interpreted as the relative differences in width along the piece. The final factor consists of one variable, the ratio of the longest sharp length to the maximum (axis) length. This was a variable in the third factor of the previous analysis and may also be interpreted as efficiency because cases with a low score on this factor (the variable is negatively correlated with the factor) will have a higher proportion of cutting edge along the margin.

Table II.9. Factor Analysis 2 Summary.

Factor (component)	Interpretation	Analysis 1 factor	% Variance
1	Volume/efficiency	2	22.1
2	Elongation	1	13.7
3	Axis of piece/precision	5	13.1
4	Core preparation	9	10.4
5	Relative width	7/8	9.5
6	Efficiency (length)	3	7.3

The differences between the second and first analyses are that the number of platform facets was not significantly correlated with any of the factors (loading < .5) in the second analysis, but was a factor in the first analysis. In addition platform size, a factor in the first analysis, merges with volume and efficiency in the second analysis and the tenth factor in the first analysis, thickness location, was not a factor in the second analysis because of variables not included. Although the total amount of variance captured in the six factors in the second analysis (76%) is less than that in the ten in the first analysis (89%), very similar interpretations arise from these analyses.

DEFINING TECHNOLOGICAL AND CHRONOLOGICAL CATEGORIES

The factor analyses describe the nature of the variance in the data set. To understand how the data differ through time, however, categories of data were used. At the site there were three primary flaking technologies: *flake blade, Levallois, and blade* technology.

Flake blade technology can be defined as any morphological blade (twice as long as it is wide), with essentially parallel flaking scars and large, thick bulbed platforms. The large platforms and bulbs indicate the probable use of percussion techniques similar to normal debitage (probably a hammer stone, or possibly bone or antler, see Inizan, Reduron-Ballinger, Roche & Tixier 1999). This technology was primarily associated with the Pre-Aurignacian levels.

Levallois technology is in many ways the defining technological strategy of the Middle Palaeolithic throughout Western Eurasia and much of Africa. Although widely used, the definition of Levallois technology is notoriously idiosyncratic. Bordes' (1961: 14) initial definition was a technique that results in the production of a "flake of a form predetermined by special preparation of the core prior to the removal of that flake". The most persuasive recent discussion of Levallois technology however is that of Boëda (1994). In his definition, he distinguishes several methods (such as recurrent and lineal) of producing Levallois flakes citing the central "Levallois concept," which focuses upon a volumetric conception of the core that limits the area of flake production to the top of the core surface. This concept is based on experimental and detailed refitting of debitage to the core. One of the problems with Boëda's definition of the Levallois concept, however, is that it is difficult to apply to flakes without the painstaking process of refitting. Attributing Levallois technology to a single flake will always remain subjective; essentially, one must see evidence that a Levallois strategy was employed in the production of the flake. Characteristics of Levallois flakes include significant preparation of the dorsal surface, distal convexity, platform preparation, relative breadth and relative thinness. Not all of these traits need be present for it to be considered Levallois, but the flake must have been created using a predetermined strategy (again a largely subjective criterion). A subsidiary aim of the present analysis is to provide a quantitative expression of the qualitative category Levallois.

The most basic definition of a blade is that it is at least twice as long as it is wide (Bordes 1961: 6). This is a morphological definition, however, not a technological one. A classic blade from the Upper Palaeolithic is one that is not only twice as long as it is wide, but also has parallel flake scars and essentially parallel edges (Bordes 1961). Upper Palaeolithic blades are either made using soft hammer or indirect percussion and thus have small, often punctiform platforms. As such, the primary distinction between a flake blade and a blade in the present analysis is the relative size of the platform, and by extension the inferred nature of the percussion used to produce the blade. Separating these two techniques will prove fruitful in determining the similarities and differences between them.

One of the problems with technological categories is that there is not a perfect correspondence between culture period and technological type. This problem is greatest with Levallois technology because although it is most clearly associated with the Middle Palaeolithic levels, it occurs in significant proportions in all of the cultural periods (Figure II.2). One of the most interesting aspects of Levallois technology at the Haua Fteah is that it is present throughout the three culture periods under analysis, thus providing some level of continuity throughout the sequence. It shares low proportions with flake blades in the Pre-Aurignacian levels, becomes the dominant technology in the Middle Palaeolithic, and although present becomes overshadowed by blade technology in the Early Dabban. Although divided into only three periods, this pattern is reminiscent of the type of stylistic change used in seriation analysis, where a specific form "gradually increases in frequency, hits a peak of popularity, and then gradually disappears from the cultural scene" (Knudson 1978: 176).

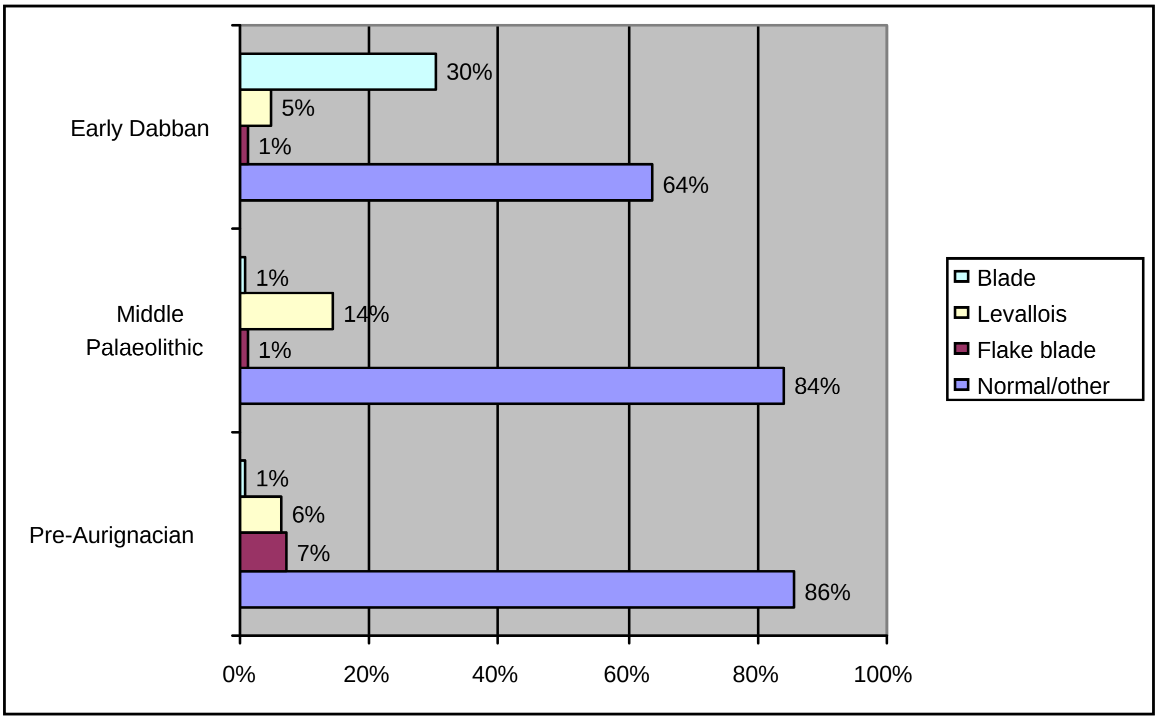


Figure II.2. Technological Type by Culture Period.

The occurrences of flake blades and blade technology at 1% in some levels could easily be interpreted as chance encounters. Flakes may appear to have been created by a specific technique, but in fact were not. In some cases it is impossible to tell for certain without the aid of refitting (as is the subjective nature of inferring technology from debitage alone). Other possibilities may include accidental mixing of materials during excavation. If, however, there were significant post-depositional mixing of layers, there should have been a greater proportion of these chance encounters.

The remaining category of flakes, the "normal and other" category, is a combination of ad-hoc flakes, core preparation flakes, trimming flakes and rare technological types that occur in very low proportions at this site (such as Clactonian flakes).

It is important to note that it is not until the Early Dabban that the technologically defined pieces (i.e., blades and Levallois) make up a significant component of the assemblage. There are several possible explanations for this, such as differences in spatial patterning or lithic transportation to or from the site. However, the presence of cores and a significant number of normal flakes (i.e., ad-hoc or preparatory flakes) suggest that lithic production was done on site and in the excavated area. In the absence of detailed spatial analysis, blade production in the Early Dabban probably resulted in a larger number of technologically defined tools (as opposed to preparatory flakes) than in the proceeding culture periods.

Because of the lack of correspondence between technology and culture, especially in the Levallois case, the categories created to compare the different technologies at the site are a combination of technological and chronological categories. The categories used are blade, flake blade, Levallois, normal Early Dabban (ED), normal Middle Palaeolithic (MP) and normal Pre-Aurignacian (PA). The only category that is not strictly chronological is the Levallois category. It must be remembered, however, that behaviours are not necessarily bounded by temporal or cultural designations. It is just as important to understand the nature of the Levallois phenomenon as a whole as to divide it into further sub-categories. The latter option also has the statistical disadvantage of creating smaller sample sizes.

ANALYSIS OF THE VALIDITY OF THE CATEGORIES DEFINED

Before describing the differences between the groups, it remained to be seen whether the qualitatively defined techno-chronological categories represented quantitatively real categories. Discriminant analysis was performed on both sets of factor scores produced in the preceding analyses.

A factor score is the solution of the linear equation derived from the factor analysis for each case (i.e., each flake). Discriminant analysis, like factor analysis, explains the variance in the sample. Rather than looking strictly at the variance in the overall sample, however, it explains the variance in terms of pre-assigned categories (Klecka 1980). The coefficients of the equations are produced so that the means for each category are as different from each other as possible. In doing this, the variance between the groups is maximised and the variance within each group is minimised.

Discriminant analysis can show which variables explain the differences between the groups. The most useful application of discriminant analysis is to develop a predictive model of group membership on the basis of the equations produced. The scores for each case are compared to the means for each group and then reclassified according to their predicted category membership. This results in a classification table.

Using the scores from the first factor analysis, for the whole set of artefacts 69.5% are correctly classified. However, there is an important distinction between the defined technological categories and the remaining, so-called normal categories. Blades, Levallois and flake blades are better classified using this predictive model, with scores of 100, 85 and 91% respectively. The normal Early Dabban, normal Middle Palaeolithic and normal Pre-Aurignacian are less well defined with scores of 80, 50 and 61%, respectively. It is also important to note that within the normal categories, in most instances, an individual piece is more likely to be assigned to another normal category than a defined technological type. Furthermore, none of the pieces that were classified as belonging to one of the defined types were reclassified as belonging to a normal category (Table II.10).

When the scores from the second factor analysis are used a similar pattern emerges with blades, Levallois and flake blades having high predictive scores of 100, 92 and 78%, respectively. The normal Early Dabban, Middle Palaeolithic and Pre-Aurignacian categories have scores of 69, 56 and 56% respectively. As with the previous analysis, the technologically defined and normal categories are to a large extent exclusive of each other (Table II.11).

Before proceeding, we can conclude that the technological categories are well defined for the purposes of comparison and there are important chronological differences within the normal categories, although the normal categories are all more similar to each other than to the defined technological categories.

Table II.10. Predicted Technology using Discriminant Analysis on Factor Analysis 1 Scores.

				Predicted				
	Technology	Blade	Flake blade	Levallois	Normal ED	Normal MP	Normal PA	Total
Original count	Blade	6	0	0	0	0	0	6
	Flake blade	1	11	1	0	0	0	13
	Levallois	0	2	20	0	0	0	22
	Normal ED	0	2	0	12	0	1	15
	Normal MP	0	1	5	7	18	5	36
	Normal PA	1	4	1	2	6	22	36
	Ungrouped cases	2	4	6	13	15	12	52
Original percentage	Blade	100.0	.0	.0	.0	.0	.0	100.0
	Flake blade	7.7	84.6	7.7	.0	.0	.0	100.0
	Levallois	.0	9.1	90.9	.0	.0	.0	100.0
	Normal ED	.0	13.3	.0	80.0	.0	6.7	100.0
	Normal MP	.0	2.8	13.9	19.4	50.0	13.9	100.0
	Normal PA	2.8	11.1	2.8	5.6	16.7	61.1	100.0
	Ungrouped cases	3.8	7.7	11.5	25.0	28.8	23.1	100.0

Table II.11. Predicted Technology using Discriminant Analysis on Factor Analysis 2 Scores.

				Predicted				
	Technology	Blade	Flake blade	Levallois	Normal ED	Normal MP	Normal PA	Total
Original Count	Blade	6	0	0	0	0	0	6
	Flake blade	1	12	0	0	0	0	13
	Levallois	0	4	18	0	0	1	23
	Normal ED	0	2	0	11	2	1	16
	Normal MP	0	5	4	6	17	5	37
	Normal PA	0	6	2	5	4	22	39
	Ungrouped cases	1	10	8	5	19	9	52
Original Percentage	Blade	100.0	.0	.0	.0	.0	.0	100.0
	Flake blade	7.7	92.3	.0	.0	.0	.0	100.0
	Levallois	.0	17.4	78.3	.0	.0	4.3	100.0
	Normal ED	.0	12.5	.0	68.8	12.5	6.3	100.0
	Normal MP	.0	13.5	10.8	16.2	45.9	13.5	100.0
	Normal PA	.0	15.4	5.1	12.8	10.3	56.4	100.0
	Ungrouped cases	1.9	19.2	15.4	9.6	36.5	17.3	100.0

SUMMARY

The main purpose of this chapter was to simplify the units of comparison for the analysis of the debitage in the Middle and Early Upper Palaeolithic levels at the Haua Fteah. After discussing the nature of the sample and the variables used, two factor analyses were conducted which both reduced the number of variables used and described which factors best explained the variance in the sample. One factor included the variables as measured and various ratios and the other removed several variables strongly correlated with the ratios used. The resulting factors form the basis of the units of comparison in the following chapter.

A second goal of this chapter was to define a set of techno-chronological groups to be compared in the next chapter. Six groups were created. Three represented the dominant technology of each time period (blade, Levallois and flake blade) and three represented the normal, preparatory and unclassified debitage from each time period (normal ED, normal MP and normal PA). In practice, the dominant technologies to a greater (in the case of Levallois) or lesser degree (flake blades and blades) crosscut the time periods, but it was decided to use these groups both because they increase sample size and because there is not a perfect correspondence between culture period and technological type. A final discriminant analysis was conducted which assessed the validity of these groups. This showed that the technologies (blade, Levallois and flake blade) were well defined and that the normal categories, although less well defined, were suitable for purposes of comparison.

III. Analysis of the Differences between Categories of Debitage

In the preceding chapter, a set of multivariate exploratory analyses showed that the variables measured on the debitage from the Haua Fteah formed a number of correlated groups and that the considerable number of variables could be explained in a simpler, more conceptually coherent way. The factors were then used to test the validity of the techno-chronological groups defined for the purpose of comparison. These exploratory multivariate analyses, however, are not particularly well suited for describing the nature of the differences between the categories in question. The factors produced are heavily derived and are often difficult to interpret. The current chapter takes the analysis further and describes the differences between the defined categories so that the nature of the changes across time and technological tradition can be detailed more thoroughly.

This chapter will determine which of the factors best explain the differences between the techno-chronological categories of debitage. They then will be broken down into conceptually (as opposed to just statistically) related groups of variables. A hypothesis testing procedure will be used for each of the variables discussed. Simply put, the hypothesis is that the groups do not differ in terms of the variables used. If they do differ, the nature of these differences will be discussed and compared with the cores. Finally, the distribution of the conceptual modes across the techno-chronological categories will be used to build a chronological sequence that is amenable to interpretation in the following chapters.

Comparing Technological and Chronological Categories

Having defined and analysed the validity of the categories, it is important to compare the technological and chronological categories and provide a description of the nature of the differences between them. The first step is to compare the factor scores using analysis of variance (ANOVA) and to define a conceptual model of the differences before turning back to the original variables to describe the differences in detail.

The factor scores were compared to see which of them accounted for the greatest differences between the groups. An ANOVA was carried out on the factor scores for the first analysis. The flakes were broken down into the categories mentioned above. The results of the ANOVA of the factors from the first analysis are presented in Table III.1. At a significance level of .05, only seveb of the factors from the first analysis showed differences between the technological categories. Using the *F* statistic (a comparison of the group variances) the factors can be ranked in terms of the degree to which the groups differ. A high value of *F* indicates a greater significance level (see Table III.2).

Table III.1. Analysis of Variance for Factor Analysis 1.

Factor score	**Variance**	**Sum of squares**	**Degrees of freedom**	**Mean square**	***F***	**Signifi-cance**
1 (elongation)	Between groups	21.103	5	4.221	5.126	.000
	Within groups	100.448	122	.823		
	Total	121.550	127			
2 (volume/ efficiency)	Between groups	18.374	5	3.675	4.569	.001
	Within groups	98.120	122	.804		
	Total	116.494	127			
3 (length/ efficiency)	Between groups	21.023	5	4.205	5.687	.000
	Within groups	90.198	122	.739		
	Total	111.222	127			
4 (platform size)	Between groups	12.621	5	2.524	2.447	.038
	Within groups	125.845	122	1.032		
	Total	138.466	127			
5 (axis of piece)	Between groups	7.987	5	1.597	1.667	.148
	Within groups	116.878	122	.958		
	Total	124.865	127			
6 (platform preparation)	Between groups	19.227	5	3.845	4.975	.000
	Within groups	94.303	122	.773		
	Total	113.529	127			
7 (planform)	Between groups	13.237	5	2.647	2.305	.049
	Within groups	140.141	122	1.149		
	Total	153.378	127			
8 (uniformity)	Between groups	3.044	5	.609	.711	.616
	Within groups	104.417	122	.856		
	Total	107.461	127			
9 (core preparation)	Between groups	27.222	5	5.444	6.365	.000
	Within groups	104.359	122	.855		
	Total	131.581	127			
10 (thickness location)	Between groups	9.857	5	1.971	2.085	.072
	Within groups	115.365	122	.946		
	Total	125.222	127			

Table III.2. Significant Factors Ranked (Analysis 1).

Factor	Interpretation	*F*	Significance
9	Core preparation	6.365	.000
3	Length/sharpness	5.687	.000
1	Elongation	5.126	.000
6	Platform preparation	4.975	.000
2	Volume/efficiency	4.569	.001
4	Platform size	4.569	.038
7	Planform	2.305	.049

Although in the first factor analysis core preparation accounted for only approximately 6% of the variance in the sample, it accounts for the greatest differences between the groups. Length and sharpness come second, followed by elongation, platform preparation, volume/efficiency, platform size and planform. The ANOVA for the second group of factors shows similar features (Table III.3). The first three factors in both analyses correspond, but are ranked in a different order of significance (Table III.4). Elongation, core preparation and the sharpness to length ratio (efficiency) have the highest significance in both studies.

Table III.3. Analysis of Variance for Factor Analysis 2.

Factor score	Variance	Sum of squares	Degrees of freedom	Mean square	*F*	Signifi-cance
1 (volume/ efficiency)	Between	12.265	5	2.453	2.439	.038
	Within groups	128.743	128	1.006		
	Total	141.008	133			
2 (elongation)	Between	35.755	5	7.151	9.285	.000
	Within groups	98.584	128	.770		
	Total	134.339	133			
3 (axis of piece)	Between	12.495	5	2.499	2.568	.030
	Within groups	124.586	128	.973		
	Total	137.081	133			
4 (core preparation)	Between	35.017	5	7.003	8.484	.000
	Within groups	105.666	128	.826		
	Total	140.683	133			
5 (relative width)	Between	7.703	5	1.541	1.832	.111
	Within groups	107.628	128	.841		
	Total	115.331	133			
6 (length/	Between	20.195	5	4.039	5.274	.000

efficiency)	Within groups	98.035	128	.766
	Total	118.231	133	

Table III.4. Significant Factors Ranked (Analysis 2).

Factor	**Interpretation**	***F***	**Significance**
2	Elongation	9.285	.000
4	Core preparation	8.484	.000
6	Length/efficiency	5.274	.000
3	Axis of Piece	2.568	.030
1	Volume/Efficiency	2.439	.038

When we compare the results of the ANOVAs from both factor analyses, we see that four significant factors with similar interpretations are shared. Three of these four are the three most significant factors in the ANOVA: core preparation, elongation and sharpness/length (efficiency). The fourth factor is the volume/efficiency factor. To simplify the interpretations of these groups and to summarise the information, three conceptual modes can be defined (Table III.5).

Each conceptual mode is a different way of conceiving of a piece of debitage. The notion of modes does not refer to Clark's (1977) ideas, but rather to the statistical sense of a common central tendency. The modes represent a clustering of attributes that describe a behavioural tendency. It is conceptual in a dual sense, both in terms of analysis and in terms of the fact that the modes represent aspects of debitage production that the maker is likely aware of to some extent.

All of the significantly variable factors from these analyses can be accounted for by using these conceptual modes. The first conceptual mode is core preparation or *technological complexity*. The more complex the core preparation is, the greater the number of preparatory steps is required to produce the desired flake. In other words, the flake has a longer chaîne opératoire. The second conceptual mode is basically *shape* and more specifically the elongation of the piece. The third is *efficiency*, the amount of cutting edge produced per unit of flint (whether length or weight). This combines the two factors discussed above. These three modes correspond to classic features in the archaeological debate, namely, behavioural complexity, form and function.

Table III.5. Conceptual Modes.

Conceptual mode	Description	Factor (Analysis 1)	Factor (Analysis 2)
1	Technological complexity	9/6	4
2	Shape	1/7	2/3
3	Efficiency/size	3/2/4	6/1

CONCEPTUAL MODE 1 - TECHNOLOGICAL COMPLEXITY

The variables common to Factors 9 and 4 from the first and second factor analyses respectively are the number of dorsal scars, the orientation of the dorsal scars, and the amount of cortex. Although not represented in any of the factors from Factor Analysis 2, Factor 6 (the number of platform facets) is both significant and conceptually related to the notion of technological complexity and core preparation. These four variables were chosen to describe the differences in complexity between the categories. Other than the number of dorsal scars, these variables are ordinal. For each variable, an ANOVA was used with a Student-Newman-Keuls (S-N-K) post-hoc test. The S-N-K test produces a set of Homogeneous subsets, which were tested at a probability of .05. ANOVAs are relatively tolerant of deviations from normality; however, the results of the tests were compared with non-parametric tests to ensure statistical validity.

Number of Dorsal Scars

A box plot of the different technological categories for the number of dorsal scars is shown in Figure III.1 and the results of the S-N-K tests are shown in Table III.6. The ANOVA for the number of dorsal scars is significant at $p = .000$ ($F = 39.686$, $df = 5$). In the S-N-K table, the mean number of dorsal scars is shown for each technological category in rank order from lowest to highest. This S-N-K test shows that the Levallois, blade and normal Early Dabban groups are all significantly different from each other and the remaining categories and that normal Pre-Aurignacian, normal Middle Palaeolithic and flake blades form a Homogeneous subset (the differences between these categories are not significant).

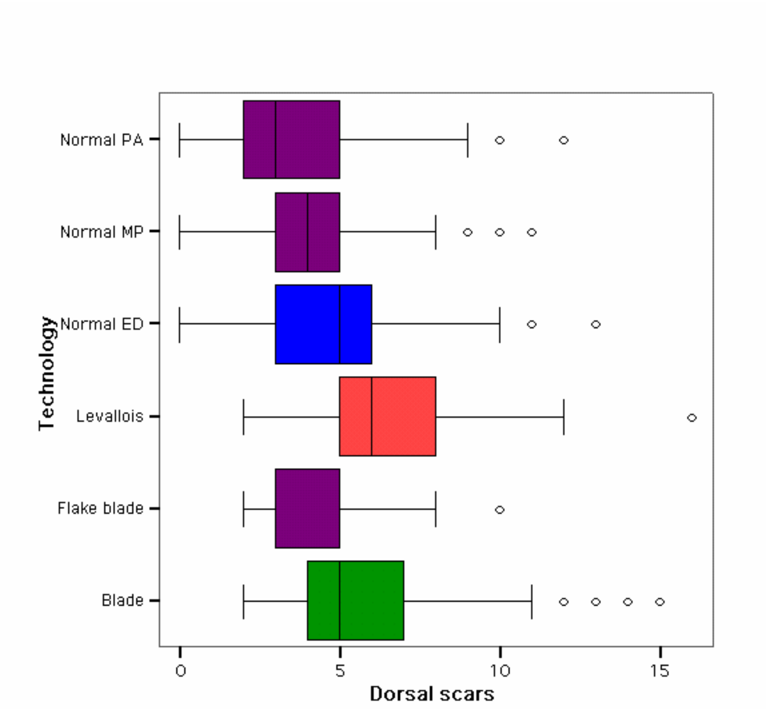


Figure III.1. Box Plot of Number of Dorsal Scars by Technology.

Table III.6. Homogeneous Subsets (S-N-K) for Number of Dorsal Scars.

Technology	***n***	**1**	**2**	**3**	**4**
Normal PA	295	3.57			
Normal MP	216	4.14			
Flake blade	33	4.15			
Normal ED	206		5.05		
Blade	106			5.83	
Levallois	77				6.78
Significance		0.165	1	1	1

A set of M-W (M-W) tests (a non-parametric test that decides whether a pair of groups belongs to the same population by comparing the distributions of the variable for each group) was used to make pair-wise comparisons of each technological category. Table III.7 shows which categories are statistically distinct from each other (at a level of $p = .05$).

Table III.7. Pair-wise M-W Tests for Number of Dorsal Scars.

	Normal PA	Normal MP	Flake blade	Normal ED	Blade	Levallois	Mean
Normal PA	-	.001	.405	.000	.000	.000	3.57
Normal MP	.001	-	.408	.000	.000	.000	4.14
Flake blade	.405	.408	-	.004	.000	.000	4.15
Normal ED	.000	.000	.004	-	.159	.000	5.05
Blade	.000	.000	.000	.159	-	.000	5.83
Levallois	.000	.000	.000	.000	.000	-	6.78

This table supports a number of the findings of the S-N-K test because Levallois is distinct from the remaining groups. The M-W test, however, suggests that blades and normal Early Dabban flakes are not distinct from each other in terms of the distributions of the number of dorsal scars. As in its parametric equivalent, normal PA, normal MP and flake blades seem to form a subset, although normal Pre-Aurignacian appears to be distinct from normal Middle Palaeolithic. This corresponds to the low significance of the Homogeneous subset in the S-N-K test (p = .165).

In terms of the number of dorsal scars, a crude measure of the length of the chaîne operatoire, Levallois technology is the most complex, with a mean of 6.78 scars per flake. It is statistically distinct from all of the remaining categories on this variable. Blades and normal Early Dabban, both found exclusively in the Early Dabban levels, appear to share the next highest level of complexity although they are statistically distinct (M-W p = .159). They have means of 5.83 and 5.05 scars, respectively. The remaining normal flakes and flake blades share a level of complexity, with normal Pre-Aurignacian having a different distribution from normal Middle Palaeolithic. This group averages around 4 scars each.

Dorsal Scar Orientation

Dorsal scar orientation is an ordinal variable that measures the complexity of the orientation of the dorsal scars. This variable was recorded using the categories described in Table III.8 (this is a ranked modification of Ashton & McNabb 1996: 243). The ranking takes into consideration the dorsal scar pattern in relation to the axis of flaking. In each category the first number in parentheses indicates the number of different directions of flaking on the dorsal surface, and the second indicates the number of different directions including the axis of flaking. The ranking also takes into consideration the differences between lateral and opposed flaking, with lateral flaking given a higher ranking (giving sub-radial preparation a higher rank score). An ordinal measure, going from unipolar to radial flaking, is thus created.

Table III.8. Ranked Dorsal Scar Patterns.

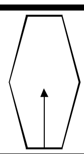
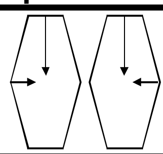
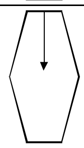
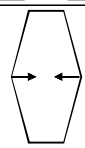
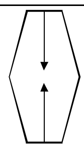
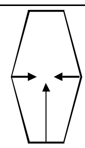
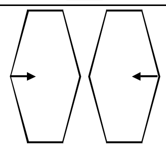
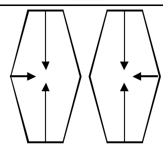
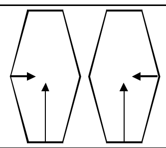
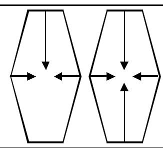
Ranked category	**Dorsal scar patterns**	**Ranked category**	**Dorsal scar patterns**
1- Unipolar (1)		6- Sub-radial opposed (2/3)	
2- Opposed (1/2)		7- Bilateral (2/3)	
3- Bipolar (2/2)		8- Sub-radial (3/3)	
4- Lateral (1/2)		9- Sub-radial opposed (3/3)	
5- Sub-radial (2/2)		10- Radial (3/4; 4/4)	

Table III.9 shows the S-N-K Homogeneous subsets for this ranked category. The ANOVA test resulted in a significance of $p = .000$ ($F = 28.527$, $df = 5$). This statistic distinguishes three groups and presents their mean scores. As before, an M-W test was conducted to compare the distributions (Table III.10). As in the S-N-K test the only two technologies which are unique from the remainder are flake blades and Levallois.

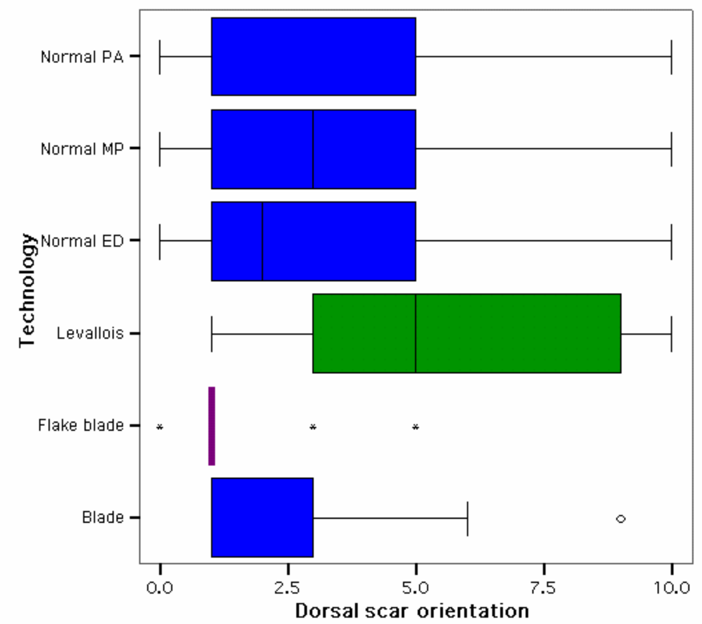


Figure III.2. Box Plot of Dorsal Scar Orientation by Technology.

Table III.9. Homogeneous Subsets (S-N-K) for Dorsal Scar Orientation.

Technology	*n*	1	2	3
Flake blade	33	1.52		
Blade	106		2.43	
Normal PA	295		2.70	
Normal ED	207		3.09	
Normal MP	216		3.15	
Levallois	77			6.05
Significance		1.000	.195	1.000

Table III.10. Pair-wise M-W Tests for Dorsal Scar Orientation.

	Flake blade	Blade	Normal PA	Normal ED	Normal MP	Levallois	Mean
Flake blade	-	.038	.016	.001	.001	.000	1.52
Blade	.038	-	.458	.031	.018	.000	2.43
Normal PA	.016	.458	-	.053	.031	.000	2.70
Normal ED	.001	.031	.053	-	.931	.000	3.09
Normal MP	.001	.018	.031	.931	-	.000	3.09
Levallois	.000	.000	.000	.000	.000	-	6.05

To summarise this variable, the means, medians and modes of the categories (Table III.11) can be examined to describe the dominant dorsal scar orientation for each technology. Both of the blade technologies tend towards a unipolar scar orientation, with a secondary emphasis on bipolar reduction. They may be more varied, however, with occasional sub-radial pieces (due to the use of a *lamecrette* core preparation; see below). All of the normal pieces across the temporal divisions have similar patterns and should be treated as a group. They are all predominantly unipolar, with sub-radial patterns as the secondary emphasis. The Middle Palaeolithic pieces have a higher proportion of sub-radial pieces than the remainder. Finally, various forms of the sub-radial predominate among Levallois pieces, although bipolar and radial are also found in significant proportions (not shown on table). The distributions are shown in a box plot (Figure III.2).

Table III.11. Measures of Central Tendency Dorsal Scar Orientation by Technology.

Technology	Mean	Median	Mode (1)	Mode (2)
Flake blade	1.52	1	1 (73%)	3 (21%)
Blade	2.43	1	1 (60%)	3 (20%)
Normal PA	2.70	1	1 (44%)	5 (21%)
Normal ED	3.09	2	1 (42%)	5 (25%)
Normal MP	3.15	3	1 (43%)	5 (30%)
Levallois	6.05	5	5 (23%)	9 (21%)

Amount of Cortex

The amount of cortex was also measured in ranked categories. In the statistics a value of 1 indicated no cortex, 2 indicated 1-10%, 3 indicated 11-50%, 4 indicated

51-90% and 5 indicated 91-100% cortex. The ANOVA for this variable resulted in *p* = .000 (*F* = 11.346, *df* = 5). The S-N-K test divides the technologies into two groups (Table III.12). The defined technological types (Levallois, blade and flake blade) all have means near 1 (no cortex), whereas the *normal* types all have means closer to 2 (1-10%). In other words, the defined technological types tend to have little if any cortex, whereas the normal types tend to have more. The M-W test (Table III.13) further distinguishes Levallois as being distinct from the rest of the group due to an almost complete lack of cortex. Flake blade technology also appears to be less distinct from the normal categories than the other defined technological types, although it is statistically exactly at *p* = .05 (M-W).

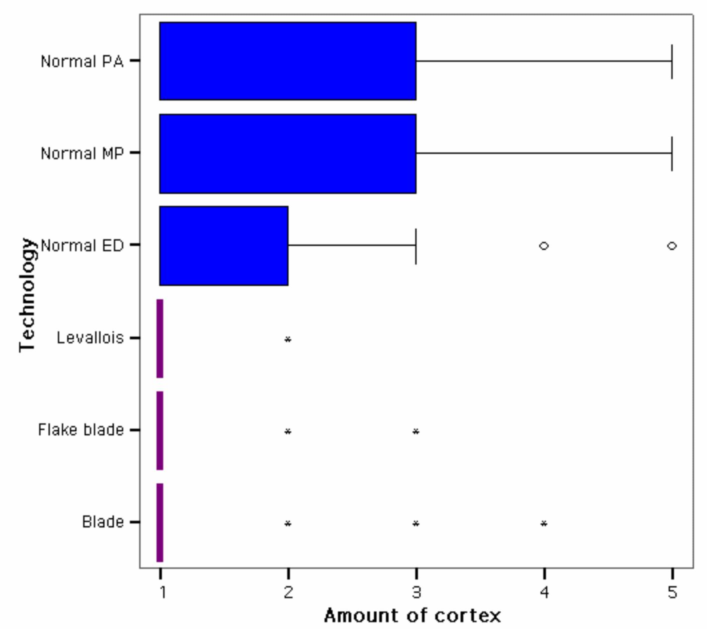


Figure III.3: Box Plot of Amount of Cortex by Technology.

Table III.12. Homogeneous Subsets (S-N-K) for Amount of Cortex.

Technology	*n*	1	2
Levallois	77	1.03	
Blade	105	1.25	
Flake blade	33	1.27	
Normal ED	205		1.68
Normal PA	291		1.74
Normal MP	215		1.78
Significance		.211	.779

Table III.13. Pair-wise M-W Tests for Amount of Cortex.

	Levallois	Blade	Flake blade	Normal ED	Normal PA	Normal MP	Mean
Levallois	-	.004	.001	.000	.000	.000	1.03
Blade	.004	-	.491	.000	.000	.000	1.25
Flake blade	.001	.491	-	.050	.037	.022	1.27
Normal ED	.000	.000	.050	-	.763	.459	1.68
Normal PA	.000	.000	.037	.763	-	.629	1.74
Normal MP	.000	.000	.022	.459	.629	-	1.78

Table III.14. Measures of Central Tendency for Amount of Cortex by Technology.

Technology	Mean (rank)	Median (% cortex)	Mode (1)	Mode (2)
Blade	1.25	0%	0% (85%)	1-10% (8%)
Flake blade	1.27	0%	0% (79%)	1-10% (15%)
Levallois	1.03	0%	0% (97%)	1-10% (3%)
Normal ED	1.68	0%	0% (64%)	11-50% (18%)
Normal MP	1.78	0%	0% (62%)	11-50% (19%)
Normal PA	1.74	0%	0% (64%)	11-50% (18%)

In summary, the defined technological types have little cortex, whereas the normal categories have a statistically greater proportion of cortex (see Figure III.3 for the distributions). This is simply the distinction between primary flakes and secondary flakes. A significant number of the normal flakes come from the initial stages of core reduction (over 25% of normal flakes in all time periods have greater than 10% cortex). The defined technological types, however, tend to be produced after the bulk of the cortex has been removed (less than 8% of the defined types have greater than 10% cortex and none are all cortical (Rank 5; Table III.14, Figure III.3).

Platform Facets

Rather than counting the often very small platform scars, a ranked scale was used: 0 = cortical, 1 = punctiform or plain, 2 = dihedral, 3 = facetted and 4 = *chapeau de gendarme*. The ANOVA for platform facets was p = .000 (F = 31.069, df = 5). With the exception of Levallois Table III.15 shows the homogeneous subsets overlapping. The mean rank for Levallois is between dihedral and facetting. The M-W statistic supports the distinctness of Levallois (Table III.16).

It is important to note the differences between flake blades and blades. Blades in the Early Dabban have predominantly punctiform platforms (49%) whereas flake blades have predominantly plain platforms (69%) and no examples of punctiform platforms (hence the hard hammer blade definition). They are statistically discrete (M-W p = .01). Flake blades also are not statistically distinct from the normal categories. The only other category to have punctiform platforms in significant quantities (20%) is the normal Early Dabban. The means, medians and modes are presented in Table III.17 and Table III.18, and the distributions in Figure III.4.

In general, Levallois flakes tend to have the highest proportion of facetted platforms. Although not used in the current study, it is interesting to note that McBurney's definition of Levallois flakes for his analysis of the Haua Fteah includes only "flakes showing evident traces of multiple preparation of the dorsal surface together with the use of a true faceted platform" (1967: 77). Although numerically dominant, the second most frequent platform type was plain (26%; Table III.18). However, as there were no Levallois flakes with cortical platforms, this means that 74% of all Levallois flakes in this study have either dihedral, facetted or chapeau de gendarme platforms. This points toward a significantly higher amount of core preparation (on average) for Levallois than for any other technological type.

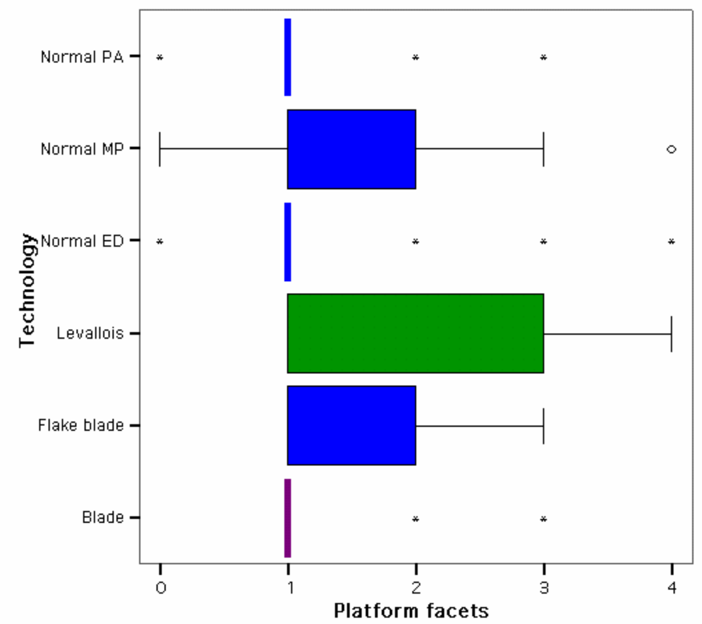


Figure III.4. Box Plot of Platform Facets by Technology.

Table III.15. Homogeneous Subsets (S-N-K) for Platform Facets.

Technology	*n*	1	2	3	4
Blade	84	1.17			
Normal ED	177	1.25	1.25		
Normal PA	274	1.35	1.35		
Flake blade	33		1.48	1.48	
Normal MP	193			1.69	
Levallois	73				2.41
Significance		.286	.129	.079	1.000

Table III.16. Pair-wise M-W Tests for Platform Facets.

	Blade	Normal ED	Normal PA	Flake blade	Normal MP	Levallois	Mean
Blade	-	.629	.037	.010	.000	.000	1.17
Normal ED	.629	-	.083	.069	.000	.000	1.25
Normal PA	.037	.083	-	.312	.000	.000	1.35
Flake blade	.010	.069	.312	-	.146	.000	1.48
Normal MP	.000	.000	.000	.146	-	.000	1.67
Levallois	.000	.000	.000	.000	.000	-	2.41

Table III.17. Measures of Central Tendency for Platform Facets by Technology.

Technology	Mean	Median	Mode (1)	Mode (2)
Blade	1.17	1	1 (89%)	3 (6%)
Flake blade	1.48	1	1 (70%)	3 (18%)
Levallois	2.41	3	3 (60%)	1 (27%)
Normal ED	1.25	1	1 (74%)	3 (11%)
Normal MP	1.67	1	1 (51%)	2 (24%)
Normal PA	1.35	1	1 (73%)	3 (13%)

Table III.18. Most Frequent Platform Types by Technology.

Technology	Most frequent	2nd most frequent
Blade	Punctiform (49%)	Plain (36%)
Flake blade	Plain (69%)	Facetted (18%)
Levallois	Facetted (60%)	Plain (26%)
Normal ED	Plain (50%)	Punctiform (20%)
Normal MP	Plain (48%)	Dihedral (24%)
Normal PA	Plain (71%)	Facetted (13%)

Discussion of Technological Complexity

As shown in the preceding discriminant analysis, each of the defined technological types is essentially a unique category. The normal types are much less well defined and share similarities with each other. These conclusions are supported when only the dimension of technological complexity is considered.

In terms of technological complexity, Levallois is statistially distinct on each of the four variables compared. Of all the types under consideration it is the most complex. With a mean of 6.78 dorsal scars, predominantly sub-radial dorsal scar orientation, negligible cortex and predominantly facetted platforms, Levallois technology involves the greatest amount of core preparation immediately prior to flake removal. In these terms it is safe to suggest that the Levallois has a longer chaîne opératoire than the other categories.

Blade technology is also unique in terms of technological complexity, with 5.83 dorsal scars, unipolar and bipolar dorsal scar patterns, little cortex and punctiform platforms. In a number of important ways, however, Early Dabban blades appear to be less unique from the other technologies than are the Levallois. The M-W score suggests a distribution similar to normal Early Dabban in terms of the number of dorsal scars. The dorsal scar orientations are similar to flake blades although statistically discrete (M-W p = .038), due to a more variable set of orientations. In this way blades are also similar to normal types. In terms of the amount of cortex, blades along with Levallois and flake blades, are produced later in the core reduction sequence than many of the normal flakes. In terms of platform facets they are predominantly punctiform. Blades involve less core preparation before the removal of the piece than Levallois, although they are still complex and involve different strategies such as either a soft hammer or punch blade flake removal strategy. I was able to replicate blades similar to those found at the Haua Fteah using a soft hammer. However, it is often difficult to distinguish between soft hammer and indirect percussion techniques from the debitage alone (see Inizan, et al. 1999: 76). It should also be noted that a number of lamecretes (n = 17) were identified in the Early Dabban whereas none were identified in the Pre-Aurignacian. This supports the notion that clear preparation and planning went into the manufacture of Early Dabban blades, although the number of steps preceding the removal of a blade may be less than in the case of Levallois technology.

Of the three well-defined technologies, flake blades are clearly the least complex and technologically most similar to the normal types. In terms of the number of dorsal scars they are not distinct from the normal Pre-Aurignacian (M-W p = .405) or the normal Middle Palaeolithic (M-W p = .408). The only variable on which they appear to be unique is the overwhelming predominance of unipolar removals. Flake blades are not distinct from normal flakes in terms of platform preparation; however, they are clearly a secondary flake removal due to the low amount of cortex. It is more their shape (see below) and the unipolar flake removal strategy than their complexity per se that makes them a defined technology. It is important to note that technologically, the Pre-Aurignacian hard hammer blades can be distinguished from the more recent Early Dabban blades (and likely from many other Upper Palaeolithic blades). This clearly has been demonstrated statistically.

The normal categories tend to be similar to each other in many ways. At the same time, however, they share similarities with the dominant technologies of their associated time periods. For example, normal Early Dabban flakes have a high number of dorsal scars and similar platform preparation. Normal Middle Palaeolithic flakes, although statistically distinct from Levallois, show a greater tendency toward sub-radial preparation and slightly more prepared platforms. Normal Pre-Aurignacian flakes differ from flake blades in terms of the amount of cortex (although this is a weak significance, M-W p = .37) and dorsal scar orientation. Especially when the amount of cortex is taken into consideration, the normal flake categories represent flakes that are either preparatory to the defined technology or are ad-hoc removals. The fact that there are technological similarities on a limited scale to the dominant technology of their time period supports the notion that many of them are preparatory removals.

CONCEPTUAL MODE 2 - SHAPE

In the second conceptual mode, two variables were selected that have a bearing on the shape of the piece. From the second factor analysis, these variables represent Factors 2 and 3, elongation (along the axis of the piece) and the deviation of the longest symmetrical axis of the piece from the axis of flaking. ANOVA, post-hoc S-N-K and M-W tests were performed. On the continuous variable, in this case the elongation of the piece, the arcsine-transformed variable was used for the ANOVA and post-hoc tests and a M-W test was performed on the untransformed variable. In the case of the axis of the piece, a M-W test was also performed on the ordinal variable.

Elongation

This variable essentially measures whether the piece is like a blade, a flake, or is broad. The variable was calculated so that a value of less than 0.5 (width/length) indicated that the piece was twice as long or greater than it was wide. This method meant that in practice there were no broad flakes (width > length) because in using the axis of the piece, the longest length was automatically the length to which the width was measured perpendicularly. Broad flakes can only be defined using the box and Jelinek elongation methods.

The ANOVA for this variable across the defined categories results in p = .000 (F = 84.515, df = 5). The S-N-K test indicates three distinct groups at the .05 level (Table III.19). Blades form a distinct group, as do flake blades. The remaining categories are lumped in a single sub-set. These results are confirmed using the M-W non-parametric test on the untransformed variable (Table III.20). In the non-parametric case, the only difference is that normal Middle Palaeolithic flakes are statistically distinct from the remaining normal types. The distributions of the transformed variable are shown in Figure III.5.

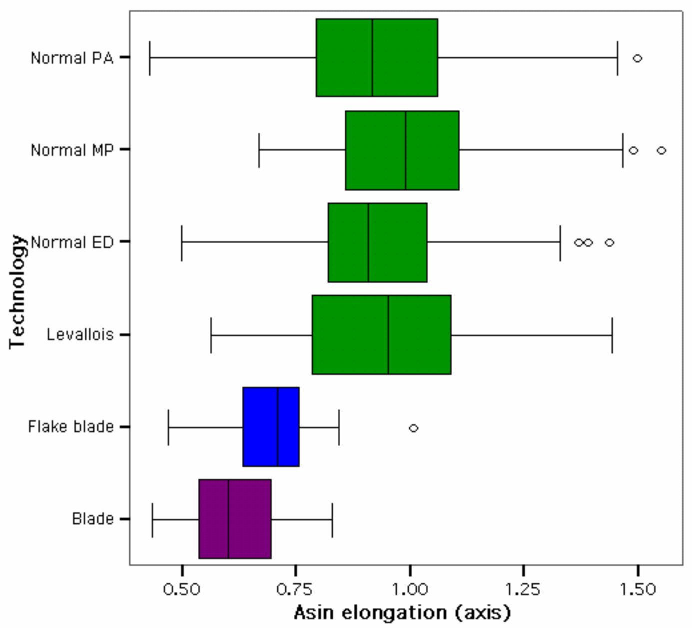


Figure III.5: Box Plot of (Asin) Elongation by Technology.

This makes sense when one looks at the untransformed means for this variable (Table III.20). Normal Middle Palaeolithic flakes are the most squat of the group on average. However, they are not significantly different from the Levallois flakes, which in turn are not significantly different from any of the normal categories. Blades are on average almost three times as long as they are wide (elongation axis = 0.335), whereas flake blades are less elongated but morphologically still blades.

Table III.19. Homogeneous Subsets (S-N-K) for (Asin) Elongation.

Technology	*n*	1*	2*	3*
Blade	106	.6140		
Flake blade	33		.6939	
Normal PA	291			.9304
Normal ED	206			.9308
Levallois	77			.9513
Normal MP	212			.9942
Significance		1.000	1.000	.061

* Note that the means in this table are the asin transformed means (see Table III.20 below).

Table III.20. Pair-wise M-W Tests for Elongation with Untransformed Means.

	Blade	Flake blade	Normal ED	Normal MP	Normal PA	Levallois	Mean
Blade	-	.000	.000	.000	.000	.000	.3348
Flake blade	.000	-	.000	.000	.000	.000	.4107
Normal ED	.000	.000	-	.000	.848	.481	.6364
Normal MP	.000	.000	.000	-	.000	.079	.6375
Normal PA	.000	.000	.848	.000	-	.543	.6375
Levallois	.000	.000	.481	.079	.543	-	.6495

Axis of the Piece

The other significant variable selected for shape was the axis of the piece. This variable is the deviation of the axis of the piece from the axis of flaking. When measured, the axis of the piece was divided into approximate intervals of -90°, -60°, -30°, 0°, 30°, 60° and 90°. In the analysis, howeve r, the absolute value of this ordinal scale was used (0°, 30°, 60° and 90°). In the fact or analyses, the box elongation shared a high loading with the axis of the piece and is in fact well correlated (Pearson's r = .773, significant at p = .01). For example, if a flake is broad its box elongation will be positive, or in other words width/length > 1; therefore, the axis of the piece is likely to deviate greatly from the axis of flaking.

The ANOVA across the technological categories for this variable is p = .000 (F = 20.026, df = 5). The S-N-K test produced three subsets, two of which overlap (Table III.21). However, the M-W test suggests that each of the defined technology types has a significantly different distribution but the normal types are similar (Table III.22). Because this is an ordinal scale measurement, it is also useful to look at the median and modal values for each technology (Table III.23). As can be seen in these comparisons, the flake blade group has the highest proportion of pieces with a 0° axis (78%), followed by blades (59%) and Levallois (51%). All of the normal flakes have median values of 30° and have similar proportions in those categories. The distributions are shown in the box plot in Figure III.6.

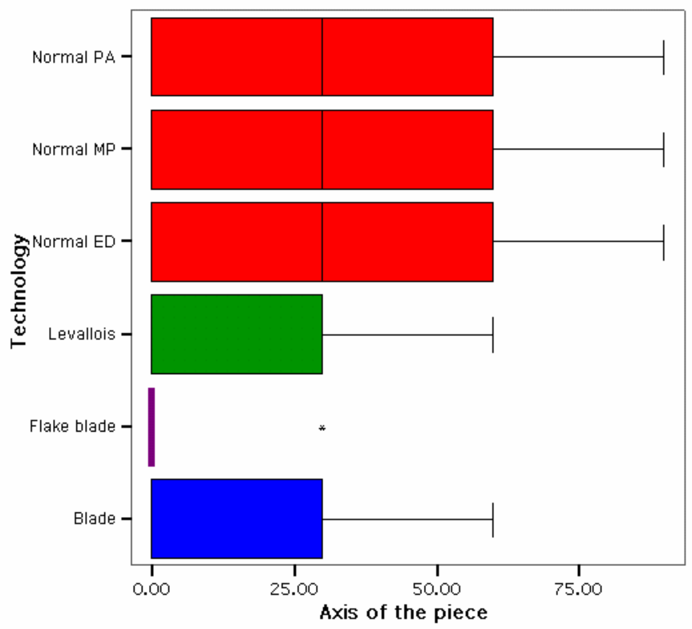


Figure III.6. Box Plot of the Axis of the Piece by Technology.

This variable distinguishes between predetermined flakes on the one hand and normal or in many cases predetermining flakes on the other. All of the defined technologies have median and modal values of 0° deviation of the axis of the piece from the axis of flaking (Table III.23). When their distributions are compared using the M-W test, however, each has a unique distribution of axes. Blades and flake blades are most similar (M-W p = .038) whereas Levallois technology has a higher proportion of flakes whose longitudinal axis deviates from the axis of percussion (49% are 30° or more). This relates to the higher proportion of broad pieces;

however, the predetermination of the Levallois strategy suggests a statistically important difference in shape from the normal categories.

Table III.21. Homogeneous Subsets (S-N-K) for Axis of Piece.

Technology	*n*	1	2	3
Flake blade	33	6.3636		
Blade	92	12.7174	12.7174	
Levallois	76		18.5526	
Normal ED	200			32.8500
Normal PA	290			34.4483
Normal MP	214			36.8692
Significance		.117	.150	.583

Table III.22. Pair-wise M-W Tests for Axis of Piece.

	Flake blade	Blade	Levallois	Normal ED	Normal PA	Normal MP	Mean
Flake blade	-	.038	.004	.000	.000	.000	6.36
Blade	.038	-	.012	.000	.000	.000	12.72
Levallois	.004	.012	-	.000	.000	.000	18.55
Normal ED	.000	.000	.000	-	.776	.169	32.85
Normal PA	.000	.000	.000	.776	-	.293	34.45
Normal MP	.000	.000	.000	.169	.293	-	36.87

Table III.23. Measures of Central Tendency for Axis of Piece by Technology.

Technology	Mean	Median	Mode (1)	Mode (2)
Blade	12.72	0	0 (59%)	30 (40%)
Flake blade	6.36	0	0 (78%)	30 (22%)
Levallois	18.55	0	0 (51%)	30 (36%)
Normal ED	32.85	30	30 (39%)	0 (29%)
Normal MP	36.87	30	30 (32%)	60 (30%)
Normal PA	34.45	30	0 (34%)	30 (29%)

Discussion of Shape

In terms of shape, Early Dabban blades are distinctive in that on average they appear to be very elongated, almost three times as long as wide. They have a unique distribution of axes of the pieces as well; this is most similar to flake blades (M-W p = .038).

Like Early Dabban blades, flake blades are also statistically distinct. They are clearly blades morphologically, but statistically their shapes are not identical to Early Dabban blades. They are less elongated and more often than Early Dabban blades have an axis of the piece that is oriented along the axis of flaking. This may be the result of the different flaking techniques involved, with hard hammer blades possibly exhibiting a less skewed morphology.

Levallois flakes have the least distinctive shape among the defined types. They have an elongation index that, as a whole, is statistically indistinguishable from normal flakes. Although they are the most similar to the normal categories, in terms of the axis of the piece, the predetermination of Levallois flakes makes them less skewed on average. Perhaps this is due to a higher proportion of broad flakes.

The normal or "preparatory" flakes across the different time periods show a relative uniformity. Normal Middle Palaeolithic flakes tend to be less elongated than their early Dabban and Pre-Aurignacian counterparts. As with technological complexity, this suggests their status as preparatory flakes (or possibly as failed attempts at the defined technology). Relative to the other normal flakes, there is a slight tendency toward more elongated flakes in the two blade technologies (Figure III.5).

CONCEPTUAL MODE 3 - EFFICIENCY/SIZE

The final conceptual mode identified is the size and efficiency of the pieces. Three variables from the factor analyses were selected to represent this mode: the ratio of the length of the longest sharp edge to the weight of the piece; the length of the longest sharp edge to the length of the piece; and the weight of the piece. The same battery of statistical tests was used.

Longest Sharp Edge/Weight

This variable is simply the length of the longest continuous sharp edge (non-abrupt) divided by the weight of the piece in grams. The ANOVA for this (log transformed) variable was significant at p = .000 (F = 22.381, df = 5). The S-N-K post-hoc test divided the categories into two groups, separating the Early Dabban blades from the remainder of the categories (Table III.24). In comparing the distributions of the original variable using the non-parametric M-W test, however, in addition to the blades, Levallois technology becomes a distinct group except in relation to normal Pre-Aurignacian flakes (Table III.25). An examination of the means and medians as well as the distributions (Table III.26, Figure III.7) for this variable by technological category shows that the blades have the highest sharpness to weight ratio and Levallois pieces and normal Pre-Aurignacian flakes have the lowest. The remaining categories (the normal Early Dabban and Middle Palaeolithic flakes, and flake blades) share similar sharpness to weight ratios.

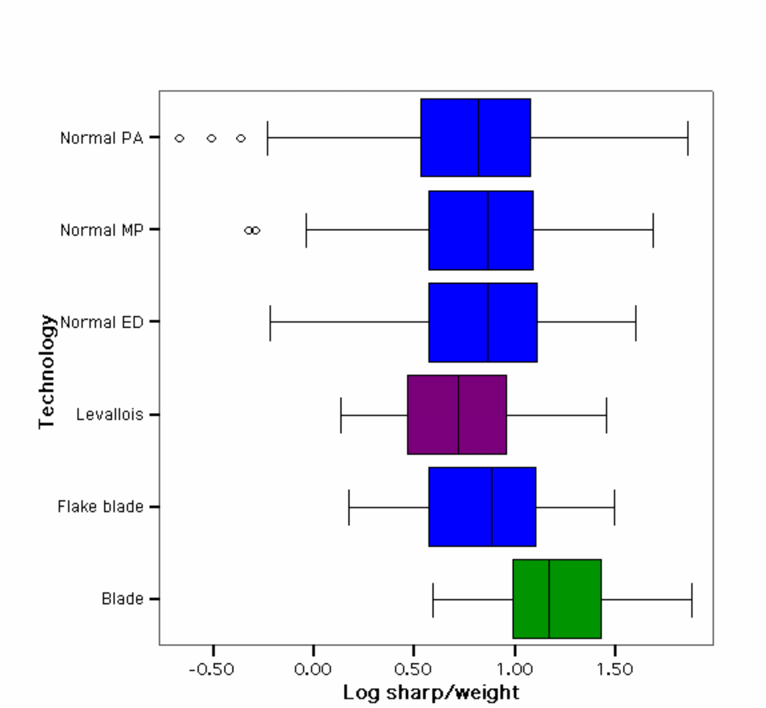


Figure III.7. Box Plot of Longest Sharp Edge/Weight by Technology.

Table III.24. Homogeneous Subsets (S-N-K) for (Log) Sharpness/Weight.

Technology	*n*	1*	2*
Levallois	77	.7256	
Normal PA	292	.7959	
Normal MP	216	.8336	
Normal ED	205	.8423	
Flake blade	33	.8541	
Blade	106		1.2062
Significance		.135	1.000

*Note that the means are the log (10) of sharp/weight.

Table III.25. Pair-wise M-W Tests for Sharpness/Weight.

	Levallois	Normal MP	Normal PA	Flake blade	Normal ED	Blade	Mean
Levallois	-	.009	.056	.043	.007	.000	6.81
Normal MP	.009	-	.388	.742	.815	.000	9.27
Normal PA	.056	.388	-	.434	.275	.000	9.27
Flake blade	.043	.742	.434	-	.886	.000	9.57
Normal ED	.007	.815	.275	.886	-	.000	9.70
Blade	.000	.000	.000	.000	.000	-	20.73

Table III.26. Measures of Central Tendency for Sharpness/Weight by Technology.

Technology	Mean	Median
Blade	20.73	15.05
Flake blade	9.57	7.73
Levallois	6.81	5.27
Normal ED	9.70	7.42
Normal MP	9.27	7.40
Normal PA	9.27	6.70

Longest Sharp Edge/Length(Axis)

In addition to comparing the length of the sharpest edge, another measure of efficiency comes from comparing the length of the sharpest edge to the length of the piece along the axis. The ANOVA for this (asin) transformed variable is significant at $p = .000$ ($F = 14.699$, $df = 5$). The S-N-K post-hoc test results in four overlapping groups (Table III.27). This can be clarified by examining the M-W tests (Table III.28) in addition to the means and median values of the untransformed variables (Table

III.29). Blades and flake blades share a statistically similar high proportion of sharp edge/length. The differences between Levallois and normal Middle Palaeolithic are not significant and normal Pre-Aurignacian flakes seem to be similar to all of the defined technological types. In short, as Table III.27 and Figure III.8 show, the distributions of each of these types overlap. Within the defined technological types, Levallois is distinct from the blade and flake blade types; it is less efficient and most similar to the normal types. Within the normal types, the Early Dabban flakes are distinct in that they are the least efficient.

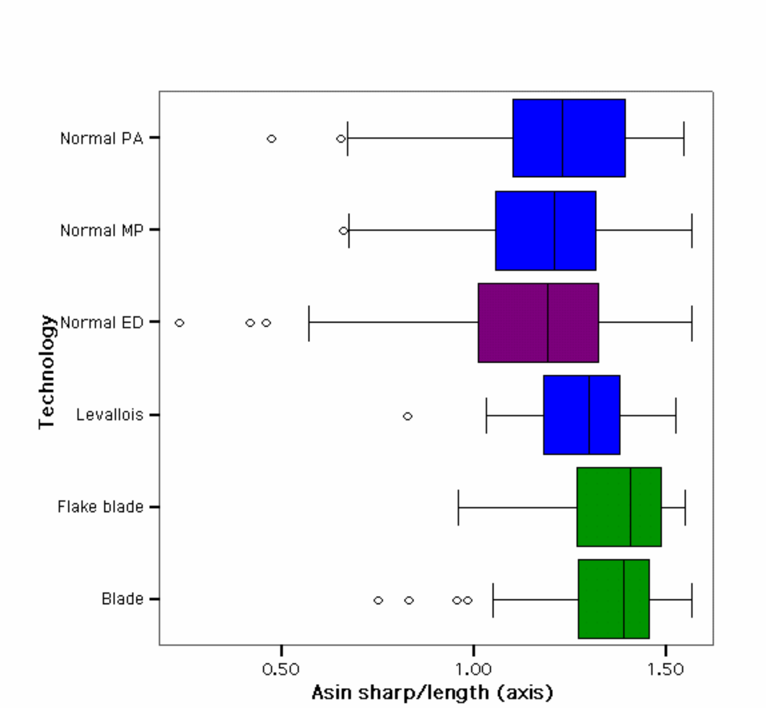


Figure III.8. Box Plot of Longest Sharp Edge/Length by Technology.

Table III.27. Homogeneous Subsets (S-N-K) for (Asin) Sharp/Length.

Technology	***n***	**1***	**2***	**3***	**4***
Normal ED	165	1.1460			
Normal MP	154	1.1876			
Normal PA	174	1.2175	1.2175		
Levallois	62		1.2794	1.2794	
Blade	83			1.3449	1.3449
Flake blade	23				1.3641
Significance		.107	.079	.064	.588

*Note that the means are the arcsine of sharp/weight.

Table III.28. Pairwise M-W Tests for Sharp/Length.

	Normal ED	Normal MP	Blade	Levallois	Normal PA	Flake blade	Mean
Normal ED	-	.016	.000	.001	.000	.000	.88
Normal MP	.016	-	.000	.104	.001	.000	.91
Blade	.000	.000	-	.002	.477	.056	.94
Levallois	.001	.104	.002	-	.199	.001	.94
Normal PA	.000	.001	.477	.199	-	.081	.96
Flake blade	.000	.000	.056	.001	.081	-	.97

Table III.29. Measures of Central Tendency for Sharp/Length by Technology.

Technology	Mean	Median
Blade	.94	.97
Flake blade	.97	.99
Levallois	.92	.94
Normal ED	.82	.88
Normal MP	.87	.91
Normal PA	.91	.96

Weight

The transformed (log) weight (in grams) of the pieces varied across the technological categories at a significance of p = .000 (F = 15.649, df = 5). The S-N-K post-hoc test of the log weight (Table III.30) and the M-W test of the untransformed value (Table III.31) showed that blades were significantly lighter than the remaining categories and that Levallois flakes were significantly heavier than any other category except flake blades. Flake blades in turn were also not significantly different than normal Pre-Aurignacian flakes. With the exception of Levallois flakes, there is a temporal trend in the data, with the most recent flakes being lighter. The normal flakes take an intermediate position between blades on the one hand, and flake blades and Levallois on the other (see Table III.32 and Figure III.9).

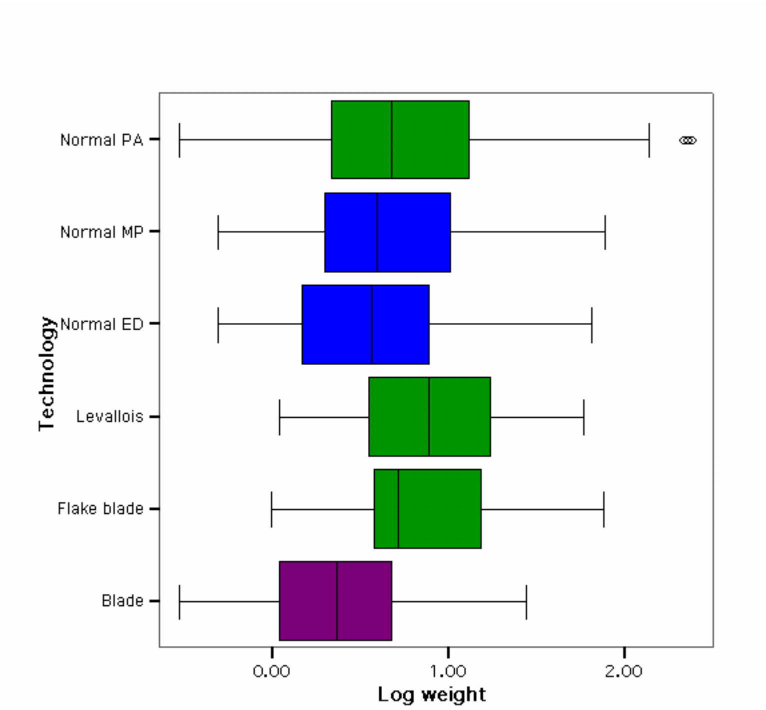


Figure III.9. Box Plot of Log (10) Weight by Technology.

When the normal pieces are compared with the dominant technology of their time period, flake blades are the same as normal Pre-Aurignacian flakes, Levallois flakes are heavier than normal Middle Palaeolithic flakes and Early Dabban blades are lighter than their normal Early Dabban counterparts.

Table III.30. Homogeneous Subsets (S-N-K) for (Log) Weight.

Technology	***n***	**1**	**2**	**3**	**4**
Blade	106	.3793			
Normal ED	206		.5862		
Normal MP	216		.6405	.6405	
Normal PA	295			.7548	.7548
Flake blade	33				.8671
Levallois	77				.9100
Significance		1.000	.449	.111	.077

*Note that the means are the log (10) of weight.

Table III.31. Pair-wise M-W Tests for Weight.

	Blade	Normal ED	Normal MP	Levallois	Flake blade	Normal PA	Mean
Blade	-	.000	.000	.000	.000	.000	3.86
Normal ED	.000	-	.311	.000	.003	.002	6.85
Normal MP	.000	.311	-	.000	.015	.039	8.08
Levallois	.000	.000	.000	-	.562	.000	12.50
Flake blade	.000	.003	.015	.562	-	.171	13.77
Normal PA	.000	.002	.039	.004	.171	-	14.35

Table III.32. Measures of Central Tendency for Weight by Technology.

Technology	Mean	Median
Blade	3.86	2.35
Flake blade	13.77	5.20
Levallois	12.50	7.90
Normal ED	6.85	3.70
Normal MP	8.08	3.95
Normal PA	14.35	4.80

Discussion of Efficiency/Size

The blade technology which predominates in the Early Dabban is by far the smallest and most efficient technology with an average of approximately 21 mm of cutting edge per gram of flint and around 94% of its length as a sharp cutting edge. The amount of cutting edge by weight is over double that of any of the other technologies. This is in part a product of its small size, considering that smaller volume pieces have a relatively greater proportion of surface area and thus possible sharp edge. However, the technology used to produce such a small and efficient technology is very different from what preceded it. In the Early Dabban, the blades are also statistically smaller than the preparatory and ad-hoc flakes. This supports the notion of a difference in flake production strategies. This can also be coupled with the observation that in the Early Dabban, blades made up 30% of the unretouched stone artefacts, relatively more predetermined flakes in relation to the total amount of debitage than in the other culture periods. This points toward a specialised and efficient technology for lithic reduction strategy.

Flake blades are similar to normal flakes in their ratio of cutting edge to weight. However, they exhibit an efficient use of their long axis, with an average of 97% of this being cutting edge. Of all the defined technologies these are the heaviest, but as mentioned previously their bulk does not differ significantly from their corresponding normal debitage. Thus, flake blades, despite their elongated shape, are not significantly more efficient than their corresponding debitage.

An examination of the normal categories as they are distributed through time shows that in terms of cutting edge to weight, they are similar to each other. Given the previous argument that these represent preparatory or ad-hoc flakes, their level of efficiency forms a benchmark from which to compare other flakes. There is a temporal patterning to the ratio of cutting edge to overall length, with Early Dabban flakes having the lowest ratio and Pre-Aurignacian flakes having the highest. Early Dabban flakes are statistically unique from blades, Middle Palaeolithic normal flakes are statistically similar to Levallois flakes and Pre-Aurignacian flakes are not statistically distinct from the defined technological categories. In terms of weight there is an overall trend toward a reduction in mean flake size over time.

Having set normal flakes as a benchmark in terms of cutting edge to weight, in this regard Levallois flakes have the lowest amount of cutting edge per gram of flint (see Table III.25). In addition, Levallois flakes are statistically similar to normal flakes from the Middle Palaeolithic and Pre-Aurignacian periods. They are also statistically heavier than their contemporaneous normal flakes and are more similar in size to the flake blades. Levallois flakes are relatively inefficient in terms of cutting edge per unit of raw material and are larger in relation to preparatory flakes.

CORES

Core technology is the final aspect to be examined. Five main core types were distinguished: single surface, shapeless, prismatic, disc and Levallois. Single surface cores are simple nodules of flint that have been exploited on a single surface without a clear technological patterning. Similarly, shapeless cores do not have a clear technological patterning but have been exploited on multiple surfaces or have a small number of removals. Prismatic cores (including pyramidal, which occurred in small proportions) are classic blade cores having parallel flaking scars and either one flat platform or two opposed platforms. In contrast to Levallois cores, the area of flake removal is the margin of the flake, rather than the surface (Boëda 1988b). Platform size was not taken into consideration when evaluating whether a core was prismatic or not. Disc cores are characterised by centripetal flaking around the core margin on one or both sides (Debénath and Dibble 1994). They share features with Levallois technology but lack clear signs of preparation for a specific flake form. Mousterian discs are included in this category. It has been argued by some that disc cores lacking the volume of Levallois cores represent reduced Levallois end products (see Mellars 1996a).

As mentioned above, there is considerable disagreement on what constitutes Levalloisness. In the current analysis, the basic principles outlined by Boëda (1991) are used. Levallois cores exhibit a continuous, striking platform around the bulk of the perimeter of a nodule and the deliberate shaping of the upper surface of the core. This shaping produces an area on the surface of the core from which all of the flakes are removed in a predictable fashion. This is known as the volumetric conception of the core (Boëda 1988a). In addition, the upper surface is dome shaped, creating flakes that are distally convex (Boëda 1988a). A number of subdivisions of Levallois cores (e.g., lineal and recurrent) have been made; these definitions are in part, however, dependant on refitting analysis. The majority of Levallois cores at the Haua Fteah appear to be recurrent centripetal, due to the predominance of radial and sub-radial preparation.

The distribution of the different core technologies across the three time periods is shown in Figure III.10. In the Pre-Aurignacian, shapeless and single surface cores predominate, although there are a number of prismatic and some disc cores, with the latter two making up 22% of the cores in the assemblage. In the Middle Palaeolithic, disc and Levallois cores predominate and there are very few prismatic cores. This suggests an industry geared toward the production of radial and sub-radial products. As mentioned above, the dividing line between disc and Levallois cores is unclear. The disc cores likely represent the point of discard in a Levallois technological process. If prismatic, disc and Levallois cores are combined, these predetermined cores constitute 65% of the total. The Early Dabban period shows a numerical predominance of prismatic cores, although Levallois and disc cores are also present.

The cores point to an industry geared toward blade production. Almost 60% of the cores fall into the prismatic category, and along with disc and Levallois cores, 66% appear to involve predetermination of one form or another.

An interesting pattern emerges when the proportion of defined flakes is compared to the proportions of predetermined cores (prismatic, disc and Levallois). In the Early Dabban the ratio of the proportion of defined technologies to the proportion of predetermined cores is .55, In the Middle Palaeolithic, it is .25 and in the Pre-Aurignacian it is .64. If we account for the small sample size in the Pre-Aurignacian, this is roughly similar to the Early Dabban. Assuming that the archaeological sample is representative of the products of the entire reduction sequence at the site, the Levallois reduction strategy of the Middle Palaeolithic produces more preparatory flakes than Levallois flakes.

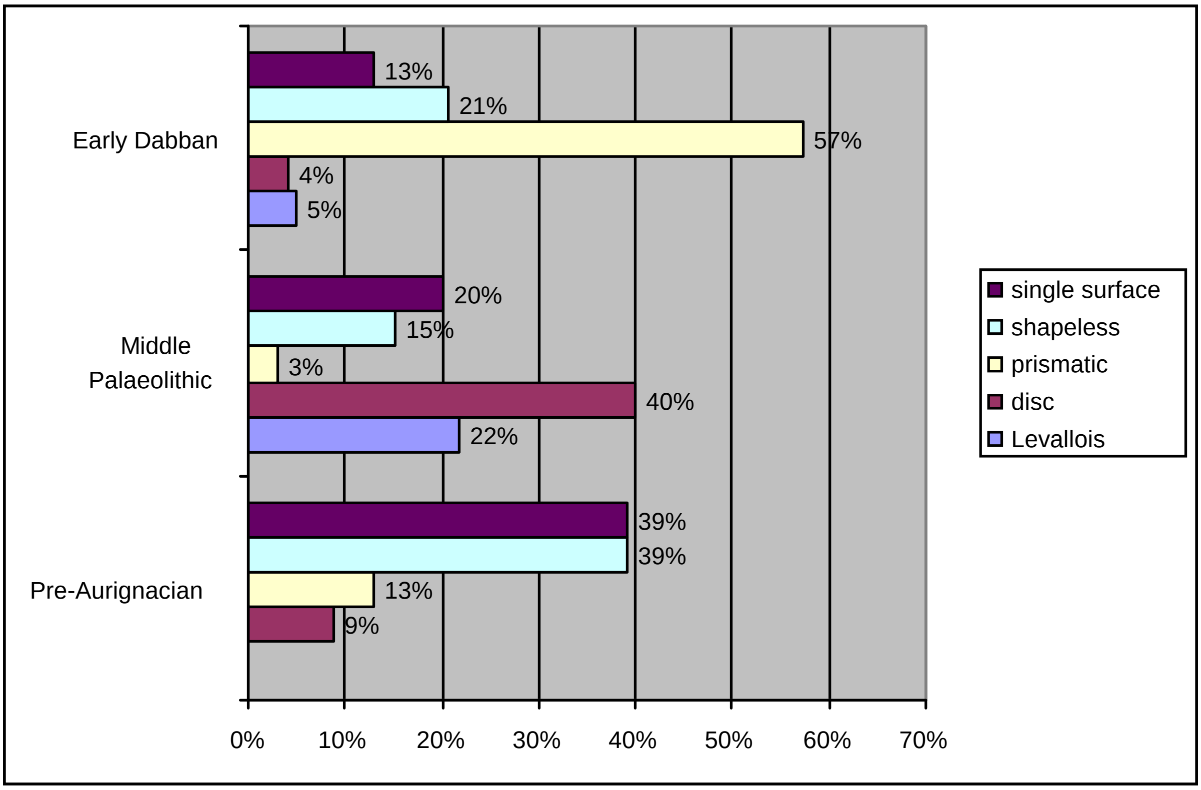


Figure III.10. Distribution of Core Types by Culture Period.

The examination of the cores took into consideration a number of variables that relate to the conceptual modes discussed above. The categories were divided by core type and time period. Only those categories with ten or more pieces assigned to them were used. Although this was an unreliable statistical sample, it provided useful information for comparing the core technologies to the unretouched flaked component of the assemblages. Due to the small number of cores in the Pre-Aurignacian levels, all of the core types for this time period were combined in a single category.

CONCEPTUAL MODE 1 - TECHNOLOGICAL COMPLEXITY

The orientation of the flake scars and an estimate of the number of flake scars were used in examining the technology of the cores. The technological attributes of the scar patterns of the last flake removal (if there were multiple final removals, the largest was used) were examined. This indicated the type of flake produced by the core before discard. The number and orientation (in line with the axis of flaking for the final removal) of the removal scars which intersected the final removal were recorded.

Number of Edge Scars

The number of scars along the perimeter of the final removal (edge scar) for each category was compared yielding an ANOVA result of $p = .00$ ($F = 8.842$, $df = 7$). As with the flakes, the S-N-K post-hoc test and M-W tests were used (Table III.33 and Table III.34). In both the S-N-K and the M-W tests, the only statistically discrete core type was Levallois, which had the highest number of edge scars. Although many of the categories overlap statistically, the single surface and shapeless cores tend to have lower numbers of edge scars than the defined technological types. Although the pattern is less clearly defined than in the flakes themselves, it points towards similar conclusions, especially in the case of Levallois.

Table III.33. Homogeneous Subsets (S-N-K) for Dorsal Scars by Core Type.

Core type and culture	*n*	1	2	3
ED single surface	13	3.00		
MP shapeless	15	3.67	3.67	
MP single surface	21	3.67	3.67	
ED shapeless	21	3.86	3.86	
PA all	23	4.09	4.09	
ED prismatic	58	4.14	4.14	
MP disc	42		4.24	
MP Levallois	23			6.13
Significance		.070	.746	1.000

Table III.34. Pair-wise M-W Tests for Dorsal Scars by Core Type

Core Type and Culture	ED single surface	MP shapeless	MP single surface	ED shapeless	PA all	ED prismatic	MP disc	MP Levallois	Mean
ED single surface	-	.353	.292	.104	.018	.004	.002	.000	3.00
MP shapeless	.353	-	1.000	.657	.391	.297	.135	.000	3.67
MP single surface	.292	1.000	-	.572	.262	.718	.084	.000	3.67
ED shapeless	.104	.657	.572	-	.628	.478	.265	.000	3.86
PA all	.018	.391	.262	.628	-	.935	.520	.000	4.09
ED prismatic	.004	.297	.718	.478	.935	-	.009	.000	4.14
MP disc	.002	.135	.084	.265	.520	.009	-	.000	4.24
MP Levallois	.000	.000	.000	.000	.000	.000	.000	-	6.13

Dorsal Scar Orientation

The ANOVA for dorsal scar orientation results in $p = .00$ ($F = 42.157$, $df = 7$). Middle Palaeolithic Levallois and disc cores are statistically distinct from all of the other categories and each other (Table III.35 and Table III.36). Over half of the Levallois cores have radial preparation, with sub-radial opposed (3 directions - Rank 9) accounting for 26% (Table III.37). At the other end of the spectrum, the various Early Dabban core types and pre-Aurignacian types cluster statistically with medians and modes of 1 (unipolar). The non-Levallois cores in the Middle Palaeolithic all have modes of 5 (sub-radial); however, at 17% each, 34% of Middle Palaeolithic disc cores have either 3 or 4 directions of scar orientations (Ranks 9 and 10).

Table III.35. Homogeneous Subsets (S-N-K) for Dorsal Scar Orientation.

Core type and culture	*n*	1	2	3	4
ED prismatic	58	1.79			
ED single surface	13	2.08	2.08		
ED shapeless	21	2.10	2.10		
PA all	23	2.26	2.26		
MP shapeless	16		3.56		
MP single surface	21		3.67		
MP disc	42			6.71	
MP Levallois	23				8.74
Significance		.881	.088	1.000	1.000

Table III.36. Pair-wise M-W Tests for Dorsal Scar Orientation.

Core type and culture	ED prismatic	ED single surface	ED shapeless	PA all	MP shapeless	MP single surface	MP disc	MP Levallois	Mean
ED prismatic	-	.810	.867	.777	.012	.001	.000	.000	1.79
ED single surface	.810	-	.944	.770	.199	.065	.000	.000	2.08
ED shapeless	.867	.944	-	.705	.175	.034	.000	.000	2.10
PA all	.777	.770	.705	-	.107	.033	.000	.000	2.26
MP shapeless	.012	.199	.175	.107	-	.820	.000	.000	3.56
MP single surface	.001	.065	.034	.033	.820	-	.000	.000	3.67
MP disc	.000	.000	.000	.000	.000	.000	-	.001	6.71
MP Levallois	.000	.000	.000	.000	.000	.000	.001	-	8.74

Table III.37. Measures of Central Tendency for Dorsal Scar Orientation.

Technology	Mean	Median	Mode (1)	Mode (2)
ED prismatic	1.79	1	1 (62%)	3 (36%)
ED shapeless	2.10	1	1 (57%)	3/5 (14%)
ED single surface	2.08	1	1 (54%)	4/5 (15%)
MP Levallois	8.74	10	10 (52%)	9 (26%)
MP disc	6.71	7	5 (24%)	9/10 (17%)
MP shapeless	3.56	4	5 (31%)	1 (25 %)
MP single surface	3.67	3	5 (24%)	*
PA all	2.26	1	1 (44%)	0 (17%)

(* More than two values with equal proportions.)

Discussion

Examination of the cores supports many of the patterns found on the flakes. This is especially true of Levallois cores. They are statistically unique in terms of the number of preparatory removals and in the dorsal scar orientations of the last flake removed from the core. Levallois cores, however, show a greater pattern of complexity in dorsal scar orientations on the final removal than do Levallois flakes. This is due to the inclusion of additional factors, such as volume, in the identification of the cores. Furthermore, it is often easier to identify the direction of the preparatory removals on the core because of the presence of inverse bulbs of percussion on the core surface.

Disc cores are relatively easy to identify, but their products are less obvious. This is complicated by the fact that it is entirely possible, if not probable, that disc cores represent the point of discard in a Levallois core reduction sequence. In other words, many disc cores may in fact be "collapsed" Levallois cores in terms of volume. Although statistically distinct from Levallois in terms of the properties examined, disc cores are the most like Levallois cores, both in terms of their relatively high number of preparatory removals and their predominance of sub-radial and radial forms (Table III.37).

Although not statistically discrete, Early Dabban prismatic cores have a higher number of preparatory removals and an almost exclusive combination of unipolar and bipolar preparation patterns. Statistically, they are more similar to the remaining non-Levallois categories in terms of the number of scars and similar to other Early Dabban and Pre-Aurignacian cores in terms of dorsal scar orientation.

The shapeless and single surface cores have lower numbers of preparatory removals than the technologically defined core types. In terms of the dorsal scar orientation of the final removals, the Middle Palaeolithic cores appear to share patterns similar to each other, as do the Early Dabban and Pre-Aurignacian cores.

The interpretation of high complexity for Levallois (and disc) technology and of moderate complexity for Early Dabban blade production is upheld upon examination of the cores. Unfortunately, the low number of Pre-Aurignacian cores makes it statistically impossible to comment on the complexity of flake blade cores, other than noting that the proportion of prismatic cores is low and that some of the flake blades are likely to have been made on single surface or shapeless cores.

CONCEPTUAL MODE 2 - SHAPE (ELONGATION)

Elongation was the most important variable pertaining to shape that was identified in the analysis of the flakes. It was measured on the final removal from the core. Due to difficulties in measuring, the Jelinek length and widths were used rather than those along the axis of the piece. This variable is strongly correlated with the axis elongation of the piece (Pearson's $r = .845$, $p < .01$).

The different core types have an ANOVA value of $p = .000$ ($F = 30.937$, $df = 7$) for the asin transformed elongation. Early Dabban prismatic cores show final removals that have an average elongation of 0.3627 and are statistically distinct from the remaining categories (Table III.38,Table III.39, Table III.40). Although there is some overlap with other categories, the Middle Palaeolithic cores tend to be reasonably distinct with broader flakes produced than in the remaining categories. The Middle Palaeolithic Levallois and disc cores both have the least elongated removals and are statistically distinct from the scar shapes of cores in the other culture periods. In terms of elongation the removals of the Levallois and disc cores are not statistically unique. The areas of overlap across the culture periods are in the shapeless and single surface categories. These are arguably analogous to the normal categories used in the flake analysis and share more in common with each other than with the defined technological categories (represented here by prismatic, disc and Levallois cores).

Table III.38. Homogeneous Subsets (S-N-K) for (Asin) Elongation.

Core type and culture	***n***	**1**	**2**	**3**	**4**
ED prismatic	57	.6253			
ED shapeless	20		.7998		
PA all	21		.8958	.8958	
ED single surface	12		.9123	.9123	
MP shapeless	13			1.0021	1.0021
MP single surface	18			1.0324	1.0324
MP disc	36				1.1146
MP Levallois	17				1.1441
Significance		1.000	.151	.109	.088

Table III.39. Measures of Central Tendency for Elongation.

Core type and culture	**Mean**	**Median**
ED prismatic	.3627	.3054
ED shapeless	.5381	.5240
ED single surface	.6700	.6499
MP Levallois	.8698	.8659
MP disc	.8192	.8213
MP shapeless	.7748	.7290
MP single surface	.7676	.7703
PA all	.6541	.6539

Table III.40. Pair-wise M-W Tests for Elongation.

Core type and culture	ED prismatic	ED shapeless	PA all	ED single surface	MP single surface	MP shapeless	MP disc	MP Levallois	Mean
ED prismatic	-	.000	.000	.000	.000	.000	.000	.000	.363
ED shapeless	.000	-	.217	.060	.000	.001	.000	.000	.538
PA all	.000	.217	-	.795	.065	.177	.005	.003	.654
ED single surface	.000	.060	.795	-	.070	.121	.005	.002	.670
MP single surface	.000	.000	.065	.070	-	.988	.194	.050	.768
MP shapeless	.000	.001	.177	.121	.988	-	.321	.079	.775
MP disc	.000	.000	.005	.005	.194	.321	-	.249	.819
MP Levallois	.000	.000	.003	.002	.050	.079	.249	-	.870

CONCEPTUAL MODE 3 - EFFICIENCY/SIZE (WEIGHT)

Because it is impossible to measure the length of the sharp edge on a flake that is not there, the only variable to indicate volume or efficiency is weight. The weight of the actual core is considered and direct comparisons to the flakes themselves cannot be made. However, something can be said about the use of flint. The weight of the core indicates the amount of flint remaining at the point of discard. If it is presumed that the sources of flint across the time periods are more or less similar, the size of the remaining core indicates the intensity of core reduction.

Although less strongly significant than the other core variables examined, the ANOVA for log weight still has a p value of .00 (F = 8.361, df = 7). The only statistically unique cores in terms of weight are from the Pre-Aurignacian (Table III.41 and Table III.43). They have an average weight of 123 grams (Table III.43). At the other end of the spectrum are the Middle Palaeolithic disc cores, which are statistically distinct from the remaining types, with the exception of the Middle Palaeolithic shapeless and single surface cores. Disc cores are different from Levallois cores, however, in this variable. This is interesting because they have similar scar patterning and produce similarly shaped removals. This lends support to the notion that disc core and Levallois may be part of a shared or similar technological process. The Levallois cores are the heaviest of the technologically defined core types, but are not statistically discrete. The Early Dabban prismatic cores are light, but not significantly different from any of the other core types. All of the distributions are skewed to the lighter end (medians are less than the means, see Table III.42). With the exception of Pre-Aurignacian cores, most cores appear to be relatively small and heavily reduced. Although not statistically different, the defined technological types are generally more reduced than the shapeless or single surface cores suggesting that the latter are more ad-hoc and less heavily reduced.

Table III.41. Homogeneous Subsets (S-N-K) for (log) Weight.

Core type and culture	*n*	1	2	3
MP disc	42	1.2957		
MP shapeless	16	1.3772	1.3772	
ED prismatic	58	1.4028	1.4028	
MP single surface	21	1.4141	1.4141	
MP Levallois	23	1.4489	1.4489	
ED shapeless	21	1.4626	1.4626	
ED single surface	13		1.6385	
PA all	23			1.9218
Significance		.581	.111	1.000

Table III.42. Measures of Central Tendency for Weight.

Core type and culture	Mean	Median
ED prismatic	30.724	26.100
ED shapeless	35.795	27.100
ED single surface	56.000	39.700
MP Levallois	36.057	25.200
MP disc	30.398	16.000
MP shapeless	39.844	14.250
MP single surface	42.957	19.400
PA all	123.422	89.300

Table III.43. Pair-wise M-W Tests for Weight.

Core type and culture	MP disc	ED prismatic	ED shapeless	MP Levallois	MP shapeless	MP single surface	ED single surface	PA all	Mean
MP disc	-	.009	.012	.025	.931	.325	.002	.000	30.398
ED prismatic	.009	-	.444	.734	.297	.719	.028	.000	30.724
ED shapeless	.012	.444	-	.742	.294	.399	.096	.000	35.795
MP Levallois	.025	.734	.742	-	.420	.464	.123	.000	36.057
MP shapeless	.931	.297	.294	.420	-	.539	.110	.000	39.844
MP single surface	.325	.719	.399	.464	.539	-	.065	.000	42.957
ED single surface	.002	.028	.096	.123	.110	.065	-	.031	56.000
PA all	.000	.000	.000	.000	.000	.000	.031	-	123.422

THE TECHNOLOGICAL DIFFERENCES BETWEEN TECHNO-CHRONOLOGICAL CATEGORIES

Because the three conceptual modes discussed above represent statistically related phenomena (they represent correlated factors) and explain the bulk of the differences between the defined techno-chronological categories, they can be used to discuss the changes in debitage technology at the Haua Fteah. There are elements of continuity and change at the site. To discuss the changes in terms of a simple evolutionary progress, however, would mask both the continuity and complexity of the changes. To be sure, there is a certain amount of what could be characterised as progress. The evolution of the technology at the site, however, can better be described as a process of progressive development marked by historical particularities, or to avoid a possible bias toward anachronism, contingent events. The story of the evolution of the technology at the site, and perhaps across a much larger temporal and geographical scope, is one of a distribution of conceptual modes in a patchwork fashion (see Figure III.11).

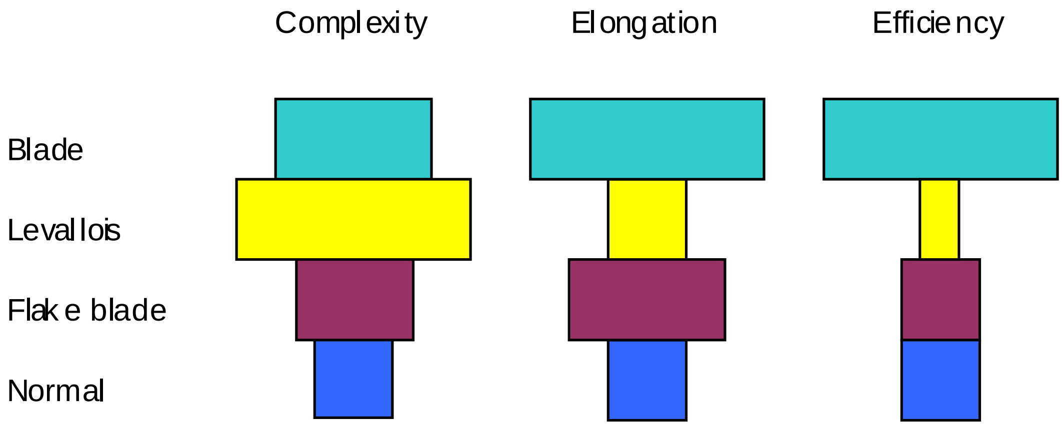


Figure III.11: Distribution of Conceptual Modes across Technological Categories

The evolutionary sequence at the site starts with the Pre-Aurignacian period, during which time hard hammer blades are the most interesting features of the debitage. This has been claimed to be one of the earliest examples of a blade industry (e.g., Mithen 1996: 25; for earlier examples, however, see McBrearty & Brooks 2000: 495). In practice, however, although morphological blades were produced, this industry was only slightly more complex (in terms of the number of preparatory removals and platform preparation) than the contemporaneous normal debitage. What distinguishes this technology is the elongation of the piece and a predominantly unipolar reduction strategy on prismatic cores. The blades produced were large, however, and represent a relatively inefficient use of the flint available.

Although they by no means dominate the assemblage, a number of Levallois flakes also occur in this period. They involve considerable amounts of core preparation and complex predetermination toward the production of flakes. The sequence of events at the site is interesting because although Levallois technology is clearly complex and involves a well-defined chaîne opératoire, it produced flakes that were barely distinguishable from normal debitage in terms of shape. They were also as large as hard hammer blades and less efficient in terms of the amount of cutting edge/gram than all other flake types except those from the normal Pre-Aurignacian category.

Levallois technology eclipsed the more efficient and what archaeologists consider more modern shaped flake blades (which essentially disappear) in the Middle Palaeolithic levels. The rise and spread of Levallois technology was an important stage in human evolution and Old World prehistory. It took over. Wherever this technology began, for some reason it replaced many things in its path, such as various forms of morphological blades, even if they were more efficient.

The Early Dabban technology is one of the earliest examples of modern behaviour. This is true not only in terms of the presence of blade debitage technology, but also because of other factors such as its essentially Upper Palaeolithic tool kit of burins, backed knives, etc., and the presence of bone tools at Hagfet ed Dabba (McBurney & Hey 1955). The changes that occur at the Early Dabban (and arguably in the technologically related industries of the Initial Upper Palaeolithic in the Eastern Mediterranean) is revolutionary. Early Dabban blade technology integrated the three conceptual modes. Early Dabban blade production involves a complex, well-defined technological strategy marked by a dramatic increase in efficiency, both in terms of the numbers of blades produced (making up 30% of the debitage) and the extraction of more useable sharp edges per unit of flint.

Why did the revolution happen? The reasons are not obvious. With flake blade and Levallois technology, only one conceptual mode, either shape or complexity, predominated at a time. In the Early Dabban, three conceptual modes were combined to produce a significantly different technology. Flake blades by the standard definition (being twice as long as they are wide) are blades, but they lack complexity and efficiency. The conceptual underpinnings or their *design* is inherently different from the Early Dabban blades. Levallois technology, on the other hand, is hyper-complex in comparison to the Early Dabban blades. It does not yield flakes with long cutting edges/gram of flint and results in flakes that are similar in shape to preparatory and ad-hoc debitage. The designs of both technologies focus on a single rather than multiple *concepts*. There seems to be a practical limit on the design of these pieces that prevents multiple conceptual modes from being in operation simultaneously.

As will also be shown in the discussion of tools, nevertheless, there is continuity. Levallois is present (as a flake, tool or core) throughout the sequence. In fact, it is only absent from those levels having a small number of lithic artefacts, which is more likely a statistical rather than a real absence. In the absence of supporting data (e.g., human fossil remains in all levels) it cannot be determined whether the transitions from Pre-Aurignacian to Middle Palaeolithic or from Middle Palaeolithic to Early Dabban represent in situ developments or the migrations of people. The impact of the latter option can be overemphasised in the Palaeolithic record. Even in recent ethnographic times, it is often difficult to draw hard and fast boundaries between populations and cultures. The continuities at the site suggest that even if there was demographic replacement, there was overlap in terms of technological practice and probably the populations themselves. The fact that Levallois technology appears in the Pre-Aurignacian, blossoms in the Middle Palaeolithic and then persists in the Early Dabban suggests that the transitions were not as abrupt as those that would be brought about by a dramatic population replacement.

A number of important points can be made from the analysis of the lithic debitage in the Middle and Early Upper Palaeolithic at the Haua Fteah.

1. Three conceptual modes can be used to explain the bulk of the differences between the three techno-chronological categories defined in the previous chapter. These are complexity, shape and efficiency.
2. Despite an overall pattern of progressive development, the evolution of the technology at the Haua Fteah is marked by contingent changes and the patchwork distribution of conceptual modes over time.
3. The Early Dabban shows an integration of all three conceptual modes in a single, numerically abundant technology. The previous periods are dominated by only one conceptual mode at a time and have lower proportions of the defined technologies.
4. The fact that before the Early Dabban only one conceptual mode predominates in each technology suggests that there is a practical limit to the design of Levallois and flake blade technologies. This practical limit is transcended in the Early Dabban blades.

5. Despite significant changes at the site, there is also an important amount of continuity linking the Early Dabban, Middle Palaeolithic and Pre-Aurignacian across time, notably the presence of Levallois technology.

IV. Analysis of the Differences between Categories of Tools

Chapters II and III discuss the debitage at the Haua Fteah. The current chapter examines the nature of the retouched pieces, commonly referred to as *tools*. Four aspects will be considered: blank selection and morphology; retouch location; retouch intensity; and typological diversity. As in the previous chapters, the goal in this analysis is to describe the nature of the changes through time. In this chapter, however, the technological nature of the blanks is compared to the retouched pieces.

THE SAMPLE

The examination of the retouched pieces was a comprehensive analysis and no sampling was used. With the exception of pieces smaller than 20 mm, all tools, broken or not, were examined. In the case of complete tools, the measurements from the previous chapters were used and information on retouch location, retouch intensity and typology were also recorded (see below). The broken pieces were categorised as being proximal, distal or medial. These categories were used to calculate the MNT for typological analysis.

Although typological information was collected, the typologies used were far too specific for comparative purposes. For the analysis in this chapter a set of tool classes was used instead (Table IV.1).

Table IV.1. Tool Class Definitions.

Tool class	Definition (based on Inizan et al. 1999, and/or Debénath & Dibble 1994 unless otherwise noted).
Backed knife	A piece with continuous, abrupt retouch on one or more lateral margins, leaving an unmodified sharp edge opposite the abrupt retouch (this does not include naturally, i.e., unretouched, abrupt edges).
Burin	A piece with the intersection of either two flake scars or one flake scar and another edge suitable as a striking platform (such as break, abrupt or retouched edge) forming a dihedral angle, normally perpendicular to the plane of the blank.
Chamfer	Although similar to a transverse burin, this tool has a larger retouch scar that creates a sharp edge on the end of the tool, suggesting a different function than that of burins (Azoury 1986). However, as this type is technologically related to the truncation burin (Azoury 1986: 47) and occurs only in relatively small numbers in the Early

	Dabban, it was lumped with burins for comparative purposes.
Composite	Any piece incorporating more than one type of retouch, e.g., having a notch on one edge and a scraper on another. This may include any combination of different types and any number, as long as they are not together part of the normal manufacture of a defined type (e.g., a burin made on a retouched edge).
Endscraper	A flake or a blade having continuous, non-abrupt retouch on either or both ends. This retouch is normally rounded to a greater or lesser extent.
Notch/denticulate	Tools produced through the removal of one or more notches. In the case of denticulates, there must be at least two contiguous notches. Each notch may be simple (a single blow) or complex (produced through multiple retouching blows).
Piercer/awl	Tools which have one or more small pointed tips. These small pointed elements may occur at any place on the margin of the tool (distinguishing them from points).
Point	Any flake or blade shaped by continuous non-abrupt retouch to form a pointed end, the distal end having a sharp angle. In Bordes' *Typologie du Paléolithique Ancien et Moyen* (1961), the difference between points and convergent scrapers is highly subjective (see Debénath and Dibble 1994: 62). In the current study, convergent scrapers are normally considered as points.
Sidescraper	A flake or blade with continuous, regular, smooth retouch along at least one edge. Although normally non-abrupt, it may be abrupt as long as there is not a sharp blade opposite (otherwise it is a backed knife).
Truncation	A piece that is "truncated" on the distal or proximal end through the use of continuous, abrupt retouch. The truncation is normally straight, but can be any shape as long as it is abrupt.
Other	Any type that does not fit into the preceding categories. It may be an unidentifiable or ambiguous piece or a well-defined but uncommon type such as a truncated-facetted piece.

The culture types in the previous chapters further divided these tool classes (Table IV.2). Those tool classes with low proportions (less than 10 items) were excluded from the analysis because they yielded very low statistical samples for comparison (the tool classes retained are highlighted). Although the number of tools in most cases is relatively small for statistical comparison, such analyses were conducted because the sample was comprehensive.

Table IV.2. Proportion of Tools by Culture.

Tool class		ED	MP	PA	Total
Backed knife	Count	19	3	3	25
	% within culture	13.3%	2.1%	5.7%	7.4%
Burin/chamfer	Count	28	15	18	61
	% within culture	19.6%	10.4%	34.0%	17.9%
Composite	Count	14	16	1	31
	% within culture	9.8%	11.1%	1.9%	9.1%
Endscraper	Count	21	12		33

	% within culture	14.7%	8.3%		9.7%
Notch/denticulate	Count	12	45	10	67
	% within culture	8.4%	31.3%	18.9%	19.7%
Other	Count	4	3	3	10
	% within culture	2.8%	2.1%	5.7%	2.9%
Piercer/awl	Count	1	1		2
	% within culture	.7%	.7%		.6%
Point	Count	2	10	1	13
	% within culture	1.4%	6.9%	1.9%	3.8%
Sidescraper	Count	19	32	15	66
	% within culture	13.3%	22.2%	28.3%	19.4%
Truncation	Count	23	7	2	32
	% within culture	16.1%	4.9%	3.8%	9.4%
Total	Count	143	144	53	340
	% within culture	100.0%	100.0%	100.0%	100.0%

BLANK SELECTION AND TOOL MORPHOLOGY

One of the most important aspects in understanding tools is the extent to which they were *intentional*. In other words, was the final tool manufactured to a planned form (Mellars 1989), and how much design went into its manufacture? The first consideration is blank selection: Which pieces of debitage were used to make the tools? To answer this question the proportions of tools made from each of the four main technological types as defined in the previous chapter were compared with the proportion of the overall debitage for each culture period. Was the distribution of technological types random, i.e., did it reflect the proportions of the population of debitage, or was it patterned, with specific technologies selected for specific tool classes? The second consideration is tool morphology. Were any aspects of the tools' morphology selected for or transformed in the retouching process?

To determine whether there was intentional selection of specific technologies for specific types of tools, each tool class (with 10 or more items) was compared with the proportions of technological types in the debitage as shown in Table IV.3. The proportions of the debitage were compared with the proportions of technology for each tool class (providing the expected values) using the chi-square test as shown in Table IV.4, which uses Early Dabban backed knives as an example. Probability values were calculated for each tool class, and also for the population of tools in each culture (Table IV.5).

Table IV.3. Number of Technological Types by Culture.

	ED	MP	PA
Blade	101	2	3
Levallois	16	38	23
Flake blade	4	3	26
Normal	212	224	311
Total	333	267	363

Table IV.4. Chi-Square Test of Backed Knives by Technology.

ED backed knives	Observed	Expected	O-E*	$(O-E)^2/e$	
Blade	14	5.76	8.24	11.774	
Levallois	0	0.91	-0.91	0.913	
Flake blade	0	0.23	-0.23	0.228	
Normal	5	12.10	-7.10	4.163	
Sum	19	19.00		17.078	= Chi-square
				df =	3
				p =	.001

***** O-E = Observed – Expected

Table IV.5. Probability Values (Chi-Square) Showing Preferential Technology by Tool Type.

Tool type	*p*	Preference	O-E
ED backed knife	.001	Blade	8.24
ED burin/chamfer	.483		
ED composite	.807		
ED endscraper	.468		
ED notch/denticulate	.000	Flake blade	1.86
ED sidescraper	.031	Normal	5.9
ED truncation	.045	Blade	6.02
MP burin/chamfer	.959		
MP composite	.236		
MP endscraper	.895		
MP notch/denticulate	.553		
MP point	.932		
MP sidescraper	.209		
PA burin/chamfer	.969		
PA notch/denticulate	.793		
PA sidescraper	.599		

ED tools	.093 Blade	8.63
MP tools	.714	
PA tools	.817	

In this analysis the only tool classes showing non-random patterns of technological selection were in the Early Dabban period. In the Early Dabban there is a statistically weak but nonetheless important overall tendency for the selection of blades for tools. These blades are primarily selected for the production of backed knives and truncations (which show a statistically significant selection for blades). On the other hand, notches and denticulates appear to be made on flake blades in the Early Dabban. This is based, however, on a very small statistical sample of only 12 notched and denticulated pieces, with two of them being made on flake blades. As discussed previously, these flake blades may represent accidental cases, perhaps blades with overly large platforms. Early Dabban sidescrapers primarily are made using normal debitage (again statistically significant). The remaining tool classes show essentially random associations between tools and technology.

This blank selection pattern shows that there is a clear division between the Early Dabban and the preceding culture periods. This is significant in two ways. First there appears to be a clearly planned production strategy with blades being selected or perhaps specifically manufactured for the production of two specific tool types. In addition, another tool type (sidescraper) shows preferential selection for normal technology. To the makers of the Early Dabban tools, there is a clear differentiation between tool categories and technology is part of the design of these tools. This cannot be said of the Middle Palaeolithic or Pre-Aurignacian periods.

To understand the morphology of the tools, four variables were chosen to represent the three conceptual modes described in the previous chapter. These were the number of dorsal scars, the elongation of the piece (asin[axis]), the length of the longest sharp edge divided by weight (log[sharp/weight]) and the weight of the piece (log[weight]). For each variable, statistical comparisons were made between the tool class, the corresponding dominant technology from the time period and the normal category for that time period.

COMPLEXITY (NUMBER OF DORSAL SCARS)

To compare the complexity of the tool types, the number of dorsal scars (an indicator of the length of the chaîne opératoire immediately before removal) was compared with normal flakes (from that time period) and the dominant technology of each culture period using the M-W statistic. This test was chosen because the data was independent, ordinal and non-parametric.

Early Dabban

In the Early Dabban, each tool class was not significantly different from either normal Early Dabban flakes or blades in terms of the number of dorsal scars. This is largely because the differences between these types of debitage are not great (Table IV.6; see mean values). Both Early Dabban composite and truncated pieces are more similar to normal flakes in this regard, with probability values near .05 in comparison to blades.

Table IV.6. M-W Tests Comparing Number of Dorsal Scars for Early Dabban Tool Types with Blade and Normal (Early Dabban) Technologies.

Tool class	**M-W normal ED (Mean = 5.05)**	**M-W blade (Mean = 5.83)**	**Mean**
ED backed knife	.684	.212	5.00
ED burin/chamfer	.563	.698	5.50
ED composite	.186	.053	4.50
ED endscraper	.604	.797	5.35
ED notch/denticulate	.719	.889	5.25
ED sidescraper	.642	.174	5.22
ED truncation	.189	.052	4.43

Middle Palaeolithic

In the Middle Palaeolithic, there appears to be some selection on the basis of dorsal scar complexity (Table IV.7). Sidescrapers in the Middle Palaeolithic appear to be more similar to Levallois flakes in terms of number of dorsal scars, although as noted above there is no evidence that Levallois flakes are specifically selected for this tool type. The only other category that appears to select for high numbers of dorsal scars is the composite class, which is similar to both normal and Levallois flakes. The number of dorsal scars, however, falls between the number for normal and Levallois flakes. Notches and denticulates also have a mean that falls between the two; however, it appears to be similar to neither. This is probably because the distribution is different from both; M-W tests are sensitive to this situation.

Table IV.7. M-W Tests Comparing Number of Dorsal Scars for Middle Palaeolithic Tool Types with Levallois and Normal (Middle Palaeolithic) Technologies.

Tool class	**M-W normal MP (Mean = 4.14)**	**M-W Levallois (Mean = 6.78)**	**Mean**
MP burin	.656	.000	4.20
MP composite	.113	.150	5.77
MP endscraper	.474	.000	3.83
MP notch/denticulate	.034	.000	4.89
MP point	.993	.000	4.00
MP sidescraper	.000	.177	5.94

Pre-Aurignacian

Pre-Aurignacian tools from the Haua Fteah are similar to normal and flake blade debitage (Table IV.8). There appears to be no selection on the basis of the number of dorsal scars. As in the case of the Early Dabban, this is partly due to the fact that the mean number of dorsal scars on flake blades is similar to that of normal flakes in the Pre-Aurignacian.

Table IV.8. M-W Tests Comparing Number of Dorsal Scars for Pre-Aurignacian Tool Types with Flake Blade and Normal (Pre-Aurignacian) Technologies.

Tool class	**M-W normal PA (Mean = 3.57)**	**M-W flake blade (Mean = 4.15)**	**Mean**
PA burin	1.000	.495	3.81
PA notch/denticulate	.568	1.000	4.00
PA sidescraper	.599	.399	3.14

SHAPE (ELONGATION)

The elongation along the axis of the piece was used to compare the shape of the tool classes with the dominant technology and that of normal flakes for each period.

As in the analysis of the debitage, the elongation was transformed using the asin transformation.

Early Dabban

In terms of elongation, the only tool class that is similar to blades is the backed knife (see Table IV.9). Thus elongated pieces are selected for in this tool class. Early Dabban truncations are statistically indistinguishable from normal flakes in terms of elongation; however, they are more often than not made on blades. As the tool's name implies, the tools selected for this type have their shape altered significantly. This suggests that the shapes of truncated pieces have more to do with the process of the transformation of the blank than original shape. Sidescrapers, on the other hand, have a normal, if not slightly less elongated shape, than do normal pieces. This further supports the view that sidescrapers are made preferentially on normal flakes. Burins, chamfers and composite pieces all have average elongation indices that give them blade morphology (less than .5 elongation, i.e., they are on average more than twice as long as they are wide), but these values lie between blades and normal pieces. Although there is no preference for blades for these tools, there appears to be a preference for pieces more elongated than normal.

Table IV.9. *t* tests Comparing (Asin) Elongation for Early Dabban Tool Types with Blade and Normal (Early Dabban) Technologies.

Tool class	***t* test normal ED (untransformed mean = .636)**	***t* test blade (untransformed mean = .335)**	**Untransformed mean**
ED backed knife	.000	.227	.383
ED burin/chamfer	.000	.001	.449
ED composite	.001	.000	.491
ED endscraper	.199	.000	.578
ED notch/denticulate	.343	.009	.557
ED sidescraper	.169	.000	.691
ED truncation	.220	.000	.566

Middle Palaeolithic

In the Middle Palaeolithic, the majority of the tool types are similar to both normal and Levallois flakes (Table IV.10). Again this is because these two types of debitage are similar in terms of elongation. Burins, however, are slightly more elongated on average and are more similar to Levallois than normal. Notches and denticulates are more like normal in that they are less elongated than Levallois. Overall, elongation does not seem to be an important factor in blank morphology for the tools in the Middle Palaeolithic

Table IV.10. *t* tests Comparing (Asin) Elongation for Middle Palaeolithic Tool Types with Levallois and Normal (Middle Palaeolithic) Technologies.

Tool class	*t* test normal MP (untransformed mean = .696)	*t* test Levallois (untransformed mean = .649)	Untransformed mean
MP burin	.017	.226	.595
MP composite	.744	.615	.677
MP endscraper	.196	.533	.672
MP notch/denticulate	.076	.013	.731
MP point	.951	.558	.688
MP sidescraper	.745	.471	.701

Pre-Aurignacian

For all tools in the Pre-Aurignacian, there is a bias towards pieces that are not elongated (Table IV.11). All of the tool classes are, on average, more similar to normal flakes than to flake blades. This reflects the low proportion of flake blades overall and the relatively low number of tools (there are only 3 tools made on flake blades and 53 complete Pre-Aurignacian tools in the entire sample). Despite the existence of a flake blade industry, there is no evidence that this had any special significance when tools were made.

Table IV.11. *t* tests Comparing (Asin) Elongation for Pre-Aurignacian Tool Types with Flake Blade and Normal (Pre-Aurignacian) Technologies.

Tool class	*t* test normal PA (untransformed mean = .637)	*t* test flake blade (untransformed mean = .411)	Untransformed mean
PA burin	.629	.002	.630
PA notch	.155	.004	.694
PA sidescraper	.526	.000	.606

EFFICIENCY (SHARP EDGE/WEIGHT, WEIGHT)

In order to examine efficiency, the third conceptual mode in the preceding chapter, both the amount of sharp cutting edge per gram of flint (log sharpness/weight) and the weight of the piece (log weight) were examined. It is important to note that sharp retouch (i.e., not abrupt) was measured as a sharp edge.

Early Dabban

In the Early Dabban, backed knives have a statistically similar efficiency to blades ([log] sharpness/weight; Table IV.12). In terms of weight, however, with an average between the two types of debitage, they are similar to neither (Table IV.13). In terms of blank selection, therefore, a similar efficiency to blades with slightly larger pieces is selected. None of the other tool types have an efficiency ratio similar to blades. Only composite pieces and truncated pieces are similar to normal flakes, with the remainder being less efficient than both types of debitage. This is due to the fact that composite and truncated pieces have weights statistically similar to normal Early Dabban debitage. In spite of truncation, the weights for truncated pieces show that larger blades are selected in the case of backed knives. Burins and chamfers, endscrapers, notches and denticulates, and sidescrapers all show a selection for larger than normal flakes. The fact that backed knives are heavier than blades but just as efficient shows that tools with a higher amount of cutting edge are selected for this tool type.

Table IV.12. *t* tests Comparing (log) Sharpness/Weight for Early Dabban Tool Types with Blades and Normal (Early Dabban) Technologies.

Tool class	***t* test normal ED (untransformed mean = 9.70)**	***t* test blade (untransformed mean = 20.73)**	**Untransformed mean**
ED backed knife	.005	.183	17.02
ED burin/chamfer	.005	.000	5.96
ED composite	.219	.000	7.05
ED endscraper	.000	.000	4.84
ED notch/denticulate	.007	.000	4.24
ED sidescraper	.000	.000	3.04
ED truncation	.921	.000	8.42

Table IV.13. *t* tests Comparing (log) Weight for Early Dabban Tool Types with Blades and Normal (Early Dabban) Technologies.

Tool class	*t* test normal ED (*p*) (untransformed mean = 6.85)	*t* test blade (*p*) (untransformed mean = 3.86)	Untransformed mean
ED backed knife	.148	.623	4.02
ED burin/chamfer	.000	.000	12.69
ED composite	.121	.001	9.70
ED endscraper	.000	.000	14.21
ED notch/denticulate	.001	.000	14.52
ED sidescraper	.000	.000	21.52
ED truncation	.531	.008	5.57

Middle Palaeolithic

In the Middle Palaeolithic, burins show a statistically similar efficiency to Levallois; they are less efficient than normal flakes (Table IV.14). The remaining flakes are all less efficient in terms of cutting edge. Much of this is due to the fact that heavy flakes were selected for all tools, with all of the mean weights heavier than normal debitage (Table IV.15); burins, endscrapers, and notches and denticulates have the same weight statistically as Levallois pieces, and the remainder heavier than both. The type of retouch in burins, and notches and denticulates, likely plays a role in the lower proportion of sharp edge, with burin blows often creating a blunt margin, and notches and denticulates creating an irregular or discontinuous sharp edge. Endscrapers, on the other hand, by definition exploit a smaller sharp edge on the ends rather than the lateral margin, i.e., a long sharp edge is not necessary. Overall, the most important criteria for blank selection in the Middle Palaeolithic is that the flakes are large.

Table IV.14. *t* tests Comparing (log) Sharpness/Weight for Middle Palaeolithic Tool Types with Levallois and Normal (Middle Palaeolithic) Technologies.

Tool class	*t* test normal MP (untransformed mean = 9.27)	*t* test Levallois (untransformed mean = 6.81)	Untransformed mean
MP burin	.001	.087	4.17
MP composite	.000	.002	2.81
MP endscraper	.002	.024	3.92
MP notch/denticulate	.000	.001	4.71
MP point	.001	.011	3.83

MP sidescraper	.000	.000	3.57

Table IV.15. *t* tests Comparing (log) Weight for Middle Palaeolithic Tool Types with Levallois and Normal (Middle Palaeolithic) Technologies.

Tool class	***t* test normal MP (untransformed mean = 8.08)**	***t* test Levallois (untransformed mean = 12.50)**	**Untransformed mean**
MP burin	.000	.469	10.82
MP composite	.000	.005	32.91
MP endscraper	.002	.208	19.75
MP notch/denticulate	.000	.137	18.68
MP point	.000	.027	20.46
MP sidescraper	.000	.001	29.58

Pre-Aurignacian

In the Pre-Aurignacian, as in the Middle Palaeolithic, there is an overall selection for heavy pieces and the efficiency for all the tool classes is less than either normal flakes or flake blades (Table IV.16 and Table IV.17). Notches are marginally similar to flake blades in terms of weight; however, at p = .52 and a small sample size, they are essentially heavier than both. As above, the type of retouch can partly explain the lower efficiency for burins and notches, and sidescrapers are clearly less efficient due to size alone.

Table IV.16. *t* tests Comparing (log) Sharpness/Weight for Pre-Aurignacian Tool Types with Flake Blade and Normal (Pre-Aurignacian) Technologies.

Tool class	***t* test normal PA (untransformed mean = 9.27)**	***t* test flake blade (untransformed mean = 9.57)**	**Untransformed mean**
PA burin	.000	.000	2.74
PA notch	.001	.001	2.40
PA sidescraper	.001	.001	4.68

Table IV.17. *t* tests Comparing (log) Weight for Pre-Aurignacian Tool Types with Flake Blade and Normal (Pre-Aurigacian) Technologies.

Tool class	***t* test normal PA (untransformed mean = 14.35)**	***t* test flake blade (untransformed mean = 13.77)**	**Untransformed mean**
PA burin	.000	.001	31.92
PA notch	.002	.052	19.69
PA sidescraper	.001	.017	32.51

DISCUSSION

Over time, there is a change in blank selection. In the Pre-Aurignacian, when tools are less frequent, there appears to be no selection on the basis of technology, complexity or elongation. The only factor that shows selection in the Pre-Aurignacian is size, with larger blanks being transformed into tools. The presence of hard hammer blades, a statistically distinct type of debitage, appears to have no bearing on tool manufacture. Therefore, apart from a deliberate selection for larger blanks to make tools, the relationship between debitage and tools is ad hoc.

In the Middle Palaeolithic there appears to be some selection for more complex pieces for sidescrapers and composite tools. Although Levallois flakes per se are not selected, there is some selection for complexity, which is the most significant conceptual mode in Levallois technology and the Middle Palaeolithic as a whole. Thus there is recognition of the important attribute in Levallois technology, without it being specially selected. In addition, building on the pattern in the earlier Pre-Aurignacian, large flakes are also selected.

Blank selection becomes an important aspect of tool manufacture in the Early Dabban. Backed knives and truncated pieces are preferentially made on blades, and sidescrapers are preferentially made on normal flakes. There is clear selection for the products of blade technology, not just some of its attributes. Although there appears to be little selection on the basis of complexity, elongation is an important criterion for backed knives, burins and chamfers, and composite pieces. Although blades are not preferentially selected, the attribute of elongation is selected. Truncations, on the other hand, show a process of significant alteration of their shape, beginning life as elongated blades and, on average, being reduced to less than twice as long as they are wide, becoming more similar to normal Early Dabban pieces. This is a statistically supported example of imposed form.

Concerning efficiency and weight, there are important differences between tool categories, despite an overall selection for larger pieces. Backed knives made on blades show similar efficiency and weight. They reveal a tendency toward higher efficiency, however, when their weight is examined in conjunction with sharpness/weight. Truncated pieces are also heavier than blades, despite being significantly reduced in size through retouch. This suggests that size selection among blades may be important. An overall tendency for the selection of heavier than average blanks appears to be a constant throughout each culture period. The only exceptions appear to be Early Dabban backed knives, which are statistically similar to blades in terms of weight.

Overall Early Dabban tool manufacture shows the most behaviourally complex relationship between blank production, selection of blanks for tools and tool transformation. Thirty percent of the debitage are blades (Table IV.2). A large proportion is geared toward the production of two tool types, suggesting intentional planning. There is an integration of processes between blank production and subsequent transformation. The principle of elongation is important even when there is no support for preferential use of blades (as in the case of burins, chamfers and composite pieces). It is also important to note that the two tool types that have preferential blade selection occur only in very small proportions in the previous culture periods (Table IV.3) and involve a unique form of retouching (blunting rather than sharpening).

This said, there is a difference between Pre-Aurignacian tool manufacture and Middle Palaeolithic tool manufacture in terms of blank morphology, with selection on the basis of complexity in the latter. Complexity, if anything, is a *paradigm* in the Middle Palaeolithic. In the Pre-Aurignacian there is no significant selection of blanks other than that for larger flakes, which runs as a constant through the whole sequence. Thus, although the differences between the Early Dabban and the remainder are more dramatic, change does occur before this transition.

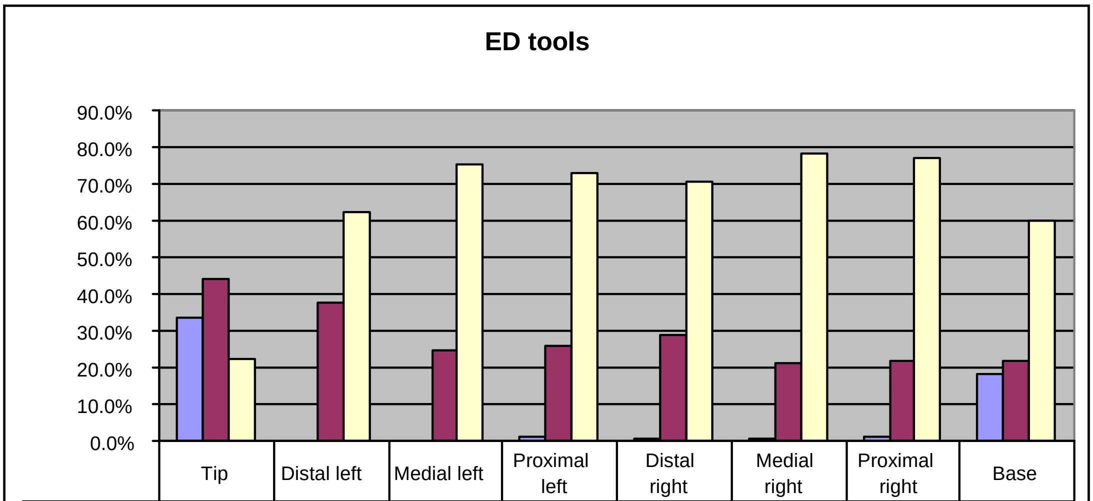
In short, blank selection occurs to some extent in all culture periods. In the Pre-Aurignacian, heavy blanks are selected. In the Middle Palaeolithic heavy blanks, and those with a higher than normal number of dorsal scars are selected. Thus, size and attribute selection occurs. This continues in the Early Dabban, with the products of a specific technological process being selected as well. There is clear blank selection in the Early Dabban and blades make up a much larger proportion of the debitage when compared to Levallois blanks and flake blades in the Middle Palaeolithic and Pre-Aurignacian, respectively. It appears that blade production is done with the specific aim of producing blanks for certain tool types. There is cumulative change in blank selection across the periods. As with the technology of the debitage itself, however, the difference between the Early Dabban and preceding periods is more dramatic.

RETOUCH LOCATION

Simple bar charts were used to examine the differences in retouch location. Eight possible locations for retouch were considered for each tool. It was determined if there was retouch, if the region was unmodified or if it was not applicable to measure that location. In order to describe retouch location each piece was oriented along its longest symmetric axis (as in the length along the axis measurement) and dorsal face up. The piece was segmented into thirds (distal, medial and proximal). When the platform was not at the base of the tool (as in the case of skewed pieces), the tool was positioned so that the point of percussion on the platform was in the proximal half of the tool (see McPherron and Dibble 1999). In addition, if the tip or the base of the piece formed a substantial edge (or in the case of curves, the tangent of the curve at the most distal end) that was roughly perpendicular to the axis, this edge was recorded. If there was no edge (as in the case of the tip or the base) or the edge was damaged, *n/a* was recorded. Each location was independently recorded, i.e., it was noted simply whether there was retouch or not at that location. The location of the majority of retouch was not determined.

Early Dabban

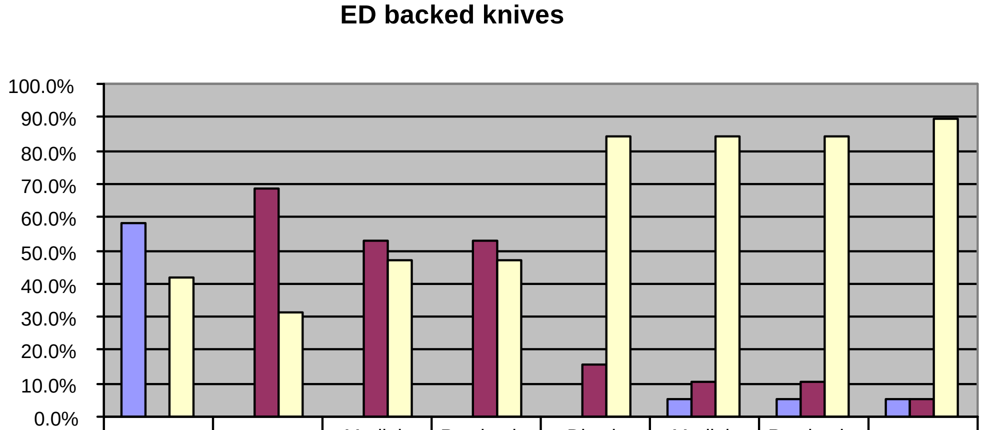
In the Early Dabban the part of the tool with the highest number of retouched pieces is the tip (Figure IV.1). There is also a slight bias toward the distal end and there are more retouched edges on the left than the right. Otherwise, apart from the tip and perhaps the distal right, the retouch is fairly evenly distributed around the margin of the tool.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	33.6%	0.0%	0.0%	1.4%	0.7%	0.7%	1.4%	18.2%
retouch	44.1%	37.8%	24.5%	25.9%	28.7%	21.0%	21.7%	21.7%
unmodified	22.4%	62.2%	75.5%	72.7%	70.6%	78.3%	76.9%	60.1%

Figure IV.1. Location of Retouch for All Early Dabban Tools.

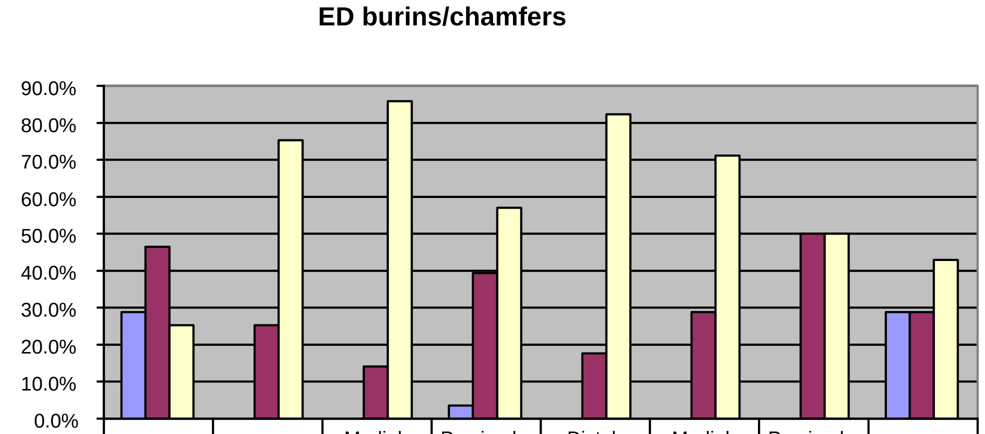
There are important differences, however, when the individual tool types that comprise the Early Dabban are examined. The backed knives show an interesting distribution that differs from the overall pattern for the Early Dabban. In all 19 backed knives there is not a single piece that has a modified tip (Figure IV.2). There is also a very strong bias towards retouching the left side of the tool.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	57.9%	0.0%	0.0%	0.0%	0.0%	5.3%	5.3%	5.3%
retouch	0.0%	68.4%	52.6%	52.6%	15.8%	10.5%	10.5%	5.3%
unmodified	42.1%	31.6%	47.4%	47.4%	84.2%	84.2%	84.2%	89.5%

Figure IV.2. Location of Retouch for Early Dabban Backed Knives.

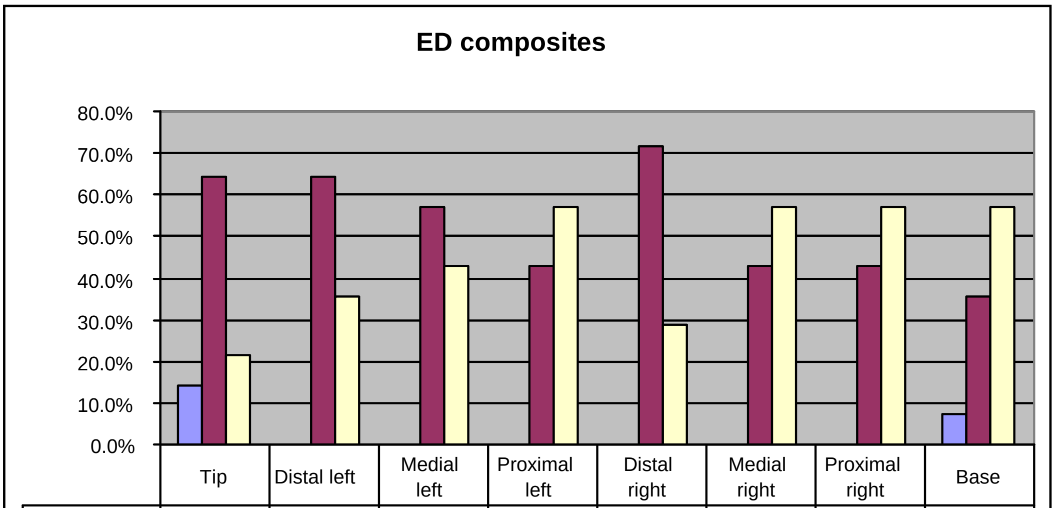
Burins and chamfered pieces in the Early Dabban show relatively high numbers of retouched edges on the tip and the base (Figure IV.3). The proximal end is also worked more than on other Early Dabban tools.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	28.6%	0.0%	0.0%	3.6%	0.0%	0.0%	0.0%	28.6%
retouch	46.4%	25.0%	14.3%	39.3%	17.9%	28.6%	50.0%	28.6%
unmodified	25.0%	75.0%	85.7%	57.1%	82.1%	71.4%	50.0%	42.9%

Figure IV.3. Location of Retouch for Early Dabban Burins and Chamfers.

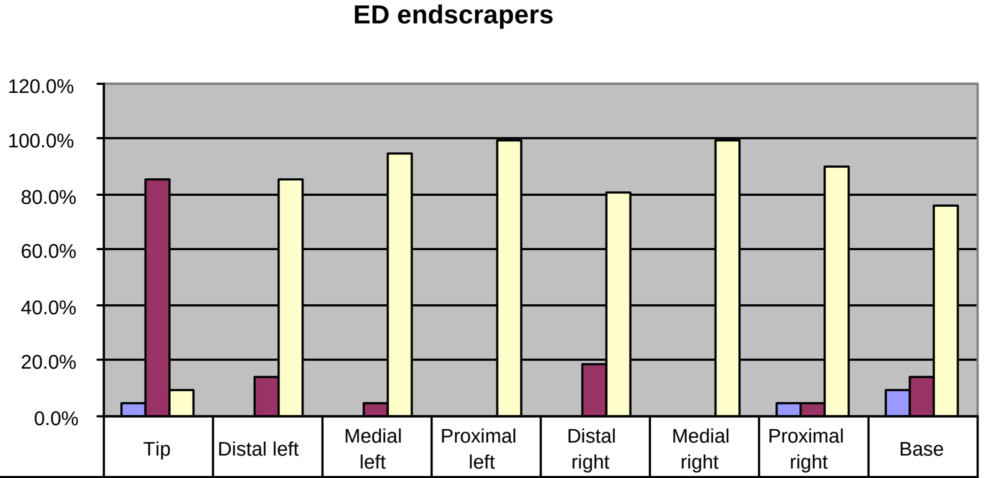
Composite pieces show higher amounts of reworking on all edges than other Early Dabban tools (Figure IV.4).



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.1%
retouch	64.3%	64.3%	57.1%	42.9%	71.4%	42.9%	42.9%	35.7%
unmodified	21.4%	35.7%	42.9%	57.1%	28.6%	57.1%	57.1%	57.1%

Figure IV.4. Location of Retouch for Early Dabban Composite Pieces.

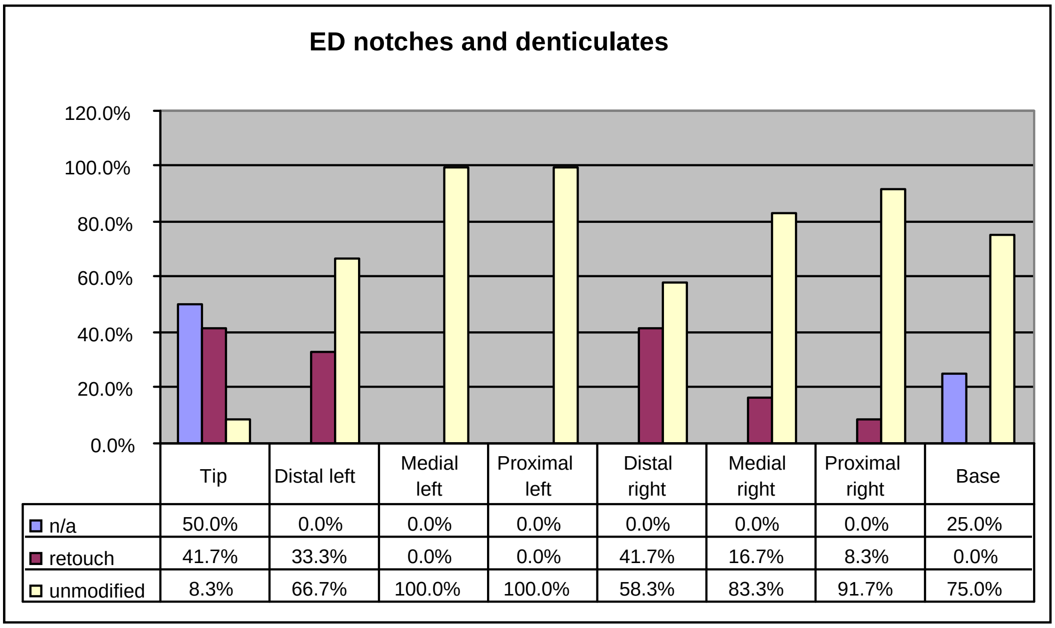
Endscrapers have a unique distribution. As one would expect, the proportion of retouching on the tip is very high at 86% (Figure IV.5). The 14% of pieces with retouch on the base meet the requirements for this type. The relatively low proportion of retouch on other margins is noteworthy. The location of retouch is extremely localised and does not appear to "spill" down the edges. It is interesting to compare the Early Dabban to the Middle Palaeolithic endscrapers, which are of the same general type of tool but exhibit considerable retouch on the distal margins.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	9.5%
retouch	85.7%	14.3%	4.8%	0.0%	19.0%	0.0%	4.8%	14.3%
unmodified	9.5%	85.7%	95.2%	100.0%	81.0%	100.0%	90.5%	76.2%

Figure IV.5. Location of Retouch for Early Dabban Endscrapers.

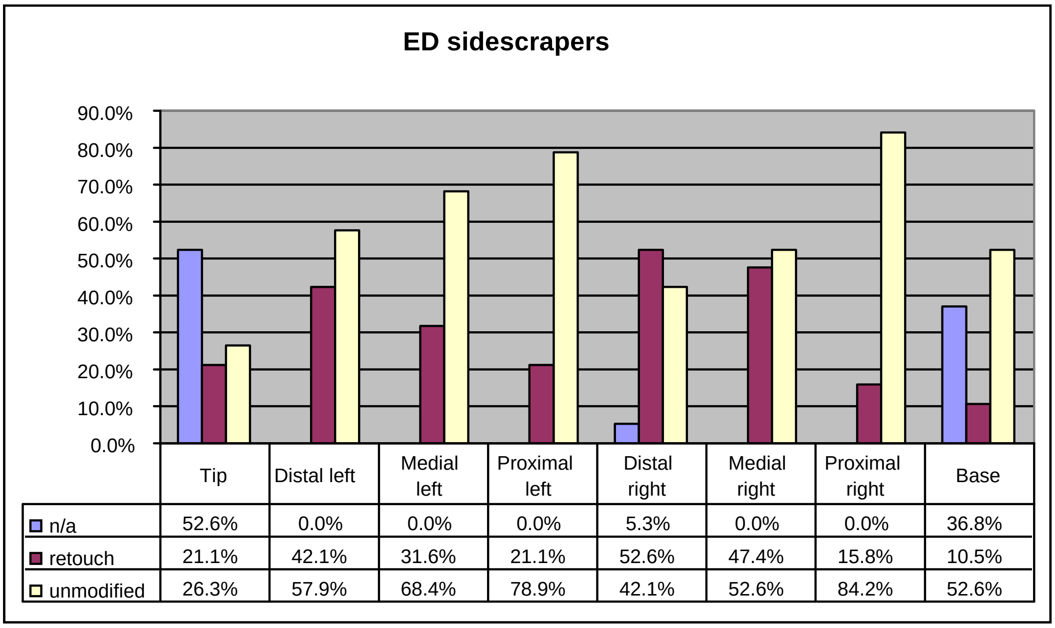
Notches and denticulates show an interesting pattern. There are several end-notched pieces, with over 40% of all notched pieces in the Early Dabban having notches or denticulates on the tip (Figure IV.6). The distal sides also appear to have considerable retouch; the medial and proximal left edges and the base have no retouch. Again there is an interesting contrast with the Middle Palaeolithic.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%
retouch	41.7%	33.3%	0.0%	0.0%	41.7%	16.7%	8.3%	0.0%
unmodified	8.3%	66.7%	100.0%	100.0%	58.3%	83.3%	91.7%	75.0%

Figure IV.6. Location of Retouch for Early Dabban
Notches and Denticulates.

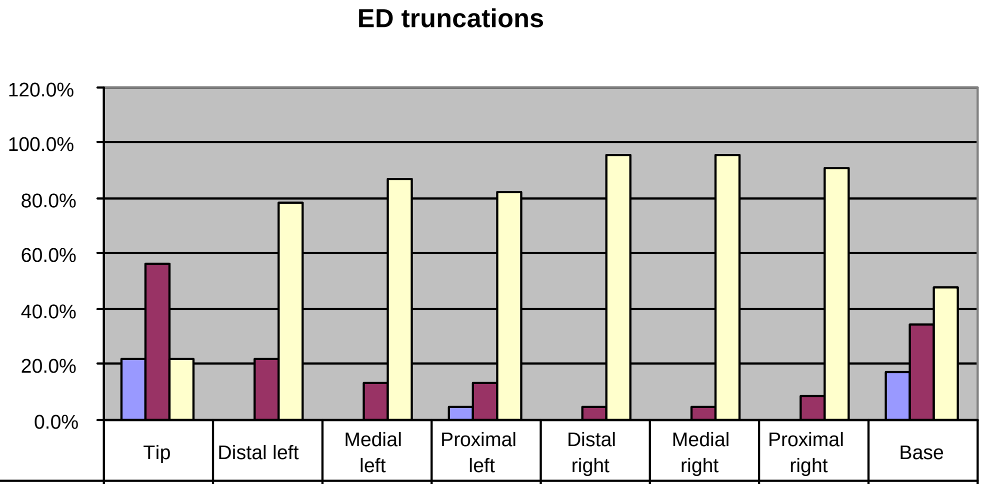
Sidescrapers in the Early Dabban tend to have more retouch on the distal right and medial right than on the left side (Figure IV.7). The remaining locations of retouch appear to be similar to the overall pattern.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	52.6%	0.0%	0.0%	0.0%	5.3%	0.0%	0.0%	36.8%
retouch	21.1%	42.1%	31.6%	21.1%	52.6%	47.4%	15.8%	10.5%
unmodified	26.3%	57.9%	68.4%	78.9%	42.1%	52.6%	84.2%	52.6%

Figure IV.7. Location of Retouch for Early Dabban
Sidescrapers.

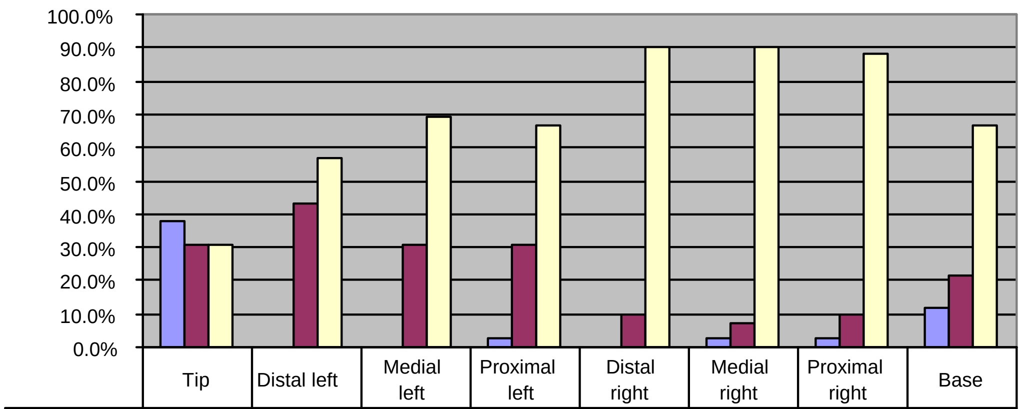
As one would expect, Early Dabban truncations have the majority of retouch on the tip and base, but like backed knives they show slightly more retouch on the left than on the right (Figure IV.8). This is important because the type of retouch for truncations is the same as backed knives, i.e., blunted.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	21.7%	0.0%	0.0%	4.3%	0.0%	0.0%	0.0%	17.4%
retouch	56.5%	21.7%	13.0%	13.0%	4.3%	4.3%	8.7%	34.8%
unmodified	21.7%	78.3%	87.0%	82.6%	95.7%	95.7%	91.3%	47.8%

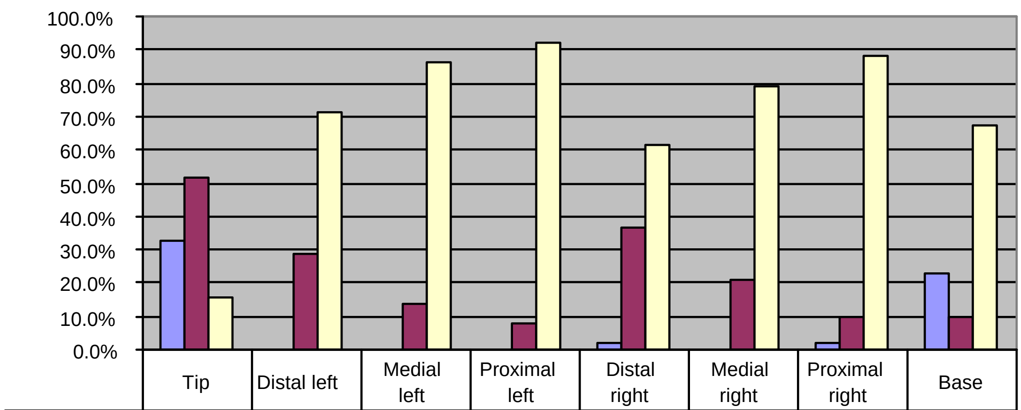
Figure IV.8. Location of Retouch for Early Dabban Truncations.

There is a tendency to retouch the left (Figure IV.9) on pieces with blunted edges (backed knives and truncations). However, when pieces have a sharpened edge (endscrapers, notches and denticulates, and sidescrapers) there is a tendency, although less strong, for the retouched edge to be on the right (Figure IV.10). This shows that in the manufacture of Early Dabban tools, the working or sharp edge is normally on the right. This appears to be an intentional design element in the Early Dabban.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	38.1%	0.0%	0.0%	2.4%	0.0%	2.4%	2.4%	11.9%
retouch	31.0%	42.9%	31.0%	31.0%	9.5%	7.1%	9.5%	21.4%
unmodified	31.0%	57.1%	69.0%	66.7%	90.5%	90.5%	88.1%	66.7%

Figure IV.9. Location of Retouch for Early Dabban Tools
with Blunted Edges.

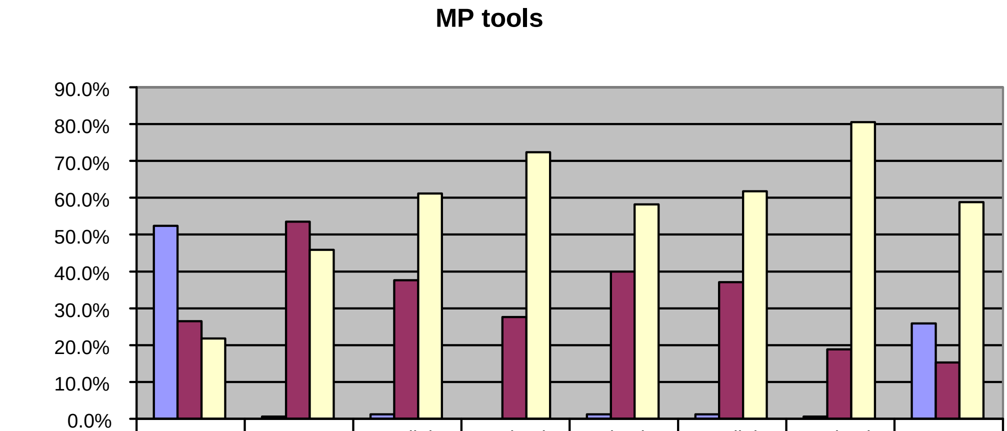


	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	32.7%	0.0%	0.0%	0.0%	1.9%	0.0%	1.9%	23.1%
retouch	51.9%	28.8%	13.5%	7.7%	36.5%	21.2%	9.6%	9.6%
unmodified	15.4%	71.2%	86.5%	92.3%	61.5%	78.8%	88.5%	67.3%

Figure IV.10. Location of Retouch for Early Dabban Tools
with Sharp Edges.

Middle Palaeolithic

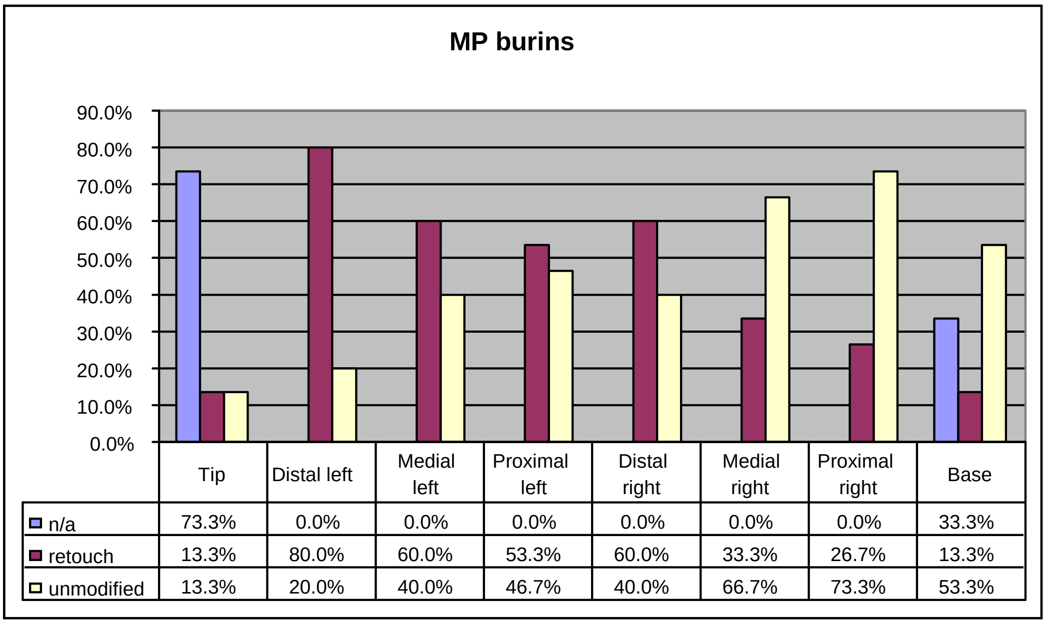
In the Middle Palaeolithic there is a slight tendency for the tools to have more retouch on the distal end and on the right margin (Figure IV.11). When there is a sufficient edge on the tip (i.e., not n/a) this margin is retouched more often than not.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	52.1%	0.7%	1.4%	0.0%	1.4%	1.4%	0.7%	25.7%
retouch	26.4%	53.5%	37.5%	27.8%	40.3%	36.8%	18.8%	15.3%
unmodified	21.5%	45.8%	61.1%	72.2%	58.3%	61.8%	80.6%	59.0%

Figure IV.11. Location of Retouch for All Middle Palaeolithic Tools.

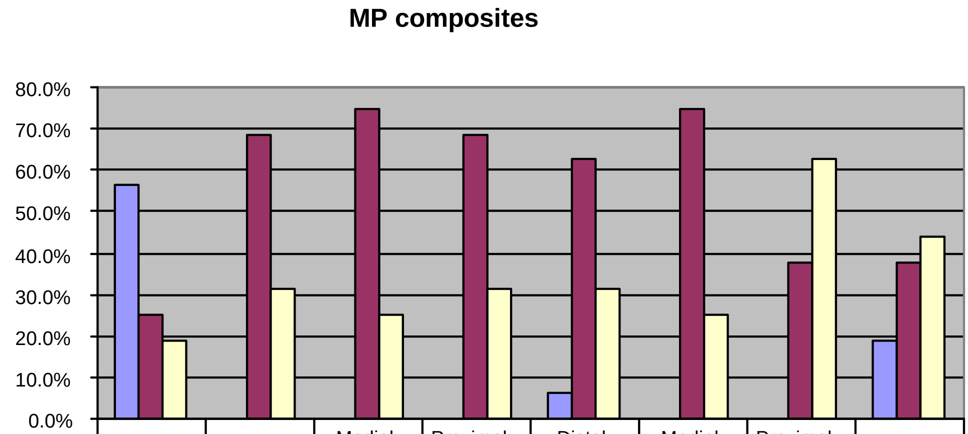
Regarding the different tool classes, Middle Palaeolithic burins show a similar tendency to the overall pattern. They are more intensively retouched overall, however, and fewer pieces have a suitable edge on the tip, focusing on the lateral margins rather than on the ends (Figure IV.12). Retouch location on burins in the Middle Palaeolithic is also very different from that of the Early Dabban.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	73.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%
retouch	13.3%	80.0%	60.0%	53.3%	60.0%	33.3%	26.7%	13.3%
unmodified	13.3%	20.0%	40.0%	46.7%	40.0%	66.7%	73.3%	53.3%

Figure IV.12. Location of Retouch for Middle Palaeolithic Burins.

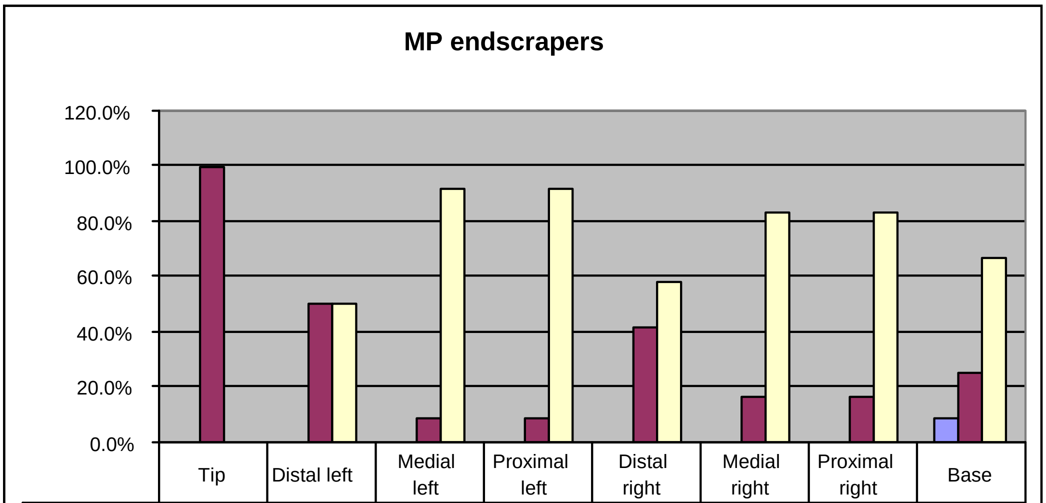
As in the Early Dabban, composite pieces in the Middle Palaeolithic exhibit a greater number of retouched edges (Figure IV.13). Unlike the Early Dabban, however, the tip is less worked. Compared to the overall pattern in the Middle Palaeolithic, the most often retouched edges are the medial left and right edges. There is also a slight bias toward working the left margin, especially compared to the proximal left and right.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	56.3%	0.0%	0.0%	0.0%	6.3%	0.0%	0.0%	18.8%
retouch	25.0%	68.8%	75.0%	68.8%	62.5%	75.0%	37.5%	37.5%
unmodified	18.8%	31.3%	25.0%	31.3%	31.3%	25.0%	62.5%	43.8%

Figure IV.13. Location of Retouch for Middle Palaeolithic Composite Pieces.

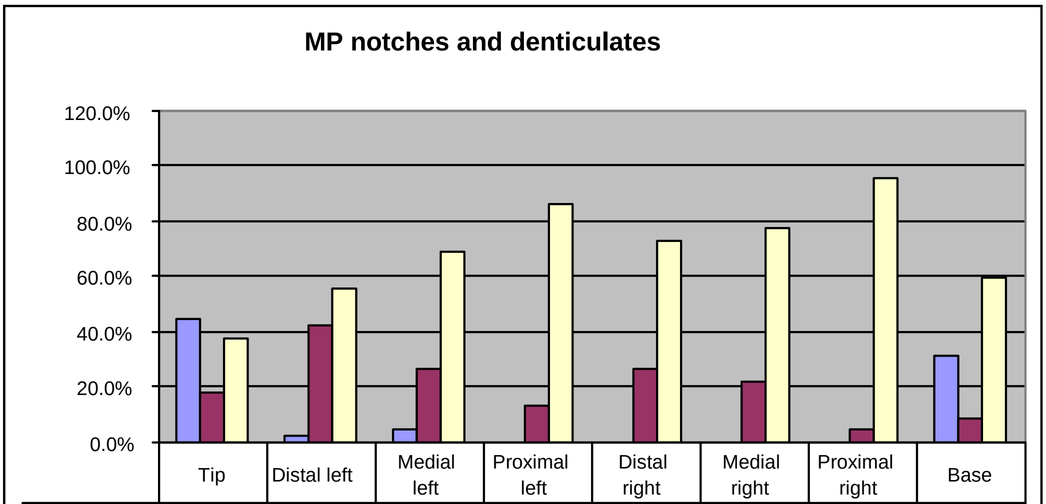
The endscrapers in the Middle Palaeolithic all have retouch on the tip and 25% of them have retouch on the base (Figure IV.14). This fits well with the typological definition of endscrapers. Compared to Early Dabban endscrapers, however, this retouch is less localised, with between 40 and 50% of both distal edges having been retouched. This suggests a proportionally larger retouched edge spilling down the margin of the piece. Like the Middle Palaeolithic tool population as a whole, there is a distal tendency; however, there is less retouch on the medial and proximal margins.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%
retouch	100.0%	50.0%	8.3%	8.3%	41.7%	16.7%	16.7%	25.0%
unmodified	0.0%	50.0%	91.7%	91.7%	58.3%	83.3%	83.3%	66.7%

Figure IV.14. Location of Retouch for Middle Palaeolithic Endscrapers.

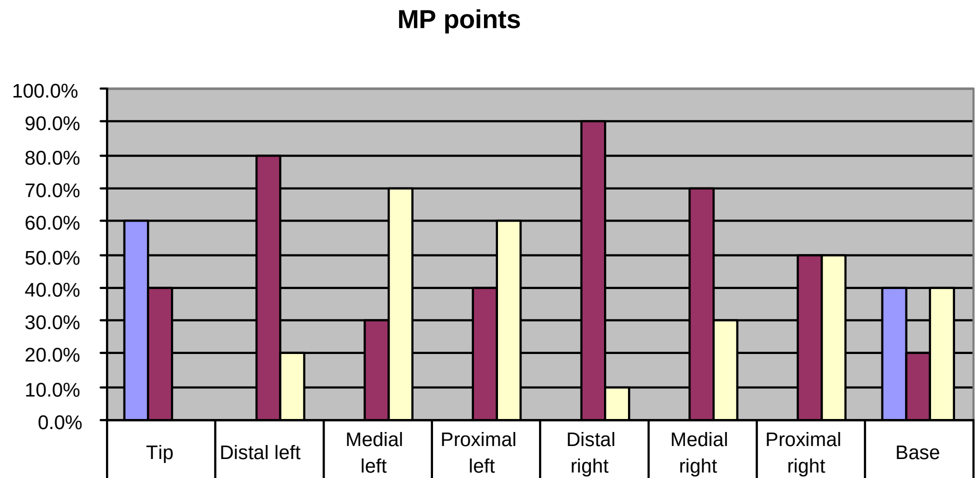
Notches and denticulates have relative proportions of retouch very similar to Middle Palaeolithic tools in general, but with slightly less retouch overall (Figure IV.15). This suggests that usually only one or two edges have a notched or denticulated edge.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	44.4%	2.2%	4.4%	0.0%	0.0%	0.0%	0.0%	31.1%
retouch	17.8%	42.2%	26.7%	13.3%	26.7%	22.2%	4.4%	8.9%
unmodified	37.8%	55.6%	68.9%	86.7%	73.3%	77.8%	95.6%	60.0%

Figure IV.15. Location of Retouch for Middle Palaeolithic Notches and Denticulates.

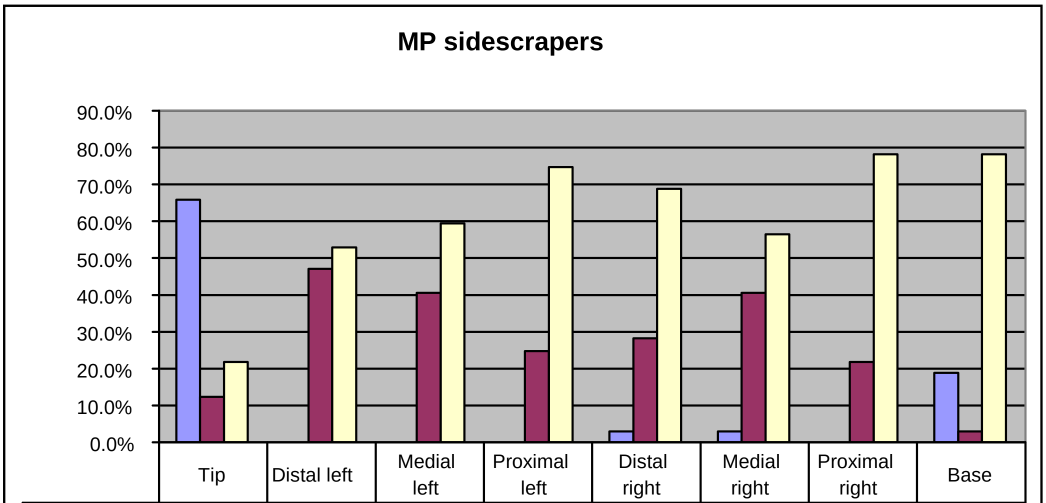
Although there are only 10, Middle Palaeolithic points show a strong bias toward the distal end (Figure IV.16). When there is a tip margin, it is always retouched and 80 and 90% of the distal left and right margins are retouched, respectively. There is also a greater tendency toward working the right margin than the left than in Middle Palaeolithic tools overall.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	60.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	40.0%
retouch	40.0%	80.0%	30.0%	40.0%	90.0%	70.0%	50.0%	20.0%
unmodified	0.0%	20.0%	70.0%	60.0%	10.0%	30.0%	50.0%	40.0%

Figure IV.16. Location of Retouch for Middle Palaeolithic Points.

Sidescrapers have a relatively higher proportion of retouch on the medial right margin than on other edges (Figure IV.17). The amount on the distal right margin is lower than expected. Overall, however, the left margin is slightly more retouched than the right whereas the medial left and right have identical proportions of retouch. These proportions are also similar to Middle Palaeolithic tools in general. This implies that for some reason, the distal right is not retouched as often. Part of this may be explained on typological grounds. Pieces that show retouch on both the distal left and right margin together are likely to be classed as points. The pattern for Middle Palaeolithic sidescrapers is also similar to that for the Early Dabban.

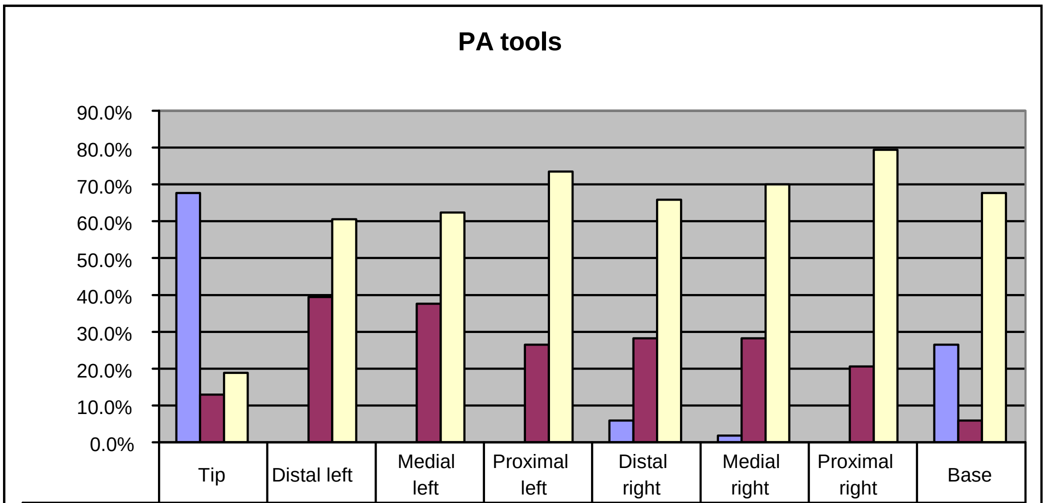


	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	65.6%	0.0%	0.0%	0.0%	3.1%	3.1%	0.0%	18.8%
retouch	12.5%	46.9%	40.6%	25.0%	28.1%	40.6%	21.9%	3.1%
unmodified	21.9%	53.1%	59.4%	75.0%	68.8%	56.3%	78.1%	78.1%

Figure IV.17. Location of Retouch for Middle Palaeolithic Sidescrapers.

Pre-Aurignacian

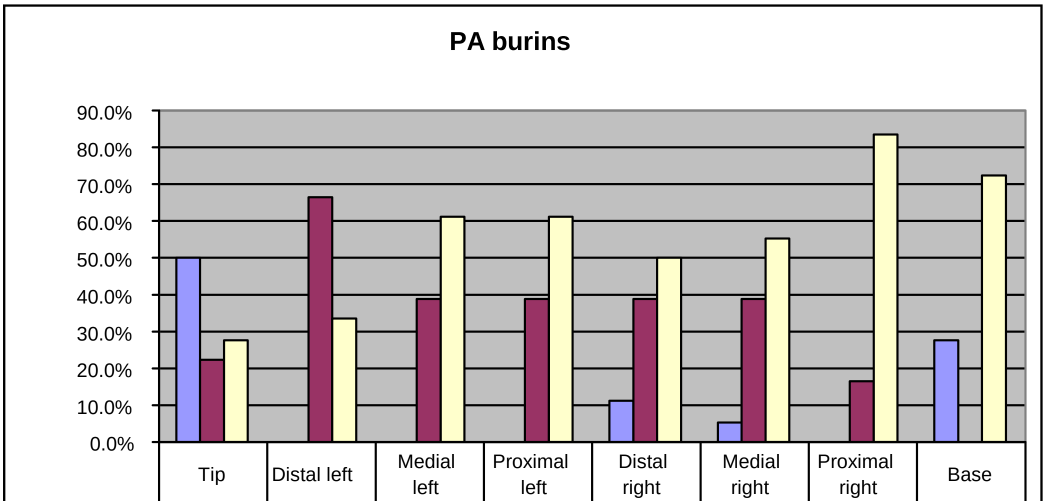
In the Pre-Aurignacian the overall tendencies for retouch location (Figure IV.18) are similar to those of the Middle Palaeolithic with a slight bias toward lateral and distal retouching. The number of different retouched locations, however, is less than in the Middle Palaeolithic and the Early Dabban. All of the possible retouch locations are more often unmodified than retouched. Thus, in many cases, only one or two of the possible retouch locations were exploited.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	67.9%	0.0%	0.0%	0.0%	5.7%	1.9%	0.0%	26.4%
retouch	13.2%	39.6%	37.7%	26.4%	28.3%	28.3%	20.8%	5.7%
unmodified	18.9%	60.4%	62.3%	73.6%	66.0%	69.8%	79.2%	67.9%

Figure IV.18. Location of Retouch for All Pre-Aurignacian Tools.

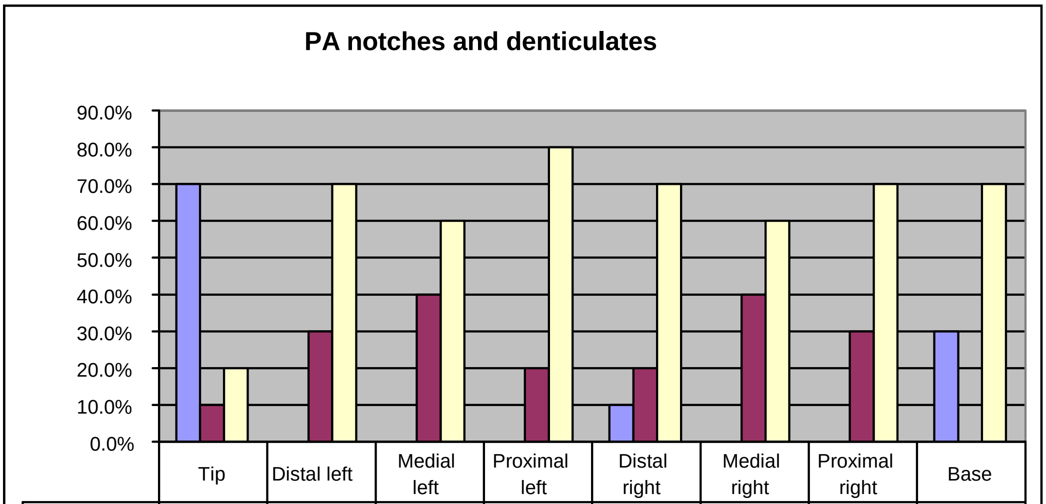
Because there were only three tool classes with 10 or more tools, the comparisons are limited. Burins, the most common tool class, show a strong tendency toward retouching on the distal left margin (Figure IV.19). Apart from this location, the patterns appear to be basically similar to the overall Pre-Aurignacian pattern.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	50.0%	0.0%	0.0%	0.0%	11.1%	5.6%	0.0%	27.8%
retouch	22.2%	66.7%	38.9%	38.9%	38.9%	38.9%	16.7%	0.0%
unmodified	27.8%	33.3%	61.1%	61.1%	50.0%	55.6%	83.3%	72.2%

Figure IV.19. Location of Retouch for Pre-Aurignacian Burins.

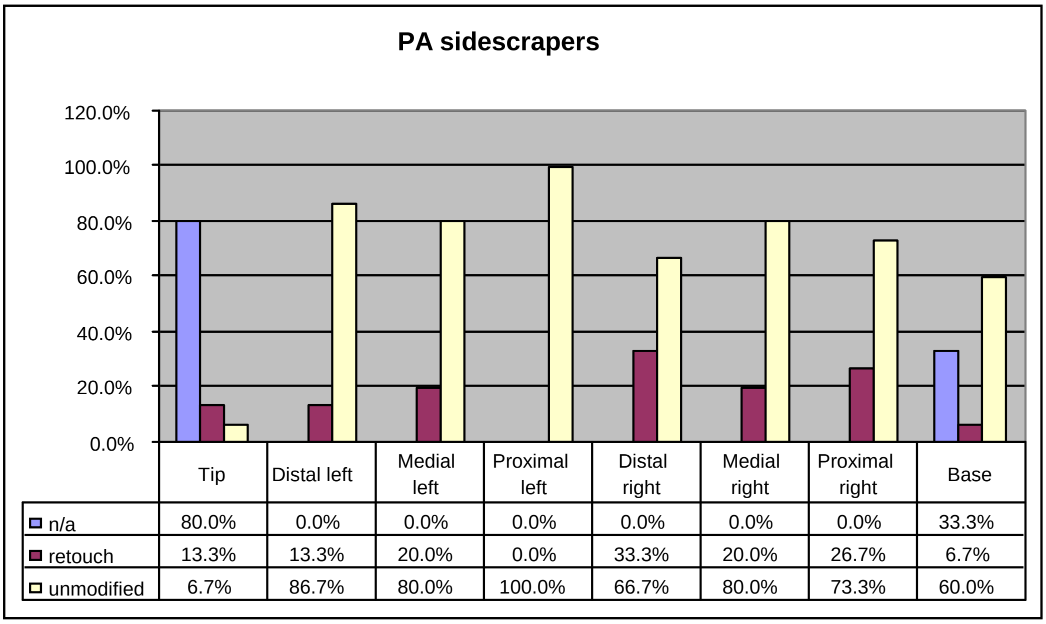
Unlike the overall pattern, however, notches and denticulates in the Pre-Aurignacian have more retouch than normal on both the medial left and right (Figure IV.20).



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	70.0%	0.0%	0.0%	0.0%	10.0%	0.0%	0.0%	30.0%
retouch	10.0%	30.0%	40.0%	20.0%	20.0%	40.0%	30.0%	0.0%
unmodified	20.0%	70.0%	60.0%	80.0%	70.0%	60.0%	70.0%	70.0%

Figure IV.20. Location of Retouch for Pre-Aurignacian Notches and Denticulates.

Finally, the most important aspect of Pre-Aurignacian sidescrapers is that there is relatively little retouch overall, especially in comparison to the later Middle Palaeolithic and Early Dabban periods (Figure IV.21). Despite the low proportions, there is more retouch on the right than the left, which is different from the population of Pre-Aurignacian tools as a whole.



	Tip	Distal left	Medial left	Proximal left	Distal right	Medial right	Proximal right	Base
n/a	80.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%
retouch	13.3%	13.3%	20.0%	0.0%	33.3%	20.0%	26.7%	6.7%
unmodified	6.7%	86.7%	80.0%	100.0%	66.7%	80.0%	73.3%	60.0%

Figure IV.21. Location of Retouch for Pre-Aurignacian Sidescrapers.

DISCUSSION

An examination of the distribution of retouch location in Early Dabban tools shows that there are two axes of differentiation. The first is on the utilisation of the tip. Especially when compared to the Middle Palaeolithic and the Pre-Aurignacian, the use of the tip is high; however, not all tools utilise the tip extensively. Backed knives rarely have a tip and when they do it is never modified. Sidescrapers also do not utilise the tip extensively. Endscrapers and truncations do utilise the tip extensively. In endscrapers the tip retouch is extremely localised, with a relatively small proportion of retouch occurring on the distal margins.

The second axis of differentiation is on retouch type, with a distinction between retouch that creates a working edge and retouch that does not. When abrupt retouch is applied (creating a dull edge, either for holding or potentially for hafting), it is more often than not on the left margin. Working or sharp retouch is biased toward the right lateral margin, but also slightly toward the distal end and the tip.

A different pattern emerges in the Middle Palaeolithic. The distal left is the most commonly used site for retouch overall, and occurs in relatively high proportions in all tool types. This shows that there is relatively little differentiation between tool categories. Endscrapers provide the only distribution that stands out. As one might expect, the proportion of retouch on the tip of endscrapers is high (in this case 100%, although it can occur at the base and be considered an endscraper); however, 50% of the endscrapers in the Middle Palaeolithic have retouch on the distal left margin. Despite the high proportion of retouch on the end, the remainder of the retouch fits well within the overall pattern for the Middle Palaeolithic. In fact, 50% is a greater proportion of retouch than for the distal left of sidescrapers. In many ways these tools do not appear to differ as much as one would expect and endscrapers, in part, simply stand out because of their typological distinction. The contrast between the types is much greater in the Early Dabban. Despite a bias toward the tip in endscrapers, the pattern for the Middle Palaeolithic in terms of retouch location is relatively undifferentiated across the tool types.

Finally, in the Pre-Aurignacian there is a slight lateral bias with the exception of burins. Burins have a bias toward the distal left and have more locations of retouch overall than the other categories; apart from this location, however, they are similar to the other tool types. Notches, denticulates and scrapers have relatively fewer regions that have retouch, suggesting a less intense retouching strategy. Overall, there may be a slight differentiation between burins and the other categories; however, in other respects they are similar. The pattern of retouch in burins is, in fact very similar to that in the Middle Palaeolithic and may relate to a technical process (in the Early Dabban, there is a bias towards the tip and base, which is due in part to the inclusion of chamfers in this category).

To summarise, the Early Dabban shows two important ways in which tools differ: type of retouch and location of retouch. There is a bias toward creating a working edge on the right of the tool and a blunting retouch on the left. There is also a greater and more localised use of the tip than in the preceding period. Other tool types show a preferential use of the lateral margin (backed knives and sidescrapers). Despite the differentiation of a single tool type in each period, in both the Middle Palaeolithic and the Pre-Aurignacian the overall patterns of retouch location are relatively undifferentiated. In the case of endscrapers in the Middle Palaeolithic and burins in the Pre-Aurignacian, all but one of the retouch locations are similar to the general pattern. Unlike in the Early Dabban, typological or technical considerations, rather than an intended pattern, may simply explain these differences.

INTENSITY OF RETOUCH

Only the dominant edge was recorded in this analysis. For example, if a sidescraper had two locations of retouch, the most modified continuously retouched edge was measured. Two measures of retouch intensity were taken for each tool. The first measure was the length of the retouched edge divided by the length of the tool along the axis. The second was the invasiveness of the retouch, i.e., how far the retouch travelled into the tool perpendicular to the edge of the retouched piece. The most invasive retouch scar was recorded and for burins and abrupt edges the thickness of the retouch was measured.

For both measures, comparisons were made between the different tool types within each culture and the categories of tools occurring across different cultures. *t* tests were used to compare each tool class and within each culture S-N-K tests were used. The retouch to length ratio was not transformed because it had an essentially normal distribution. A log (10) transformation was used to normalise the invasiveness of the retouch.

RETOUCH/LENGTH BY TOOL TYPE

Early Dabban

Although there is considerable overlap (Table IV.18 and Table IV.19), two groups appear when S-N-K and pair-wise tests are done on the different tool types within the Early Dabban. Backed knives show the greatest retouched length to axis ratio, with almost two thirds of their margins retouched. Notches and denticulates have just over one third of their margin retouched. Backed knives are similar to sidescrapers and composite pieces ($p > .05$), but were statistically distinct from notches and denticulates, endscrapers, burins and truncations. Notches are similar to endscrapers, burins and truncations, but not to backed knives, sidescrapers and composite pieces. Thus there are two main groups, despite some overlap. The two groups differ essentially on the location of retouch, with the laterally retouched pieces (see above) having greater proportions of retouch than those with retouch on their ends. This ratio reflects the length of the margin used for retouch in the different tool types and a division into two strategies.

Table IV.18. Homogenous Subsets (S-N-K) for Retouch/Length in the Early Dabban by Tool Type.

Tool category	*n*	1	2	3
ED notch/denticulate	12	.3481		
ED endscraper	21	.3905	.3905	
ED burin/chamfer	28	.4678	.4678	
ED truncation	23	.4708	.4708	
ED composite	14		.5421	.5421
ED sidescraper	19		.5820	.5820
ED backed knife	19			.6629
Significance		.307	.054	.203

Table IV.19. Pair-Wise *t* tests for Retouch/Length in the Early Dabban by Tool Type.

	ED notch/ denticulate	**ED endscraper**	**ED burin/ chamfer**	**ED truncation**	**ED composite**	**ED sidescraper**	**ED backed knife**	**Mean**
ED notch/denticulate	-	.583	.106	.108	.022	.003	.000	.3481
ED endscraper	.583	-	.211	.214	.041	.005	.000	.3905
ED burin/chamfer	.106	.211	-	.960	.289	.074	.003	.4678
ED truncation	.108	.214	.960	-	.325	.095	.004	.4708
ED composite	.022	.041	.289	.325	-	.596	.110	.5421
ED sidescraper	.003	.005	.074	.095	.596	-	.244	.5820
ED backed knife	.000	.000	.003	.004	.110	.244	-	.6629

Middle Palaeolithic

The only tool class in the Middle Palaeolithic to stand out is the point category (Table IV.20 and Table IV.21). Points have more retouch/length than the other categories. On average, the retouch length is greater than three quarters of the length of the piece. Although there is considerable overlap in the remaining categories, notches and denticulates have less retouch than three other categories, with a ratio of retouch to length of less than one half.

Table IV.20. Homogenous Subsets (S-N-K) for Retouch/Length in the Middle Palaeolithic by Tool Type.

Tool category	***n***	**1**	**2**
MP notch/denticulate	45	.4285	
MP composite	16	.5035	
MP endscraper	12	.5532	
MP burin/chamfer	15	.5765	
MP sidescraper	32	.5893	
MP point	10		.7583
Significance		.182	1.000

Table IV.21. Pairwise *t* tests for Retouch/Length in the Middle Palaeolithic by Tool Type.

	MP notch/ denticulate	**MP composite**	**MP endscraper**	**MP burin/ chamfer**	**MP sidescraper**	**MP point**	**Mean**
MP notch/denticulate	-	.222	.070	.020	.001	.000	.4285
MP composite	.222	-	.536	.335	.184	.003	.5035
MP endscraper	.070	.536	-	.776	.613	.024	.5532
MP burin/chamfer	.020	.335	.776	-	.846	.036	.5765
MP sidescraper	.001	.184	.613	.846	-	.028	.5893
MP point	.000	.003	.024	.036	.028	-	.7583

Pre-Aurignacian

Although there is overlap between the groups in the Pre-Aurignacian, burins have the highest retouch to length ratio with a ratio of retouch being two-thirds of the length (Table IV.22 and Table IV.23). This is statistically significant when compared to sidescrapers and, although not significant at p = .05, it is higher than notches and denticulates (at p = .07). Sidescrapers have the lowest ratio at 0.44. Notches and denticulates have a value between the two and are thus not distinct from either group.

Table IV.22. Homogenous Subsets (S-N-K) for Retouch/Length in the Pre-Aurignacian by Tool Type.

Tool category	***n***	**1**	**2**
PA sidescraper	15	.4448	
PA notch/denticulate	10	.5126	.5126
PA burin/chamfer	18		.6783
Significance		.439	.063

Table IV.23. Pairwise *t* tests for Retouch/Length in the Pre-Aurignacian by Tool Type.

	PA sidescraper	**PA notch/ denticulate**	**PA burin/ chamfer**	**Mean**
PA sidescraper	-	.466	.005	.4448
PA notch/denticulate	.466	-	.070	.5126
PA burin/chamfer	.005	.070	-	.6783

RETOUCH/LENGTH BY CULTURE

Burins and Chamfers

Burins are present in all cultures, and chamfers are present only in the Early Dabban. Among the different types, only burins from the Pre-Aurignacian are statistically distinct from Early Dabban burins and chamfers (Table IV.24); the retouch length to overall length ratio is very high in the Pre-Aurignacian, with an average of 0.68 retouch to length ratio. Middle Palaeolithic burins overlap the two with a retouch to length ratio of 0.58. Over time there is a clear tendency for the burin scars to become shorter in length. This result is to some extent independent of the size of the pieces because retouch length is divided by the length.

Table IV.24. Pairwise *t* tests for Retouch/Length for Burins/Chamfers by Culture.

	ED	**MP**	**PA**	**Mean**
ED	-	.122	.002	.4678
MP	.122	-	.243	.5765
PA	.002	.243	-	.6783

Composite Tools

Composite tools are only present in the Middle Palaeolithic and the Early Dabban. They do not appear to be statistically distinct using a *t* test (*p* = .617). Early Dabban composite tools have a ratio of .54 retouch to length and Middle Palaeolithic composite pieces have a ratio of .50.

Endscrapers

As in the case of composite tools, endscrapers are only present in significant numbers in the Early Dabban and Middle Palaeolithic. Unlike composite tools, however, there are statistical differences between cultures with a significantly lower proportion of retouch to length. In the Early Dabban this is just over one third of the length (.39) and in the Middle Palaeolithic it is over half (.55). This difference is significant at *p* = .001. Although endscrapers by definition have retouch on either the tip or the base of the tool, this retouch appears more localised in the Early Dabban and supports the findings in the retouch location comparisons. Part of this is due to the fact that endscrapers are more elongated in the Early Dabban and some are made on blades, making the ends narrower. As shown above, however, endscrapers in the Middle Palaeolithic have retouch that more often spills down the sides.

Notches and Denticulates

This tool type occurs in all of the culture periods but there are no significant differences in the length of the retouch (Table IV.25).

Table IV.25. Pairwise *t* tests for Retouch/Length for Notches and Denticulates by Culture.

	ED	MP	PA	Mean
ED	-	.137	.100	.3481
MP	.137	-	.170	.4285
PA	.100	.170	-	.5127

Sidescrapers

The final tool class, which occurs in all culture periods, is the sidecraper category. The sidescrapers in the Early Dabban and Middle Palaeolithic have very similar retouch to length ratios (0.58 and 0.59 respectively). In the Pre-Aurignacian, less of the possible length is utilised for retouching (0.44; Table IV.26). Although not significant at $p < .05$, both Pre-Aurignacian and Middle Palaeolithic sidescraper retouch/length ratios are significantly different at $p \leq .06$. This is also supported by the retouch location comparisons, which show low proportions of retouch overall by location. This points to a less intensive retouching strategy.

Table IV.26. Pairwise *t* tests for Retouch/Length for Sidescrapers by Culture.

	PA	**ED**	**MP**	**Mean**
PA	-	.060	.056	.4448
ED	.060	-	.917	.5820
MP	.056	.917	-	.5893

INVASIVENESS BY TOOL TYPE

Early Dabban

In the Early Dabban, backed knives are the only tool class that appear distinct; the other values overlap considerably (Table IV.27 and Table IV.28). Backed knives have the lowest invasiveness (in their case due to the thickness of the retouch, because they are abrupt) with an untransformed mean of 3.0 mm. On the high end, burins and endscrapers (both with means of greater than 7 mm) are distinct from truncations although they form part of a range of overlapping means. Backed knives tend to be made on thin, very elongated blades having low weights (see above). Truncations, also preferentially made on blades, also have a low mean invasiveness at just less than 5 mm. Invasiveness in the Early Dabban appears to be a product of blank selection, rather than location of retouch as in the case of the retouch/length ratio.

Table IV.27. Homogenous Subsets (S-N-K) for (log) Invasiveness by Tool Type.

Tool category	*n*	1	2
ED backed knife	19	.4406	
ED truncation	23		.6421
ED notch/denticulate	12		.6487
ED composite	14		.6922
ED sidescraper	19		.6952
ED endscraper	21		.8014
ED burin/chamfer	28		.8089
Significance		1.000	.250

Table IV.28. Pairwise *t* tests for (log) Invasiveness in the Early Dabban by Tool Type.

	ED backed knife	**ED truncation**	**ED notch/ denticulate**	**ED composite**	**ED sidescraper**	**ED burin/ chamfer**	**ED endscraper**	**Mean**
ED backed knife	-	.006	.016	.002	.001	.000	.000	3.0221
ED truncation	.006	-	.936	.524	.460	.011	.024	4.9561
ED notch/denticulate	.016	.936	-	.633	.586	.046	.070	5.0242
ED composite	.002	.524	.633	-	.971	.125	.173	5.5214
ED sidescraper	.001	.460	.586	.971	-	.100	.148	6.3137
ED burin/chamfer	.000	.011	.046	.125	.100	-	.911	7.0468
ED endscraper	.000	.024	.070	.173	.148	.911	-	7.7086

Middle Palaeolithic

In the Middle Palaeolithic there is considerable overlap in the means. Notches and denticulates have the lowest mean invasiveness at just over 5 mm (Table IV.29 and Table IV.30). They are statistically distinct from the other tool classes except for burins, which have the next lowest mean invasiveness. Because notches and denticulates are similar in weight, shape and retouch location to most of the other pieces, the nature of the type of retouch makes this category more distinct.

Table IV.29. Homogenous Subsets (S-N-K) for (log) Invasiveness by Tool Type.

Tool category	*n*	1	2
MP notch/denticulate	45	.6685	
MP sidescraper	32	.7751	.7751
MP burin/chamfer	15	.7847	.7847
MP composite	16	.8077	.8077
MP point	10	.8622	.8622
MP endscraper	12		.9116
Significance		.103	.418

Table IV.30. Pairwise *t* tests for (log) Invasiveness in the Middle Palaeolithic by Tool Type.

	MP notch/ denticulate	**MP burin**	**MP sidescraper**	**MP point**	**MP endscraper**	**MP composite**	**Mean**
MP notch/denticulate	-	.088	.044	.016	.001	.037	5.3058
MP burin	.088	-	.892	.404	.151	.779	6.3680
MP sidescraper	.044	.892	-	.291	.077	.639	6.6994
MP point	.016	.404	.291	-	.611	.552	7.5740
MP endscraper	.001	.151	.077	.611	-	.232	8.9050
MP composite	.037	.779	.639	.552	.232	-	8.9106

Pre-Aurignacian

Sidescrapers have a significantly lower invasiveness (4.8 mm) than notches and denticulates and burins (Table IV.31 and Table IV.32). As with the retouch to length ratio, this suggests a relatively less intensive retouching strategy.

Table IV.31. Homogenous Subsets (S-N-K) for (log) Invasiveness in the Pre-Aurignacian by Tool Type.

Tool category	*n*	1	2
PA sidescraper	15	.5939	
PA notch/denticulate	10		.8160
PA burin/chamfer	18		.9251
Significance		1.000	.209

Table IV.32. Pairwise *t* tests for (log) Invasiveness in the Pre-Aurignacian by Tool Type.

	PA sidescraper	PA notch/ denticulate	PA burin	Mean
PA sidescraper	-	.019	.000	4.8100
PA notch/denticulate	.019	-	.220	7.0950
PA burin	.000	.220	-	9.2244

INVASIVENESS BY CULTURE

Burins and Chamfers

Although not significant at p = .05, burins in the Pre-Aurignacian (Table IV.33) have a significantly higher mean invasiveness than those of the Middle Palaeolithic (p = .02) and a higher one than Early Dabban burins and chamfers. Thus burin scars in the Pre-Aurignacian are thicker than those of the other periods. In part this is connected to the relatively large size of Pre-Aurignacian blanks; because most flake blanks taper into a thin edge, the nature or force of the burin blow is likely different.

Table IV.33. Pairwise *t* tests for (log) Invasiveness for Burins by Culture.

	MP	ED	PA	Mean
MP	-	.673	.021	6.368
ED	.673	-	.057	7.047
PA	.021	.057	-	9.224

Composite Tools

Although there appear to be differences in the means for the invasiveness of composite tools in the Early Dabban and Middle Palaeolithic (approximately 6 and 9 mm respectively), these differences are not statistically significant (p = .297).

Endscrapers

As with composite tools, the differences between these tools in the Early Dabban and Middle Palaeolithic (approximately 8 and 9 mm) are not significant (*p* = .231) in terms of invasiveness.

Notches and Denticulates

Pre-Aurignacian notches and denticulates are significantly more invasive than those of the Early Dabban and Middle Palaeolithic (Table IV.34). On average the retouch has an invasiveness of over 7 mm, whereas Early Dabban and Middle Palaeolithic notches and denticulates have mean invasiveness values of just over 5 mm.

Table IV.34. Pairwise *t* tests for (log) Invasiveness for Notches and Denticulates by Culture

	ED	**MP**	**PA**	**Mean**
ED	-	.778	.068	5.024
MP	.778	-	.047	5.306
PA	.068	.047	-	7.095

Sidescrapers

As shown above, Sidescrapers in the Pre-Aurignacian have relatively non-invasive retouch at less than 5 mm. This is statistically significant when they are compared with those from the Middle Palaeolithic, which have a mean of 6.7 mm. The Early Dabban sidescrapers, although not statistically distinct from those of the Pre-Aurignacian, do have a higher mean at 6.3 mm.

Table IV.35. Pairwise *t* tests for (log) Invasiveness for Sidescrapers by Culture.

	PA	**ED**	**MP**	**Mean**
PA	-	.293	.019	4.810
ED	.293	-	.264	6.314
MP	.019	.264	-	6.699

DISCUSSION

Some important differences emerge when the intensity of retouch is examined across types within each culture and across cultures within each type. Within each culture two factors stand out: the location of the retouch and the type of retouch. Across cultures, the Pre-Aurignacian stands out as different from the Middle Palaeolithic and Early Dabban in each of the three tool types common to all cultures. The only significant differences between the Early Dabban and the Middle Palaeolithic are in the length of retouch of the endscrapers.

In the Early Dabban examining the ratio of retouch length to length divides the tools into two groups on the basis of the location of retouch. Those tools that utilise the ends (tip or base) show shorter relative retouch length. This shows that when retouch is applied to the ends of the pieces it is confined to that location (especially in the case of endscrapers, which is supported by the retouch location study above). This is partly due to the predominance of elongated pieces in the Early Dabban; the ends by definition utilise the possible width of the piece, which is relatively short. There is an apparent selection of location over longest possible sharp edge. Invasiveness in the Early Dabban, on the other hand, appears to be a product of the type of retouch, with those having abrupt or blunting retouch being much less invasive. This is due to the fact that the thickness of the abrupt edge is being measured. The retouch travels from the ventral to dorsal side (in most cases) rather than from the edge along the dorsal surface. This creates a shorter possible length for the retouch to travel. Because these types occurred in very small proportions in the Middle Palaeolithic, valid comparisons cannot be made. In the Early Dabban, backed knives and truncations are made preferentially on blades as well and are relatively thin in cross section. The Early Dabban tool types thus show important differences in retouch intensity along two lines: type of retouch and location of retouch. Interestingly, backed knives are differentiated along both lines and only occur in significant proportions in the Early Dabban.

In the Middle Palaeolithic only two tool types are statistically distinct in terms of retouch intensity, one in terms of relative length of retouch and the other in terms of invasiveness. Points with an average ratio of over 0.75 show the highest retouch to length ratio of any tool type in the sample. Notches, on the low end, are more similar to the remaining tool categories than to points. In terms of invasiveness, however, notches have relatively low invasiveness and are also distinct. Points have more retouch along their margins, despite having a type of retouch similar to scrapers. This is to be expected because they are essentially convergent scrapers by definition. A classic question regarding points is whether or not they represent an example of imposed form, or are simply heavily reduced sidescrapers. I chose to define points as any convergent scraper or point because it is difficult to distinguish the two on anything other than purely subjective grounds. Of the "points," 3 were Mousterian points, 2 *limaces*, and 5 *déjéte* scrapers. As a group they did not differ significantly in shape from sidescrapers in terms of elongation, pointedness, planform or uniformity (p = .914, p = .445, p = .488, p = .956 respectively, using t tests). The differences between the intensity of the tools in the Middle Palaeolithic are typological in the case of points because they appear to represent intensively retouched scrapers and may not be a unique category (Dibble 1987). In the case of notches and denticulates the differences in intensity are due to the type of retouch.

In the Pre-Aurignacian the differences between the tool types are in terms of retouch type. Each type of tool involves a different type of retouch: scalar retouch in the case of sidescrapers, burin blows and notching. It is noteworthy that burins are very distinctive in terms of retouch intensity only in the Pre-Aurignacian. In the Pre-Aurignacian, burin scars are both relatively long and thick, especially when compared to those of the Early Dabban and Middle Palaeolithic. Notches are also more invasive in the Pre-Aurignacian than in the later periods. These blows are relatively crude and large. This is partly due to the large, thick blank size. It is also partly due to a hard blow, however, because tool weight is more similar in size in the Pre-Aurignacian and the Middle Palaeolithic than in the Middle Palaeolithic and the Early Dabban, where the differences are not significant. Pre-Aurignacian sidescrapers do not have very intense retouch. This, combined with the preceding sections, suggests a relatively limited and simple tool making tradition in the Pre-Aurignacian, with low numbers and simple, ad-hoc transformation.

To summarise, as in the case of retouch location in the Early Dabban, there is a differentiation based upon the location and type of retouch, with lateral retouch being relatively longer and a differentiation in retouch type with blunt retouch having shorter retouch scars. In the Middle Palaeolithic, the only tool category to stand out is the point, which has considerably longer retouch than other tool types. Following Dibble's suggestion, this may simply be due to points, or convergent scrapers, being the product of more intensive retouch with the typology driving the significance of the differences. In the Pre-Aurignacian, the difference between burins and the other categories is that burins appear to be more intensively retouched. The size of their retouch suggests a crude application of the burin-blow technique. Sidescrapers, on the other hand, show relatively light, ad-hoc retouch. Overall this suggests a limited, ad-hoc tool making tradition.

TYPOLOGICAL DIVERSITY

The final aspect of tool use to be discussed is differences in typology. This is a problematic area at best. One of the most difficult features of typology is comparing assemblages from different time periods. Several different typologies are available to analyse material. I have chosen two: Bordes’ assemblage typology (1961; Debénath & Dibble 1994); and the typology used by Azoury (1986) to analyse the Ksar 'Akil collection. Bordes' typology for the Middle Palaeolithic is widely used. The Azoury typology is a modified version of de Sonneville-Bordes’ typology (1960) for the Upper Palaeolithic, and is used primarily in France. Azoury's typology was chosen because it included different types of chamfered blades, which are present at only a few sites in the world.

Rather than using Bordes' typology for the Middle Palaeolithic and Pre-Aurignacian assemblages and Azoury's typology for the Early Dabban, both typologies were applied to each retouched piece from each assemblage. In addition, an index of typological diversity was made - the type numbers from both type lists were concatenated to create a unique typology. For example, a piece with a single laterally retouched convex edge was 10-51 (Bordes-Azoury). The number of unique types generated from this list was used to measure the richness of artefact diversity. Simply put, a combined typology was used because Bordes' typology accentuates the differences between the types common in the Middle Palaeolithic (especially sidescrapers, types 9 to 29) and lumps the types that are not common (e.g., Upper Palaeolithic types such as burins and endscrapers). Conversely, the Upper

Palaeolithic typology lumps most sidescrapers into a single type (51) and creates several types for burins and endscrapers and other tool types common in the Upper Palaeolithic. The combined typology, although not practical for description or field use, solves the problem of comparing typological diversity among assemblages for which different typologies are traditionally used. Another problem with typological studies is broken pieces Shott (2000). As described in Chapter II, the simple MNT measure was used for each of the new tool types.

Combining this new typological system with the regression methodology used by Grayson and Cole (1998) proved fruitful for comparing assemblage richness. In their methodology, they compare the number of artefact classes with the log of the assemblage size, correcting for the skewed distribution of assemblage sizes. Taking the regression line between the number of tool types present and the log10 assemblage size, they indicated typological diversity in relationship to assemblage size. The slope of the regression line is important. As the assemblage gets larger, what is the rate of increase in typological diversity? Their methodology was used in the present study, with the added modification that each of the regression lines taken went through the origin (0,0) when they included a non-zero intercept. This is logical because an assemblage with zero artefacts would have zero types of artefact present. In fact, the intercept when using the log transformation should be (1,0), representing one artefact and one type (log10 (1) = 0. (You cannot take the log of 0; however defining an intercept was not an option available in SPSS). In Grayson and Cole's model small assemblage sizes would have a negative number of types. The use of the correction for assemblage size allowed use of all of the layers present in the Pre-Aurignacian, Middle Palaeolithic and Early Dabban at the Haua Fteah, rather than grouping these layers into culture periods for sample size reasons. The layers used, their MNT scores and number of tool types present are shown in Table IV.36.

Table IV.36. Number of Technological Types and MNT Values by Level and Culture.

Level	MNT	No. types	Log10 MNT	Culture
XXe	99	46	1.996	ED
XX/XXI int	206	62	2.314	ED
XXI/XXII	38	24	1.580	ED
XXII	26	20	1.415	ED
XXII-XXIV	6	5	0.778	ED
XXIV	12	9	1.079	ED
XXIV/XXV	5	5	0.699	ED
XXVa-b	2	2	0.301	ED
XXVc-d	9	7	0.954	ED
XXV-XXVII	11	9	1.041	MP
XXVII/XXVI	11	10	1.041	MP
XXIX-XXXI	6	4	0.778	MP
XXXI/XXXII	16	10	1.204	MP
XXXII/XXXI	108	31	2.033	MP
XXXIV/XXXV	176	65	2.246	MP
Top deep	19	14	1.279	MP
55-59	1	1	0.000	PA
55-60	1	1	0.000	PA
55-69	4	4	0.602	PA
55-170	11	8	1.041	PA
55-171	22	19	1.342	PA
55-172	30	18	1.477	PA
55-173	23	12	1.362	PA
55-174	29	17	1.462	PA
55-175	7	5	0.845	PA
55-176	12	7	1.079	PA

The resulting regression lines show that despite a slightly more sloped regression line for the Early Dabban, with a slightly higher assemblage richness overall, the difference between this line and that for the Middle Palaeolithic is small (Figure IV.22; the black line indicates all assemblages regardless of culture). The regression line for the Early Dabban has a slope of 19.06 (r = .93, p = .000), whereas the regression line for the Middle Palaeolithic has a slope of 17.41 (r = .90, p = .003). This means that the increase in the number of artefact types per (log10) assemblage size is roughly similar. The regression line for the Pre-Aurignacian, however, is different; it is a much less steep line with a slope of 10.25 (r = .97, p = .000). A certain amount of caution has to be used when interpreting these results because the largest MNT for the Pre-Aurignacian sites was only 30 tools.

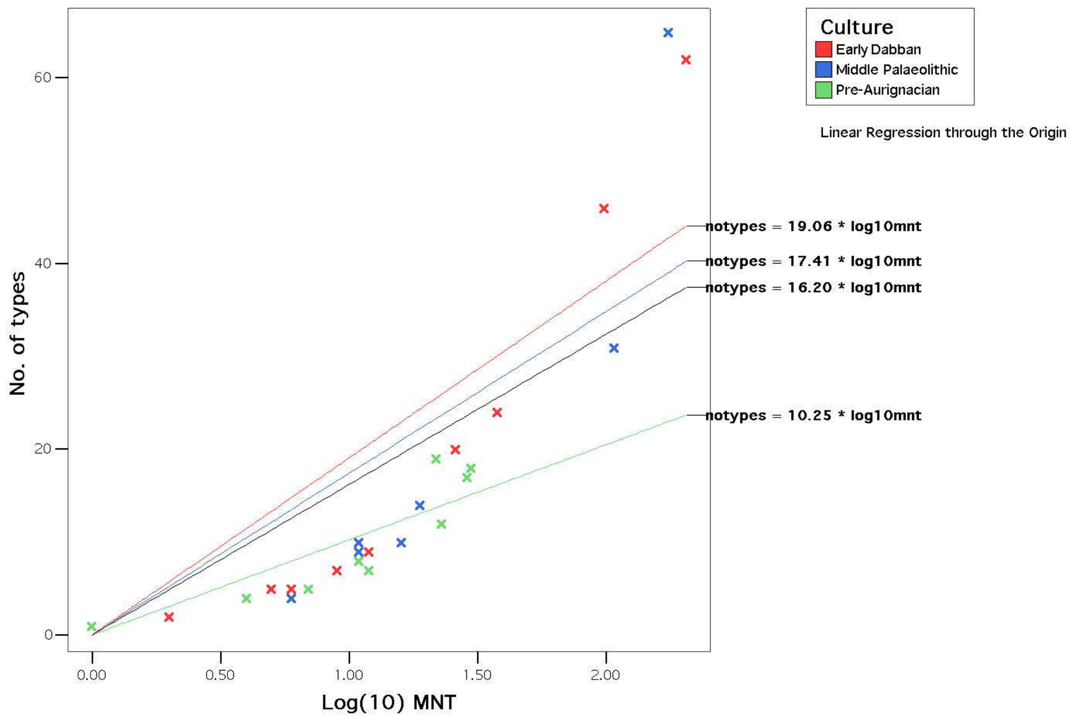


Figure IV.22. Linear Relationship Between (log10) MNT and Assemblage Richness by Culture.

As Grayson and Cole conclude, assemblage size is strongly correlated with assemblage richness. The similarities between the Early Dabban and Middle Palaeolithic assemblages in terms of assemblage richness are due to a small number of large assemblages. The Pre-Aurignacian sample is small and the level units are in spits rather than in the combined levels in the later periods. Furthermore, these spits are smaller in area than those of the subsequent levels. How much this has to do with the smaller sample remains unanswerable.

To better understand the impact of assemblage size on typological diversity, it was useful to plot the untransformed MNT values against the number of types present (Figure IV.23). Following this, various curve estimation procedures were used to find the mathematical model which best fit the results. The power curve, whose formula is $y = x^b$, was employed (as with the linear relationship no constant, i.e., intercept, value was used). This model resulted in an *R* squared value (a measure of goodness of fit of the observed values to those predicted by the mathematical model) that was very high (.994). When plotted, this model fits especially well with the smaller assemblages (Figure IV.24). The formula for this line is: number of types = $MNT^{0.837334}$.

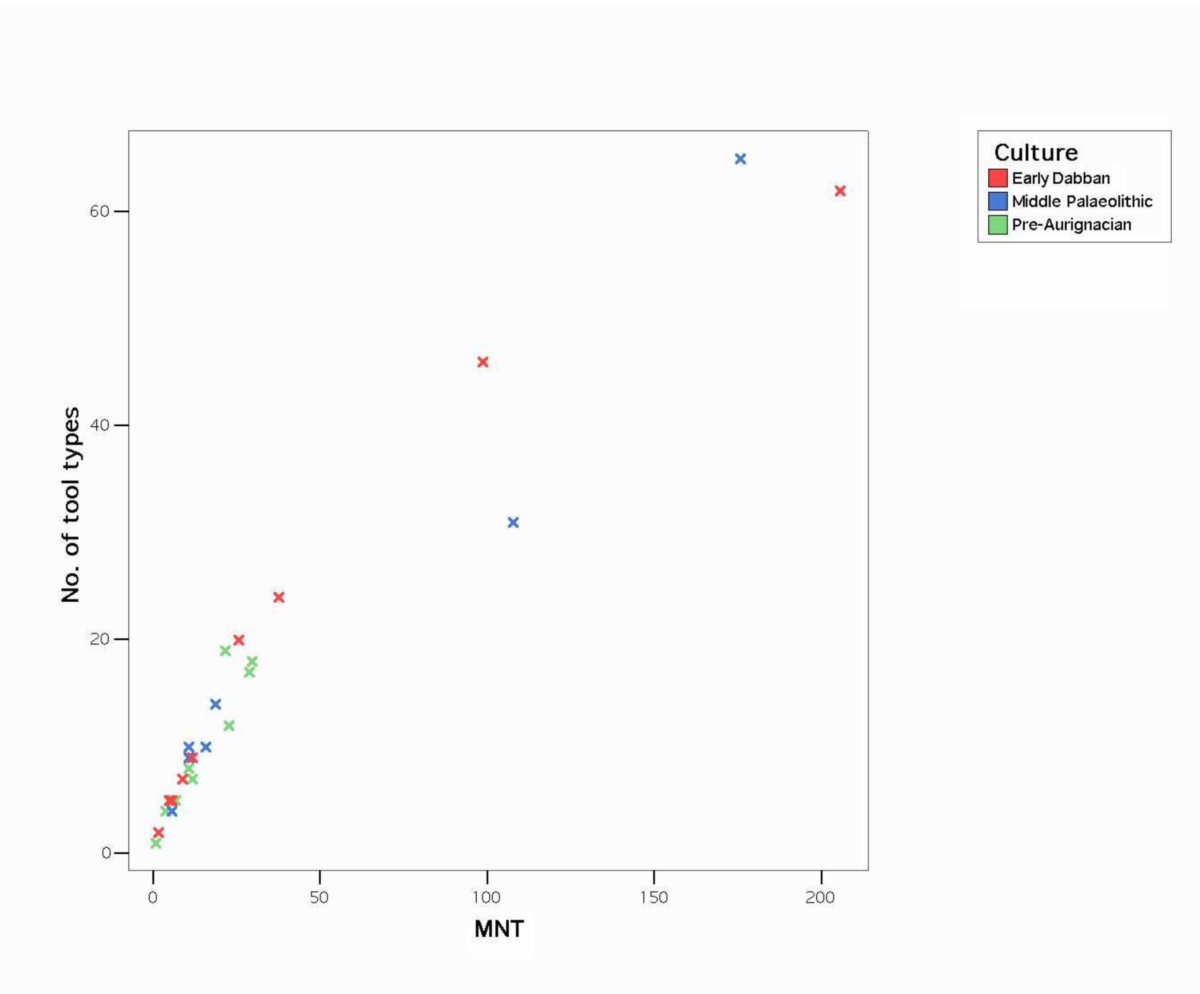


Figure IV.23. Plot of Number of Tool Types by MNT.

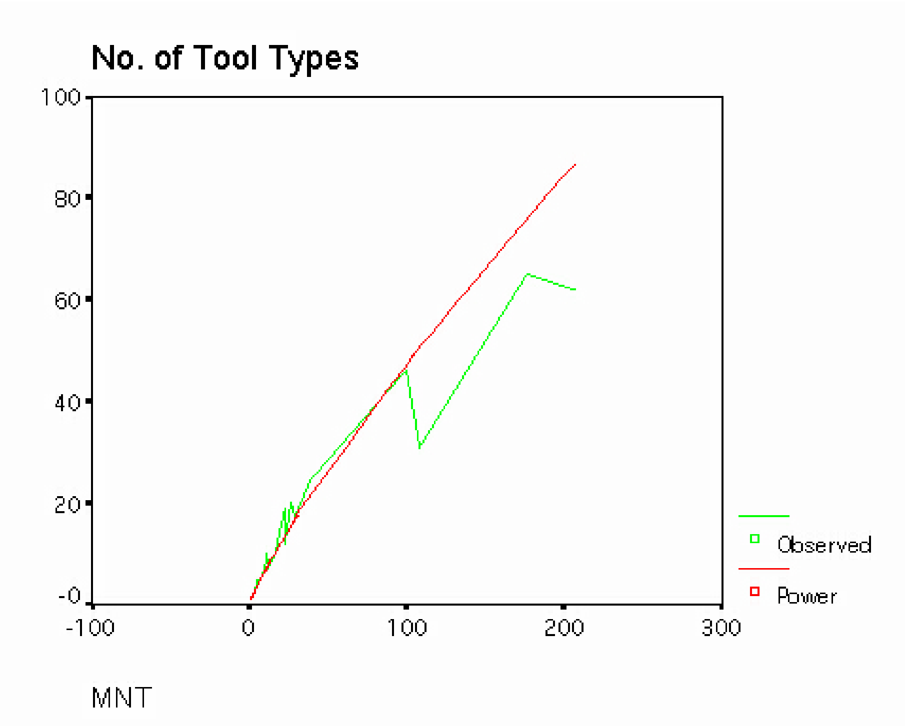


Figure IV.24. Predicted Power Curve and Observed
Values for all Assemblages

Because the assemblage sizes play an important factor in determining the number of types in this model, only those assemblages with an MNT of 30 or fewer were compared, 30 being the largest MNT among the Pre-Aurignacian assemblages (Figure IV.25, Figure IV.26 and Figure IV.27). To a certain extent this should correct for the biases in sample size. A separate power curve was created for each culture type. In theory, this should provide an interesting statement about behaviour: When there are only a limited number of artefacts in an assemblage, how many types are in that assemblage? In addition to creating a sample with roughly equivalent assemblage sizes, it also shows how diverse the minimal tool kit might be. When larger assemblages are examined, the total possible number of tools becomes a limiting factor on the actual number of types present.

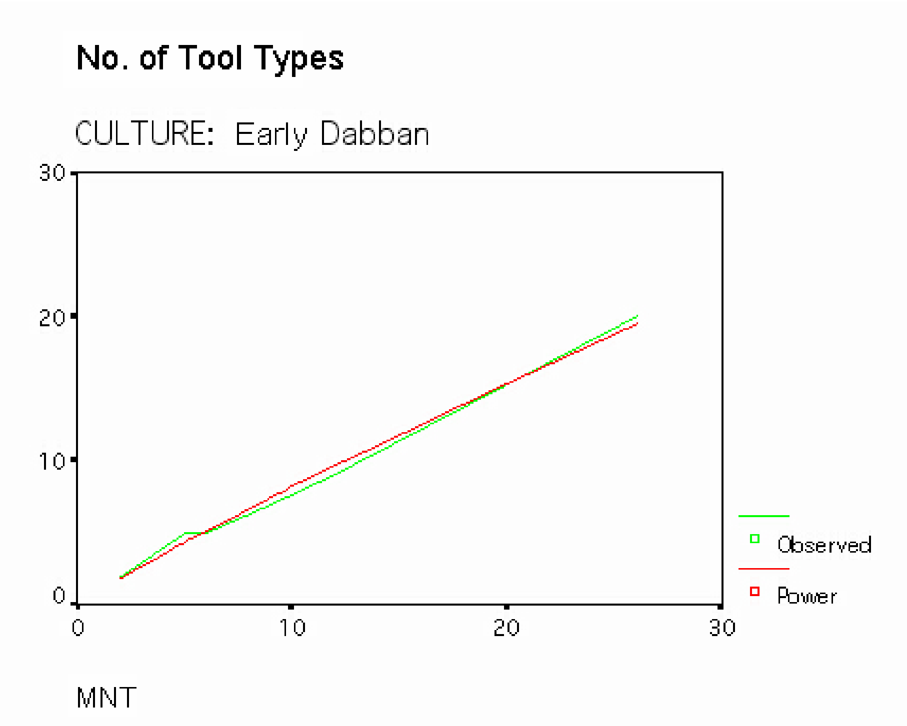


Figure IV.25. Predicted Power Curve and Observed Values for Early Dabban Assemblages with an MNT of 30 or Less.

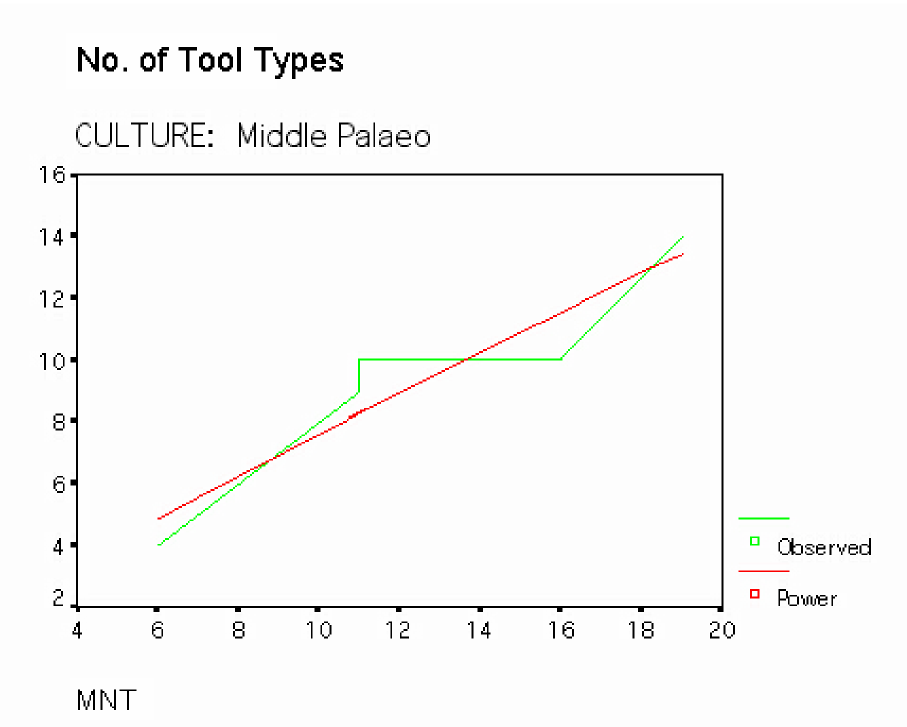


Figure IV.26. Predicted Power Curve and Observed Values for Middle Palaeolithic Assemblages with an MNT of 30 or Less.

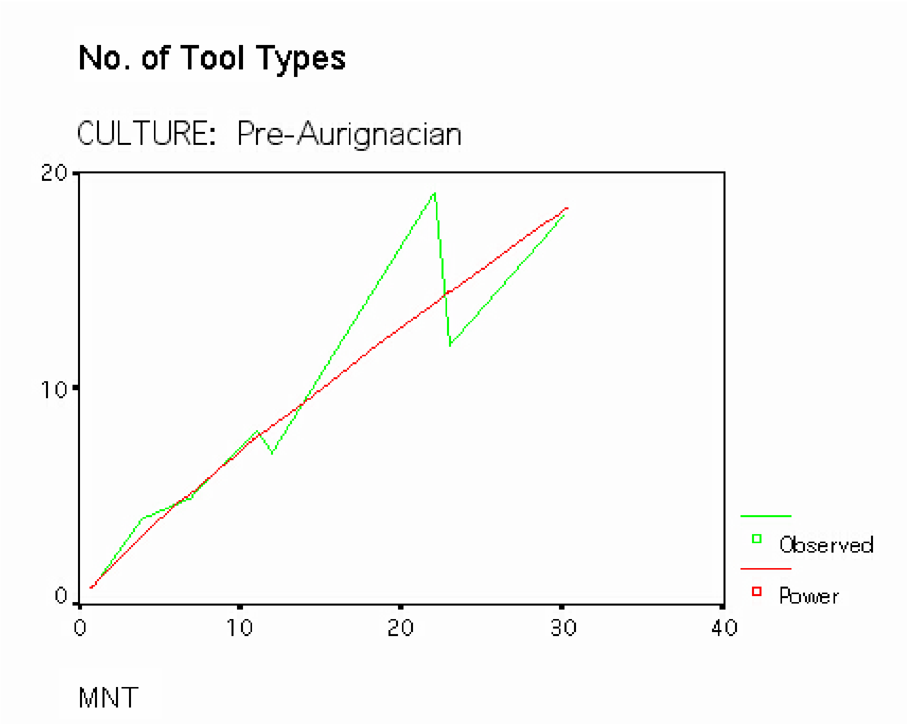


Figure IV.27. Predicted Power Curve and Observed Values for Middle Palaeolithic Assemblages with an MNT or 30 or Less.

The results of the curve fit analysis are shown in Table IV.37 (number of types = MNT^b). Despite the small sample size, the pattern is informative. The rate at which the number of types increases in the Early Dabban is greater than in the Middle Palaeolithic and greater in the Middle Palaeolithic than in the Pre-Aurignacian. The predicted number of tool types for MNT values (intervals of 5 up to 30) is shown in Table IV.38.

Table IV.37. Variables and Statistics for Power Curve Equations for Assemblages with an MNT of 30 or Less by Culture.

Culture	*b* value	*R* squared	*p*	Sample
ED	.912235	.998	.000	6
MP	.882882	.995	.000	5
PA	.853375	.995	.000	10

Table IV.38. Predicted Number of Tool Types for Hypothetical MNT Values by Culture.

MNT	ED	MP	PA
5	4	4	4
10	8	8	7
15	12	11	10
20	15	14	13
25	19	17	16
30	22	20	18

The differences are small and the sample size is a cause for concern. The information available suggests that, for small assemblages, typological diversity increases as one progresses from the Pre-Aurignacian to the Early Dabban. To validate the methodology a curve fit analysis was performed on 68 published Middle Palaeolithic assemblages (taken from Moyer 1998; Moyer and Rolland 2001) from Western Europe using Bordes' essential count and assemblage size (not MNT). Results showed that the power curve provided the best fit for the data. The *R* squared value was .989 in the European sample.

On a more basic level, the number of tool classes used in the preceding analyses generally supports these results. In the Early Dabban and the Middle Palaeolithic, all 10 of the possible tool classes were present; in the Pre-Aurignacian, only 8 were present. If one counts those tool classes with 5% or more of the complete tools (thus removing the potential for chance encounters and misclassifications), there were 7 in the Early Dabban, 6 in the Middle Palaeolithic and 5 in the Pre-Aurignacian.

DISCUSSION

Typological diversity increases over time. However, the differences depend in part on the assemblage size (and are thus sensitive to differences in the archaeological sample throughout the excavation) and they are not as great as expected. As assemblage size increases up to an MNT of 30 the rate of increase in typological diversity is greatest in the Early Dabban and least in the Pre-Aurignacian.

Discussion of the Differences in Tool Manufacture between Techno-Chronological Categories

To conclude this chapter it is important not only to briefly summarise the results of the statistics, but also to see how the four aspects of tool manufacture discussed, i.e., blank selection, retouch location, retouch intensity and typological diversity, relate to one another within each culture and through time. The degree of integration of the different elements in the technological system and their diversity are not opposed ideas. The discussion is merely on two levels: firstly, how unique or discrete is each element in the system; and secondly, how well integrated are the parts of this system.

Beginning with the Pre-Aurignacian, the tool component of this earliest culture period is the least diverse and least integrated. Perhaps the most important point is that there is no positive blank selection apparent from the sample, either in terms of technological products or attributes, apart from a selection for large blanks. In terms of typological diversity the Pre-Aurignacian has the lowest typological diversity of the three periods, even when the small tool assemblage size is corrected. There is some evidence for differences between the tool types in terms of retouch location and intensity. However the large, crude burin blows and the relatively light retouch of the sidescrapers in this industry suggest an ad-hoc industry, i.e., there is a low level of design involved in tool manufacture.

In the Middle Palaeolithic, there is a slight increase in evidence for intentional planning in the manufacture of tools. The strongest evidence comes from a selection of blanks that have a high number of dorsal scars in two tool types. This is important because complexity in the debitage, as discussed in the previous chapter, appears to be an important conceptual mode in this period. There is a limited level of integration between blank production and subsequent retouching, building on the selection of larger blanks in the preceding period. There is also an increase in typological diversity; as discussed above, however, the changes throughout the sequence are less than expected. Concerning retouch location and intensity of retouch, the two tool types of endscrapers and points stand out. Endscrapers have a unique distribution of retouch on the tip, which differs from the overall tendency toward retouch on the distal left margin. Apart from the tip, however, the retouch pattern is very similar to the remaining tool categories. Points have a statistically high ratio of retouch length to overall length. Although these tool types stand out, there are considerable similarities with sidescrapers and other tool types in terms of retouch location and intensity. Both have statistically indistinguishable invasiveness of retouch and endscrapers have a statistically indistinguishable retouch length to length ratio. Their statistical uniqueness may be a product of the tool typology used in the current study. Whether or not they are discrete types is an open question, especially if one takes into consideration the position taken by Dibble (1987) and others. Nonetheless, there is a shift in real terms from the preceding period, with more variation in retouch location. There are no examples of endscrapers and only one point in the Pre-Aurignacian (see Table IV.2). As predicted by the Dibble model, this points toward a more intensive retouching strategy in this period than in the Pre-Aurignacian.

Finally, the clearest evidence for planning and design of tools is in the Early Dabban. Again, the strongest evidence for this comes from blank selection. Blades are positively selected for in two tool classes and non-blades are selected for in two other tool classes. This provides evidence that blank production was in fact a preliminary stage in an integrated debitage and tool manufacturing chaîne opératoire. The relatively high proportion of blades, compared with the proportions of Levallois and Flake Blade technology in the preceding periods, coupled with positive selection for blades in some tool types, strongly supports this. In addition to the positive selection for blades, some tool types, notably composite pieces, burins and chamfers, show selection for elongated pieces, whether or not they were preferentially made blades. In the preceding period the relationship between blank production (with the exception of some selection for complexity in the Middle Palaeolithic) was essentially random, i.e., ad hoc.

Typological diversity, retouch location and retouch intensity all relate to this point. In the Early Dabban, the two tool types that are preferentially made on blades, backed knives and truncations, do not occur in significant proportions in the preceding period (hence an increase in real terms in typological diversity). They also have unique retouch location patterns and are different from the other tools in the nature of retouch. They share a blunting form of retouch that does not produce a sharp working edge and has a statistically different invasiveness. The blunting form of retouch is oriented toward leaving a sharp right edge opposed to the blunted left margin. That said, however, in terms of retouch length ratios and retouch location, these two tool types are different. Backed knives have a relatively high proportion of the lateral margin retouched, whereas the retouch in truncations is shorter because it is located on either the tip or the base and cuts across the cross section of the blanks. Furthermore, truncations are significantly modified in their shape through this process; they lose their blade elongation morphology through the process of retouching. This is a statistically supported example of imposition of form. The distinction between end and laterally oriented retouch is also a factor that distinguishes other tool types. Endscrapers have a strongly localised retouch pattern on the tip, many notches and denticulates have retouch on the tip, and burins and chamfers extensively utilise the base and tip. Sidescrapers, which show a positive selection for normal Early Dabban pieces, exhibit a tendency toward lateral right retouch. This is supported by the differences in retouch to length ratios.

The following points provide a summary.

1. The Early Dabban shows an organised, integrated approach that is largely missing in the preceding periods. Blank selection and/or intentional production of blades are important aspects of tool design. Blank selection appears to be related to retouch type, intensity and location.

2. There is evidence of recognisable patterns differentiating tool types by retouch type, intensity and location in the Early Dabban. This occurs only to a limited degree in the preceding periods, in which differences represent more ad-hoc tool production strategies. The tools in the Early Dabban exhibit greater differences between each other, i.e., they are more internally homogenous and externally heterogeneous. The strong localisation of features and the greater number of differences between types support this.

3. There is a cumulative pattern in these elements. Pre-Aurignacian tools show blank selection only on the basis of size. Middle Palaeolithic tools show selection on blank attributes, rather than debitage technology, in addition to

size. The Early Dabban shows selection on size, attributes and technological type. There are real increases in tool type diversity across the periods. This is based both on typological studies and on the relative proportions of the main tool classes used in this study.

4. Despite a cumulative pattern, the changes in the Early Dabban signify a much larger and important shift. As in the case of debitage production, a larger number of conceptual modes seem to be in operation simultaneously. These modes are also integrated, i.e., much more organised.

V. Starting Points: Mithen's Cognitive Change Model of Human Evolution

Having examined the Haua Fteah site and described the nature of the differences between the lithic industries of three broad temporal phases as defined by McBurney (1967), the data must be placed in an interpretative framework. This and the following chapters explain these differences in terms of changes in social behaviour and cognition. A social explanation was chosen for a number of reasons:

1. The influence of social behaviour on human behavioural and biological evolution (as opposed to vice versa) has largely been neglected in the study of human origins.
2. A new research paradigm in archaeology privileges the role of social agency in the understanding of technology (e.g., Dobres 2000).
3. Although the role of kinship and social organisation in the transition to modern[2] human behaviour has been discussed before (e.g., Mellars 1996a), the mechanisms by which changes in kinship and social organisation may have led to the emergence of this behaviour have been underemphasised.
4. In recent years the role of cognitive and linguistic developments (e.g., Mithen 1994, 1996; Mellars 1991; Chase & Dibble 1987) has been given pre-eminence in explaining the transition to modernity, this privileges the structure of thought and language rather than the content.
5. Recent research in biology and psychology points towards the importance of social organisation in shaping behaviour and cognition specifically (e.g., Rose & Rose 2001).

[2] *Modern* is an essentially meaningless term. It means something different in each context in which it is used. As Latour states (1993: 10): "When the word 'modern', 'modernization', or 'modernity' appears, we are defining, by contrast, an archaic and stable past. Furthermore, the word is always being thrown into the middle of a fight, in a quarrel where there are winners and losers, Ancients and Moderns." It can mean the twentieth century, post-medieval, or the last 40 ky. In essence, all that modern means is that history is written by the winners and the winners are us, the moderns. It also defines a time when we won the fight. I can think of no better description of the use of modern in Palaeolithic archaeology than this. That said, it does have a conventional meaning, which is mainly a list of traits (see McBrearty & Brooks 2000: 491 for just one of many recent lists).

Social psychological theory, specifically the theory of social representations, provides a bridge between social behaviour and cognition in the shift to modern behaviour by examining how thought is socially situated. This will further be put into a perspective placing this socially centred cognition into a biological context that stresses the role of social and developmental factors (rather than solely genes) in explaining human and animal behaviour.

The essence of the theory proposed, based on the evidence currently available, is that a change in the structure of society, rather than that of the structure of the brain or the structure of language *itself*, best explains the shift to modern behaviour. Although language, cognition and social organisation are all interrelated, changes in social organisation, and specifically the emergence of modern kinship, is a potentially important driving force behind the other changes. Concerning the data examined in the previous three chapters, changes in social organisation can explain how the different elements of the technological system are arranged in relationship to one another, as elucidated by the exploratory data analysis. The technological and the social are linked by the idea of the *total social fact* of Marcel Mauss (1967 [1925]). Mauss states that "...social phenomena are not discrete; each phenomenon contains all the threads of which the social fabric is composed" (1967: 1). The central notion, that all the elements of behaviour in a society are intertwined, underwrites the current understanding of the role of technology in society (Dobres 2001). Mauss (1979 [1924]) was also the pioneer of the study of technology as opposed to that of material culture in anthropology, the former being a dynamic understanding of human social process and the latter a disembodied understanding of objects. Technology (in modern humans at least) is simultaneously a cognitive, social and corporeal process.

The data points to a dramatic shift in the organisation of technology with the emergence of the Early Dabban period. This does not deny the fact that there was change before this time. The previous periods exhibit both cumulative change and non-progressive changes in technology (commonly known as drift); however, there appears to be a practical limit on the extent to which technology is organised. There is no denying, as McBrearty & Brooks (2000: 453) persuasively argue, that there is a "gradual assembling of the package of modern human behaviours in Africa," but to put all of these assembled pieces into an integrated package required organisation. That organisation is arguably the result of social innovation, enabled, rather than caused by, biological changes. Modern human kinship, in its dual capacity of structuring behaviour and providing social categories for people and things, made it possible for the *amount* of knowledge of the group to greatly exceed that of the individual. Kinship *is* cognition, language and behaviour, not a product of them; one cannot separate the content from the structure of thought and language. Furthermore, kinship structures provide a direct example of how human biological systems are regulated by social behaviour.

The current chapter briefly outlines some of the previous theories for the emergence of modern human behaviour. A detailed examination of one cognitive biological argument for this transformation forms the bulk of the chapter. An examination of this model, and more generally the application of evolutionary psychology to the archaeological problem of human origins, will be used to present available evidence that will be summarised at the end of the chapter. The following chapter will use this evidence, in the context of social and social psychological theory, to build a model that brings social, cognitive and biological theory together in a new synthesis.

Previous Models Explaining the Upper Palaeolithic Revolution

Antonio Gilman (1996 [1984]) divides the models explaining the transition from the Middle to Upper Palaeolithic into three groups: the biological, the particularist, and the cultural materialist approach. Recently, mitochondrial DNA (mtDNA) studies (Stoneking & Cann 1989) and a refinement of chronometric dating techniques (Aitken, Stringer & Mellars 1993) have made the biological replacement model the dominant paradigm to explain the transition. Briefly, the biological model asserts that "the Upper Palaeolithic Revolution is the technological and social manifestation of a full [biological] capacity for culture" (Gilman 1996: 227). The particularist approach emphasises the continuity across the transition and argues for "the existence of intermediate cultures in a number of areas and the presence of Upper Palaeolithic elements in earlier contexts" (Gilman 1996: 227). It views the change as gradual and in essence denies that a revolution as such occurred. Finally, the cultural materialist approach provides "an ecological explanation for the development of the group co-operation which is the practical basis of the hunter-gatherer band" (Gilman 1996: 218). To a greater or lesser extent, all of these models discuss social aspects of the transition; however, the social changes are largely seen as the consequence of other factors such as changes in biological capacities or adaptations to localised environmental conditions.

The most important characteristic of all of these models is their European bias (see Mellars 1989). In Europe, there is almost incontrovertible evidence for the replacement of one population by another. The new species, *Homo sapiens sapiens,* replaced the indigenous Neanderthal population (*H. s. neanderthalensis or H. neanderthalensis)*. Coupled with the evidence for a relatively recent shared genetic ancestor for all living humans in Africa (Stoneking & Cann 1989), this gave the biological replacement model the edge over most other competing models. Most challenges to this model arise with data from other regions such as Africa. Interestingly, the particularist model has a strong foothold in discussions about non-European evidence, e.g., in Africa. All of the hallmarks of this approach are found in McBrearty & Brooks' recent paper, which appropriately enough is entitled "The revolution that wasn't: a new interpretation of the origin of modern human behaviour" (2000). Such a perspective is also seen in discussions of the European evidence in the recent debate concerning the chronology of Neanderthal extinction and acculturation (e.g., d'Errico, Zilhão, Julien, Baffier & Pelegrin 1998).

In many ways the cultural materialist approach is subsumed under the biological model. This is largely due to a shared intellectual heritage, the adaptationist perspective. As Trigger points out, throughout archaeology's history much theory has been borrowed from the natural sciences (Trigger 1989: 17). This position is common in Neo-Darwinian theory and is the basic premise underlying sociobiology. What this shares with the biological approach is the view that any behaviour must have necessarily been adapted to a specific environment. This occurs either through a direct process of natural selection on human biology (genes that determine behaviour) or through an analogous process acting on behavioural traits (in its most extreme form the idea of memes in sociobiology, e.g., Dawkins 1976). Both share the same assumption, i.e., behaviours are necessary adaptations to a specific natural environment (Gould 2001: 88).

Much of cultural materialism has its roots in the American neo-evolutionary perspective of Steward and White who greatly influenced archaeologist Binford in the 1960s. The neo-evolutionary perspective formed the basis of the New Archaeology (Binford 1968; Trigger 1989: 290-296). This approach, although it was much more interested in systems and group co-operation than in traits, shared the view that behaviour was adapted to ecological or environmental factors, largely independent of human action.

THE COGNITIVE-BIOLOGICAL OR EVOLUTIONARY PSYCHOLOGY ARGUMENT

One of the more interesting and thoroughly argued discussions about the emergence of modern human behaviour is found in Mithen's (1996) book *The Prehistory of The Mind: A Search for the Origins of Art, Religion and Science*. This work appears to make a break from the positions described by Gilman. On the surface, the argument is good and it is correct in many ways: human thought changed dramatically during the Middle to Upper Palaeolithic transition. The explanation of why this occurred, however, falls explicitly within the biological transition model: the new way of thinking was exclusive to *Homo sapiens sapiens* and was the result of an adaptation by a bottleneck population which rapidly replaced other species and/or subspecies of *Homo* (Mithen 1996: 209). Furthermore, the new "mentality was presumably encoded within their genes" (Mithen 1996: 209). This is a classic biological evolutionary argument for the origin of modern human behaviour in a cognitive guise.

Cognitive studies do not necessarily pre-suppose that differences in thought and behaviour are strictly genetically determined (Elman et al. 1996). Indeed, in the context of differences between modern human populations or individuals, this type of thinking is generally considered to be distasteful. The equality and uniqueness of humans is a fundamental tenet of the humanities, social sciences and international law (Ingold 1994). In the study of early humans, the easiest escape from the moral implications of this tenet is to employ some version of the species concept. In Mithen's argument, humankind emerged from a well-adapted bottleneck population. Biological and genetic arguments for differences in intelligence deny the humanity (in the biological and cultural sense) of pre-modern humans. Indeed, before approximately 40 kya, biologically modern humans did not appear to have humanity in the cultural sense. The archaeological and the biological evidence for this bottleneck population still evades us (McBrearty & Brooks 2000).

Despite its simple underpinning, which serves to explain rather than challenge the consensus view of a rapid biological replacement by better adapted creatures, the argument is well laid out and deserves to be examined closely. A discussion and critique of this argument follows. Based on cognitive and evolutionary psychology, Mithen (1996: 69) postulates three phases for the evolution of the human mind from a hypothetical chimpanzee/human ancestor to fully modern humans:

> Phase 1. Minds dominated by a domain of general intelligence - a suite of general-purpose learning and decision-making rules.
>
> Phase 2. Minds in which general intelligence has been supplemented by multiple specialized intelligences, each devoted to a specific domain of behaviour, and each working in isolation from the others.
>
> Phase 3. Minds in which the multiple specialized intelligences appear to be working together, with a flow of knowledge and ideas between behavioural domains.

These phases are based on Mithen's hypothesis that cognitive evolution mirrors the phases in the development of the child, or to put it another way, the ontogeny of the mind recapitulates the phylogeny of the mind. To understand the nature of his argument, some of the terms he introduces need to be defined. *General intelligence* is "a suite of general purpose learning and decision making rules... the rate of learning would be slow, errors would be frequent and complex behaviour patterns could not be acquired" (Mithen 1996: 73). In the second phase Mithen describes a situation in which separate intelligences, each corresponding to four possible domains of behaviour, supplement general intelligence. Each of these intelligences is independent of each other, with no or very little access of one domain to another. The three domains are social intelligence, natural history intelligence and technical intelligence. He also discusses a possible linguistic intelligence, which he admits is unlikely to have existed in isolation from the other domains (1996: 73-75). In the final phase, Mithen introduces a new mental module that allows for direct access between the four cognitive domains. He calls this a *superchapel* and relates it to Sperber's idea of a *module of metarepresentation* in which ideas from all of the domains are harmonised, allowing experience gained in one domain to influence others (1996: 63, 76-7). This final stage is the modern human mind.

It is important to point out that Mithen (1996: 52), although rejecting domain independence, believes that modern humans have cognitive domains that contain "intuitive knowledge," i.e., they are innate and content-rich:

> Young children seem to have intuitive knowledge about the world in at least four domains of behaviour: about language, psychology, physics and biology. And their intuitive knowledge within each of these appears to be directly related to a hunting and gathering lifestyle long, long ago in prehistory.

PHASE 1

Having laid out this basic framework, Mithen examines the evidence for the social, natural historical, technical and linguistic domains and correlates it with a chronological sequence and archaeological materials. He begins at a reasonable place in the understanding of the evolution of human behaviour - the common human-chimpanzee ancestor. According to Mithen, chimpanzees never exhibit more than a single component technology. Recent evidence for regional variation, or cultures in chimpanzee tool use behaviour (e.g., Whiten et al. 1999), is dismissed because it consists mainly of differences in the presence or absence of techniques rather than regionally dispersed variants of a single functional technique. As such, Mithen finds no evidence for the existence of a specialised technical intelligence (1996: 83-4):

> The failure of Tai chimpanzees to use termite sticks is most likely to arise simply from the fact that no individual within that group has ever thought of doing such a thing, or discovered it accidentally or managed to learn it from another chimp before that chimp forgot how to do it, or passed away with his great tool-use secret. This is not cultural behaviour; it is simply not being good at thinking about making and using physical objects. It is the absence of a technical intelligence.

As far as natural history intelligence, the knowledge that chimpanzees exhibit in their hunting and gathering strategies shows rote memorisation of familiar surroundings without creative insight. However, their ability to effectively understand their environment shows some evidence for a few specialised natural historical cognitive processes.

Finally, Mithen asks whether chimpanzees show any specialised social cognitive processes. He asserts that social intelligence was likely the first cognitive domain to emerge. However, he looks at social intelligence almost exclusively from the perspective of the individual. For him the main feature of social intelligence is the *theory of mind* - the ability of "an individual to predict the behaviour of another" using one's own thoughts as a model (1996: 92) and "knowing who allies and friends are" (1996: 91). Mithen believes chimpanzees have a well developed social intelligence, but one which is distinct from other domains by the lack of the use of tools in social interaction and the lack of social implications in food sharing. Overall, Mithen rates chimps as having a strong general intelligence, some natural history intelligence, no technical intelligence and a specialised domain of social intelligence. The domains that exist are cut off from each other.

Discussion

Chimpanzee intelligence is a highly contentious issue, but some issues in Mithen's account must be challenged. The first aspect to examine is technical intelligence. Were chimps good at making tools? Mithen raises the issues of the numbers of techno-units and regional variation in tool use. Although chimps rarely combine elements to make tools, their tool use is not simply a repeated process of trial and error - they remember. Turning to the example that Mithen himself discusses, using twigs, a number of interesting points contradict Mithen's statement. Although the Taï chimpanzees do not use sticks to collect termites, they do use sticks for four tasks: nut emptying, eating of bone marrow, ant dipping and honey fishing (Boesch & Boesch 1990). In Boesch and Boesch's (1990) study, two interesting factors of stick preparation emerge: the length and width of the stick used varies by task; and the tools are almost exclusively modified before their use. In the first instance, sticks used for bone marrow and nuts are shorter and finer than those used for ant dipping and honey fishing (Boesch & Boesch 1990: 94). Secondly, twigs are modified in only

6.5% of the cases after they are first used and most twigs involve three modifications before use (Boesch & Boesh 1990: 94). All of this suggests that twigs were modified with a limited notion of intentional design and task specificity.

Interestingly enough, twig use also shows evidence of regionally variable "different ways of doing the same task" (Mithen 1996: 83). In 1999 the major researchers in field studies of chimpanzees collated their data, created a standardised typology of 65 chimpanzee behavioural traits and compared the distribution of these across seven locations in East and West Africa (Whiten et al. 1999). Three techniques of ant collecting with sticks were noted: using a probe to extract ants; collecting ants on a stick (without probing the nest) and then using the hand to place them in the mouth; and finally, collecting ants on a stick and using the mouth to remove the ants. The first technique, although infrequently observed at Boussou and Gombe, was practised customarily at Mahale. The second was observed at Boussou, but was only customary at Gombe. Finally, the third was customary at Boussou and Taï, but only observed infrequently at Gombe (Whiten et al. 1999: 683, Table 1). Furthermore, the ant collection techniques at Mahale and Taï are mutually exclusive. There were no ecological explanations for this (Whiten et al. 1999). The tools were used in three different ways to achieve the same functional purpose. What does this mean? There is evidence for regional variation and intentional design in chimp technology - occurrences which, according to some, are not supposed to happen in the *Homo* lineage until 40 kya.

The solution to this riddle is twofold. Chimpanzees are simply not as intelligent as humans are - they have smaller brains and process less information at any given time (Gibson 1993). Secondly, despite clear evidence for relatively complex social behaviour, there are very important social differences between humans and chimps. The issue can be resolved by looking at how chimps learn. Although controversial, there is no strong evidence that chimpanzees have a theory of mind as Mithen suggests. Simply put, as Tomasello (1999) argues, chimps emulate and humans imitate. The first area to consider is the acquisition of tool use behaviour. Chimp learning is done in a social situation, normally in an infant and mother context. The mother draws the attention of the infant to the "results of changes of state in the environment" that she produces (i.e., *emulation*; Tomasello 1999: 520). The infant learns the task by independent discovery in a socially *focused* context. In humans, the child copies the method of the parent, showing an understanding of the goals of the parent. This is *imitation* (Tomasello 1999: 521). Thus the child is guided by the behaviour of the parent, rather than being focused on the results of the behaviour. Human learning involves the active participation of the parent. To phrase it in Ingold's terms, if humans learn technology through a process of *guided rediscovery* (1997), chimpanzees learn technology through a process of *focused rediscovery*.

In the case of nut cracking among the Taï chimpanzees, "teaching" through emulation is shown by the fact that the mother leaves intact nuts near the hammer and anvil. The child thus is focused on the objects and observes the result of the behaviour. Active guidance is extremely rare (see Boesch & Tomasello 1998: 601). The learning is left up to the infant chimp, but in a socially constructed environment. There appears to be no communication of states of mind, goals or intentions either way between a mother and her child.

If the social and technical were distinct, as Mithen says, one might expect this. However, this type of learning applies to other aspects of chimp behaviour, including various forms of gestures and communication - which are clearly social. According to Boesch and Tomasello, communication in chimps involves a process they call *ontogenetic ritualisation* (1998: 600):

> In ontogenetic ritualization a communicatory signal is created by two individuals shaping one another's behaviour in repeated instances of social interaction... two individuals essentially shape one another's behaviour over time. It is not the case that one individual is seeking to imitate the behaviour of another...

Communicative gestures in chimpanzees are highly specific and idiosyncratic. If chimps were able "to infer the mental states" (Mithen 1996: 91) of others, it is hard to imagine that they would not imitate as humans do in both tool learning and communication.

Does deception (Mithen 1996: 91) imply a theory of mind in chimps, or can this develop by focusing on and retaining personal experiences and motivations after observing the *results* of others' behaviour? Tomasello argues that such behaviours "represent cases in which nonhuman primates have acquired clever strategies to manipulate the behaviour, not the mental states, of others" (1999: 524).

It appears that chimpanzees are somewhat better at making tools and not as proficient at reading minds as Mithen leads us to believe. The final issue that Mithen considers is whether or not the domains are distinct. The relationship between technology and social behaviour can be examined in two ways. Is technology used for a social purpose (following Mithen's criterion) or is technology dependent on a social context? As far as chimps are concerned, the answer to the second is clear; although imitation does not occur, chimpanzee mothers leave nuts for their infants to crack, which they do not do for anyone else (Boesch & Tomasello 1998). Technological learning in chimps is thus a socially mediated process. Emulation is a social activity in chimps; however, "imitative learning... is simply a *more* social strategy" (Tomasello 1999: 521, emphasis mine). The existence, however limited, of regional variations of the same functional task supports the dependence of technological learning on social processes - certain techniques are specific to certain social groups. It is as difficult to separate social behaviour from other forms of behaviour in chimps as it is in humans. In chimps, both technology and social behaviour are relatively simple compared to humans (this is more likely a product of their brain size than of anything else). The limits of chimpanzee technology are a product of limits of their abilities to interact socially. If chimps could imitate, through an understanding of the goals and intentions of others, they would be able to learn to make tools more quickly and be able to transmit and retain innovations more effectively. Such a process would lead to greater *technical intelligence*.

PHASE 2

Mithen begins his discussion of Phase 2 of his model by looking at the earliest toolmakers, *Homo habilis*, who developed the earliest Oldowan technology. In this phase technical intelligence emerged. It was very limited because of "the stasis in Oldowan technology, the absence of imposed form and the preference for the easier raw materials" (Mithen 1996: 109). Mithen next discusses *natural history intelligence* and asserts that *H. habilis* was capable of developing hypotheses about resource location and distribution, whether for hunting or scavenging. However, these early hominids remained in a narrow set of African environments. Despite the advances in these areas, general intelligence still played the dominant role.

In Mithen's account of chimpanzee cognition, social intelligence was the most advanced form of intelligence. In Phase 2 it leads the other domains. At this point Mithen introduces cranial capacity as an important criterion for evaluating social intelligence (1996: 119). Following Dunbar's (e.g., 1998) work on the correlation between brain size and group size, the number of other individuals that one *H. habilis* would have social knowledge of is 82. Mithen states that "the more people that one chooses to live with, the more complex life becomes" (1996: 118). He also looks at ecological criteria, specifically that *H. habilis* gathered food "in large parcels that are irregularly distributed around the landscape" (1996: 119). This favoured large group sizes. Finally, he considers language and says that incipient language might emerge because Broca's area (the part of the brain associated with language) appears more developed than it does in the Australopithecines. He argues that language likely emerged as a part of social intelligence and was limited to that domain. He suggests, again following Dunbar, that language began as a supplement to grooming and gradually replaced it in hominid evolution (1996: 124).

Concerning the domains, Mithen sees a pattern similar to that of chimpanzees in *Homo habilis*, with the addition of technical intelligence and more elaborate forms of natural history and social intelligence.

Mithen next examines early human minds, ranging from *Homo erectus* through archaic *Homo sapiens,* including Neanderthals and *H. heidelbergensis*. Mithen groups these together for the sake of simplicity and focuses discussion on the archaeology of these early modern humans between approximately 250 kya and 40 kya. He first discusses the domain of technical intelligence. The Levallois method appeared 250 kya. Mithen compares it to modern human technology (i.e., blades; 1996: 134):

> ...the production of a blade from a prismatic core - as is characteristic of the Upper Palaeolithic period beginning 40,000 years ago... is incomparably easier than the manufacture of a Levallois point.

He believes the Levallois technique provides evidence that the technical domain of intelligence is fully formed by this stage.

Mithen sets out a number of questions regarding tool manufacture that need to be resolved. The first concerns the use of raw materials, specifically the lack of bone and ivory tools. Secondly, the tools do not appear to have been made for specific purposes. Thirdly, there were no multi-component tools. Lastly, there was little variation in these technologies across time and space.

Before resolving these issues, Mithen deals with natural history intelligence. He believes that natural history intelligence, comprising knowledge about animals, plants and geography, is "as sophisticated as that of modern hunter-gatherers" (1996:146). He cites these early humans' skill as hunters, the fact that they were able to move out of Africa and inhabit new environments in large groups, as their cranial capacity would suggest.

Mithen then proceeds to the technological questions raised. The solution to these problems is simple; there is no access between the domains. Early humans cannot conceive of using bones as tools because bones and stones apparently belong to two separate domains of thought. The lack of task-specific and multi-component tools again is a product of this lack of crossover between the domains, e.g., to combine a hunting task with a technical task would require crossover. Finally, the lack of regional variation can be explained by the fact that the knowledge about the different environments that they inhabited did not influence their tool making repertoires.

The most contentious issue that Mithen raises in Phase 2 is the sophistication of early human social intelligence. He returns to the brain size - group size correlation. Because these early modern humans, including Neanderthals, had cranial capacities similar to modern humans, they must have had social knowledge of as many people as modern humans do. Thus early modern humans must have lived in large groups and must have had extensive social networks. This raises a number of questions, mostly related to the fact that the archaeological evidence does not support this "circumstantial evidence" (1996: 119). Firstly, as Mithen admits, the archaeological evidence supports universally small group sizes, lack of spatial patterning of site features (implying limited social interaction), a lack of personal decoration and a lack of ritualised burial. Mithen's solution to this problem is that each domain of intelligence is cut off from the other. He states (1996: 154-6):

> If technical intelligence was not integrated with social intelligence, there is no reason to expect that social activity and technical activity took place at the same place in the landscape... Because of this intimacy between technical and social activities [in modern humans], the artifact distributions of Modern Humans may well reflect the size of the social groups and their social structure. But the artifact scatters left by Early Humans have no such implications... the complex social behaviour and large social aggregations of Early Humans took place elsewhere in the landscape, perhaps no more than a few meters away - and are archaeologically invisible to us today...

The lack of integration between advanced social behaviour and advanced technical behaviour explains the lack of personal ornamentation. Similarly, this points to the lack of ritual in burial practices.

The final aspect of the early human mind in Mithen's account is the linguistic domain. Based on the large cranial capacity of these early humans and the close association in the brain between language and "the ability to reflect on one's own and other people's mental states" (1996:159), Mithen argues that language existed but was restricted solely to the social domain.

To sum up, the early human mind was a "Swiss-army-knife" type mentality. In this model set forth in the work of Tooby and Cosmides (1992), each domain of the mind was distinct and specialised. Each domain was "designed by natural selection to cope with one specific adaptive problem" (Mithen 1996: 43).

Discussion

As in Phase 1 the evidence must be examined. The data from the Middle Palaeolithic and Pre-Aurignacian levels of the Haua Fteah provide a detailed case study on the sophistication of technical intelligence. Simply put, were these technologies as complex as those developed by behaviourally modern humans (as represented by the Early Dabban industries)? If only one aspect of the Middle Palaeolithic industries was considered, the answer to this question would be yes.

Levallois flakes involve the greatest amount of core preparation prior to flake removal; this is reflected in the high number of dorsal scars and the amount of platform preparation. A number of essential elements that the current lithic analysis points out, however, are missing from Mithen's analysis. Debitage production from the Middle and Early Upper Palaeolithic at the Haua Fteah suggests that there were three conceptual modes in operation: complexity (i.e., strictly the amount of core preparation), shape, and efficiency. In the Pre-Aurignacian and the Middle Palaeolithic only one of these conceptual modes seems to dominate in each of the *defined technologies* (in this case flake blades and Levallois flakes). In the Early Dabban, however, all three are integrated into the manufacture of blades. Furthermore, the proportion of blades produced in this period is around 30%, whereas in the Middle Palaeolithic and Pre-Aurignacian the proportion of all defined technologies is around 13-14%. Taken together, this suggests that debitage production in the Early Dabban is quantitatively and qualitatively different from that which preceded it. The level of technical expertise (shown by the integration of elements and the higher proportion of predefined flakes) is greater than that of the earlier periods at the site.

The above does not, however, take into consideration the tool component of the technology. In the Early Dabban tool production and debitage production were integrated. Blades in the Early Dabban appear to have been specifically produced for the manufacture of certain tool types and not others. There is blank selection before this, with larger flakes being selected in the Pre-Aurignacian and large, relatively complex flakes being selected in the Middle Palaeolithic. However, this involves selection on an attribute level rather than selection on the combined features of the finished product. Leaving aside any question of function, the process of tool manufacture in the Early Dabban appears to involve a much higher degree of planning and organisation than that which precedes it. It also involves a further step, evidence that the blade blank, once manufactured, was conceived of as such by the group making it, i.e., it comprised an *emic* category. The Middle Palaeolithic and the Pre-Aurignacian technology can be described as ad-hoc lithic strategies and the Early Dabban as an organised strategy. In short, there is greater technical expertise, or as Mithen would put it, technical intelligence, in operation in the Upper Palaeolithic component at this site. His assertions stem from the separation of one aspect of a technological system (the amount of work employed in the manufacture of a blank) from the system as a whole.

The materials used must be considered. Due to poor bone preservation (Klein & Scott 1986) at the levels of interest at the Haua Fteah, other parts of the world must be examined. The biggest problem with Mithen's discussion of non-lithic tools is the narrow scope of his argument. The intentional shaping of wood, as suggested by the wooden "spears" at Clacton (ca. 350 kya), Lehringen (ca. 110 - 130 kya) and Schoeningen (ca. 400kya), provides a strong argument against Mithen's argument (Mellars 1996b: 227; Oakley, Andrews, Keeley & Clark 1977; Thieme 1997). As Mithen states, natural history intelligence comprises knowledge about animals, *plants* and geography (1996: 139, emphasis mine). Certainly the use of wood implies a crossover between these domains - wood tools were manufactured by entirely different means than the contemporaneous stone tools; furthermore, they were arguably manufactured using those stone tools. Knowledge about which plants to use as tools would have involved some decision-making process about the suitability of this natural, biological product for making a spear and where one could find it in the landscape. Regarding bone and antler, Mithen's account suffers from an end product focused vision of technology itself. Bone, antler and wood were routinely used in the manufacture of stone tools before the Upper Palaeolithic, without necessarily being the end product of the technology itself (Inizan et al. 1999: 32):

> Direct percussion with a soft hammer (wood, antler, bone, ivory, etc.) occurs later in time [than hard hammer percussion]... Evidence for this technique dates back to 700 000 years in Africa, but it probably appeared even earlier.

The flaking of large mammal bone also dates back to the Oldowan (McBrearty & Brooks 2000: 503). It was the *way* in which bone was used and modified that changed dramatically in the Upper Palaeolithic. Bone and ivory were no longer used in an ad-hoc way. On the other hand, they were transformed using a time-consuming and organised process of cutting, grinding and engraving that has no parallel in lithic technologies such as Levallois technology or biface manufacture. Early humans could and regularly did use bone, antler and wood as tools, but with the possible exception of the wood spears mentioned above, they were used in a relatively simple way. The use of wood for spears and the more controversial evidence for hafting (e.g., Anderson-Gerfaud 1990) suggest that early humans thought about using natural materials other than stone. This begs the question whether there is a more parsimonious explanation as to why early humans did not utilise these materials more intensively. In many ways, the greater planning and organisation of "finished" tool production in the Upper Palaeolithic was a prerequisite for the manufacture of bone tools, which are arguably more labour intensive.

The final lithic puzzle is the question of regional variation. Two points must be made: 1) regional variation did occur; however, 2) each "region" was much larger and less patterned than in subsequent periods. It is important to note that Levallois technology has a regional limit, albeit a very large one. Towards the later Middle Palaeolithic in Europe, among the Neanderthals, there are important regional lithic industries such as the Mousterian of Acheulian tradition in France and the bifacial leaf points of Central and Eastern Europe (Mellars 1996b: 124-130). In Africa, there is considerable regional variety in point forms in the Middle Stone Age, with the Aterian and the Nubian Complex being just two of several varieties (McBrearty & Brooks 2000: 497-8). The regional distributions of these types in most cases are, however, relatively large and less patterned than in Upper Palaeolithic contexts (e.g., Mellars 1996b: 136).

Mithen's most contentious idea is that early humans lived in large, socially complex groups, similar to those in existence today. He admits that the archaeological evidence argues against this. From an archaeological perspective the evidence for large groups is entirely circumstantial. It is difficult to believe that social and technical activities were separated spatially, with no remaining evidence of the former and abundant evidence for the latter. In fact, many aspects of the archaeological evidence point to the contrary. The overriding pattern of archaeological sites in this period suggests that diverse activities took place at occupation sites. Three important elements are co-present at many Middle Palaeolithic occupation sites: lithic debitage, hearths and animal remains (Mellars 1996b: 363; and at Haua Fteah). At the least, technological and natural historical thinking appear to occur in the same place. Why would social activities occur further away?

Fire is an essential element in Middle Palaeolithic human occupation. It is more than just a technical or natural historical act. It provides heat and light, and sleeping and dwelling likely occurred nearby, especially in temperate or glacial regions. Later in his book Mithen (1996: 219-221) points to the importance of the mother-child nursing bond as a cornerstone of emergent cross-domain thinking. Due to the long period of children's dependence on adults for food, social negotiations referring to food provisioning for this mother-child bond would have resulted in the need to access multiple domains simultaneously, and given rise to cognitive fluidity. Even if early humans such as Neanderthals had somewhat shorter periods of dependency, the mother-child social unit would need to have food and shelter. I would argue that much social negotiation occurred in the "home," where the hearth is. Suggesting that social intelligence was expressed in some as yet unspecified locale is simply a diversionary tactic.

The fact that many deliberate burial sites were located in and around the living areas of Middle Palaeolithic sites (Mellars 1996b: 375-380) confirms that at least one socially important activity occurred in the same place as technological and natural historical intelligence. In addition, the probable social implications of the presence of ochre and manganese dioxide in these living areas must not be overlooked (e.g., Bordes 1952).

Throughout his work Mithen stakes his claim on biological and psychological inferences rather than on evidence from archaeology and/or social anthropology. Big brains must mean big groups; therefore the archaeology must be wrong. Part of this sleight of hand comes from the idea that because early humans had minds that were fundamentally different from our own, analogies from later archaeology or the social sciences in general cannot be used. If the connection between brain size and social group were to break down, so would the argument that early humans lived in socially complex large groups, and archaeological evidence would have to be relied upon. Brain size must be examined, because in many ways archaeology is of little use in Mithen's logic.

The assertion that group size can be predicted from brain size (specifically from the relative size of the neocortex) involves a standard flaw of biological arguments for behaviour, the failure to take into account the difference between capacity and expression. Although it can easily be argued that the ability to maintain and negotiate large social groups and networks of relationships would require significant information processing capabilities, this does not result in a necessary causation. In other words, if these large brained ancestors had the abilities to maintain large groups, it does not necessarily follow that they did. The predicted group size based on cranial capacity and neocortex size is a hypothesis that requires independent confirmation.

Dunbar (1998) claims that his prediction for average human group size, based on the correlation between primate group size and the relative size of the neocortex, is accurate at around 150. Determining an average group size for human populations is very difficult in practice, however. Aiello and Dunbar argue that approximately 150 is correct because many groups are this size and that (1993: 185):

> When groups significantly exceed this intermediate size, it becomes increasingly difficult to co-ordinate their members' behaviour through personal contacts. At this point they can no longer be egalitarian in their organisation but must increasingly develop stratification involving specialised roles relating to social control.

The last point is crucial: Dunbar purposefully ignores complex societies in his calculations (1998: 187). Although it is likely that there is a finite limit to the number of other people with which one individual can meaningfully interact, this ignores the fact that human populations have lived in groups much larger than 150 individuals for millennia. Primate groups tend to be the same size as their personal knowledge limits dictate because they do not have social organisation in the modern human sense, whereas human groups often vastly exceed this limit.

How human brains work also appears to differ from our closest primate relatives. Firstly, as Dunbar admits, the neocortex ratio differs considerably between humans and extant primates. To complicate this further, the nature of brain development is very different between humans and the great apes, with foetal rates of brain growth continuing for a year or more after birth in humans but not in apes (Jolly 1985: 296).

Gibson argues that large brain size in humans relates to a gradual evolutionary increase in "information processing capacity" (1993). The largest areas of growth in the brain in human evolution have been in the neocortical association regions, which are related to "higher order simultaneous or sequential constructs" (1993: 259). These regions allow humans to "break perceptions, motor actions and concepts into smaller component parts and then recombine these parts into higher order constructs" (1993: 252). The ability to do this in humans can be applied to a range of tasks, including tool use and language or negotiating complex social arrangements. The majority of increases in brain size appear to relate to this general-purpose information processing capacity.

Without evidence from archaeology or elsewhere, it would be difficult to pinpoint the precise reasons for the evolution of the neocortical association regions. There are likely multiple interrelated causes relating to social behaviour, language and tool use (Gibson 1993). Large brains in the *Homo* line suggest that a general-purpose *capacity* for complex thought evolved considerably before fully blown human behaviour. Without controlling for other functions of the neocortex, such as tool use or language, it would be difficult to calculate how neocortical size would constrain tool use, language and social behaviour simultaneously, especially since the first two are poorly developed in primates other than humans.

As Tobias states (1994: 44, 63):

> Later hominids (from about 2.0 million years ago (Myr) onwards) showed a strong enlargement of endocranial capacity, and this increase was out of proportion to changes in body size. There was thus an evolutionary trend towards increasing both absolute and relative endocranial capacity.

Furthermore

> ...on the evidence of both the sulcal pattern and Broca and Wernicke protrusions, the brain represented by the endocast of H. habilis closely resembles that of the modern human.

There appear to be two different brain size spurts, with the emergence of *Homo habilis* (ca. 2.0 mya) with a cranial capacity near 600 cm^3 and ca. 500-200 kya when archaic humans (including Neanderthals) developed cranial capacities and neocortex ratios within the modern human range (Aiello and Dunbar 1993: Figure 3). Therefore, according to the available evidence, essentially modern human brain size appears to have emerged by approximately 200 kya and the structure of the brain from this time on "closely resembles" the human brain. Brain size has been remarkably stable since then. In fact, modern human brain size and neocortex ratios appear to be lower than many Neanderthals and all early modern *H. sapiens* (Aiello and Dunbar 1993: Table 1).

If this evidence from brain development is correct, hominid brains had similar information processing capacities and the *ability* to use language (as suggested by Broca's region) from 200 kya. This information-processing centre sounds remarkably similar to Mithen's superchapel. Is there evidence for a lack of cross-fertilisation between these technical domains? As seen above, non-lithic material was used, but 1) in an ad-hoc way and 2) did not involve the imposition of standardised forms. Although lithic technology was clearly more sophisticated than the contemporaneous non-lithic technology, the fundamental nature of lithic production before 40 kya shares these features for the most part. The less sophisticated use (as opposed to absence) of bone, antler and wood appears to be the product of the ad-hoc nature of technology in general. This suggests a lack of organised, integrated technological behaviour and fewer "concepts" combined in a single tool rather than a lack of communication between cognitive domains. As discussed above, the spatial patterning of archaeological sites from this period shows that different domains of intelligence were being practised in the same locales, contrary to Mithen's idea that social activities occurred "off camera." Furthermore, as Gibson states: "the attainment of fully human capacities in each of these domains depended on the ability to integrate achievements in all three" (1993: 251). In other words, it is misleading to claim that one can have equivalent abilities (Mithen 1996: 137) to modern humans in terms of stone tool manufacture without the integration of these elements. As the data from the Early Dabban at the Haua Fteah points out, what distinguishes modern lithic technology is the organised integration of conceptual elements and evidence for deliberate planned production of blanks for specific categories of tools.

Phase 2 is summarised as follows:

1. In three of the domains that Mithen sets out pre-modern humans do not attain the levels of proficiency that modern humans do.
2. These domains do not appear to be mutually exclusive based on the evidence from the use of bone and wood technologies.
3. The evolution of the brain suggests that modern *capabilities* and neurological structures were in place by 200 kya in several taxa of the hominid line.

The final point raises a paradox. There is no evidence that points to the brains of these "early humans" being structured in a fundamentally different way than that of modern humans. However, fully modern behaviour did not emerge for approximately another 160 ky.

PHASE 3

Mithen's final phase is from approximately 40 kya to the present. In general, the modern human mind is relatively easier to explain than what preceded it because ethnography and modern psychology can provide an undisputed source of analogy. However, the equation of contemporary hunter-gatherers as studied by anthropologists for the last century and a half with the hunter-gathers of the Upper (i.e., modern) Palaeolithic ignores the fact that the complex co-existence of all known forms of human social organisation that exists today did not exist then. The co-existence of these different forms of society (e.g., the coexistence of agricultural and hunter-gatherer) is part of the cognition of both anthropologist and hunter-gatherer in the modern world. In this sense at least, modern (in the sense of the last hundred years or so) hunter-gatherer cognition is different than that of the modern Upper Palaeolithic hunter-gatherer. Another crucial difference is that contemporary hunter-gatherers tend to live in ecologically and politically marginal environments, whereas in the remote past there were no politically complex societies to marginalise them. These important points aside, in the archaeological record of the Upper Palaeolithic there are processes and behaviours that are more familiar to us than what precedes them.

Mithen focuses upon two of these familiar aspects of the Upper Palaeolithic: art and religion. His explanation for the rise of these nearly universal human phenomena is the emergence of *cognitive fluidity*. He begins by examining art. He states that there are three *mental attributes* that are needed for art to emerge (Mithen 1996: 181):

1. The making of a visual image involves the planning and execution of a preconceived mental template.

2. Intentional communication with reference to some displaced event or object.

3. The attribution of meaning to a visual image not associated with its referent.

Mithen says that early humans were competent in each of these mental attributes; however, each belonged to a different domain of thought. The first is found in the technical domain, e.g., the preconception of stone tools. The second is found in social intelligence, where to him language is based. The third is found in natural history intelligence, e.g., the ability to track game by using visual clues such as tracks from the environment. The inability to communicate across these domains, however, meant that early humans were incapable of making art. Furthermore, Mithen suggests that because art emerges fully formed, as in the case of the painted caves of South-western France, it must have been due to a change in cognitive abilities. Likewise, the appearance of personal ornamentation signifies the overlap between natural historical intelligence and social intelligence.

Secondly, Mithen looks at religion. He begins by examining anthropomorphism and totemism, both of which are the product of "a fluidity between social and natural history intelligences" (1996: 186). Mithen further believes that anthropomorphic thinking underlies changes in hunting strategies; essentially the theory of mind is applied to animals. By projecting human emotions and impulses on animals, their behaviour can be predicted in the same way that the emotions and impulses of humans can. Moving to religion proper, Mithen focuses on supernatural beings. An essential feature of supernatural beings is that they violate "intuitive" principles of biology, psychology and physics. Mithen basically argues that this feature of the supernatural can be explained by "a mixing-up of knowledge about different types of entities in the real world - knowledge which would have been 'trapped' in separate cognitive domains within the Early Human mind" (1996: 202).

Discussion

On one level, there is less to criticise in Mithen's account of modern human behaviour than in his account of the earlier phases. The notion that modern humans show considerable cross fertilisation in domains of thought is in accord with Mauss' (1967) notion of total social phenomena, i.e., that all elements in a society are interrelated. The ability to use experience gained in one area of behaviour in another is part of human cognition. Furthermore, this is in agreement with the principles of the theory of social representations (discussed in the next chapter). The main criticism of Phase 3 is that the theory is based almost exclusively from the perspective of the individual. The forms of social organisation that occurred in this new period are hardly even discussed.

This becomes important in Mithen's discussions of art and religion. Both of these serve a collective purpose but Mithen ignores their functional role in regulating and representing social behaviour. In his discussion of art, Morphy (1994) states that there are three perspectives that should be used to analyse art cross culturally: iconographic, aesthetic and functional. Mithen's discussion of art focuses primarily on the first. In fact many discussions of Palaeolithic art focus upon art as a system of symbols (e.g., Chase & Dibble 1987; Davidson & Noble 1989). Art clearly conveys meaning, but that meaning is embedded in a system of social relationships between people. To the anthropologist (Morphy 1994: 662):

> The material object also provides a vehicle for engaging in dialogue with members of a culture to see how different people at different times and places, and of different age, status, and gender, respond to, or interpret, or use, or make, the same object or the same type of object.

Archaeologists cannot engage directly in those dialogues, but an understanding of the meaning of a piece of art must ask the same questions. An art object has a collective meaning, but the meaning of that object to any individual varies according to the position of that individual in the social order. This exposes the relationship that exists between social structure and individual behaviour. Individual behaviour is clearly structured by social norms and regulations - as is thought itself. However, the role of an individual as an agent in that system who is free to use his or her own intelligence to negotiate and manipulate that system is also an essential part of human behaviour (Giddens 1984). A central theme is inequality and social differentiation. An individual's position in a society influences how that person regards a piece of art. Gender is perhaps the most obvious example: the meaning of a female figurine (today or when it was made) is likely to evoke different thoughts among men than among women. As Morphy states (1994: 667), "art varies in meaning according to the status, position and even the mood of the observer."

To have meaning, art must be as much a participant in the social structure as a product of it. Art requires social complexity in two ways:

1. There has to be sufficient time allowed and skill required for the production of art because in most cases there is no direct economic benefit in its creation.
2. The meaning of art (or any other symbolic code) emerges through a process of social interaction, i.e. "'meaningfulness' is actively and continually negotiated, not merely the programmed communication of already established meanings" (Giddens 1993: 111).

Social differentiation and complex interaction are needed for art production. The time allocated to the artist to learn and practice his art must come from the overall pool of labour of the group. Some redistribution of resources is required and some degree of task specialisation is necessary to produce art on the scale of the painted caves or the complexity of portable forms known from the Upper Palaeolithic.

Meaning itself is more than simply symbolic in a static sense; it is constantly reproduced and modified through social interaction. The intensity of social interaction both increases the need for shared meaning, and produces more tension between divergent responses and interpretations of that meaning. My hypothesis is that art emerges through the need to represent fixed meaning among variable opinions in a material object. It is an attempt by an individual or group to make an enduring, *authoritative* statement about the referent. In this sense the production of art provides a focal point for discussion and/or action; however, the discussion is initially framed by the intent of the author. The success of art in conveying meaning is based both on the skill of the artist in representing the referent and in making a novel variation which succeeds in appealing to the right people and the right moods. The intensity of social interaction creates a tension between diversity of opinion and the greater need for shared meaning. Greater tension logically results in more rapid changes in the form of these objects and their referents.

Function is the final aspect that needs to be discussed. It has been suggested that art fixes meaning in a material way. This is perhaps the most basic purpose of art. However, in non-western societies art is normally used for something other than being stared at by bored school children in museums or bought by people to decorate their lounges. Art is employed in ceremony, exchange and the display of social position. The value invested in art marks the activity it is associated with as being different or special. As Morphy suggests, there is an important difference between an undecorated utilitarian object such as a club, which can be used as a weapon, and one which has been decorated (1994: 664):

> The 'art' aspect of an object - i.e. its semantic/aesthetic dimensions - may provide a way of establishing connections across objects in different functional sets, for example by defining ceremonial sets or sets of objects associated with social groups or classes, or it may be a way of linking classes of objects with ideology or cosmology...

A decorated club might be used only in certain ritual contexts, or signify the identity or social group to which it belongs. It may be difficult to determine the exact meaning or function of an art object from the Upper Palaeolithic; however, it is safe to assume that the object was in some way associated with a social function which was ceremonial, ideological or a marker of identity. All of these functions suggest that art objects mirror social complexity itself.

Religion also has a social function. In Mithen's account religion appears to be primarily a result of the abilities of individuals to mix together different cognitive domains. As with art, religion as a system of meaning emerges through a process of social interaction, consensus and conflict. However, religion has two other features that require attention:

1. Religion invariably deals with *ancestors* or *lineages* in one way or another.
2. Religious beliefs are associated with a moral order, i.e., there are sanctions for improper behaviour.

Both of these are tied closely to the social organisation of a society.

Regarding supernatural beings, the persistence of life after death is the main feature of religion that Mithen discusses. However, in most societies one characteristic of life after death is the belief that dead *relatives* are still active in the world of the living. An example that illustrates both features comes from the Ndembu (Samuel 1990: 86):

> The Ndembu suppose that illness, death and misfortune frequently result from the action of the ancestral 'shades', that is the spirits of ancestors in the last two or three generations (i.e. the grandparental or great-grandparental generation). Specific ancestors from this group become upset or annoyed at the acts of their descendants and indicate their displeasure through causing the affliction.

In this agricultural society, the link between the ancestor and the afflicted is through kin ties and the affliction results from some perceived wrongdoing. Among the hunter-gatherer Dobe Ju/'hoansi a similar relationship between the living and dead emerges (Lee 1993: 114):

> "Longing," she [Chu!ko] said. "Longing for the living is what drives the dead to make people sick... they miss their people on earth. And so they come back to us. They hover near the villages and put sickness into people, saying, 'Come, come here to me'"... Chu!ko's view, corroborated by others, made the process of death a struggle between two loving sets of relatives, one living, the other dead, each wanting the individual for themselves.

In both cases, the relationship between the living and the dead is a persistence of existing relationships and the social order in the afterlife. The afterlife is more than merely the ability to think about such an idea; it is also governed by the social conventions current among the living. The religious systems discussed both provide a supernatural legitimisation of the social order, but also, through fear of sickness and death, regulate what is considered to be improper behaviour in the group. Supernatural beings may violate intuitive principles of biology, psychology and physics but tend not to undermine the social order. Indeed, the violation of social rules in myths and legends often produces hilarious and/or disastrous results that reinforce the social order in a negative way.

Mithen also examines totemism, which is more than a confusion of mental domains. Mithen states that totemism "involves embedding human individuals and groups within the natural world" and "requires a cognitive fluidity between thinking about animals and people" (1996: 188). In practice, however, totemism is a classification system and a set of behavioural rules rooted in social organisation. Although the totem bridges the animal and the human world in a cognitive sense, the logic of any particular totemic system cannot be explained by a simple mixing of ideas from different cognitive domains. In the individual sense of social intelligence that Mithen proposes, the totem also has very little to do with the theory of mind.

Totemism can take several forms, two of which will be examined. Clan totemism involves the association of a totem with a specific social group. The hunter-gatherer Tlingit of southern Alaska provide a good example of how totemism is rooted in social life, not simply an embedding of human categories in the natural world (de Laguna 1990: 212-3):

> Tlingit social, political and economic life was based on the fact that every individual (other than a slave of foreign origin) belonged to one of two exogamous moieties: Raven… and Wolf... Each of these was, in turn, made up of some 30 clans… most of which were subdivided into lineages or house groups…. Membership in moiety, clan, and lineage was matrilineal.
>
> It was the clan, and under it the house, that possessed territories, including rights to all game, fish, berries, timber, drinking water, and trade routes (for Chilkat and Chilkoot); house sites in the winter village and the prerogatives associated with the totemic crests, represented in the decorations of houses, heirloom objects, and personal names...
>
> The most treasured possessions of clan or lineage were their crests. These represented their totems, that is, certain animals, birds, fish, and invertebrates, heavenly bodies, prominent landmarks, and even ancestral heroes and certain supernatural beings associated with them...

> Crests are displayed as paintings or carvings on or inside houses, on totem poles..., graves, canoes, feast dishes...[etc.] and on the important possessions of the group's chief... Crests may be reflected in personal names, especially titles of house owners, and in the names given to houses, canoes and other crest objects and heirlooms.
>
> The totem was clearly more than an emblem or beautiful design. The actual animals, the mountains, glaciers, or bodies of dangerous waters that were associated with clans were addressed by kin terms, according to the relationship of the speaker to the clan in question, and the creature or natural entity would respond. The te·q^{w}e·dí, who had a special claim on the Bear, were therefore great hunters; the children of te·q^{w}e·dí men could appeal to bears as "father's brothers and sisters."

Furthermore, "marriage was always with a member of the opposite moiety, preferably with a member of the father's clan and house" (de Laguna 1990: 217). These lengthy quotations show the complexity involved in discussing clan-based totems. Totemic associations on the moiety level dictate whom one can marry, they were associated with artefacts and personal names, and the relationship between the totem animal or feature was wholly incorporated into the social hierarchy. The crests and totems were not fixed, however, and played an important role in negotiating political, economic and social life. Crests were "alienable: by sale, as potlatch or marriage gifts, as indemnity for injuries or as part of a peace settlement, or as booty taken in war" (de Laguna 1990: 213). Furthermore, geographically based crests were associated with actual territorial claims of the clan. Crests and totems, like art, symbolise and fix meaning in a dynamic social arena. They are contested and negotiated; they structure relationships and reinforce social conventions such as kinship terminology and marriage patterns. In short, totems are the products of social interaction, not solely cognitive action.

A second type of totemism is the personal totem system of the Mardu Aborigines of Australia. Each individual in Mardu society has two totems, an ancestral and a conception totem. The ancestral totem is linked to an estate, i.e., " the heartland of a local group and the locus of its members' attachment to territory; its sites are of considerable mythological and totemic significance to group members..." (Tonkinson 1991: 195). One's ancestral totem comes from one's estate of birth and signifies the spiritual ancestor from which that person is descended. The geographical association of the totem can cause problems, however, and there are various social mechanisms for their resolution, as illustrated by this example (Tonkinson 1991: 68-9):

> Most men who head families that constitute the several bands whose estate locus is Giinyu are related in the male line. This situation comes about because of a strong preference for children to be born somewhere in or near the estate of their father so that both will share the same ancestral totem. When adverse conditions force bands away from the Giinyu estate for long periods, some children may be born elsewhere. In this case, the father may try to arrange a birthplace that is associated with one of the Dingari mobs [i.e., other people associated with the dingo totem, a common totem among the Giinyu], but again this may not be possible.
>
> Birth on the estate is thus not the only criterion for membership, a person can be a member by virtue of having being conceived there or because his or her father's membership of the estate group... For males, there are other important avenues which exist through the religious life. The estate in which a youth is circumcised becomes "his" (to the extent that, when asked for his ancestral totem, he may give the name of his circumcision site rather than that of a Dreaming being)...

Apart from creating an association with one's father's estate and creating a spiritual link to a Dreaming being, one's ancestral totem also creates a shared social identity with those who have the same totem (Tonkinson 1991: 110):

> Many ancestral totems are widely shared and generate feelings of spiritual kinship with others, elsewhere, who were left behind by the same Dreaming beings. Totemism operates simultaneously in time and space, to link the past to the present, and humans to the Dreaming, to the land, and to one another. In so doing, it reinforces among Mardu a pervasive awareness of wider social unities and shared cultural identity, fostered by a huge cast of Dreaming beings and the vast expanses of country through which they have travelled.

In fact, one of the functions of Mardu totemism is to diffuse tensions and create a broader cultural unity (Tonkinson 1991: 140):

> The overriding significance of Mardu totemic associations lies in their linking of individuals, rather than social categories and groups, to the life-sustaining spiritual realm. Even members of the same estate group may have different ancestral totems, as noted earlier. Totemism, like ritual, cuts across other memberships and therefore dilutes rather than reinforces parochial tendencies among Mardu groups.

Thus despite the preferences for being born in the right estate, totemic associations ease social tensions by deferring ancestry to the spiritual world. Mardu totemism appears to have a role opposite to that of the clan totems in Tlingit society, where totems accentuate and reinforce differences between social categories.

Whereas the ancestral totem provides cohesion, the purpose of conception totems is to reinforce the individual's link to the spirit world (Tonkinson 1991: 80):

> Spirit-children, who wander far in the search of nectar from flowers and dew for their sustenance, take on the form of a particular animal, plant, or mineral before first encountering their human mother; this manifestation is later identified as the baby's jarrin or nyuga (conception totem).

The spiritual imperative is so strong that in some cases a spirit-child "chooses not to enter its 'proper' mother, but goes into the womb of one of her 'sisters' instead" (1991: 80). In this case, a birthmark or an association with an unusual event that links the spirit-child with a woman other than the physiological mother, results in the human child belonging to the woman with the spiritual connection. The father of a child is in all cases the husband of the mother, i.e., the social father, regardless of the physical paternity of the child. In fact, "when questioned, they deny the relevance of semen or intercourse to procreation" (1991: 80). Although the idea of a conception totem has many levels, because of the nature of marriages in Mardu society the ruling out of issues of biological paternity might serve a useful purpose in resolving conflict and reinforcing social roles and practices. Marriage is often polygynous and "is never solely the concern of the couple, but brings two family groups into closer alliance" (Tonkinson 1991: 98). Due to various male initiation rituals and stages, the age at which men and women are married can differ greatly, with men often being much older than their wives. Pre-marital and extramarital sexual activity is seen as inevitable, although subject to existing incest rules. Men may offer their wives to their guests "as a demonstration of hospitality and friendship" (Tonkinson 1991: 99-100). If physical paternity was recognised in the social concept of fatherhood as it is in other societies, the role of marriage in forging social alliances could be undermined. The conceptual totem supports important social alliances and mechanisms.

There is no special link between an individual's conception totem and the object or species that the spirit-child chose to inhabit. To the Mardu, "the medium itself seems less important than the message of a personalised link between each individual and a spirit-child that was left behind by some Dreaming being" (Tonkinson 1991: 81). Furthermore, there is no special link between those who share the same conception totem; the ancestral totem fulfils that function.

Among the Mardu, it is clear that the natural object that the totem represents is of secondary importance and totemism is a matter of a person's relationship to the Dreaming beings and to the ancestral movements of those beings in the landscape. Is it simply a case of "thinking about animals as people," as Mithen (1996: 189) suggests? Mithen discusses Australian Aboriginal totemism, remarks on the spiritual associations with the landscape, and states that their "landscapes are socially constructed and full of meaning" (1996: 189). This is no doubt correct, but can such a complex state of affairs arise simply from a change in the physiology of the brain? The structure and history of that society plays a crucial role in how totemism is perceived and why it is so variable across cultures. Among the Tlingit, a totem is tied up with strict rules of lineage, social identity and differentiation. It strengthens the fundamental differences between socially defined groups. A special relationship is created between the totem animal and a person by virtue of existing kinship relations. Among the Mardu, a more general relationship between the spirit world and the human world is created through ancestral totems; this relationship fosters a general sense of shared identity and dilutes differences. In the case of the conceptual totem, the spiritual and social basis of an individual's identity is privileged over the biological basis. Although sharing a general theme in both societies, totemism serves very different social functions, which are a product of the different organisation of those societies. Explaining totemism as primarily the product of an individual capacity to think across different domains of thought ignores the importance of social organisation and complexity.

SUMMARY

The above goes beyond providing a critique of Mithen's work; the ultimate goal is to put forward a new theory. The data presented in response to Mithen's account of prehistory must be assembled to provide a basis for the theory proposed in the next chapter. The underlying assumptions of Mithen's theory, the ideas of evolutionary psychology (especially those pertaining to Phase 2 in his model), will be dealt with in a different manner. At the outset, the next chapter provides a different view of how the mind works - one that has a basis in both biology and social theory.

A brief but important criticism of evolutionary psychology must be made. Many biologists disagree with the popular notion of one to one mappings between genes and behaviour. Much of the work of evolutionary psychology and its predecessor sociobiology is done at a theoretical level which is disassociated from traditional biology as an understanding of the nature of organisms, populations and species (see Gould 2001 & Rose 2001). Both sociobiologists and evolutionary psychologists deal with units such as genes, memes or modules, which they believe adapt and evolve independently of the organisms that house them. To academics in various disciplines (see Rose & Rose 2001) evolutionary psychology represents a gross misunderstanding of biology and evolutionary theory, an insult to Darwin's good name and an untenable position for understanding human behaviour.

Having reviewed Mithen’s work and compared it to the literature available, the main conclusions the current study draws is:

1. The various domains put forward are essentially equivalent in development to each other for each period.
2. There is strong evidence for crossover between domains in each period.
3. In each period, the different domains involve social mediation.
4. In the final phase, social organisation plays a fundamental role in shaping modern human behaviours such as art, religion and lithic technology.

Phase 2 is the most problematic phase in Mithen's account. From approximately 200 kya until 40 kya, available evidence suggests that all extant hominids had brain sizes and neurological structure similar to humans, but they did not attain the levels of technical, social and natural historical sophistication of modern humans. Mithen makes two fundamental assertions:

1. In phase 2 hominid cognitive modules were individually as sophisticated as those of modern humans.
2. There was little if any crossover between these domains.

The differences in the level of sophistication of the lithic industries at Haua Fteah and the use of non-lithic materials contradict these two points, respectively. Concerning social group size and complexity, Mithen's assertion that early humans were as adept as modern humans contradicts the archaeological evidence from intra-site spatial organisation.

Important changes occurring at the Middle to Upper Palaeolithic transition appear to have little to do with the structure of the brain, in terms of neurology, size or domain accessibility. However, the assertion that human thought changed radically at this time remains uncontested. New forms of behaviour did emerge. In the case of lithic technology at the Haua Fteah, a change in thought is evident in:

1. The ability to simultaneously integrate multiple conceptual modes in debitage production;
2. The organised production of specific blanks for specific tool types; and
3. The selection of blanks to make tools based on the blank type rather than on specific attributes.

All of these changes reflect a shift from ad-hoc tool manufacture toward an organised production strategy.

Direct archaeological evidence for religion and art is found after the Middle to Upper Palaeolithic transition. These behaviours are socially mediated processes that reflect the complexities of social organisation. Art implies that time and effort is freed from the social pool of labour for behaviour that is of no immediate economic consequence. In most human societies, religion both evokes and supports kinship structures and regulates and maintains the social order. Neither art nor religion could evolve from cognitive fluidity alone, but are shaped by and produced through social organisation.

It is also important to note that there were important changes before the Upper Palaeolithic. Changes in the lithic technology at the Haua Fteah show that some cumulative processes were occurring before this transition. At the Haua Fteah this occurs most notably in blank selection for tool manufacture, with the introduction of core preparation complexity as an attribute of selection in addition to blank size.

In this chapter two important points were made:

1. Human brain structure does not appear to have changed significantly in the last 200 ky.
2. Human behaviours and cognition did.

These two points are irreconcilable from an evolutionary psychological perspective. There is no simple leap from our biological make-up to our behaviour or cognition, neither today nor in the past and not among humans or chimpanzees (who likewise show regionally variable forms of behaviour).

The most plausible alternative to Mithen's account is that there was an important change in the organisation of some human societies at the Middle to Upper Palaeolithic transition that produced important developments in lithic technology, and brought about the emergence of art and religion. This change had wide-reaching consequences for human cognition and behaviour, creating an historical (as opposed to genetic) advantage for those groups in which these behaviours occurred. Furthermore, evidence suggests that human social behaviours play an important role in physiological and neurological development in ontogeny.

VI. Social Cognition and the Emergence of Modern Human Behaviour

The claims of evolutionary psychology are not in agreement with the understanding of human behaviour put forward by social anthropologists. A primary lesson of social anthropology is that human cultures currently and through history are amazingly diverse. The search for human universals, which was popular in the works of Levi-Strauss and others, has largely been abandoned. One of the claims of evolutionary psychology is that humans have innate knowledge of things such as language, music, biology, etc. Although Mithen allows for more flexibility and development in cognition than the extreme views of evolutionary psychologists, he shares with evolutionary psychology two important features: 1) the mental modules or "specialized intelligences" are "content-rich" (1996: 52); and 2) mentality is "presumably encoded within... genes" (1996: 209). Essentially, Mithen argues that humans go through a phase in which the ideas of evolutionary psychologists are true, but that we emerge beyond them, allowing for separate, flexible and content-rich parts of our brain through the addition of a new mental module. This coincides with the emergence of fully modern human behaviour at the Middle to Upper Palaeolithic transition.

Matching the data to this account is problematic, particularly in Mithen's Phase 2. This chapter presents an alternate cognitive model that is in accord with social theory and the ideas of social psychology. This model begins with a discussion of evolution and the nature of the brain.

Biology and Cognition

One of the problems with many biological models explaining the evolution of human behaviour is their rigid adherence to neo-Darwinian, or as Gould (2001) would call them, ultra-Darwinian rules. Two elements are combined: "ultra-Darwinists share a conviction that natural selection regulates everything of importance in evolution, and that adaptation emerges as a universal result and ultimate test of selection's ubiquity" (Gould 2001: 86). Another feature common to the ultra-Darwinists is that selection occurs at the sub-organism level. In other words, discrete traits (whether they are features such as eye colour or mental modules) are selected for independently and are adaptive. Gould argues emphatically that each of these features of the ultra-Darwinist synthesis is false. His point that natural selection operates at the population level is perhaps the most important to the traditional Darwinian view (Gould 2001: 90):

> ...individual organisms do not branch; only populations do - and the causes of a population's branching can rarely be reduced to the adaptive improvement of its individual organisms.

Related to this, Gould states that (2001: 103-4):

> All organisms evolve as complex and interconnected wholes, not as loose alliances of separate parts, each optimised by natural selection. Any adaptive change must also generate, in addition, a set of spandrels or non-adaptive byproducts.

Essentially, not all traits of a species or organism are adaptive. All species carry non-adaptive baggage with them. Nature selects populations that are the fittest to survive in an environment given alternative competing populations. Nature does not design optimal solutions to that environment. This leads to the assertion that natural selection is not the only process that has shaped evolution. Gould introduces the notion of spandrels - non-adaptive by-products, which play an important role in evolution. Non-adaptive elements in an organism, which did not arise for any adaptive purpose whatsoever, may later be co-opted for other uses.

Other factors affect evolution. These include the remarkable conservation of traits that constrain the adaptation of biological organisms. Many genes regulate developmental pathways that are shared by humans and fruit flies (Gould 2001: 89). These result in broad structural stability across wide ranges of species and through time (in the range of hundreds of millions of years). Many of the fundamental building blocks of life are shared and these place constraints on the possibilities for adaptation rather than enabling adaptation. Included among these constraints are features such as morphological symmetry and cell maintenance mechanisms.

Another important aspect of evolution is contingency: "chance, uniqueness, unpredictability" (Gould 1999: xii). In brief, things happen at certain times for no particular reason. This explains aspects of the earth's evolutionary history, such as a meteorite hitting the earth and causing mass extinction, or a migratory herd getting lost and finding itself in a new environment to which it is well suited.

Finally behaviour, especially social behaviour, plays an important role in evolution. Patrick Bateson (1988: 205) introduces a number of ways in which animals can affect evolutionary outcomes through behavioural processes:

> First, animals make active choices and the consequences of their choices are often important. Second, animals change the conditions in which they live by altering the physical and social environment and again the consequences are likely to be important. Third, animals are able to modify their behaviour in response to changed conditions and thereby make further genetic change possible. Finally, active animals often expose themselves to new conditions which may reveal variability, with some variants more likely to survive than others.

The choices that animals make can have important consequences on their chances of survival. These choices, unless one believes in an extreme form of biological determinism, cannot be seen as "natural."

GENES AND CELLS, OR WHY WE ARE NOT WORMS

It is useful to understand how the brain works before making a statement about how the mind works. Recent advances in neuroscience have provided important empirical evidence that has taken a certain amount of guesswork out of understanding the brain. Before looking at the specifics of the brain itself, it is important to understand how genes operate and how they relate to the phenotypes that emerge in an organism. Any theory about how the brain develops and operates must take into account the existence of genes; there is no denying that human genes give rise to human beings and worm genes give rise to worms. That said, do genes explain everything?

Elman et al. (1996) address commonly held misconceptions about how genes operate. The only way to assess the claim that a type of thought is encoded in one's genes is by asking whether this is the sort of thing that genes are capable of doing.

Elman et al. make a number of points that serve as a backdrop to the more complex issues of the relationship between biology and cognition (1996: 8-12):

> Genes are often physically distributed in space...
>
> Genes are not binary in their effects...
>
> Genes do their work with other genes...
>
> Genes are often re-used for different purposes...
>
> There is a great deal of genetic redundancy in eukaryotes...
>
> The relationship between genome and phenotype is highly non-linear...

These points lead to the conclusion that (Elman et al. 1996: 12-13):

> Genes work in concert with large numbers of other genes, and tracing a particular gene's contribution to the emerging phenotype is very indirect and rarely possible without considering the whole network of interactions in which that gene participates.

Between genes and brains lie cells. A number of important points can be made about all cells in the body. First, "all cells (with one or two minor exceptions) contain the same genetic information" (Elman et al. 1996: 13). In other words, the cells that make up the brain and the cells that make up one's feet share the same genetic information. How cells form different tissues and organs in the body occurs through processes of development. An understanding of the organism's development is necessary in order to understand the functions of organs such as the brain or the foot.

Cells develop through two different types of development, mosaic and regulatory. Elman et al. (1996: 13) state:

> In mosaic development, cells develop more or less independently. They tend to be largely unaffected by each other and by the environment. The fate of each cell or group of cells is determined early on by their location. When and what a cell becomes is under relatively tight genetic control.

This type of development is common in relatively simple organisms such as the nematode (a type of worm), whose entire cellular development occurs through a process of mosaic development (Elman et al. 1996: 13-14). Mosaic development has clear advantages - it is fast and precise. Each cell develops independently according to its genetic pre-specification. The down side of mosaic development is due to the same reasons. Because everything is pre-specified, the organism has very little flexibility coping with changing environments. The tight control over cell specification also means that mosaic development is genetically expensive. As Elman et al. (1996: 15): state:

> The genome [in mosaic development] comes close to being a blueprint for the body; it must specify everything... Such direct specification of the human brain alone, for example, could plausibly require something on the order of 10 trillion base pairs of DNA, which is far in excess of what is structurally feasible.

Regulatory development, on the other hand, accounts for a significant proportion of development in many species, with higher vertebrates showing "more regulatory development" (Elman et al. 1996: 15). Regulatory development has a number of distinct advantages over mosaic development. The most important of these is that fewer genes are required to produce complex phenotypic results. The mechanisms of regulatory development are very different from those of mosaic development (Elman et al. 1996: 15):

> Regulatory systems rely heavily on cellular level interactions. The orchestration of cell differentiation and the final outcome are under broad genetic control, but the precise pathway to adulthood reflects numerous interactions at the cellular level that occur *during development.*

Another advantage of regulatory development is that the systems produced have incredible flexibility. The same genetic material and the same mechanisms under different environmental conditions can produce modified results and the system can compensate for damage to groups of cells much more easily.

The costs of regulatory development, however, are the opposite of those of mosaic development. Regulatory development is slow, dependent and variable. Cells do not develop according to a pre-specified code, but through lengthy processes of interaction with other cells. Often tissues and organs have to wait for other systems to develop first. Developmental timing becomes incredibly important in regulatory development.

Regulatory development explains how a human, with 100 trillion cells, can emerge from about only 200 types of cells (which are more or less the same as those found in all snakes, birds and mammals) and how 98.4% of human DNA is shared with chimpanzees (Elman et al. 1996: 13). Regulatory mechanisms of development point out that gene expression is algorithmic rather than descriptive in humans and other complex animals. Phenotypic expressions in humans emerge through the interaction of various genetic algorithms, previous cellular production and environmental input.

HOW THE BRAIN WORKS.

The human brain develops primarily through a process of regulatory development. Recipe ingredients for an 18-year-old human brain might include genes, some other cells and organs for support, and a rich diet. Bake for 18 years and 9 months in a pre-heated real world, stirring constantly. When ready, send to university. For best results, talk to it only until it is 13 years old, at which age it will no longer listen.

A developmental perspective is required to understand the human brain. Neuroscience studies have shown that one of the most important features of the brain is its plasticity, especially early in development. The argument for developmental plasticity in the brain comes from empirical data. First, animal research has shown that when brain tissue from one region (e.g., the visual cortex) is transplanted to other parts of the brain (e.g., the sensorimotor cortex), the transplanted tissue begins to function like tissue in the new region (Elman et al. 1996: 3).

Human research naturally precludes brain transplantation. Studies of people with brain impairments or brain injury, however, have supported the notion of plasticity in humans. Karmiloff-Smith cites research showing that (2001: 152):

> ...in the rare cases in which the left hemisphere has to be removed to treat epilepsy, the development of language in the single, remaining right hemisphere has a far better prognosis if the operation is carried out early in the development process.

Studies of people with Williams Syndrome (WS) show that they have "good levels of proficiency in face processing, language and social interaction" but are severely impaired in terms of spatial cognition, number and problem-solving skills (Karmiloff-Smith 2001: 148). In the past such cases have been used to support the claim that tasks such as language and spatial awareness are discrete "hard-wired" modules in the brain. Karmiloff-Smith, however, has conducted experiments showing that (2001: 151):

> ...people with WS do not simply call on an intact language module fashioned by evolution and innately specified. Rather, people with WS appear to follow a deviant developmental pathway in their language acquisition.

This points to a much more general cross-domain deficit along with the ability to use language with different brain parts and learning mechanisms than those of normal children. Furthermore, in children with WS the relative success in facial recognition emerges through a different process from that found in normal children. In WS cases, facial recognition comes via recognising parts of the face, rather than from a holistic, spatially rich awareness of the whole face. As in the case of language, the person with WS puts together a competent "domain" using different brain mechanisms and learning strategies.

In other words, WS cases show that domains such as language and face recognition are not pre-specified but dependent on more general *constructive* learning mechanisms. However, as Karmiloff-Smith states in her earlier research, there are some innate "domain-specific attention biases" (1992: 166) that, in concert with domain-general learning mechanisms in species-typical social environments, result in typical language and typical face recognition abilities.

In addition to new findings in neuroscience, the development of computer simulations of *neural networks* has shown that computers can be taught complex tasks using only simple learning algorithms and no pre-specified content. These are *connectionist* models, as described by Karmiloff-Smith (1992: 177):

> The most common type of connectionist network is composed of a large number of simple processing units, each of which takes varying degrees of activation and sends excitatory or inhibitory signals to units to which it is connected. The architectures of these networks are typically composed of an input layer, one or more layers of hidden units corresponding to the network's evolving internal representations, and an output layer, with a vast network of connections between layers. In general, the hidden layers have fewer units than the input layer, which causes the representation of the information from the unit to be compressed.

Models such as these have been exposed to repeated simple English phrases and (Karmiloff-Smith 1992: 185):

> ...with time the network learns to predict, not necessarily the actual next word, but the correct *category* of word (noun, verb, etc.), as well as the correct subcategorization frame for the next verb (transitive or intransitive) and the correct number marking on both noun and verb (singular or plural).

These experiments have shown that without pre-specified content *general* learning mechanisms can learn and produce abstracted representations of grammar. What these models do not do is go beyond rule-based behaviour and "form theories about how, for instance, language and the physical world function" (Elman et al. 1996: 395). Having developed this successful language *task*, the representation inherent in the coding of the neural network has to become generalised and available to other levels of cognition for it to resemble human theory making.

Based on empirical evidence and computer simulation, two important points can be made.

1. Brain development shows considerable plasticity and can produce in abnormal cases alternate solutions to behavioural problems.

2. Computer simulations show that tasks such as grammar usage can be learned using simple, general-purpose mechanisms in a content rich environment.

Together, these argue against innately pre-specified, content rich modules.

Elman et al. (1996) make a number of crucial points regarding what is and what is not innate in human cognition. Without question, numerous studies and experiments have shown that there are species level similarities in healthy adult human minds in species-typical social environments: they all speak a language of some sort and the physiology of the brain shows that linguistic representations become localised.

The first point that Elman et al. discuss is the difference between mechanisms and content. One aspect of this is the confusion inherent in the term *module* as used by neuroscientists and cognitive scientists. To the neuroscientist, the term module "is usually referring to the fact that brains are structured, with cells, columns and layers, and regions which divide up the labor of information processing in various ways" (Elman et al. 1996: 36). For many cognitive scientists and linguists it means something else; to them "a module is a specialized, encapsulated mental organ that has evolved to handle specific information types of particular relevance to the species" (Elman et al. 1996: 36). The latter is the meaning used or implied by psychologists such as Fodor, evolutionary psychologists, and as discussed above, archaeologist Mithen. Essentially, the former definition refers to mechanisms by which information is gathered and processed, and the latter emphasises the content that is processed. The latter, however, conflates the two, mixing mechanisms and content.

As Elman et al. (1996: 359) state, there is not a necessary relationship between mechanism and content: during the process of development "most domain-specific outcomes are probably achieved by domain-independent means." In other words, they take the stand that it is the mechanisms, not the contents, that are most likely innate.

Theoretically, mechanisms operate at three levels (Elman et al. 1996: 25-35; 360-362): *representational*, *architectural* and *global*. Each mechanism can be described in terms of constraints. Representational constraints are the most specific and are "expressed at the neural level in terms of direct constraints on fine-grained patterns of cortical connectivity" (Elman et al. 1996: 360). In these terms, representational constraints relate directly to constraints on the storage of knowledge. "Knowledge ultimately refers to a specific pattern of synaptic connections in the brain" (Elman et al. 1996: 359). Architectural constraints refer to the way that the brain is put together and can be subdivided into three levels (represented in Table VI.1).

Table VI.1: Types of Architectural Constraint (based on Elman et al. 1996: Table 1.3).

Type of architectural constraint	Example in brain
Unit	Cytoarchitecture (neuron types); firing thresholds; transmitter types; heterosynaptic depression; learning rules.
Local	Number of layers; packing density; recurrence; basic cortical circuitry.
Global	Connections between brain regions; location of sensory and motor afferents/efferents.

The final type, global constraints, limit developmental timing such as the number of cell divisions, spatio-temporal waves of synaptic growth and temporal development of sensory systems.

Elman et al. (1996: 361) conclude that

> ...representational constraints... are certainly plausible on theoretical grounds, but the last two decades of research on vertebrate brain development force us to conclude that innate specification of synaptic connectivity at the cortical level is highly unlikely. We therefore argue that representational nativism is rarely if ever, a tenable position.

Therefore the types of constraints that exist are those that deal with:

1. the types of cells in the brain;
2. the locations of these cells;
3. how they are connected and form regions; and
4. in what sequence brain cells and regions develop in relationship to each other and other systems in the body.

Basically, the human brain has specific learning devices and processing mechanisms (that develop through architectural and timing constraints) making possible the acquisition of domain-specific (but not modular) representations. The representations (i.e., specific knowledge such as grammar, physics or theory of mind) are not innate themselves, but the ability and mechanisms for acquiring them are. Furthermore, the fact that representations are domain-specific does not mean that the mechanisms for acquiring them are as well.

This theory arises from the biological argument set forth earlier. The way genes operate; how cells, organs and tissues develop in humans; and how simple learning mechanisms can arrive at complex solutions without pre-specified knowledge all support the notion that the human mind develops in an algorithmic way through regulatory controls on developmental timing and brain architecture. Development is the key and plays two important roles (Elman et al. 1996: 365):

> First, a long period of development allows greater time for the environment (both sociocultural and physical) to play a role in structuring the developing organism. Second, the view we have proposed is that development is the key to the problem of how to get complex behaviours (in the mature animal) from a minimal specification (in the genes).

IMPLICATIONS FOR COGNITION

This model of how the brain works clearly suggests that there is great flexibility at the outset and that domain-specific representations emerge over time. Another important implication is that the representations do not spontaneously appear in the mind. Representations can only develop through interaction with real world situations. Over time, they are coded into specific patterns of synaptic connections that are distributed through the brain in relevant places using relevant mechanisms. From an evolutionary standpoint, this model of cognitive flexibility and plasticity has adaptive potential. It supports Gibson's (1993) notion that brain size and structure have a lot to do with our information processing capabilities. It explains why we can drive cars, ride bicycles, operate VCRs and play video games, all of which are recent phenomenon that have no clear representational antecedents, not even in the last few hundred years. In fact, what our brains do today likely represents more behavioural spandrel than evolutionary adaptation. This model also explains why some people are better at some things than others and why practice makes perfect. Such a model of brain development makes the social sciences interesting and indeed *possible*, without naively discounting the fact that genes are relevant.

Cognition is related to how our brains work. Using innate learning mechanisms, over time the brain develops representations and stores them in patterns of synaptic connections governed by architectural and developmental constraints. How are these representations fashioned? Karmiloff-Smith (1992) introduces the notion of *representational redescription* (RR). Unlike the results of the connectionist computer simulations, RR explains how children's minds become progressively more flexible, allow for conscious access and exhibit theory building. "In other words, representational redescription is a process by which implicit information *in* the mind subsequently becomes explicit knowledge *to* the mind, first within a domain and then sometimes across domains" (Karmiloff-Smith 1992: 18). Before going into the mechanics of this model, three points must be made.

1. RR is a domain-general process.
2. The process occurs recurrently within "microdomains" (i.e., specific subject areas of knowledge) throughout development.
3. Each phase of the model is age independent.

There are generally three recurrent phases within each microdomain. Phase 1 is a data driven stage in which "the child focuses upon external data to create 'representational adjunctions'" (Karmiloff-Smith 1992: 18). These representations are unmodified and simply add to existing representations. They do not affect the existing representations. This phase culminates in consistent performance and “behavioural mastery,” which are not explicit to the mind. Phase 2 is a stage in which internal representations take over from external data. The representations continue to be redescribed (see below), without taking into account new data. This may lead to behavioural errors and some inflexibility. Phase 3 is when the internal representations (which continue to change) are reconciled with external data.

Representations are redescribed within this phase system. According to Karmiloff-Smith (1992), this process of redescription goes through four stages. Representations begin at the implicit level (I). Implicit representations "are in the form of procedures for analyzing and responding to stimuli in the external environment" (Karmiloff Smith 1992: 20). These representations are procedural, sequential, independent and bracketed (i.e., there are no links between these and other inter- or intra-domain representations). The first level of explicit representations (E1) is a reduced description of the implicit representation and corresponds to the beginning of Phase 2 in the model above (i.e., after behavioural mastery). Karmiloff-Smith uses the example of a zebra. The image of a zebra delivered through perception is stored as an implicit representation. This representation would then be redescribed into a new representation such as “striped animal.” The representation thus becomes conceptual and allows for the use of analogies and comparisons with other explicit representations, e.g., zebra crossings on roads, which share the feature of being striped. "The redescribed representation is, on the one hand, simpler and less special purpose but, on the other, more cognitively flexible" (Karmiloff-Smith 1992: 21). An important feature of E1 representations is that they are not yet available to conscious access and verbal report - they operate in the background. The second level of explicit representation (E2) is available to conscious access, but not to verbal report. Examples include spatial representations that can be diagrammed (in the mind or on paper) or kinaesthetic representations that are not verbalised. Finally, E3 representations can be verbalised and are directly accessible to consciousness. "At level E3, knowledge is recoded into a cross-system code" (Karmiloff-Smith 1992: 23). This code is not necessarily stored linguistically, but is "close enough... for easy translation into statable, communicable form" (Karmiloff-Smith 1992: 23).

It is important point to note that although representations are progressive condensations and re-representations, prior levels are not erased in the process. Knowledge is thus stored at multiple levels, which can or cannot be accessed at multiple levels. Furthermore, some knowledge does not develop fully into E3, linguistically accessible format.

E3 representations potentially can enter the system in linguistic format, without necessarily going through the direct data oriented implicit level. This information can then be compared with other representations at various explicit levels. Karmiloff-Smith also states that she does "not wish to foreclose the possibility of consciously accessible spatial, kinesthetic, and other non-linguistically-encoded representations" (1992: 23). This is important when considering techniques such as walking (Ingold 1997, 2001; Mauss 1979) and stone-tool manufacture, which can be explicit and consciously accessible, but not directly taught linguistically.

Karmiloff-Smith reiterates a final point (1992: 25):

> At any given time the child may have only level-I representations available in one microdomain, but may have E1 representations available in another microdomain and E2/3 representations in yet another. This obviously holds across domains, too. It is hypothesized that there are no overarching domain-general changes in representational format at any given age. There is no such thing as a "phase E2 child".

Before discussing other important aspects of cognition, Mithen's cognitive stage argument should be revisited. We have already seen that, according to Elman et al. (1996), content rich innate representations are highly unlikely to exist from a biological perspective, nor could such representations be plausibly encoded in one's genes. Karmiloff-Smith also argues against a universal stage approach to either cognitive development or any stage where domains are cut off from one another. Young children appear to be able to mix and match those explicit representations once they have formed. At a young age my son made a leap from his perceptions of size and shape to social relations. He had three toy cars, two large and one small, all of the same make and model. The two large ones were Mom car and Dad car and the small one was the baby car. He made the leap from similarity in appearance and relative size to social relatedness, i.e., he played with his explicit representations. At a later age he had no difficulty knowing on a practical level that 5 20p coins made a pound (behavioural mastery), but had difficulty with the concept that 5 x 20 = 100 (explicit representation). In other words, different stages were reached in different domains at different times.

It is useful to consider the differences between primates and humans in terms of this model. Grammar itself does not appear to be innately specified. However, the abilities and mechanisms to learn language do. Gibson states that "parallel distributive processing" is one of the ways that the brain processes information (1993: 259). In other words, the brain does not operate sequentially, but spreads information into different regions (modules in the neurological, *not* the cognitive sense) for processing. The larger the brain, the more parallel processes can occur at the same time. This allows humans to "break perceptions, motor actions and concepts into small component parts and then combine and recombine these parts into higher order constructs" (Gibson 1993: 252). Hypothetically, the lack of brain size would restrict chimpanzees to an E1 level of representation in normal circumstances, and effectively limit them to behavioural mastery and some explicit representations. These representations would not be consciously accessible or reportable. In other words, chimps do not engage in theory building or direct sharing of representations. This might explain predetermination of twig size (as discussed in the previous chapter) and chimps' ability to learn basic communication in captivity, without progressing as far as children go in areas such as language and theory building. The E1 level would allow chimps to mix domains, thus combining social and technological activities as in the case of teaching nut-cracking through emulation, but not to the extent that humans do.

SOCIAL COGNITION

In humans, a final level of cognition goes beyond the brain and is found in organised group behaviour. Edwin Hutchins (1995: xiii) says, "depending on their organization, groups must have cognitive properties that are not predictable from a knowledge of the properties of the individuals in the group." He makes a recurrent analogy between cognition and energy in human groups (Hutchins 1995: 175):

> In anthropology there is scarcely a more important concept than the division of labor. In terms of the energy budget of a human group and the efficiency with which a group exploits its physical environment, social organizational factors often produce group properties that differ considerably from the properties of individuals.

Physical tasks are parcelled out and combined to create results that can exceed the capabilities of and take a different form from the behaviour of individuals participating in the group. Like labour, cognition is distributed throughout human societies. The division of labour and distributed cognition are, however, more than analogy (Hutchins 1995: 176):

> All divisions of labor, whether the labor is physical or cognitive in nature, require distributed cognition in order to coordinate the activities of the participants.

One important aspect is that differences in the nature of groups' cognition, like differences in the nature of human energy systems, are a product of differences in social organisation (Hutchins 1995: 177-8):

> ...if groups can have cognitive properties that are significantly different from those of the individuals in them, then differences in the cognitive accomplishments of any two groups might depend entirely on differences in the social organization of distributed cognition and not at all on differences in the cognitive properties of individuals in the two groups.

Distributed cognition has a number of important features. Elements of a task can be distributed through the group, allowing several people to operate in parallel (Hutchins 1995: 226). The distributed elements of the cognitive task, however, have to be communicated through the group, resulting in a reduction of information held by the individual when it is shared with the group (Hutchins 1995: 227). In other words, to use Karmiloff-Smith's terms, representations are redescribed in a way that is accessible to the other members of the group. This sharing is often, but not necessarily, linguistic in nature. Thus in Karmiloff-Smith's mode I, the internal representations must be either type E2 or E3 to be shared.

For group cognition to be effective, members of the group must learn their parts in the system. Hutchins (1995: 289) describes this process as "*adaptive reorganisation in a complex system.*" The individual participating in the group has to align his/her own cognition and behaviour to that of the other members of the group and to the nature of the group and task as a whole. This will have an effect on the individual's cognition. As Hutchins notes, the inside/outside dichotomy of the human mind is problematic (1995: 355).

Hutchins (1995: 262) used computer simulations to demonstrate that "even while holding the cognitive properties of individuals constant, groups may display quite different cognitive properties, depending on how communication is organized within the group over time." He compared various models of group decision making which were either hierarchical or consensual.

The cognitive properties of co-ordinated groups are such that both the properties of cognition and the *amount* of information processed differ from those of individuals. Hutchins (1995: 262) states:

> All human societies face cognitive tasks that are beyond the capabilities of any individual member. Even the simplest culture contains more information than could be learned by any individual in a lifetime... so the tasks of learning, remembering, and transmitting cultural knowledge are inevitably distributed. The performance of cognitive tasks that exceed individual abilities is always shaped by a social organization of distributed cognition.

Group cognition operates at a number of levels. The first level, which Hutchins describes in detail, is the task level: an organised group engaging in a common purpose task with a distribution of labour and cognition. The second is the group level. Here cognitive tasks are distributed across segments in society and this corresponds more closely to the traditional concept of a division of labour (e.g., by age groups or gender) as used in anthropological literature. The final level is between societies. Behaviours such as trade and alliance formation also involve a distribution of cognition. Groups such as the Nuer (Evans-Pritchard 1990 [1951]) show how different segments of society can be organised and combined in expanding or contracting hierarchical levels depending on what problems are faced.

SUMMARY OF BIOLOGY AND COGNITION

This chapter introduces a number of compatible theories of how cognition operates. They are placed in the context of an expanded view of evolutionary theory which goes beyond (but does not deny) the role of natural selection in human evolution.

Emphasis is placed on structures and mechanisms rather than on content. The content and the nature of social relations will be examined below.

The preceding discussion points out that there is a strong relationship between social organisation, behaviour and cognition. Social organisation has a strong impact on how cognition operates. Individual cognition is shaped by and develops in the context of a pre-existing social order full of both existing representations and interpersonal relationship structures. In the context of this pre-existing, socially constructed world an individual's cognitive and biological development takes place. The principles of regulatory development in cells, plasticity in brain development, progressive domain specificity, and the impact of behaviour on evolution support the argument that changes in social organisation have had a strong impact on human biology. The point is not that our behaviour has altered our genetic make-up in the last 40 ky (although this is probably true to a limited extent following Bateson 1988), but rather that the nature of specific forms of social organisation changed how humans developed ontogenetically as opposed to how they developed phylogenetically. In terms of brains and cognition, the domains of intelligence which develop and how parts of the brain are "wired" in any individual must be to some extent culturally specific. This idea is not a descent into mysticism or extreme relativism, but an empirically viable and biologically plausible explanation of differences in cognition between human individuals, groups and populations, without resorting to innateness. The constraints of our genes (in terms of brain architecture and developmental timing) and environmental similarities (e.g., the laws of physics, the fact that behaviour occurs in sequential time, that we are born into socially rich contexts, etc.) can explain most cross-cultural similarities. The notion that we have content rich modules with innate knowledge of what a plant or a noun is has more in common with Jungian archetypes or Platonic forms than with biology.

These biological-social-cognitive mechanisms also provide a different way of looking at the Middle to Upper Palaeolithic transition. As stated in the previous chapter, human brains (and Neanderthal brains for that matter) appear to be fundamentally the same in size and structure before and after this transition. Resorting to a hypothetical genetically driven explanation for the dramatic changes in human behaviour (such as the emergence of language or a new hard-wired mental module) evokes a *deus ex machina*, for which there is no tangible evidence at present. An explanation based on the changes in our social behaviour and by extension in the human cognitive *phenotype* is justifiable because social and cognitive behaviour did change at this transition, whereas morphological and biological features such as brain size did not. There is no need to resort to hidden mechanisms. Based on the available evidence, a parsimonious explanation can be constructed using the biological and cognitive mechanisms discussed above.

The hypothesis presented here is that a fundamental change in human social organisation allowed the content and capacities of human cognition to be greatly expanded. New, relatively complex forms of social organisation meant that the content and capacities of cognition in the social group could greatly exceed that of an individual's cognition. Before these forms of social organisation emerged, it was likely that the content and capacities of the group were roughly equivalent to that of its constituent individuals, i.e., the social mechanisms to effectively co-ordinate behaviour and cognition were lacking.

Before the transition, brains had to be big enough to store a wide range of information. The individual had to store a wide range of information about a wide range of topics to practice loosely co-ordinated (in the social, not cognitive sense) strategies of hunting, lithic procurement and tool manufacture. The structure of cognition and the brain were likely very different from modern human societies, but had a shared genetic basis.

Human brains are metabolically expensive and require long periods for their development. Following Gould and Karmiloff-Smith, there is also no need to think of brains as optimal adaptive solutions. Indeed there is a large amount of redundancy in how brains operate (Karmiloff-Smith 1992: 23). As mentioned previously, much of what the brain does today is far removed from the environmental conditions in which brain size mediated information-processing capacities developed. Rather than taking an adaptationist perspective, the evolution of our brains can also be expressed another way: big brains were not maladaptive enough to lead to our extinction. Complex social organisation could be as much of a behavioural spandrel as flying a jet or reading a book.

An important proviso is that pre-modern hominids did not lack social organisation, which is found in many animal species. In non-human primates (Keesing 1975: 2):

> ...groups are internally structured. One axis of differentiation is based on sex, another on age... Another axis is one of dominance: one or more adult males characteristically exercise dominance and leadership... Importantly, among modern primates there is no sharing of food and no division of labor in foraging.

Forms of organisation among pre-modern hominids were likely structured along similar lines. They were less organised and involved simpler social interactions than those of modern humans. This put a limit on both the quantity of knowledge accessible to the group and the complexity of socially distributed cognition.

HUMAN SOCIAL ORGANISATION

As in the previous chapter, comparison with primate social organisation is useful. Rodseth, Wrangham, Harringan and Smuts discuss the important differences (1991: 221):

> Humans are the only primates that maintain lifelong relationships with dispersing offspring; both sexes therefore remain embedded in networks of consanguineal kin. This allows the formation of intergroup alliances through affinity. An important key to these patterns is the extent to which humans can maintain relationships in the absence of spatial proximity.

In short, human and primate kinship systems operate differently. Systems of consanguinity (blood relations) and local residence patterns govern primate kinship systems. Human kinship systems, on the other hand, following the important classification of the anthropologist Lewis Henry Morgan (1871; see also Trautman 1987), maintain social relationships both through consanguinity and affinity (relations through marriage). Rather than doubling the number of possible relatives, however, this creates the theoretical possibility of an infinite number of kin. Figure VI.1 shows the hypothetical situation of related males (red triangles) living together (patrilocal) with their female mates (red circles) and male offspring. In this pattern, the dispersing offspring belong to other residential groups and no relationship is maintained. This represents a situation *similar* to non-human primates such as chimpanzees and hamadryas baboons (although the social group may or may not be relatively stable; Rodseth et al. 1991: 226). In Figure VI.2, the dispersing offspring are highlighted in blue. This represents relatedness to the dispersing offspring (in blue), but not to their affines through them. In Figure VI.3 a relationship is formed between the dispersing offspring and the whole residence group (in green) to which she (in this hypothetical case) belongs and potentially to her dispersing offspring. Affinal systems make reciprocal relationships possible (Levi-Strauss 1969 [1949]). Whole residential groupings are related to each other and form an economic and symbolic alliance.

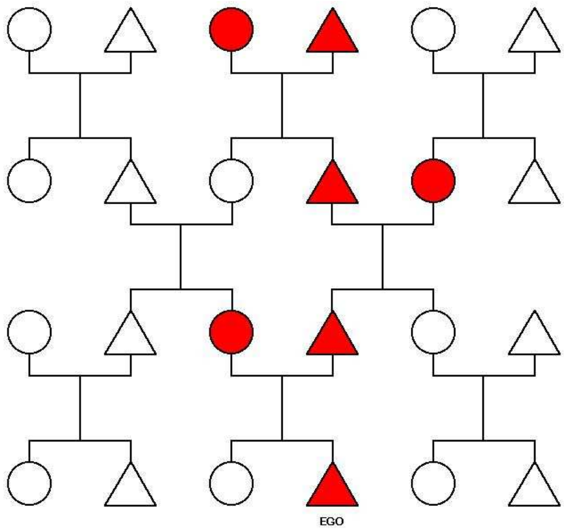


Figure VI.1. Hypothetical Male Related Residence Group.

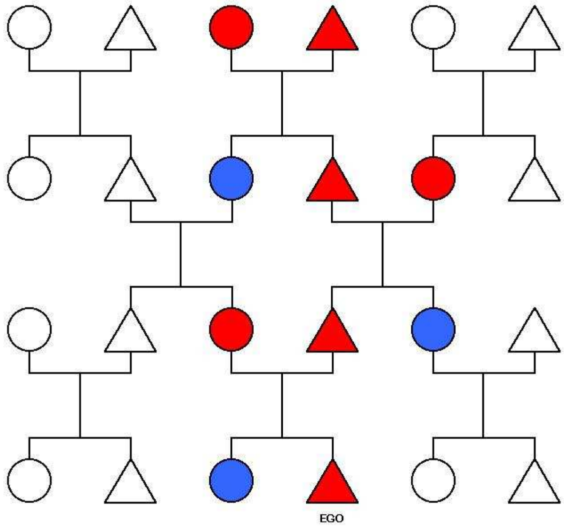


Figure VI.2. Hypothetical Male Related Residence Group with Connections to Dispersing Offspring.

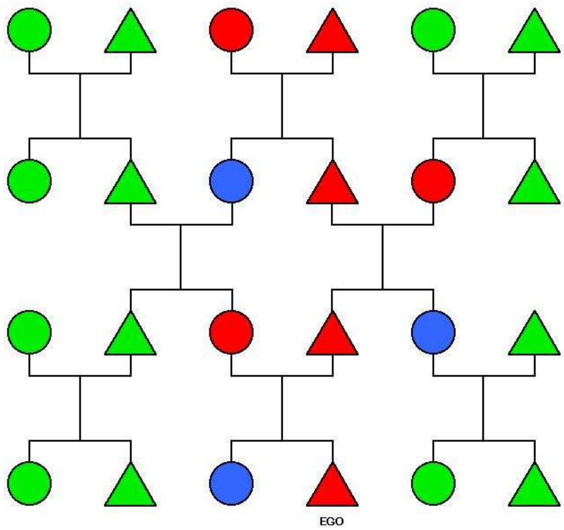


Figure VI.3. Hypothetical Male Related Residence Group with Dispersing Offspring and *Possible* Relations through Affinity.

Rodseth et al. (1991: 237) point out that the evolution of human societies and their species-specific kinship patterns required two features: marriage and inter-group affinity. Figure VI.3 thus gives way to Figure VI.4, which expresses inter-group affinity. Here three residential groups (red, green and blue, separated by vertical lines) have constructed preferential alliance bonds through marriage to the other groups in their social world. One of the features of inter-group affinity is that the relationship between groups endures through generations so that long-term alliances can be formed through the principles of exogamy *and* prescriptive marriage (Keesing 1975: 78-90; Lévi-Strauss 1969; Rodseth et al. 1991: 236,). It is important to note that the figures *do not* represent data from any known group or situation. They represent hypothetical ideal cases. Normally the numbers of offspring and gender ratios are highly variable, creating the need for flexibility and interpretation. Furthermore, in reality most societies do not strictly adhere to their own culturally constructed ideal cases of kinship rules (Bourdieu 1977; see below). Human societies may be more or less complex than this situation, and may have female-based residence groups (matrilocal). Married couples may be able to freely choose with which group they live, or live in much larger lineage based groupings or in nuclear families.

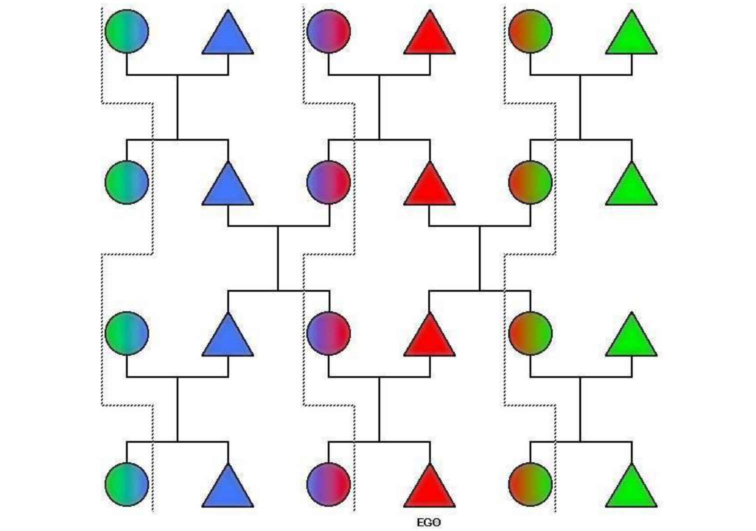


Figure VI.4. Hypothetical Male Residence Groups and Relations through Females.

Exogamy and inter-group alliances require a preceding step, marriage, which is not found in primate society. Marriage must not be thought of in an ethnocentric way however. Although still problematic, Gough's (1959; see Barnard 1994) definition of marriage involves conferring social legitimacy on children via social links through the mother. Marriage as a concept is uncoupled from sex. The case of the Mardu Aborigines discussed in the last chapter illustrates this. Marriage normally confers father status upon someone related to the child and may or may not have anything to do with biological paternity (in some cases fathers are female, spiritual or even dead). Marriage is a purely cultural as opposed to a biological phenomenon.

Among many hunter-gatherers, especially those in marginal environments, the primary residential grouping was/is the nuclear family. With the Shoshoni (Keesing 1975: 5), however:

> ...marriage alliances would be worked out between two families so that when a young man from one family married a young woman from another, the younger children of the two families would also marry when the time came... The several families united by such marriages would usually be the ones that coordinated their movements so as to group together seasonally when resources permitted... Such gatherings were times for dancing and collective religious rites.

This simple, small-scale reciprocal relationship between social *groups* through affinity and in the absence of regular spatial proximity is a situation that does not occur in primate society. In terms of human evolution, the emergence of similar systems was perhaps one of the most important innovations. Perhaps only language itself was more important. Rodseth et al. (1991: 240) use the term release from proximity to describe what the introduction of affinal kinship systems do: they construct social relationships that are not bounded by proximity or residence. As Gamble (1999: 41) rightly states:

> When people went beyond the rules of social life set by the immediate resources of their own bodies, voices and actions, is truly one of the Palaeolithic's big questions.

Gamble (1999) is correct in saying that modern human kinship systems mark the Middle to Upper Palaeolithic transition (from a European perspective at least). The problem lies with reconciling this transition, when humans develop (archaeologically visible) symbolism and the geographical and temporal extent of social life is greatly expanded, with what we know about the evolution of human biology and cognition. Are human kinship systems effects of some other change or are they the causes of other changes? The answer ultimately has to be both. Human cognition, language and relatively complex social organisation had to develop together dialectically.

KINSHIP AND COGNITIVE REDISTRIBUTION

One effect of these changes is cognitive redistribution. Cognitive redistribution (to extend the economic metaphor from distribution to redistribution) across kinship networks (and extended through time and space) opens the way for complex, and as Gamble (1999: 41) would describe it, "complicated" behaviour. This cognitive redistribution also had an affect on individual cognition and led to new domains of thought and behaviour. It also changed the context of human biological development.

As Hutchins (1995) points out (both literally and metaphorically), the distribution of cognition mirrors the division of labour in a society. Wolf (1982) creates a three-stage historical sequence through which human societies have passed. He reformulates Marxist history based upon an enriched ethnographic data set and in accord with updated theories of social anthropology. Going back through time from the present we have capitalist modes of production, tributary modes of production and kin-ordered modes of production. As with Karmiloff-Smith's ontogenetic stages, however, these should not be viewed as universal phylogenetic stages of cultural development. Wolf discusses the kin-ordered mode of production in terms of an operational view of kinship from a political economic perspective (1982: 91):

> Kinship can then be understood as a way of committing social labor to the transformation of nature through appeals to filiation and marriage, and to consanguinity and affinity. Put simply, through kinship social labor is "locked up," or "embedded," in particular relations between people. This labor can be mobilized only through access to people, such access being defined symbolically. *What* is done unlocks social labor; *how* it is done involves symbolic definitions of kinsmen and affines. Kinship thus involves (a) symbolic constructs ('filiation/marriage; consanguinity/affinity') that (b) continually place actors, born and recruited, (c) into social relations to one another. These social relations (d) permit people in variable ways to call on the share of social labor carried by each, in order to (e) effect the necessary transformations of nature.

The coming into being of this state of affairs drove the shift toward what we consider today to be human culture. Simply plugging in the term *cognition* where the term *labour* occurs and replacing *transformation of nature* with something more general such as the *solution of problems* will create a working description of cognitive redistribution in kin-ordered societies. Despite being somewhat clumsy, this definition is a good starting point for a theoretical understanding of social cognition in kin-ordered societies and demonstrates the inter-relatedness of labour and cognition. As Hutchins (1995) urges, however, the concept must be supported by examining "cognition in the wild" in kin-ordered societies (as opposed to in the laboratory).

Van der Leeuw (1981: 299-300) also discusses the relationship between the labour of a group and its cognition:

> Human exchanges are simultaneously exchanges of matter, energy and information...
>
> There is a direct relationship between the amount of information processing capacity available and the size of the flows of matter, energy and information...
>
> It follows that the rate of change in processing of information, matter and energy is linked to changes in all aspects of culture: social, organizational, technological, etc.

Although van der Leeuw's goal is to develop predictive models of changes in human social systems from material culture (particularly more complex societies in relationship to pottery), he highlights the importance of social organisation of the group to its ability to process information. His emphasis is on hierarchical systems, however, and as Hutchins (1995) points out, these are only one of many possible organisations of human systems and related types of social cognition differ accordingly. Kin-ordered modes of cognition involve a distribution of information, energy and matter across social groups. In the absence of strict hierarchies this leads to a dispersal of information processing across time and space. Nonetheless, social mechanisms exist to effectively co-ordinate and reassemble this cognition. Art and ritual provide two tangible loci where cognition is reassembled and redistributed.

SOCIAL GROUPS AND CULTURAL CATEGORIES

The previous discussion of human kinship systems has primarily focused upon the nature of the social group and its organisation. As discussed briefly above, however, the differences between codes, rules and structures, and behaviour must be distinguished. In kinship systems a difference exists between social groups (Keesing 1975: 10)

> A *social group*... consists of actual warm-blooded human beings who recurrently interact in an interconnected set of roles...

and cultural categories (Keesing 1975: 9):

> A cultural category is a set of entities in the world (people, things, events, supernaturals) that are classed as similar for some purposes, because they have in common one or more culturally relevant attributes.

The relationship between social groups and those cultural categories (or structures) which pertain to kinship is not always straightforward. Kinship as such is a dualistic system that in many ways grows and changes through tension between the principles of social reality as practised and collective representation of that reality, or in other words, the tension between how things are and how people collectively think that they should be. It is through practice (Bourdieu 1977) that kinship categories are (re-)produced and social groups are (re-)formed.

Bourdieu discusses such differences in terms of official and practical kinship (1977: 34):

> As soon as we ask explicitly about the *functions* of kin relationships... we cannot fail to notice that those uses of kinship which may be called genealogical are reserved for official situations in which they serve the function of ordering the social world and of legitimating that order. In this respect they differ from the other kinds of practical use made of kin relationships, which are a particular case of the utilization of *connections*.

Official kinship refers to that which is "explicitly codified in a magical or quasi-juridical formalism," evoked through "collective ritual" and performed by "agents interchangeable because collectively mandated" (Bourdieu 1977: 35). Practical kinship, on the other hand, is "kept in an implicit, even hidden state" and is evoked through "strategy" in "private" by "an individual or group of individuals" for "the satisfaction of practical interests" (Bourdieu 1977: 35). Official kinship uses "*representational kinship* [which] is nothing other than the group's self-representation and the almost theatrical presentation it gives of itself when acting in accordance with that self-image" (Bourdieu 1977: 35).

Social anthropologists and sociologists strive to understand the relationship between codes, rules and structures, on the one hand, and individual behaviour on the other. A long-standing analogy, favoured largely by those interested in the former, is "that between language and speech on the one hand, and on the other that between culture and conduct" (Bourdieu 1977: 23). The linguist de Saussure (1960 [1916]), privileged *langue* over *parole*, and the sign over the signified, or in other words, structure over content and practice. This notion was applied in anthropology where an understanding of symbolism and "culturally defined universes of meaning" predominated in the works of scholars such as Geertz, Turner and Lévi-Strauss (Samuel 1990: 31). Other anthropologists (e.g., Wallace and Goodenough), however, took individual psychology and motivation as a starting point for behaviour (Samuel 1990: 45). These positions assumed opposite starting points for understanding society and culture (Samuel 1990). More recently, a genuine attempt to understand the complex relationship between the two has emerged. These ideas fall under the general banner of *social theory,* which emphasises the relationship between agency and social structure (Giddens 1984: xvi).

On a logical rather than historical level, Giddens (1984: xxi) is interested in the same question that Gamble raises (see above):

> The structural properties of social systems exist only in so far as forms of social conduct are reproduced chronically across time and space. The structuration of institutions can be understood in terms of how it comes about that social activities become 'stretched' across wide spans of time-space.

The theory of structuration places human individuals in a meaningful relationship with larger social structures (Giddens 1984: 25):

> Analysing the structuration of social systems means studying the modes in which such systems, grounded in the knowledgeable activities of situated actors who draw upon rules and resources in the diversity of action contexts, are produced and reproduced in interaction.

What makes this possible is what Giddens calls the *duality of structure*: "the structural properties of social systems are both medium and outcome of the practices they recursively organize" (1984: 25). In this model, rules are "techniques or generalizable procedures applied in the enactment/reproduction of social practices" as opposed to formulations that are in turn "codified interpretations of rules rather than rules as such" (Giddens 1984: 21). Resources can be either allocative, "generating command over objects, foods or material phenomena" or authoritative, "generating command over persons or actors" (Giddens 1984: 33). Structure both enables and constrains the behaviour of individuals, who remain knowledgeable and purposive. In Bourdieu's terms they employ strategies; in Giddens' words they use resources and rules to act in a purposive way. The use of these rules and resources in turn reproduces the structure(s) of the social system. By being actively reproduced, these structures become modified and can produce change over time. Individual behaviour both produces and is produced by these structures.

The final level is the production of *culture*[3], the codes and structures themselves, the *official* version of the rules that structure practice. This is the traditional interest of the anthropologist, found in myth, ritual, religion, art and language. Much social behaviour is found in *informal knowledge,* "knowledge that is implicit in our daily activities, information and ways of behaving that we use to carry on the business of living" (Samuel 1990: 5). This relates to many aspects of what humans do and is summed up by Bourdieu's notion of *habitus* (1977: 72):

[3] The term culture has lost much of its usefulness. It can mean anything from bacterial culture in yogurt to the highbrow arts. It is used differently by ethologists and anthropologists. This causes unnecessary confusion when discussing the differences between animal and human behaviour. For the sake of simplicity, the term culture is used here exclusively for human society. Culture involves self-representation, as suggested by Bourdieu's discussion of official kinship. Although this is not a definition per se, it is an essential feature of culture and implies knowledgeable self-awareness and presentation of collective social identity (or identities). In that sense it has more to do with art than with bacteria.

> ...systems of durable, transposable *dispositions*, structured structures predisposed to function as structuring structures, that is as principles of generation and structuring of practices and representations which can be objectively "regulated" and "regular" without in any way being the product of obedience to rules, objectively adapted to their goals without presupposing a conscious aiming at ends or an express mastery of the operations necessary to attain them and, being all this, collectively orchestrated without being the product of the orchestrating action of the conductor.

What is the relationship between habitus and social codes? Bourdieu states simply that the latter are the group's self-representation. Giddens says members of society are "expert 'sociologists'" of their own societies (1984: 26). They explain and analyse their own behaviour; this is manifest in the encoded and official version of their own behaviour that they give to themselves. Official versions are presented in ritual, myth, song and art.

Samuel (1990) presents the multimodal framework (MMF), a useful analytical tool for understanding human behaviour. The central component of this theory is the *social manifold,* which is synonymous with what he calls the "flow of relatedness" (Samuel 1990: 51, 55). Samuel begins by citing Geertz's notion of a web of significance. Geertz states that "man is an animal suspended in webs of significance he himself has spun" (Geertz 1973: 5, cited in Samuel 1990: 11). He adds, as Scholte points out "a select few do the actual spinning while the vast majority is simply caught" (Scholte 1984: 540, cited in Samuel 1990: 11). Samuel (1990: 11) states that "these webs are neither purely individual (once spun, they take on a life of their own) nor are they purely social (they have spinners)." These so-called webs exist at some level that is neither individual nor social.

The time dimension is absent from Geertz's web (Samuel 1990: 11):

> These processes of spinning and being caught happen in time (through history), and if we are to describe them adequately, we should give time an explicit place within our image. Rather than speaking of 'webs of significance', therefore, I suggest that we view the structures of meaning and feeling in which and through which we live as patterns formed by the currents in the course of a vast stream or river. The direction of the stream is the flow of time...

Samuel continues by examining how individuals fit into the flow. Individuals have an explicit place in the flow of this current. People both constitute the currents in this flow and "*are constituted by them*" (Samuel 1990: 12). Samuel (1990: 12) describes the

> ...'substance' within which this flow takes place as something like 'relatedness' or 'connectedness'. The currents within the flow are concerned with the patterning of relationships between human beings.

For Samuel *relatedness* forms the fundamental basis of human society and variables descriptive of this should be the fundamental unit of analysis in anthropology.

The central assumption of the MMF is (Samuel 1990: 36):

> ...that something akin to the paradigm model can be used as a description of everyday thought, not simply of specialized scientific thought. The MMF assumes that within any society there is a repertoire of such 'paradigms', each of them constituting a framework of concepts within which 'rational thought' may take place.

Each individual may "operate in *several* different 'modes', each involving a different culturally provided framework" (Samuel 1990: 37).

> Structure exists at the level of the 'modal state' or conceptual framework. Freedom exists at two levels, that of rational thought within the framework and that of movement between frameworks (Samuel 1990: 37).

The modal state (MS) exists in the patterning of relationships between people and their environment, both social and natural. Samuel refers to these modal states as "eigenstates of the manifold," that is, they "introduce elements of structure" into the manifold (Samuel 1990: 9, 13).

From this manifold of relations other values of human behaviour can be described, individualist (Type I) and holist or collectivist (Type II) values (Samuel 1990: 13):

> The kind of quantities seen as fundamental in Type I and Type II readings are treated as derivative from these modal values. In order to generate Type I quantities, individuals and their behaviour are treated as being defined by a series of *modal states of the individual* (MS_i). Type II quantities may be reached by defining *cultural modal states* (MS_c).

Type II readings focus upon "cultural artefacts such as rituals, myths, works of art, items of language or sequences of social behaviour" (Samuel 1990: 30). What these cultural artefacts represent is derivative from the relationships between people and between people and things.

Individual modal states are also derivative of the modal states of the social manifold. Samuel provides a number of attributes of individual modal states (1990: 72-73):

> (1) the MS_i (modal state of the individual) has a cognitive function. It splits up or interprets the individual's stream of experience in characteristic ways, so that certain features of the external environment and of the body's internal processes are consciously perceived and others are not.
>
> (2) Each MS_i is associated with a set of images or symbols, in part shared by individuals within a given cultural context, by which that MS_i may be referenced or evoked.
>
> (3) Each MS_i corresponds to specific moods, motivations, feelings and emotions.
>
> (4) Each MS_i corresponds to a particular decision structure. Within it the individual will respond in certain ways to certain events, will subjectively find certain goals attractive and others unattractive.

(5) Each MS_i corresponds to a particular subjective sense of self and a particular way in which the individual perceives of his or her relationship to other individuals and other aspects of the environment.

(6) Each MS_i corresponds to certain physiological correlates, such as posture, muscle tension, blood pressure, and the like.

(7) MS_is differ in terms of possible transitions to other MS_is. They may be more or less well connected to other states. They may also allow for more or less innovation in the creation of new states.

The MS_i correlate in a general sense with the idea of domains of thought. These states are learned (implicitly and explicitly) and frame the cognitive responses of the individual to stimuli (social or physical). As Hutchins (1995: 289) states, they come about through a process of "*adaptive reorganisation in a complex system.*" To put it another way, the “stuff” of this complex system is the relatedness of its constituents (people and things).

The relationship between people and culture is complex. As Samuel argues, the important level of analysis, which explains the relationship between people and cultural codes and structures, determines how those people are related and how they are situated in what he calls the social manifold. This explains the underlying meaning of what Giddens calls the duality of structure, i.e., that individual behaviour both constitutes and is constituted by social structures. The mediating level is the interactions between people and between people and things. Another important distinction made by Bourdieu is between official and practical behaviour. Much practical behaviour comes about through inculcated 'dispositions' (Bourdieu 1977) and is "only tacitly grasped by actors" (Giddens 1984: 22). Official behaviour involves the self-representation of those behaviours by the group to themselves.

In kin-ordered societies practical kinship structures, by which people are related to one another, form MSs from which both individual behaviour is derived (but not solely determined), and social structures and categories are derived. These hierarchical levels, however, are not strictly bounded. Individual actors can influence and shape the nature of the relations in the group by employing what Bourdieu calls strategies. Cultural codes and structures, once spun out of the relations of the group, also influence the nature of the relations in the group. Interestingly, because these processes occur in time, cultural codes and structures often lag behind the practical relationships of the group. The point is that individuals cannot independently shape culture without an intervening medium, that of the social manifold or flow of relatedness. In societies where they are dominant, kinship practices do not just structure relationships between people, but shape an individual's cognition and behaviour as much as they shape official culture.

CLASSIFICATION AND SOCIAL REPRESENTATIONS

The relationships between social representations follow a logic of their own. Marcel Mauss introduced the important notion of *total social phenomena* (1967 [1925]: 1):

> ...social phenomena are not discrete; each phenomenon contains all the threads of which the social fabric is composed... In these *total* social phenomena, as we propose to call them, all kinds of institutions find simultaneous expression: religious, legal, moral, and economic.

This notion builds upon Mauss' earlier work with his uncle Émile Durkheim, (1963 [1903]), in which kinship structures are pivotal. Their fundamental argument is that the social relations of human societies have provided the prototype for the logical relations between things. The classificatory function is the product of what the authors call collective thought. The classificatory function enables the social group to "make intelligible the relations which exist between things" (Durkheim & Mauss 1963: 81). "The classification of things reproduces this classification of men" (Durkheim and Mauss 1963: 11). In other words, the organisation of ideas parallels the organisation of society.

As discussed in the previous chapter, totemism is the best example of this. Totemism is "a grouping of natural objects in accordance with social groups" (Durkheim & Mauss 1963: 17-18). The totemic divisions within a moiety correspond to the division of the phenomena associated with that moiety. Durkheim and Mauss' discussion of totemism yields the next crucial idea, that items or sub-classes within a category are "connected by relations of kinship" (1963: 8). The idea of closeness or distance of relation is part of the concept of relationship. Everything in the life of the individual in "primitive" society is viewed through the structure of kinship reckoning. Durkheim and Mauss' model proceeds through different levels of social organisation and complexity; they show that changes in the social structure lead to changes in the economy of classification systems. Their examples move from kin-ordered societies such as the Aborigines of Australia through to the tributary systems of the Chinese. They believe that in human society "classification was intended above all to regulate the conduct of men" (Durkheim & Mauss 1963: 71). Although there has been discussion of how far to rigidly extend these notions in all societies, the relationship between categories across different domains of society is clearly strong, as discussed in the previous chapter with examples from art, religion and totemism. In each of these areas, an understanding of the social organisation of the society is essential. Durkheim and Mauss put forward the fundamental idea that social relations have provided the model by which classification systems are constructed.

The relatedness of representations (e.g., categories) is also featured in the ideas of the social psychologist Moscovici (1984: 16), who clearly states his indebtedness to Durkheim's idea of collective representations. Moscovici says, however, that the term *social representations* differs in usage in social psychology and sociology (1984: 16):

> Sociology sees, or rather, has seen social representations as explanatory devices, irreducible by any further analysis... Social psychology, on the other hand, is and must be pre-occupied solely with both the structure and the dynamics of representations.

Moscovici theory necessarily begins with a definition of representation, which he equates with "image/meaning; in other words, that it equates every image to an idea, and every idea to an image" (1984: 17). Furthermore, social representations share two features (1984: 23):

> (a) social representations must be seen as an 'environment' in relation to the individual or the group; and
>
> (b) they are, in certain respects, specific to our [i.e., a specific] society.

Moscovici is interested in the functioning of these representations, not just in positing their existence: "*the purpose of all representations is to make something unfamiliar, or unfamiliarity itself, familiar*" (1984: 24). Moscovici (1984: 24) says:

> On the whole, the dynamic of relationships is a dynamic of familiarisation, where objects, individuals and events are received and understood in relation to previous encounters or paradigms.

Representations extend from what is already known and internalised to that which is unknown and external. This is a straightforward notion - humans use what they know to understand what they do not.

Moscovici introduces two mechanisms through which representations emerge (1984: 29):

> The first mechanism strives to anchor strange ideas, to reduce them to ordinary categories and images, to set them in a familiar context. The purpose of the second mechanism is to objectify them, that is to turn something abstract into something concrete, to transfer what is in the mind to something existing in the physical world.

Anchoring occurs upon confrontation of something unfamiliar. The unfamiliar is compared to "the paradigm of a category which we think to be suitable" (Moscovici 1984: 29). The something unfamiliar is then given a positive or negative relationship to the pre-existing category. In this way representations are related to one another. Anchoring involves giving the new thing a category and name. Moscovici summarises as follows (1984: 34):

> a) once named, the person or thing can be described and acquires certain characteristics, tendencies, etc.; (b) he or it becomes distinct from other persons or things through these characteristics and tendencies; and (c) he or it becomes the object of a convention between those who adopt and share the same convention.

Finally, by bringing the new, unfamiliar person or thing into the system of relationship between existing representations, those representations are altered to accommodate the new.

Objectification is the second mechanism involved in producing social representations. "To begin with, to objectify is to discover the iconic quality of an imprecise idea or being, to reproduce a concept or image" (Moscovici 1984: 38). Once turned into an image, the idea or thing becomes integrated into a "*figurative* *nucleus*, a complex of images that visibly reproduces a complex of ideas" (Moscovici 1984: 38). Finally, the image ceases to be an abstract concept but merges with reality; "the gap between the representation and what is represented is bridged" (Moscovici 1984: 40).

The second mechanism may appear counter-intuitive; a feature of social representations, however, explains the apparent contradiction. Social representations, once anchored, alter perception (Moscovici 1984: 61):

> Each stimulus is selected from a vast variety of possible stimuli and can produce an infinite variety of reactions. It is the pre-established images and paradigms that both determine the choice and restrict the range of reactions...In other words, social representations determine both the character of the stimulus and the response that it elicits, just as in a particular situation they determine which is which.

Moscovici (1984: 62) provides a diagram, which is redrawn in Figure VI.5.

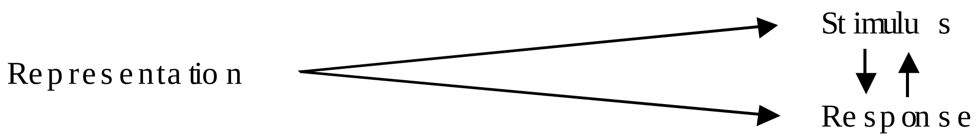


Figure VI.5. Relationship between Representation, Stimulus and Response.

The theory of social representations thus fleshes out and gives more theoretical substance to Durkheim and Mauss' notion of primitive classification. Durkheim and Mauss admit that as social organisation moves away from kin-based society, kin becomes less of a model for categories. They believe, however, that kin relations still play an important role in shaping contemporary categories of the world. The reason for this is simply the logic of social representations. The notion of *familiar* takes on a dual meaning - the starting point for our representations is the family, the most familiar thing. Moscovici makes this point (1984: 68, 36):

> Social representations are historical in their essence and influence individual development from early childhood, from the day a mother, with all her images and concepts, begins to become preoccupied with her baby.
>
> The family is another very popular image for relationships in general. Thus intellectuals or workers are described as brothers; complexes as fathers; and neurotics as sons...

Social representations, like the other ideas on cognition and psychology that have been examined, requires placement in a developmental perspective. Duveen and Lloyd (1990: 5) state that "the structure of any particular social representation is a construction and thus the outcome of some developmental process." Social representations develop in three ways (Duveen & Lloyd 1990: 6):

> There are processes of *sociogenesis*, which concerns the construction and transformation of the social representations of social groups about specific objects, *ontogenesis*, which concerns the development of individuals in relation to social representations, and *microgenesis*, which concerns the evocation of social representations in social interaction.

Sociogenesis is the generation of social representations; it explains how the representations held by individuals in a group are shared. Ontogenesis is the process through which a person born into a social world develops internalised representations.

> If, as Moscovici asserts, the society into which children are born is a 'thinking society', it is social representations which constitute the 'thinking environment' for the child. Developing the competence to participate as actors in this thinking society implies that children can acquire access to the social representations of their community... we have suggested that ontogenesis is a process through which individuals re-construct social representations, and that in doing so they elaborate particular social identities... *(Duveen & Lloyd 1990: 7).*

Microgenesis is the most important, final process through which social representations emerge and are used in daily social interaction. It underlies both sociogenesis and ontogenesis. In Duveen and Lloyd's words (1990: 8, 9):

> There is a genetic process in all social interaction in which particular social identities and the social representations on which they are based are elaborated and negotiated.
>
> In both of these examples ontogenesis and sociogenesis are the consequence of microgenetic processes. Indeed microgenesis constitutes a motor, as it were, for the genetic transformations of social representations.

The view that microgenesis is the driving force behind the development and spread of social representations fits nicely with Samuel's notion of the social manifold. Microgenesis is the process of social interaction through which social representations and individual representations are produced.

The idea of social representations can also be examined in terms of Karmiloff-Smith's notion of representations. In order to be shared, social representations must be explicit. Linguistic representations provide a powerful example because they can be shared and enter into an individual's cognition directly without requiring direct experience. As Moscovici argues, however, "unfamiliar" representations need to be anchored to existing ideas that have some experiential base. Most social representations are likely of the E2 or E3 level; however, it is possible that some representations are not consciously accessible (i.e., E1 level) but socially constructed.

Finally, it should be pointed out that although they are not explicit, in almost all cases implicit representations are a product of social relationships. This is because the contexts of learning are shared as well as the explicit representations of a society. Some things can only be discovered by individual experience. This is especially true of certain behaviours such as body techniques that are not amenable to verbal report. Ingold's notion of guided rediscovery is important (1997:111).

> ...in this process, what each generation contributes to the next is not a corpus of representations, or information in the strict sense, but the specific contexts of development in which novices, through practice and training, can acquire and fine-tune their own capacities of action and perception.

To kick-start the processes of anchoring and objectification, some behaviours must be learned through direct (but guided) experience.

On all levels, patterns of social relationships are inseparable from human knowledge. The complexity and patterns of social relationships create an environment that provides both the structure *and* content of knowledge. As Moscovici states (1984: 67): "after all, how we think is not distinct from what we think."

SUMMARY

This chapter presents an eclectic mixture of theories and quotations from diverse academic disciplines such as biology, psychology, cognitive science, computer science, social anthropology, sociology and social psychology. Two important themes are present in all of these theories. To understand human behaviour and cognition:

1. The structure of how humans are related to one another needs to be examined; and
2. The behaviour and cognition of individuals needs to be put in an ontogenetic/developmental perspective.

The relationship between genotype and phenotype, how an adult brain is physically wired, what sorts of things people think about, how humans process information and organise thoughts, all depend upon these two factors. The complexity of social relationships, i.e., how people organise themselves in time and space, has a profound impact on the complexity of cognition and behaviour. Social relationships produce both rules that constrain behaviour and resources that enable behaviour. As Samuel argues, the structuring of the social manifold produces individual and cultural states. It must be noted, however, that, although individuals are not completely free (possibilities for action are always limited by social conventions or dispositions), they remain purposive agents who employ strategies and utilise the resources (physical, cognitive, and social) that social relationships provide.

Gamble's big Palaeolithic question can be rephrased as follows. What frees human beings from the limits of our own immediate presence? How did we transcend the bounds of our relatively large, but ultimately finite, brains and the limitations of our agile, but mortal, bodies that evolution fashioned? Simply put, the answer is the first human social revolution, the advent of the kin-ordered modes of labour and cognitive production. The effects of this system, which on a practical level (as Rodseth et al. 1991 point out) was the result of the merging of systems of both consanguinity and affinity, were many. Two parallel features emerged:

1. Behaviour and cognition themselves became more complex through processes of cognitive redistribution.
2. The structure of social relationships provided a representational structure from which complex categories to classify the world could be constructed.

These features led to a great increase in information processing capacity in the social group and a greatly expanded repertoire of representations. The dialectic between the expansion of our social world and the need to structure and organise that social world has driven social change throughout human history. As Mithen states, the ability to transfer ideas across domains of thought (supported by the theory of Moscovici and the domain general processes of Karmiloff-Smith and others) is uniquely human. This did not evolve through the pseudo-mystical introduction of some meta-cognitive faculty "presumably encoded in our genes," but because humans are embedded in complex social relationships that provide a common foundation, representational and organisational, for thoughts and behaviours.

As Wolf argues, the kin-ordered mode of production is ultimately replaced through history in a multilinear and sometimes non-linear fashion (i.e., it is sometimes reversed) by other modes of social organisation. As Durkheim and Mauss argue, the classifications produced are linked to the social order even though the systems of organisation change. If nothing else, the division of mind and body and the propensity to separate knowledge into domains, memes and traits prevalent in discussions of human evolution are examples of the disembodied and individualistic social organisation of our society.

VII. Technology, Social Change and the Emergence of Modern Human Behaviour

The final aspect to be examined is the relationship between technology, cognition and social behaviour in modern humans. This will be used to assess the nature of the changes in the lithic industries up to the Early Dabban at the Haua Fteah.

As mentioned in Chapter V Marcel Mauss (1967: 1) introduced the notion of total social phenomena:

> In these *total* social phenomena, as we propose to call them, all kinds of institutions find simultaneous expression: religious, legal, moral and economic.

When Mauss (1979: 101) goes on to examine the idea of *techniques of the body* he believes that a study of the human body and its actions must also be total:

> ... I concluded that it was not possible to have a clear idea of all these facts about running, swimming, etc., unless one introduced a triple consideration instead of a single consideration, be it mechanical and physical, like an anatomical and physiological theory of walking, or on the contrary psychological or sociological. It is the triple viewpoint, that of the 'total man,' that is needed.

The theoretical thrust of the previous chapters arrives at the same conclusion. The emphasis on cognitive or on biological arguments for the emergence of modern human behaviour have tended to leave out social explanations. Those who prefer a social to a biological model emphasise cumulative change (particularists, such as McBrearty & Brooks 2000) and tend to underplay the importance of cognitive and biological change. The previous chapter shows that human behaviour has a three-fold basis, from biology (human bodies and genes), social interaction and thought. The most important point to make is that each of these three aspects of human behaviour operates simultaneously and influences the others. A holistic approach to understanding human behaviour and society is needed both in the present and in the past. The emergence of modern human behaviour is no different; it emerges through the interaction of all three aspects.

Technology is simultaneously a total social phenomenon and a total human phenomenon. In other words, technology is on the one hand "religious, legal, moral, and economic" (Mauss 1967: 1) and on the other biological, social and psychological. Neither can it be said that the religious, legal, moral and economic are merely part of the "social" aspect of humans because these have an influence on psychology and biology (largely in terms of phenotypic expression) and vice versa. As argued by Samuel (1990), the nature and structuring of social interaction is the medium linking individual cognition and cultural institutions. It is the latter that is a human phenomenon.

Hinde argues that social structure (i.e., the regular patterning of social relationships) exists in both human and non-human primates, however, "among non-human primates institutions are either non-existent or vastly less important than organisational principles depending on regularities in the behaviour of individuals" (1976: 15). He states that (1976: 16):

> Institution is used in this article to refer to sets of one or more recognised positions in a society which constrain the behaviour of the incumbents, and thus covers unique positions (e.g. the king), recognised relationships (e.g. marriage) and large-scale systems (e.g. the National Health Service).

Kinship and marriage systems are institutions that are arguably historically (Durkheim & Mauss 1963) and ontogenetically prior (Moscovici 1984) to larger scale institutions such as political positions.

TECHNIQUES

Techniques (and technologies as systems of techniques) are institutions in Hinde's sense because they constrain (and enable) behaviour. Mauss' definition of technique is one of the most influential in the anthropology of technology (Dobres 2000; Lemonnier 1992). Mauss states (1979: 104):

> I call technique an action which is *effective* and *traditional* (and you will see that in this it is no different from a magical, religious or symbolic act). It has to be *effective* and *traditional*. There is no technique and no transmission in the absence of tradition. This above all is what distinguishes man from the animals: the transmission of his techniques and very probably their oral transmission.
>
> .... But what is the difference between the effective and traditional action of religion, the symbolic or juridicial effective traditional action, the actions of life in common, moral actions on the one hand and the traditional actions of technique on the other? It is that the latter are felt by the author as *actions of a mechanical, physical or physico-chemical order* and that they are pursued with that aim in view.

This definition was largely ignored when material culture studies were dominant. Recent technological studies have gone beyond merely understanding the meaning in things, but take account of the social processes of doing them. This has come about in part because of the more recent interest of anthropology and sociology in practial and informal knowledge (Bourdieu 1977; Giddens 1984).

Acknowledging his indebtedness to Mauss, Lemonnier says that "every technique has five related components" (1992: 5):

> 1) *Matter* - the material, including one's own body, on which a technique acts....
>
> 2) *Energy* - the forces which move objects and transform matter.
>
> 3) *Objects* - which are often called artifacts, tools, or means of work. These are "things" one uses to act upon matter: a hammer, hook, team-roller, or artificial salt-pond....
>
> 4) *Gestures* - which move the objects involved in a technological action. These gestures are organized in sequences which, for analytical purposes, may either be subdivided into "sub-operations" or aggregated into "operations" and then into "technological processes...."

> 5) *Specific knowledge* - which may be expressed or not by the actors, and which may be conscious or unconscious. This specific technological knowledge is made up of "know-how," or manual skills. The specific knowledge is the end result of all the perceived possibilities and the choices made on an individual or societal level, which have shaped that technological action. I call those possibilities and choices *social representations*. Some examples of social representations which shape a technology or technological action are: (a) the choice to use or not use certain available materials; (b) the choice to use or not use certain previously constructed means of action on matter (a bow and arrow, a car, a screwdriver); (c) the choice of technological processes (i.e., sets of actions and their effects on matter) and the results of these processes (e.g., a cooked meal, a house, or recently cooked game); and (d) the choice of how the action itself is to be performed (a conception that it is the woman's role to cut firewood, or the man's to make fences for gardens).

It is the final component that houses the social and cognitive content of technology. The choices (whether individually or collectively) made are products of social interaction. At the very least, a technique is learned and socially transmitted in order for it to be traditional. What is not included in the definition of technique is potentially important. As Mauss states, a technique must be both effective and traditional. In theory, this excludes unlearned, novel innovations, for example, using the heel of a shoe to hammer a nail. The choice of using a shoe is not a technique because it is not traditional. One must be cautious, however, because many other aspects of the action are, e.g., the use of a nail to attach two boards together and the swinging action (normally reserved for a hammer) are traditional techniques (or aspects of techniques) in our society.

Although Lemonnier uses the term social representations independently of Moscovici (i.e., he does not reference him), certain parallels can be drawn. Lemonnier states (1992: 7):

> Social representations of technologies are the channel through which social phenomena influence technological systems. Alongside the physical constraints presented by the material world available to a given society, social representations of technologies, too, are responsible for making and transforming technological systems.

Social representations go beyond the notion of *style* that dominated much of the debate in archaeology in the second half of the 20th century. As Boast (1997) notes, the definition of style was problematic. Two important definitions put forward different views on style. Wiessner defined style as "*formal variation in material culture that transmits information about personal and social identity*" (1983: 256). Sackett, however, introduced the term *isochrestism*, arguing that "ethnic style is a latent quality that potentially resides in all formal variation in material culture, including variation regarded as purely functional in the utilitarian sense" (1986: 266). The difference between these viewpoints is "whether style is iconological (emblematic) or isochrestic - active in signalling identity or a more passive, culturally specific 'way of doing' something" (Boast 1997: 178). As Boast points out, both of these and most definitions of style share two problematic points (1997: 180-1):

> First, that a socially meaningful material world exists prior to our interpretation of it.... Second, that the identification of style, the categorization of similarity and difference in material objects, is represented through the properties of the object itself.

The first point raises broader epistemological problems than there is space to deal with them presently. The second raises an important point. It cannot be denied that in many cases the formal traits of artefacts vary by group and they tend to correlate with ethnic identity. However, the specific knowledge underlying the making of an object or the doing of a technique (e.g., body techniques such as walking) often leaves no material signal that indicates ethnicity or anything else for that matter. That aside, specific knowledge is employed in all technology and this knowledge varies according to groups. Important distinctions can be made in techniques, which in turn reflect the social context in which they are produced. The form of an artefact alone, however, cannot simply code this information.

Lemonnier's discussion of the anthropology of technology is important because it emphasises the social aspects of technology that are not necessarily symbolic. He emphasises the use of chaîne operatoires and the detailed recording of the social and environmental contexts in which technology occurs. This is clearly a major problem for archaeology, especially as it pertains to the distant past. If one looks at the formal properties of individual artefacts (e.g., gross morphology alone) and the variation in formal "types," only the first three (at best) of Lemonnier's aspects of technology can be determined (matter, energy and objects).

A complete picture of technology can never be drawn from the archaeological record. The further one goes back into the past the truer this becomes. Ethnographic analogy, ethnoarchaeology and historical records (where possible) have proved incredibly fruitful in reconstructing past cultures when they are linked to the archaeological record. However, when these methods are not possible or inferences based on them are tenuous at best, one is left with a certain amount of guesswork and interpretation. The best possible method to deal with this is to use the chaîne operatoire approach to construct the sequence of gestures in relation to matter, energy and objects used. This can be done through detailed refitting of cores and corresponding debitage.

The specific knowledge, as Lemonnier states, on the other hand, requires an understanding of the possibilities and choices made on an individual or social level (1992: 5). This can only be understood on a comparative basis. To understand the individual choices made in a particular instance of artefact manufacture, the possibilities available to that individual at a social level must be known. Three fundamental problems in applying the refitting approach to understanding social behaviour are

1. the lack of standardisation in presenting the chaîne operatoires,
2. the time-consuming nature of this procedure (most major refitting works focus on a few artefacts) which creates important statistical biases and
3. the inappropriateness of this method in certain types of archaeological assemblages, e.g., museum collections or sites with post-depositional disturbance.

Refitting is not normally amenable to a comparative approach.

In the past, comparative approaches tended to focus upon typological analysis. This addressed the issue of standardisation and sampling biases but there were still a number of problems. Typologies tend to create more categories than necessary (Moyer 1998) and focus primarily upon the retouched component (e.g., Bordes 1961 and de Sonneville-Bordes 1960). Many of the differences in tool types can be explained by patterns of continuous variation and factors such as retouch intensity, core size and raw material quality.

A comparative approach cannot escape from some form of typology, because categories are necessary for comparison. Categories can, however, be tested using discriminant analysis. Furthermore, any analysis of attributes of artefacts tends to employ existing methodologies and measurements. If one uses the largest practical set of measures and selects those that explain significant variance in the sample, to the best extent possible one can reduce biases inherent in the existing methodologies. The broadest possible categories should be used (e.g., Levallois vs. centripetal recurrent Levallois or sidescraper vs. double convex-concave sidescraper). These approaches have been taken in this analysis.

Evidence of social complexity from lithic manufacture rests upon three things:

1. the existence of distinct categories,
2. evidence for choice between those categories, and
3. evidence of organised, planned behaviour.

In the absence of direct observation of behaviour, categories can indicate social complexity. As noted in the previous chapter, traditional categories are social in nature. Categories are ideally internally homogenous and externally heterogenous. Choices are the arena of social action, cognition and agency. Choices can include selecting between socially accepted norms, but the manipulation of those choices and categories by individuals and social groups also creates a context where strategies can be employed and social identities explored. The choices made, through time, change the choices possible and also create new choices. Finally, organised behaviour shows regularity in strategy and how components of a system are put together. This is the realm of cognitive distribution and the organisation of labour.

An important caveat has to be made at this point. The purpose of this lithic analysis is to suggest the existence of or the relative complexity of socially organised behaviour, not to predict the *nature* of that organisation, which will likely never be achieved for the Palaeolithic. The approach thus differs from Binford's assertion that "we can recover, both from the nature of the populations of artifacts and from their spatial associations, the fossilized structure of the total cultural system" (1964: 425). A further point is a purely logical one: the presence of complex behaviour in the lithic technology in an assemblage indicates a level of social complexity. However, absence of evidence for complex lithic industries does not indicate the absence of social complexity. This is because the gestures, functions and social groups associated with a technology may not be preserved in the archaeological record, but may involve social choice and strategy.

RESULTS OF LITHIC ANALYSIS

DEBITAGE

Definition and Distribution of Technological and Chronological Types

1. Levallois technology crosscuts the different time periods, whereas flake blades and true blades are generally restricted to the Pre-Aurignacian and Early Dabban, respectively.
2. A final discriminant analysis assessed the validity of the technological groups. The defined technologies (blade, Levallois and flake blade) were well defined and the normal categories, although less well defined, were still suitable for purposes of comparison.
3. Blades in the Early Dabban were the most internally homogenous category and the normal Early Dabban flakes were the most internally homogenous category of normal debitage.

Definition and Distribution of Conceptual Modes

1. The three conceptual modes of complexity, shape and efficiency can be used to explain the bulk of the differences between the three defined technological categories.
2. Despite an overall pattern of progressive development, the evolution of the technology at the Haua Fteah is marked by contingent changes and the patchwork distribution of conceptual modes over time.

3. The Early Dabban shows an integration of all three conceptual modes in a single, numerically abundant technology: true blades. The previous technologies (Levallois and flake blades) are dominated by only one conceptual mode at a time and have lower proportions of the defined technologies.
4. The fact that before the Early Dabban only one conceptual mode predominates in each technology suggests that there is a practical limit to the design of Levallois and flake blade technologies. This practical limit is transcended in the Early Dabban blades.

TOOLS

1. The Early Dabban shows an organised, integrated approach that is largely missing in the preceding periods. Blank selection and/or intentional production of blades are important aspects of tool design. Blank selection appears to be related to retouch type, intensity and location.
2. There is evidence of recognisable patterns differentiating tool types by retouch type, intensity and location in the Early Dabban. This occurs only to a limited degree in the preceding periods, in which differences represent more ad-hoc tool production strategies. The tools in the Early Dabban exhibit greater differences between each other, i.e., they are more internally homogenous and externally heterogeneous. The strong localisation of features and the greater number of differences between types support this.
3. There is a cumulative pattern in these elements. Pre-Aurignacian tools show blank selection only on the basis of size. Middle Palaeolithic tools show selection on blank attributes, rather than debitage technology, in addition to size. The Early Dabban shows selection on size, attributes and technological type. There are real increases in tool type diversity across the periods. This is based both on typological studies and on the relative proportions of the main tool classes used in this study.
4. Despite a cumulative pattern, the changes in the Early Dabban appear to signify a much larger and important shift. As in the case of debitage

production, a larger number of conceptual modes are in operation simultaneously. These modes are also integrated, i.e., much more organised.

DISCUSSION

In terms of the criteria set forth above, the Early Dabban industries show the strongest evidence for well-defined categories based on the discriminant analysis. In addition, blank selection was made on the basis of technological group, showing that the statistical category likely corresponds to an emic category. The statistical analysis of tool diversity showed that the Early Dabban was also the most diverse in terms of typological categories in relation to assemblage size. This was supported in real terms because the Early Dabban contained tool types that were not significantly present in the earlier periods (truncations and backed knives). These tool types also involved a different form of retouch - blunting.

The Early Dabban shows considerable evidence for the existence of emic categories. The preceding levels show some evidence for the existence of categories, but to a much lesser extent. In terms of blank selection, tools were made on larger flakes in the Middle Palaeolithic and Pre-Aurignacian and on flakes with more preparation in the Middle Palaeolithic. This shows that in all of the culture periods the conceptual modes that were dominant potentially corresponded to emic categories.

The Early Dabban shows both a large number of categories and clear evidence for deliberate choice between them. This is most clear in blank selection, where backed knives and truncations were deliberately made on blades, whereas sidescrapers were deliberately made on normal flakes. Furthermore retouch location, intensity and type showed clear differences between tool categories in the Early Dabban. The preceding periods showed some variation in these features by tool type, but this could be explained in many cases by differential retouch intensity or initial blank shape.

Finally, the Early Dabban showed evidence for deliberate, organised tool production.

1. Blades show the integration of three different conceptual modes and thus represent the most complex tool type. Flake blades and Levallois debitage appear to only involve one concept at a time.

2. Blades in the Early Dabban represent a much larger proportion of the debitage than Levallois or flake blade debitage does in the Pre-Aurigncian and Middle Palaeolithic.
3. Blades appear to be deliberately produced for the manufacture of two tool types, both of which have specific patterns of retouch.

It appears that the Early Dabban lithic industry involves a chaîne operatoire that begins with raw material procurement and ends with finished tools. Tool manufacture in the Pre-Aurignacian and Middle Palaeolithic appears to be ad hoc, involving the process of continuous modification and re-use, which resulted in less standardised retouch locations and intensity.

NON-LITHIC EVIDENCE

In addition to deliberate, organised tool production and the imposition of form, the Early Dabban shows other hallmarks of what is traditionally considered to be characteristic of the Upper Palaeolithic and modern behaviour.

BONE TOOLS

1. Bone tools were not found at the Haua Fteah in the levels analysed; this is likely the result of poor bone preservation.
2. Bone tools were found at contemporaneous Dabban levels at Hagfet ed Dabba.

SYMBOLISM

1. The grooved limestone slabs in the Pre-Aurignacian levels do not show evidence of deliberate symbolism and likely were used as work surfaces.
2. The purported flute in the Pre-Aurignacian is likely the result of taphonomic factors, because it was not found in association with debitage or tools.
3. At Hagfet ed Dabba, there is evidence for symmetrical engraving of bone in the Dabban.
4. Decorated ostrich eggshells were recorded in the inventory for an Early Dabban level at the Haua Fteah.

THE SOCIAL REVOLUTION THAT WAS

Does the Upper Palaeolithic represent a gradual accumulation of modern traits or was it a revolution in human evolution? The answer ultimately has to be that it was revolutionary. Although a different methodology is used, the findings of the present lithic analysis support the view that something big happened at the Middle to Upper Palaeolithic transition. The data available on the Middle to Upper Palaeolithic transition agrees strongly with this consensus view. Although several features of modern behaviour appear much earlier (McBrearty & Brooks 2000), the co-occurrence of these modern behavioural features marks the arrival of the Upper Palaeolithic transition. Organised lithic tool production emerges at the same time as organised bone tool production, permanent art objects, expanded raw material procurement ranges and increased regional diversity. The sheer quantity of information processed makes an exponential leap. As discussed previously, cognitive distribution in human societies is a prerequisite for such a leap. Furthermore, each aspect of behaviour itself becomes more complicated. Although the making of a Levallois flake may require more steps than making a blade, the finished Early Dabban backed knife made on a blade requires a more deliberate and organised, and thus more complex and temporally longer chaîne operatoire.

Underlying the transition to the Upper Palaeolithic is a change in social organisation. The introduction of modern human kinship systems is the most probable explanation. The ability to distribute and organise knowledge across greater spans of time and space has enormous adaptive potential. The explanatory aspect of the consensus view cannot be supported. That view maintains that the Upper Palaeolithic transition was the product of a biological shift in the capacities of modern humans. As stated previously, however, the biological evidence, especially in Africa, contradicts this. Humans, Neanderthals and other late Pleistocene hominids after 200 kya have nearly identical brain sizes and neurological structures, but they do not have fully modern behaviour. It is only when labour and cognition are distributed through a group in a socially organised way that institutions in Hinde's sense emerge. Although human brains are powerful information processors due to large neocortical association regions, their abilities are ultimately finite. Human society would not be possible without a division of physical and cognitive labour.

WHY?

Answering the question why a change in social organisation took place is problematic. The answer for the Upper Palaeolithic transition must always be speculative. That it occurred, however, seems reasonable because:

1. There is no evidence of a fundamental change in the structure of the human brain at the Middle to Upper Palaeolithic transition;
2. There is no evidence for the now almost mythical "bottleneck population;" and
3. There was a fundamental shift in human behaviour and cognition at this time.

To go further and state that this occurred for a *specific* reason is to ignore the lessons learned thus far and fall back into an adaptationist perspective. As with any complex phenomenon, there are usually multiple causes.

Whatever the cause, however, complex social organisation has turned out to be highly adaptive and successful and has led to a uniquely human phenomenon: culture. The presence of a more organised social group also has an important impact on other groups with which it comes in contact.

Rather than cite causes, lists of factors that probably influenced the emergence of complex social organisation in the late Palaeolithic are given. These factors range from proximal to distal. Proximal factors are those that are directly related to the maintenance of the social order and are thus likely to be more apparent to the members of the group. Reading ethnographies reveals that such proximal factors are often closer to the answers that a group gives as an explanation for its own behaviour. Distal causes are likely to be external to the dynamics of the group and less obvious to members of that group.

PROXIMAL FACTORS

1. The need to maintain social cohesion in the face of an expanding social world.
2. The need to define the identity of one's own group as opposed to other populations (or even other hominid subspecies).
3. The need to co-ordinate knowledge across greater spans of time and space.
4. The need to respond to change in an effective and rapid way.

These proximal factors can be divided into two categories. The first two deal with increases in the density of social interaction, in the first instance within the group and in the second between groups. The last two deal with the organisation of information, which is a product of the first two "internal" factors but also of external changes. It should be noted that in some ways the proximal factors are a product of themselves. In other words, some social "adaptations" create problems of their own which require a social solution, i.e., these social problems have no causes external to themselves.

INTERMEDIATE FACTORS

Intermediate factors link some of the proximal factors to the distal factors.

1. Increases in population density.
2. Group mobility.
3. Expansion into new territories and eco-niches.

It is important to distinguish between differences in social density and population density. Social density is a measure of the amount of social interaction within and between groups, whereas population density is a measure of the number of people in an area. Both population density and mobility are likely to contribute to an increase in social density. The expansion into new territories and eco-niches is known to have occurred in the Upper Palaeolithic and would have resulted in a greater need to process information.

DISTAL FACTORS

The most important distal factor is the environment. OIS 3 was a stage of deteriorating and fluctuating climate. This led to unpredictability, which led to increased mobility and expansion into new territories. Most authors now accept that modern human behaviour developed in the Levantine corridor and surrounding regions (e.g., northeast Africa). Authors such as Bar-Yosef (1998) and Sherratt (1997) point to geographical features of this region that influenced intermediate factors. The region:

1. exhibits marked seasonality;
2. has a varied topography;

3. has several biogeoclimatic zones and ecotones; and
4. is a "funnel like structure" (Sherratt 1997: 284) connecting the Mediterranean Sea, the Indian Ocean, Asia, Europe and Africa.

These features, in conjunction with the climate of OIS 3, intensified demographic pressures and competition for varied and scarce resources. The ability of humans to store and share complex information across time and space is clearly a considerable advantage. Innovations such as intergroup exchange (economic and symbolic), complex organised technological production, and better organised subsistence strategies allowed humans to spread risk among a larger population in these unpredictable climates. As Bar-Yosef (1998: 157) points out, such innovations "would bring not only a population increase but selective advantages in long-term monitoring of the environments treasured in the prolonged 'living memory' of the group."

THE QUESTION OF EVIDENCE

Two questions could be raised concerning the current study:

1. Is there a distinction between social and cognitive complexity?
2. If so how can we distinguish between the two in the archaeological record?

To answer both questions, the observations made in Chapter VI and the triple viewpoint discussed above (from biology, social organization and cognition) mean that the distinctions between social and cognitive complexity are, in essence, artificial. As Geoffrey Samuel says of his social theory, they are "states of the entire human ecosystem" (1990: 152). A similar perspective can be adopted here.

There are two scenarios.

1. A complex way of thinking (i.e., a complex cognition) is shared by a group, but adopted by an individual for a specific purpose.
2. A group of people collectively resolve a cognitive task by distributing and communicating elements of the task through the group.

Given these situations, how does one resolve whether the complexity of the task is driven by purely cognitive or purely social factors? In human social and cognitive life the boundary is unclear. As Hutchins states (1995: 176):

> All divisions of labor, whether the labor is physical or cognitive in nature, require distributed cognition in order to coordinate the activities of the participants.

To expand, all complex social situations require complex cognitive labour. Likewise any complex cognitive task carried out by an individual depends on a complex social structure in which that task was developed and learned. Authors such as Samuel (1990), Hutchins (1995) and Moscovici (1994) suggest that the distinction between individual and social cognition is blurred.

The task facing the archaeologist is therefore not to distinguish between social and cognitive complexity, but to explain the relationships between social organisation, cognition (individual and collective) and behaviour. Complex behaviour, as indicated in the archaeological record, requires social organisation and cognition (individual and social) operating together. One cannot speak of the social driving cognitive change or vice versa. Change emerges from the tension between different aspects of the total human: biological, psychological and social.

A number of markers of the Middle to Upper Palaeolithic transition have been proposed, including (e.g., Mellars 1996a):

1. blade production
2. increased number of types and complexity of stone tools
3. proliferation of bone, antler and ivory tools
4. change in the tempo of technological change
5. personal ornamentation
6. art forms
7. specialised patterns of hunting
8. increased residence group size

Although the behavioural traits do not always appear together, a feature of modern human behaviour is that many occur simultaneously. If we take one behaviour that arguably depends on "cognitive complexity," such as art, we can just as easily evoke a "social complexity" reason for it. The truth is that both are required. Presuming that one individual made the artwork, such as a cave painting, a number of social factors underlie that behaviour. Time needs to be taken from other tasks in the group, both in making the individual artwork, but more importantly in developing and learning the skills required to make the work. As stated in Chapter V, social differentiation and complex interaction are needed for art production. Assuming that the artwork has some meaning for the group, that meaning is shared and negotiated. At the other end of the spectrum, increased residence group size could be interpreted as being driven by changes in social organisation. Following Hutchins, however, this requires a great deal of cognitive processing (individually and collectively) to coordinate the activities of the group.

More importantly, we need to look at the relationship between art works, blade production, increased residential size and specialised patterns of hunting occurring in the same residential group. Why do they co-occur? Is specialised hunting a prerequisite for increased group size or a consequence? Does the biological capacity for a behaviour necessarily precede its expression? The works of Patrick Bateson (1988) and others leave these questions open.

The argument made here, that the advent of complex forms of kin-ordered social organisation underlies the transition to the Upper Palaeolithic and to "fully modern" human behaviour, brings together what is known about human evolution, cognition and social organisation and applies it to the archaeological evidence that a major threshold in behaviour occurred at the Middle to Palaeolithic transition. The evidence from the stone tool assemblages at the Haua Fteah supports the revolutionary nature of the transition. The argument is not that the kin-ordered mode of social organisation was the sole cause of the Middle to Upper Palaeolithic transition, but rather that it was a system that came into place which *enabled* the transition, and was able to adapt to proximal, intermediate and distal factors. Many of the traits of modern human behaviour are not possible without a kin-ordered, or more complex (see Wolf 1982), mode of social organisation.

In short, we need to better understand and describe the complex relationships between the social, cognitive and biological, rather than look for uni-causal explanations. All three aspects of the human ecosystem, operating both together and in tension, drive the changes that are preserved in the archaeological record.

A growing number of authors are rejecting a genetic shift and turning to social explanations of the transition to modern human organisation. Although the current study argues that a social revolution underlies the Middle to Upper Palaeolithic transition, this transition is simultaneously biological, social and cognitive. The three cannot be separated with any degree of precision. The relationships between the three fields of the human ecosystem underlie exhibited behaviour. Archaeology looks at the physical remains produced by these relationships; only by adopting an explanatory framework that incorporates all of these aspects can we begin to explain past behaviour. The theoretical positions on techniques of authors such as Lemonnier (1992) and Mauss (1979) provide the theoretical link to explain human behaviour from the material cultural record.

Conclusions

The Early Dabban is one of the earliest Upper Palaeolithic true blade industries in the world. The first four chapters of this study arrive at a number of analytical conclusions regarding the differences between this industry and what preceded it. Most notably:

1. The Early Dabban appears to have developed in a less predictable environment than the Middle Palaeolithic and the Pre-Aurignacian.
2. The Early Dabban exhibits traits common to other Upper Palaeolithic industries (evidence of bone tool use and potential symbolism).
3. Early Dabban debitage technologies are more internally homogeneous (i.e., standardized) than those of the previous industries.
4. Early Dabban true blade industries integrate more than one conceptual mode, whereas the technologies that preceded them did not (i.e., they appear to be richer in information and design).
5. In the Early Dabban there is deliberate production of specific types of debitage for specific tool types.
6. The location and nature of retouch is standardized within Early Dabban tool categories, whereas it is not (or considerably less so) in the previous periods.

These considerations strongly support the view that the Upper Palaeolithic is qualitatively and quantitatively different from what preceded it – it exhibits more complex patterns of behaviour than what came before. This is a view held by many authors, but not universally accepted.

Chapters V and VI examine explanations for this revolution in behaviour. Chapter V critiques a genetic-cognitive explanation for this transition. It is important to reiterate that cognitive studies do not necessarily pre-suppose that differences in thought and behaviour are genetically determined. The criticisms of this and similar models are <u>not</u> meant to deny that human thought changed dramatically during the Middle to Upper Palaeolithic transition – this is exactly what the present analysis suggests. A number of observations are made in Chapters V and VI:

1. Human brain size and structure does not appear to have changed significantly in the last 200 ky.
2. Behaviour plays an important role in evolution.
3. Human brains are formed through a process of regulatory development exhibiting considerable plasticity. External factors (social and environmental) have an impact on the structure and content of the human mind.
4. Studies have shown that complex tasks such as grammar usage can be learned using simple general-purpose mechanisms.
5. Humans exhibit unique forms of social organisation based on systems of kinship, residence and exchange. These systems regulate the organisation and distribution of matter, energy and information in the group.
6. Human social groups resolve complex cognitive tasks that are beyond the capabilities of an individual by distributing the tasks throughout the group or segments in it. Different forms of social organisation result in different forms of cognition.
7. The structure of social relationships provides a representational structure by which the world is classified and ordered.

These chapters argue that the explanations for the documented increase in cognitive complexity are not reducible to a biological-genetic change. The current study emphasises that human behaviour has a three-fold basis, from biology (human bodies and genes), social interaction and thought. These observations result in the following conclusions.

1. An increase in the complexity of human social organisation correlates with more complex forms of cognition.
2. The advent of kin-ordered social organisation correlates with more complex production of labour, cognition and symbolism.
3. Given the evidence available, the advent of more complex forms of social organisation at the Middle to Upper Palaeolithic boundary is a more plausible theory than a genetic-cognitive argument that a biological change underlies the behavioural expression of the Middle to Upper Palaeolithic transition.

The catalogue of modern behaviours used to mark the transition from the Middle to Upper Palaeolithic (see Mellars 1996a and McBrearty & Brooks 2000 among others), and more importantly their co-occurrence, required a change in social organisation. The kin-ordered mode of production (economic and cognitive) that is typical of more recent hunter-gatherer societies enabled modern social and cognitive behaviour. Cognitive redistribution across such kinship networks created the possibility of an exponential increase in the complexity of behaviour and cognition.

Early Dabban blade production and subsequent tool manufacture is quantitatively different from the technologies that preceded it at the Haua Fteah. This suggests that this new technological system was the result of social-cognitive advances associated with a change to more complex social organisation. A genetic-cognitive shift is ruled out on the basis of available evidence.

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