A Preliminary Analysis of Functional Variability in the Mousterian of Levallois Facies

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EVER since the discovery, more than 100 years ago, of the remains of Neanderthal man, there has been great interest in the cultural status of this hominid. We have come a long way in our understanding of the problem since the first outraged reactions to the suggestions that this "brutish" creature might represent our ancestral population.

In 1869 de Mortillet defined the Mousterian as the culture associated with Neanderthal man, the culture taking its name from a rockshelter in southwestern France, Le Moustier (de Mortillet 1885:252). According to this early definition the Mousterian culture was characterized by the presence of points, side-scrapers, and a few handaxes that were thinner than those of the preceding Acheulian stage; also noted by de Mortillet was unifacial treatment of tools and the absence of end-scrapers. The development of the Mousterian was seen as following a unilinear development from early types with handaxes, a middle type with no handaxes, to a late manifestation characterized by special kinds of retouch.

The first step toward a more realistic understanding of the complexity of the Mousterian was taken by Denis Peyrony (1930) in his investigations of Le Moustier where he found that this tidy order of development simply did not occur. But it is the monumental work of François Bordes in systematizing Mousterian typology and in defining the complexity of occurrences of different types of Mousterian assemblages that has advanced our knowledge most remarkably.

Bordes has introduced into the methodology of archeological analysis standards of description and comparison previously unknown, and has made possible for the first time objective comparison between Mousterian assemblages. Such comparison has led Bordes to recognize four basic types of Mousterian assemblages; these are expressed quantitatively and are objectively definable. These Mousterian assemblage types have been fully described (Bordes 1953b) and summarized (1961a) and the typological units which comprise the assemblages have been defined (1961b).

The four kinds of Mousterian assemblage are:

(1) *The Mousterian of Acheulian Tradition*, characterized by the presence of handaxes, numerous side-scrapers, denticulates, and particularly, backed knives. There are two subtypes of this kind of Mousterian that appear to have temporal significance—Type A has higher frequencies of handaxes and

occurs during the first half of the Mousterian time range (Würm I and the succeeding interstadial); Type B (Würm II) has many fewer handaxes and those that are present are of a different type, and Bordes also notes an increase in backed knives and a decrease in side-scrapers.

(2) *Typical Mousterian* differs from the preceding type principally in sharply reduced frequencies of handaxes and knives.

(3) *Denticulate Mousterian* contains up to 80 per cent denticulates and notched tools; there are no handaxes or backed knives, and the percentage of the assemblage not accounted for by the denticulates and notched tools consists of end-scrapers, side-scrapers, burins, borers, etc.

(4) *Charentian Mousterian* is subdivided into two types—*Quina* and *Ferrassie.* Both are characterized by having few or no handaxes or backed knives, as well as by very high frequencies of side-scrapers. Tool types contained in the other assemblages appear here also, but the Charentian is notable for the numerous side-scrapers, often made with a distinctive kind of scalar retouch. Quina and Ferrassie assemblages are distinguished by the absence in the former and the presence in the latter of a special technique of core preparation—the Levallois technique.

The Levallois technique cross-cuts the other three types of assemblages in a complicated way. When the percentage of tools made by Levallois technique exceeds 30, the industry is defined as being *Mousterian of Levallois facies* (Bordes 1953a, 1953b). Since the Levallois technique is so prevalent in the later Mousterian of the Near East and since for a long time prehistorians thought Levallois represented a distinct cultural tradition rather than a technique, the later Mousterian in this area is often called Levalloiso-Mousterian. Actually, the superimposed levels in the rockshelters and caves of the Near East exhibit the same kind of alternation of industries which Bordes has demonstrated for Europe. This alternation of the subtypes of assemblages does not seem to have any pattern that could be said to be directional through time.

For example, at Combe Grenal, a deeply stratified site in Dordogne, France, Bordes has described a sequence beginning with Denticulate Mousterian, overlain by layers of Typical, Ferrassie, Typical, Ferrassie, followed by a long sequence of Quina layers. Overlying these are less patterned alternations of Denticulate, Ferrassie, and Mousterian of Acheulian Tradition (Bordes 1961a).

Three major hypotheses have been offered to explain the well-documented alternation of industries in the Mousterian (Bordes 1961a):

(1) The different types of Mousterian are associated with a seasonal pattern of living, each type representing the remains of activities carried out at different seasons of the year.

(2) Each assemblage represents a slightly different adaptation to a different environment, the alternation of industries being determined by environmental variations through time.

(3) Each type of Mousterian represents the remains of a different group

of people, each group characterized by its own traditional way of making tools.

Bordes (1961a:4) has amassed data which suggest that within any one type of Mousterian assemblage all seasons of the year are represented; evidence that negates the first hypothesis. The second interpretation is contradicted by the presence of more than one type of Mousterian within a single geological horizon, suggesting that assemblage type varies independently of environment. This inference is further supported by the identification of the various types of Mousterian from sites in Spain, North Africa, the Near East, and China. These areas are widely enough separated to have represented a great variety of environments but still yield the alternation of industries within a single deposit. The very distribution of the known types of Mousterian argues against a strict environmental explanation, no matter how sophisticated the terms in which it is presented.

Because of the evidence refuting the first two hypotheses, Bordes has tentatively accepted the third—that the four types of Mousterian assemblages are associated with different Neanderthal "tribes" (Bordes 1961a). Good arguments can be presented against such an explanation, based on our knowledge of formal variation in material remains of populations of *Homo sapiens*. Nevertheless, such arguments remain opinion, for as yet no one has proposed a means of testing Bordes' hypothesis. If a means of testing were developed and the hypothesis confirmed, a major contribution would be made since we would then be forced to conclude that the social behavior of Neanderthal populations was vastly different from that of *Homo sapiens*.

Studies in many parts of the world have shown that formal variation in material items that is inexplicable in terms of function or raw materials can be termed *stylistic* variation (Binford, L. R., 1963); these stylistic variations tend to cluster spatially in direct relationship to the amount of social distance maintained between societies. Spatial clusterings of the various Mousterian assemblages are not demonstrable; in fact, in the Dordogne region of France the four types of Mousterian assemblage occur interdigitated at several localities.

In view of the demonstrated alternation of industries, one must envision a perpetual movement of culturally distinct peoples, never reacting to or coping with their neighbors. Nor do they exhibit the typically human characteristics of mutual influence and borrowing. Such a stiuation is totally foreign, in terms of our knowledge of *sapiens* behavior.

The purpose of this paper is to present an alternative set of testable hypotheses as possible explanations for the observed variation and alternation of Mousterian industries demonstrated by Bordes. Another purpose is to introduce certain analytical techniques that we feel are particularly useful for the interpretation of archeological materials.

THE METHOD

There has recently been a burst of activity in the investigation of multivariate causality of social phenomena and an elaboration of general field theory (Cartwright 1964), ecological theory (Duncan 1959), and general systems theory (see *Journal of General Systems Theory.*) These represent different but compatible ways of conceptualizing multivariate causation. The phrase "multivariate causation" implies that the determinants of any given situation are multiple and may be linked, and that some determinants may contribute in different ways to different situations.

If we assume that variation in the structure and content of an archeological assemblage is directly related to the form, nature, and spatial arrangement of human activities, several steps follow logically. We are forced to seek explanations for the composition of assemblages in terms of variations in human activities. The factors determining the range and form of human activities conducted by any group at a single location (the site) may vary in terms of a large number of possible "causes" in various combinations. The broader among these may be seasonally regulated phenomena, environmental conditions, ethnic composition of the group, size and structure of the group regardless of ethnic affiliation. Other determining variables might be the particular situation of the group with respect to food, shelter, supply of tools on hand, etc. In short, the units of "causation" of assemblage variability are separate activities, each of which may be related to both the physical and social environment, as well as interrelated in different ways.

Since a summary description of a given assemblage represents a blending of activity units and their determinants, it becomes essential to partition assemblages of artifacts into groups of artifacts that vary together, reflecting activities.

If techniques were available to isolate artifact groups reflecting activities within assemblages, then the ways in which they are combined at various localities could be analyzed. We therefore seek a unit of comparison between the single artifact type and the total assemblage—a unit that will, we believe, correspond to the basic units responsible for the observable variation within assemblages.

The major methodological problem is the isolation of these units and a comparison between them, utilizing multivariate techniques. *Factor analysis* seemed the most appropriate method (Harmann 1961). This technique, although widely used in other scientific fields, has not been commonly applied in prehistory. Its application here is one step of a continuing program of research in the investigation and development of analytical methods. Much of the preliminary work was conducted over the past four years by the senior author in collaboration with students at the University of Chicago.[1]

The basic set of statistics necessary for the beginning of a factor analysis is a matrix of correlation coefficients. Correlation coefficients are expressions on a scale from -1 to $+1$ of the degree of correlation between two variables. A value of $+1$ signifies that there is a perfect one-to-one correlation between two variables; as one increases in number, the other increases in perfect proportion. A value of 0 indicates that the variables are unrelated. A value of -1 indicates that as one variable increases in number, the other decreases proportionally. Correlation coefficients must be obtained for all possible combinations of pairs of variables to be included in the study.

Another essential in a factor analysis is the concept of types of variance. The total variance squared of a variable may be subdivided into three general classes—common, specific, and error variance. Common variance is that portion of the total variance which correlates with other variables. Specific variance is that portion of the total variance which does not correlate with any other variable. Error variance is the chance variance, due to errors of sampling, measurement, etc. The latter is assumed to be uncorrelated with the reliable variance (common and specific) and other error variance.

A basic assumption of factor analysis is that a battery of intercorrelated variables has common factors running through it, and that the scores of any individual variable can be represented more economically in terms of these reference factors. The number and nature of these common reference factors is measured in terms of the configuration of *common variance* demonstrable between the numerous variables.

This assumption is essentially in perfect correspondence with the reasoning concerning the composition of an archeological assemblage. For example, if a group of people occupy a location and are engaged in a specific activity, such as hide-working, they would employ a number of different tools—knives, scrapers, and possibly pins for pinning down the hides or stretching them. The number of tools used in hide-processing will be directly related to the number of individuals engaged in the activity and the number of hides processed. Regardless of these variations, we would expect that the proportions of the tools used in the activity would remain essentially constant. In other words, they would share a high degree of common variance and would be positively correlated.

If, after the episode of hide-working, the group began to manufacture clothing, a different set of tools might be employed, along with some of the same tools used in hide-working—knives, abraders, piercing implements, etc. Once again, the relative proportions of the tools used in this activity would vary directly with the number of persons engaged in the work and the number of articles being manufactured. Therefore, there would be a high proportion of common variance between the tools used in this particular activity.

Through factor analysis of many assemblages from sites where these activities were performed, the configuration of common variance would be observable, and the analysis would result in the recognition of two *factors*. These factors express the configurations of common variance between the tools used in hide-working on the one hand and clothing manufacture on the other.

It will be recalled that one type of tool (knives) was used in both activities and would consequently be expected to exhibit some common variance with tools in both kinds of activities. In addition, if there were any relationship between the number of hides processed and the number worked into clothing, given a constant size of work force, then tools in both activities would exhibit some common variance; this common variance would be less, however, than that which would be shown among other tools used in a single activity.

Through such an analysis of the configuration of shared or common variance exhibited by a number of variables (artifact types, in this case), we hope to derive objectively defined *factors* which are summary statements of common variance. Our analysis does not provide information as to the particular activity represented by a factor; it simply allows us to identify a regular relationship between a number of artifact types. Our identification of the function of a factor depends on analogy with the tools of living peoples, tool wear, and associations with refuse. Whether or not our interpretation of a factor in terms of function is correct, this does not affect the demonstrable relationship between the variables analyzed.

The actual methods and mathematical procedures involved in factor analysis are rather complex, and for this information the reader is referred to Fruchter (1954) and Harmann (1961).

THE SAMPLE

The data used in this study come from two sites in the Near East and from one site in northern France. A number of considerations entered into the selection of these particular data. One such consideration was the need for typological consistency; we had to be sure that "scrapers," "points," "knives," etc. meant the same thing in all assemblages. The open-air station of Houppeville (near Rouen, France) was excavated and analyzed by Bordes (1952). The shelter of Jabrud (near Damascus, Syria) was excavated by Rust (1950) and the lithic assemblages were re-analyzed by Bordes (1955). The cave site in our sample, Mugharet es-Shubbabiq (Wadi Amud, Israel), was excavated by the junior author and the lithic material analyzed under Bordes' supervision at the Laboratoire de Préhistoire, Université de Bordeaux (S. R. Binford 1966).

In addition to being able to control for typological consistency, Jabrud Shelter I (Levels 2–8) was selected since it is the only other Near Eastern site yielding Mousterian of Levallois facies which was analyzed in comparable units. Houppeville was chosen since the *série claire* assemblage exhibited a marked similarity in total assemblage with Shubbabiq. One of the things we wished to test was whether total assemblages that are similar when expressed in Bordes' cumulative percentage graphs would remain similar under factor analysis. Do assemblages identified as Typical Mousterian, for example, exhibit the same configuration of factors?[2]

THE VARIABLES

A total of 40 variables was used in this study. Some of the 63 Mousterian artifact types isolated by Bordes were not included because of their absence, or near absence, in the samples under study. Variables such as cores, introduced rocks, cracked rock, and worked bone were not used since they were not present in the counts from Jabrud and since they did not occur in primary archeological context at Shubbabiq.

Table I presents the list of variables used in this study together with the number they represent in Bordes' type list. We have included a priori judg-

TABLE I

No. in Bordes' Type List	Variable Number	Variable Name	Functional Interpretation	
			First	Second
1	1.	Typical Levallois flake	Delicate cutting	
2	2.	Atypical Levallois flake	Delicate cutting	
3	3.	Levallois point	Spear point	
4	4.	Retouched Levallois point	Spear point	
5	5.	Pseudo-Levallois point	Perforating (?)	
6	6.	Mousterian point	Spear point	
7	7.	Elongated Mousterian point	Spear point	
9	8.	Simple straight side-scraper	Cutting-scrap. Nonyielding Surface	
10	9.	Simple convex side-scraper	Cutting-scrap. Nonyielding Surface	
11	10.	Simple concave side-scraper	Scraping cylindrical objects	
12–17	11.	Double side-scrapers		
18–20	12.	Convergent side-scrapers[1]		
22–24	13.	Transverse side-scrapers		
25	14.	Scrapers on the ventral surface	Push Plane	
26	15.	Scrapers with abrupt retouch		
30	16.	Typical end-scrapers		
31	17.	Atypical end-scrapers		
32	18.	Typical burin	Deep incising	Perforating
33	19.	Atypical burin	Heavy cutting	
34	20.	Typical borer	Perforating	
35	21.	Atypical borer	Perforating	
36	22.	Typical backed knife	Heavy cutting	
37	23.	Atypical backed knife	Heavy cutting	
38	24.	Naturally backed knife	Heavy cutting	
39	25.	Raclette		
40	26.	Truncated flake		
42	27.	Notched piece	Gut-stropper (small obj.)	
43	28.	Denticulate	Sawing	
44	29.	Bec	Perforating	Deep incising
45	30.	Ventrally retouched piece	?	
48–49	31.	Utilized flakes		
50	32.	Pieces with bifacial retouch		
54	33.	End-notched piece	Scraping cylindrical objects	
56	34.	Rabot (push plane)	Planing	
61	35.	Chopping tool	Heavy duty cleaving	
62	36.	Miscellaneous[2]		
—	37.	Disc		
—	38.	Unretouched flake	Delicate cutting	Unused debris
—	39.	Unretouched blade	Delicate cutting	Unused debris
—	40.	Waste flake (Trimming flake)	None	Index of flint work

[1] The various types of convergent and double scrapers recognized by Bordes were represented in such small numbers that they were lumped for the purposes of this analysis into two classes, convergent and double.

[2] This category includes not only unclassifiable tools but also those which have received some kind of special treatment (=Bordes' type No. 62—"divers").

ments as to the mechanical task for which the implements would have been utilized. When we felt our judgment was shaky or that there was ambiguity in the morphology of the tool, an alternative suggestion is offered.

RESULTS OF ANALYSIS

The computer output expresses summary information in several stages of the analysis. The final summary consists of the delineation of *factors* (five, in this case); a factor is the quantitative expression of the configuration of common variance in the matrix of variables and samples under study. The factors are described in terms of factor loadings (the square roots of the percentages of variance accounted for by each factor). Factor loadings are expressed on a scale from -1 to $+1$ and may be read as positive and negative percentages of common variance.

The five factors define clusters of artifacts that exhibit internally consistent patterns of mutual covariation; these are independent of each other with respect to the determinants of variation. It should be re-emphasized that in this method there is no built-in technique for interpreting the particular "meaning" of the factors. The computer end-product is simply a statement of configurations of common variance. The interpretation of the factors—i.e., the type of unit activities they represent—must be offered in terms of hypotheses for testing.

In general there are two types of formal differences between artifacts that can reflect human activities and social context: *functional* and *stylistic.* These may be fixed along two axes—time and space. In this context, when we ask "What kinds of activities do our factors represent?" we must consider three kinds of information:

(1) the formal content of a factor—i.e., the kinds of artifacts that exhibit a high degree of mutual covariation;
(2) the relative value of the factor scores among the artifact types with paired factors;
(3) the relative significance of the factors within a single assemblage and their temporal and geographical occurrence.

Figure 1 shows four hypothetical cases in which two factors are plotted on a Cartesian graph; the discussion that follows is to illustrate the application of the principles of interpretation outlined above.

In Pattern A we compare two factors that are functionally distinct but which share specific tasks performed with specific tools. Such a situation might arise if, for example, one factor were associated with butchering and the other with hide-working. Cutting and scraping tools would be common to both activities, but each activity would also employ artifacts not used in the other. Both might require scrapers, but butchering might require cleavers, while hide-processing might demand heavy-duty choppers. In Pattern A there are many diagnostics of the two factors clustering on the individual factor axes but with several types aligned along the diagonal. These latter would be the

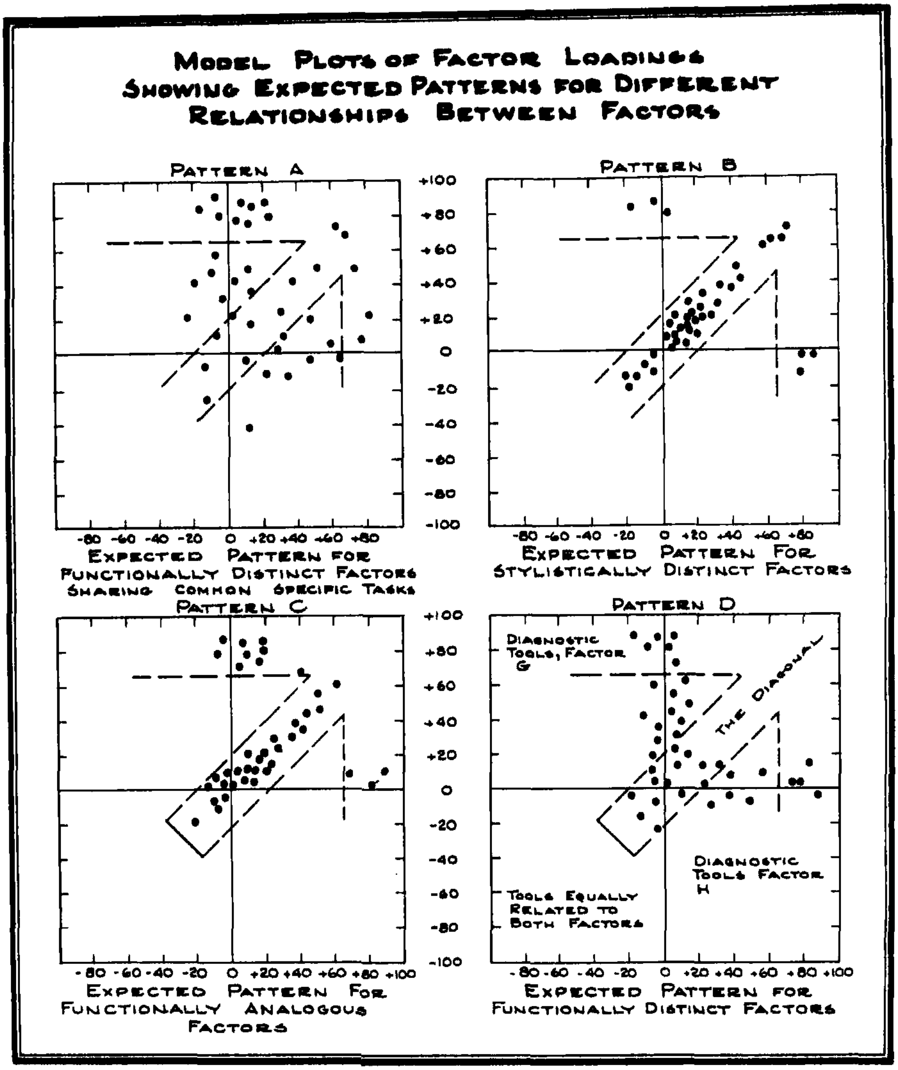

FIG. 1

types exhibiting equal factor loadings within both factors (in the case cited, these would be scrapers).

The distribution shown in Pattern B, where the great proportion of artifacts cluster along the diagonal, is interpreted as representing two factors that are similarly determined and therefore inferred as being functionally equivalent. The few tools that occur outside the diagonal cluster would, if we were comparing factors at the same site on different time horizons, represent a stylistic shift through time—a change in preference for similar tools within one functional class. If the two factors occurred on the same time horizon at different localities, it might be interpreted as reflecting regional style preferences.

Pattern C bears general resemblances to Pattern B but with the following exceptions:

(1) The numbers of tools falling outside the diagonal are not equal in both factors.
(2) Within the diagonal, some tools positive on one axis are negative on the other.
(3) Some of the artifacts in the larger cluster outside the diagonal have functional equivalents in the smaller cluster, but some do not.

Pattern C would express a situation where the two factors reflect very similar activities, but the tool kit in one factor is more complex than in the other. If this pattern occurred with respect to two factors at the same location but on different time levels, we might infer an adaptive shift as the result of minor differences in a specific activity—e.g., a change in type of animal being hunted. If the pattern obtained between two factors from different localities on the same time horizon, we could infer that we have represented different adaptations to varying local conditions. This type of pattern is potentially very informative and provocative for the framing of hypotheses.

Pattern D represents two factors that are mutually exclusive, exhibiting nothing in common in the determinants of variability. It is inferred that in this situation we have totally different activities involved.

We will examine the artifact samples studied by factor analysis to see which factors occur in combination in the assemblages, and analyze these combinations in terms of the temporal controls offered by the stratified site of Jabrud and the geographical controls provided by having samples from three spatially distinct regions.

FACTOR I

Table II presents the list of variables arranged according to a descending order of mutual determinancy as they occur in Factor I. The table is divided into six major groupings of variables, the groups having been defined by the angle of a line described when the factor loadings were plotted on a Cartesian graph in order of descending value. The tools in each group not only share the same kind of mutual determinancy but also exhibit the same relationship to the first two groups, which are the diagnostics for this factor.

These diagnostics—the first two groups in the table—exhibit a consistent pattern of proportional variation with respect to each other, and each shows a similar kind of frequency variation with respect to all other variables. Not only do they show positive correlations between themselves, but they also behave *as a group* with respect to all other variables.

The variables in the bottom two classes have no tendency to vary in the same ways as the variables within the top two groups. This does not mean

TABLE II. LIST OF VARIABLES ARRANGED ACCORDING TO A DESCENDING ORDER OF FACTOR LOADING—FACTOR I

No. in Bordes' Type List	Variable Name	Factor Loading	Percentage in Bordes' Essential Graph
35	Atypical borer	*.925	1.11
44	Bec	*.912	1.64
30	Typical end-scraper	*.834	1.79
11	Simple concave scraper	*.830	3.27
62	Misc. Tools	*.809	12.29
31	Atypical end-scraper	*.785	2.69
33	Atypical burin	*.772	5.96
45	Ventrally retouched piece	*.770	—
42	Notches	*.745	15.49
40	Truncated flake	*.739	5.09
34	Typical borer	*.719	.42
38	Naturally backed knife	*.705	9.73
2	Atypical Levallois flake	.630	—
54	End-notched piece	.625	1.18
50	Bifacially retouched piece	.582	—
43	Denticulate	.555	18.09
22–24	Transverse scrapers	*.524	.72
12–17	Double scrapers	.488	3.59
48–49	Utilized flakes	.480	—
32	Typical burins	.454	3.70
—	Unretouched flakes	.445	—
9	Simple straight scraper	.389	5.17
5	Pseudo-Levallois point	.308	.89
1	Typical Levallois flake	.265	—
10	Simple convex scraper	.212	6.09
36	Typical backed knife	.212	.31
61	Chopping tool	*.137	.03
6	Mousterian point	.094	.31
—	Waste flakes	.084	—
7	Elongated Mousterian point	.070	.18
37	Atypical backed knife	.030	.09
—	Unretouched blade	.026	—
56	Rabot	.017	.01
3	Levallois point	−.007	—
18–20	Convergent scrapers	−.016	—
—	Disc	−.032	—
25	Scrapers retouched on the ventral surface	−.041	—
39	Raclettes	−.071	—
26	Scraper with abrupt retouch	−.091	—
4	Retouched Levallois point	−.097	—

* Indicates that the variable exhibits the highest factor loadings with respect to this factor and can be considered diagnostic of the factor.

that they are negatively correlated; on the contrary, their presence is being *independently* determined by other elements not operative for Factor I.

The variables listed in the two middle groups have some tendency to vary with those in the first two classes, but they also vary independently of them. Stated another way, their frequency in any assemblage of which Factor I is a major determinant would be expected to display variability which could not be explained by a unique relationship to the determinant of the first two classes. Variation might occur which would not be proportional to the variation of the tools within the diagnostic group.

Since the artifacts within the first two classes in Table II share determinants and behave as a unit with respect to other tools in the assemblage and since archeological assemblages are the fossil remains of human activities, we postulate that the variables diagnostic for a factor represent a functionally related set of tools.

In the case of Factor I there is a high frequency among the diagnostics of tools with working edges oriented transversely to the longitudinal axis of the piece, as well as borers, becs, and burins. Nothing in this list of tools suggests hunting or butchering; many of the points and scrapers occur toward the bottom of the list, indicating that they tend to vary independently of the diagnostics of Factor I. We suggest that the diagnostic group of Factor I represents maintaining the technology—i.e., secondary tool manufacture activities—perhaps the processing of bone and wood into shafts or hafts, as well as possibly the working of skins for cordage.

Another striking fact about this group of tools is the high proportion of "Upper Paleolithic" types (Bordes 1961b). This suggests that the activities represented have much in common with activities represented by many Upper Paleolithic assemblages. Our interpretation of this set of implements as a tool-manufacturing and maintenance factor may be the clue to its "Upper Paleolithic" flavor.

If we wish to express graphically the expected frequencies of artifact types if a single factor were the sole determinant of an assemblage, the following operation is performed. A single-tailed index is derived by multiplying the factor loading by the mean for each variable. These variable indices are summed for the entire list of variables. Each variable index is then divided by the sum of all indices. The resulting figure is a percentage, to be thought of as the expected relative frequency of each variable under the assumption that only one factor was determinant.

The expected percentages for all factors are given in Figure 2. The graph for Factor I is similar to the kind of curve defined by Bordes (1953b) as characterizing the Typical Mousterian.

FACTOR II

As in the case of Factor I, the variables are arranged in table form (Table III) in a descending order of factor loading values. The first two groups of variables are taken as diagnostic of Factor II; these are remarkably consistent in that they contain all of the point forms, with the exception of the elongated Mousterian point. In addition, convergent scrapers are high on the list, and these have a number of features of gross morphology in common with points. Scrapers are also significantly present in the diagnostic groups. Unretouched flakes, blades, and Levallois points also have high factor loadings and can be seen as a class of blanks used in the production of points and scrapers.

The composition of the diagnostics for Factor II contrasts sharply with

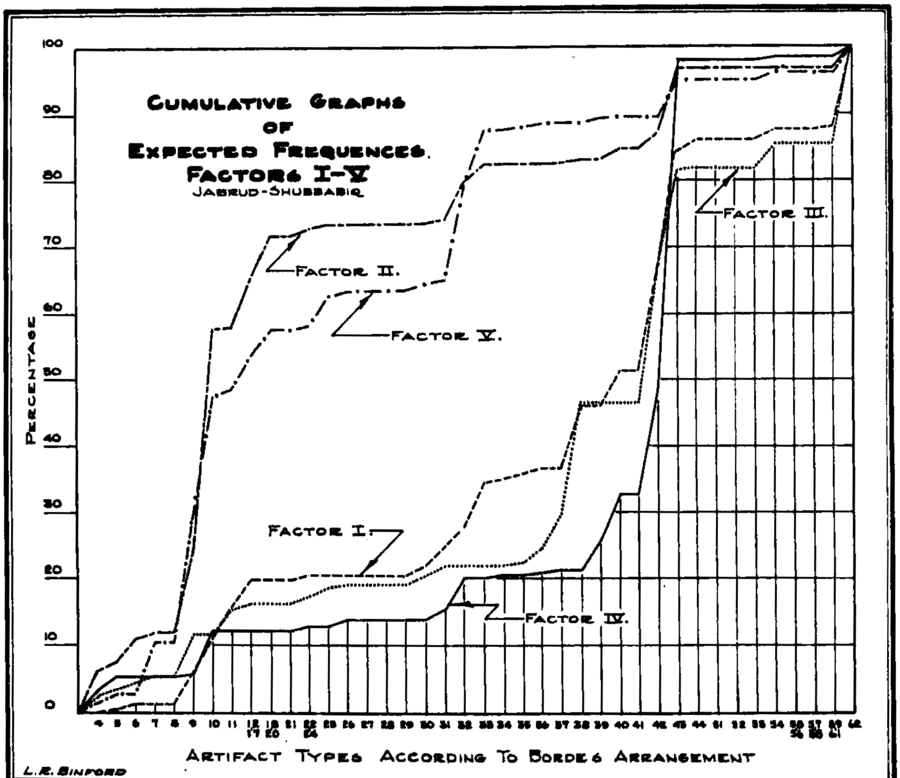

Fig. 2

Factor I, and many of the diagnostics for Factor I are not correlated with diagnostics for this factor. The nature of the diagnostic group of tools for Factor II strongly implies hunting and butchering as the major activities represented. Further, practically all of the small tools that are diagnostic for Factor I show negative loadings with respect to Factor II (see Table III), while most of the points and convergent scrapers were negative for Factor I.

If we plot the two factors on a Cartesian graph, the pattern produced essentially duplicates Pattern D (Figure 1), a pattern which is expected when two mutually exclusive activities are represented (see p. 247). The only divergence from the anticipated pattern occurs with respect to three types which

TABLE III. LIST OF VARIABLES ARRANGED ACCORDING TO A DESCENDING ORDER OF FACTOR LOADING—FACTOR II

Number in Bordes' List	Variable Name	Factor Loading	Percentage in Bordes' Essential Graph
3	Levallois point	*.893	—
18–20	Convergent scrapers	*.883	6.22
10	Simple convex scrapers	*.860	32.72
4	Retouched Levallois point	*.855	6.31
6	Mousterian point	*.834	3.56
12–17	Double scrapers	*.785	7.76
9	Simple straight scrapers	*.720	12.67
50	Bifacially retouched piece	*.651	—
—	Unretouched blade	*.591	—
1	Typical Levallois flake	*.531	—
32	Typical burin	*.517	5.58
—	Unretouched flake	*.465	—
22–24	Transverse scrapers	.373	.68
2	Atypical Levallois flake	.355	—
25	Scraper retouched on ventral surface	.304	.79
7	Elongated Mousterian point	.303	1.07
5	Pseudo-Levallois point	.248	.96
43	Denticulate	.225	9.71
33	Atypical burin	.225	2.30
40	Truncated flake	.161	1.48
62	Misc. tools	.134	2.69
11	Simple concave scraper	.113	.59
45	Ventrally retouched piece	.103	—
42	Notch	.094	2.59
30	Atypical end-scraper	.078	.13
54	End-notched piece	.071	.18
—	Disc	.061	—
37	Atypical backed knife	.047	.18
31	Typical end-scraper	.046	.90
38	Naturally backed knife	.037	.67
36	Typical backed knife	.037	.07
39	Raclette	.032	.09
26	Scrapers with abrupt retouch	.031	.03
44	Bec	.025	.06
—	Utilized flakes	.024	—
35	Atypical borer	−.029	0.00
—	Waste flake	−.078	0.00
34	Typical borer	−.189	0.00
61	Chopping tool	−.336	0.00
56	Rabot	−.486	0.00

* Indicates that the variable exhibits the highest factor loadings with respect to this factor and can be considered diagnostic of the factor.

fall along the diagonal in the moderate range of factor loadings. These types are bifacially retouched pieces, typical burins, and unretouched flakes. As a group, these appear to have little in common, and their positioning probably should not be interpreted as indicating a major overlap in the activities represented by the two factors. Rather, these three tools are probably multipurpose implements.

In general we can say that the difference between Factor I and Factor II is that they are representative of two major types of distinct activities. Factor I is interpreted as associated with maintenance activities of the group, while Factor II represents the implements used for hunting and butchering. From the very nature of these two activities, we might expect them frequently to be conducted at different locations. The maintenance activities would be carried out most often at locations selected as suitable for habitation of the group as a whole; requirements of space, protection, etc., would be important. Hunting and butchering sites, on the other hand, would be chosen in relation to distribution and habits of game as well as to the temporary maintenance requirements of a hunting group.

FACTOR III

The results of the factor analysis are presented in Table IV, with the variables arranged in descending order of factor loading. The first two classes of artifacts are diagnostic of this factor. With the exception of end-notched pieces, all of these artifacts have in common edges suitable for fine cutting. The specific context of this activity can be suggested by a comparison of Factors I and III, and the relationship both bear to Factor II.

When Factors I and III are plotted against one another on a Cartesian graph (Figure 3), the distribution which results is like Pattern A, in Figure 1. It will be recalled that this pattern suggests distinct activities with certain mechanical tasks in common; these common elements are ranged along the diagonal. In this case, the tools on the diagonal (from low to high loadings)are: Mousterian points, pseudo-Levallois points, simple straight scrapers, transverse scrapers, and naturally backed knives. All of these types are diagnostic for Factor II, suggesting that Factors I and III stand in a similar relation to Factor II, the hunting and butchering factor.

Since points are not a major diagnostic of Factor III, we suggest that the particular cutting and incising tasks represented by this factor are related not to butchering at kill sites but to the processing of animal products for consumption. If this inference is correct, we would expect to find Factor III as a consistent component in base-camp sites and to be associated with hearths.

If we tentatively identify this factor as primarily related to food processing, versus food procurement (Factor II) and maintenance activities (Factor I), the association of Factors I and III with base-camp activities and with different aspects of maintenance can be seen in the similar curves for these factors as they have been plotted in Figure 2. It should be noted that the curve for Factor III in Figure 2 is very like the curve for the Mousterian of Acheulian Tradition (Type B) of Pech de l'Azé (Bordes 1954). Unfortunately, bifaces were not in-

TABLE IV. LIST OF VARIABLES ARRANGED ACCORDING TO A DESCENDING ORDER OF FACTOR LOADING—FACTOR III

Number in Bordes' List	Variable Name	Factor Loading[1]	Percentage in Bordes' Essential Graph
37	Atypical backed knife	*–.976	5.35
36	Typical backed knife	*–.938	2.57
1	Typical Levallois flake	*–.752	—
54	End-notched piece	*–.704	2.49
—	Unretouched flake	*–.697	—
2	Atypical Levallois flake	*–.664	—
38	Naturally backed knife	*–.638	16.55
42	Notch	–.534	20.91
—	Unretouched blade	–.532	—
62	Miscellaneous	–.520	14.82
45	Ventrally retouched piece	–.466	—
26	Scraper with abrupt retouch	–.413	.46
22–24	Transverse scrapers	–.412	1.06
25	Scraper with retouch on ventral surface	–.381	1.41
11	Simple concave scraper	–.341	2.53
9	Simple straight scraper	–.290	7.24
7	Elongated Mousterian point	–.261	1.30
31	Atypical end-scraper	–.259	1.67
43	Denticulate	–.247	15.12
4	Retouched Levallois point	–.237	2.48
30	Typical end-scraper	–.223	.90
5	Pseudo-Levallois point	–.213	1.17
3	Levallois point	–.169	—
6	Mousterian point	–.106	.65
—	Waste flake	–.106	—
12–17	Double scrapers	–.074	1.03
48–49	Utilized flakes	–.056	—
35	Atypical borer	–.054	.12
44	Bec	–.049	.16
	Tools showing positive loading on Factor III		
39	Raclette	.011	0.00
10	Simple convex scrapers	.019	0.00
18–20	Convergent scrapers	.030	0.00
34	Typical borers	.048	0.00
31	Atypical burins	.102	0.00
50	Bifacially retouched piece	.104	0.00
56	Rabot	.136	0.00
61	Chopping tool	.141	0.00
40	Truncated flake	.174	0.00
—	Disc	.180	0.00
32	Typical burin	.246	0.00

[1] The variance is the square root of the standard deviation. Variance may, therefore, be expressed positively or negatively. For purposes of clarity the factor loadings may be expressed either positively or negatively for different factors. The square of the factor loading is the percentage of common variance accounted for by a single factor. Therefore, the sign of the factor loading itself is irrelevant.

* Indicates that the variable exhibits the highest factor loadings with respect to this factor and can be considered diagnostic of the factor.

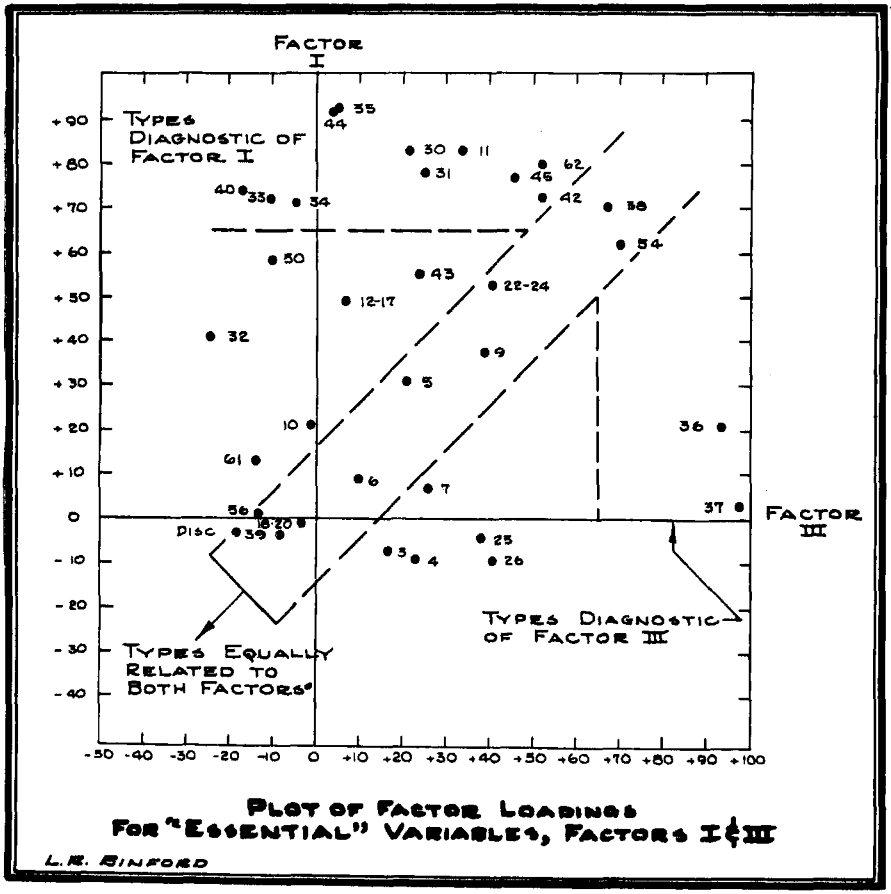

FIG. 3

cluded in our variables, since they occurred in low frequency in three of the samples and were absent from the others.

FACTOR IV

Table V presents the variables arranged in descending order of determinancy by Factor IV. This factor differs from the others in that there is a very sharp break in the value loadings between the diagnostics for the factor and those variables related in a minor way (see the factor loadings for the fourth and fifth items in Table V). A percentage plot of expected frequencies of Factor IV according to Bordes' type list Figure 2) reveals a curve strikingly similar to that for Denticulate Mousterian (Bordes 1953b, 1962).

Comparisons between Factor IV and all other factors reveal some interesting relationships. It will be recalled that Factor II was identified as a hunting and butchering factor, and Factor V is similarly identified (see below, p. 256). If

TABLE V. LIST OF VARIABLES ARRANGED ACCORDING TO A DESCENDING ORDER OF FACTOR LOADING—FACTOR IV

Number in Bordes' List	Variable Name	Factor Loading	Percentage in Bordes' Essential Graph
39	Raclette	*.905	4.36
48–49	Utilized flakes	*.824	—
26	Scrapers with abrupt retouch	*.792	1.03
43	Denticulates	*.707	49.79
#40	Truncated flakes	.477	7.15
34	Typical borers	.381	.49
42	Notches	.347	15.63
5	Pseudo-Levallois points	.326	2.05
4	Retouched Levallois point	.296	3.56
—	Disc	.268	—
31	Atypical end-scraper	.254	1.88
—	Unretouched flake	.242	—
22–24	Transverse scrapers	.236	.70
32	Typical burins	.230	4.05
—	Unretouched blade	.227	—
3	Levallois point	.218	—
54	End-notched piece	.120	.49
36	Typical backed knife	.119	.37
2	Atypical Levallois flake	.117	—
50	Bifacially retouched piece	.102	—
10	Simple convex scrapers	.101	6.26
62	Miscellaneous tools	.043	1.41
37	Atypical backed knife	.039	.24
9	Simple straight scraper	.018	.52
1	Typical Levallois flake	.015	—
33	Atypical burin	–.002	0.00
44	Bec	–.020	0.00
30	Typical end-scraper	–.046	0.00
6	Mousterian point	–.059	0.00
12–17	Double scrapers	–.095	0.00
7	Elongated Mousterian point	–.107	0.00
38	Naturally backed knife	–.117	0.00
33	Atypical borer	–.135	0.00
45	Ventrally retouched piece	–.165	0.00
25	Scraper with retouch on ventral surface	–.187	0.00
11	Simple convex scraper	–.190	0.00
—	Waste flake	–.192	0.00
18–20	Convergent scrapers	–.200	0.00
61	Chopping tool	–.242	0.00
56	Rabot	–.352	0.00

* Indicates that the variable exhibits the highest factor loadings with respect to this factor and can be considered diagnostic of the factor.

Factor IV is plotted against Factors II and V on a Cartesian graph, a pattern is obtained which strongly resembles Pattern D (Figure 1). This pattern is interpreted as representing mutually exclusive activities.

A Cartesian graph comparison of Factor IV with Factors I and III reveals distributions like those shown in Pattern A (Figure 1), where, it was argued, there existed distinct activities with analagous mechanical tasks in common. The types which exhibit mutual variation in both Factors I and IV are: denticulates, retouched flakes, truncated flakes, typical borers, notches, and atypical end-scrapers. Many of these can easily be seen as implements for sawing, fine scraping, and planing. Bordes (1962:47) has suggested that Denticulate Mousterian might be associated with the processing of plant material, a suggestion which is borne out by our analysis.

Comparison of Factors III and IV shows a pattern of greater exclusiveness of function for the two factors; nevertheless, there is common determinancy exhibited with respect to notches, denticulates, and scrapers with abrupt retouch. If Factor III represents food processing as we have suggested above, we might see in these tools common functions in preparing plants and possibly scraping bones.

FACTOR V

The variables are arranged in descending order of determinancy by Factor V in Table VI; the first six variables in the list are the diagnostics for this factor. The cumulative percentages of types when Factor V determines the assemblage can be seen in Figure 2; the curve closely resembles that for Ferrassie Mousterian, according to Bordes' system (1953b).

Comparison between Factor V and the other factors on a Cartesian graph yields the following results. Factors IV and V when when paired exhibit mutual exlusiveness of the two activities represented (Pattern D, Figure 1). When Factor IV is plotted against Factors I and III, a distribution like that in Pattern A (Figure 1) is obtained, suggesting distinct activities with minor overlap of the kinds of tools used in both. In the comparison with Factor I, simple straight scrapers and typical burins are shared; in the case of Factor III, the tools shared with Factor IV are simple straight scrapers, scrapers with retouch on the ventral surface, and utilized blades. In both instances, cutting and scraping tasks appear to be involved.

The most instructive comparison, however, is that between Factor II and Factor V (Figure 4), where the pattern closely resembles that of Pattern C (Figure 1). This configuration would be expected if there were represented two very similar activities, one being more complex in terms of tool differentiation. In Figure 4 the majority of the variables are aligned along the diagonal, indicating that most of the implements were being employed in the same way. However, in the diagnostic cluster for Factor II there are artifacts that have no functional counterparts in the diagnostics of Factor V. These tools are various scrapers—convergent, double, simple straight, and convex forms. This distribution suggests the presence of component tasks as part of the activities repre-

TABLE VI. LIST OF VARIABLES ARRANGED ACCORDING TO A DESCENDING ORDER OF FACTOR LOADING—FACTOR V

Number in Bordes' List	Variable Name	Factor Loading	Percentage in Bordes' Essential Graph
7	Elongated Mousterian point	*.869	7.29
—	Disc	*.749	—
25	Scraper with retouch on ventral surface	*.744	4.64
32	Typical burin	*.569	14.67
—	Unretouched blade	*.517	—
9	Simple straight scrapers	*.461	19.41
10	Simple convex scrapers	.368	17.48
33	Atypical burin	.339	8.27
56	Rabot	.293	.39
12–17	Double scrapers	.241	5.62
22–24	Transverse scrapers	.217	.94
18–20	Convergent scrapers	.205	3.45
30	Typical end-scrapers	.204	1.38
5	Pseudo-Levallois point	.166	1.53
1	Typical Levallois flake	.164	—
36	Typical backed knife	.142	.66
3	Levallois point	.129	—
26	Scraper with abrupt retouch	.111	.21
54	End-notched piece	.102	.61
39	Raclette	.096	.68
4	Retouched Levallois point	.084	1.48
11	Simple concave scrapers	.082	1.02
—	Waste flake	.077	—
62	Miscellaneous tools	.073	3.50
2	Atypical Levallois points	.072	—
43	Denticulate	.057	5.88
50	Bifacially retouched piece	.052	—
31	Atypical end-scraper	.037	.40
40	Truncated flake	.021	.46
—	Unretouched flake	.009	—
35	Atypical borer	−.007	0.00
37	Atypical backed knife	−.012	0.00
48–49	Utilized flakes	−.026	0.00
45	Ventrally retouched piece	−.051	0.00
44	Bec	−.059	0.00
6	Mousterian point	−.084	0.00
61	Chopping tool	−.102	0.00
42	Notch	−.128	0.00
38	Naturally backed knife	−.237	0.00
34	Typical borer	−.290	0.00

* Indicates that the variable exhibits the highest factor loadings with respect to this factor and can be considered diagnostic of the factor.

sented by Factor II which do not characterize those of Factor V. Points and cutting-scraping tools are diagnostic for both factors, leading us to conclude that both Factors II and V are related to hunting and butchering.

The functional analogy between Factors II and V together with the greater

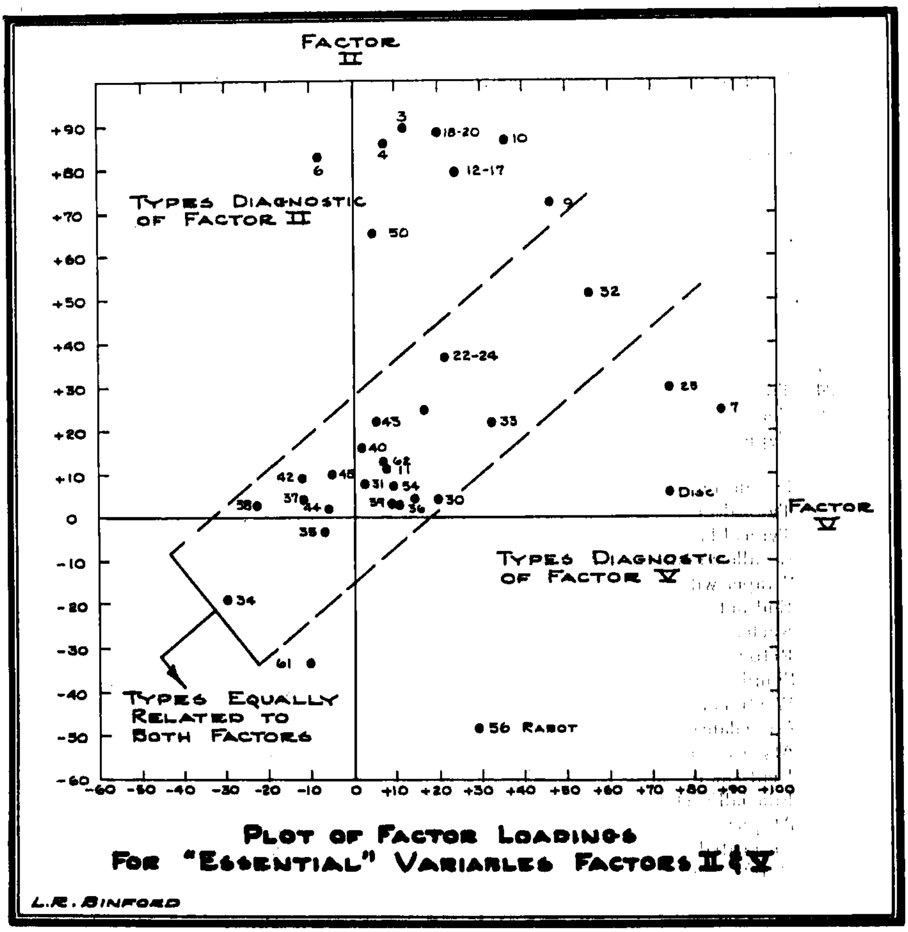

FIG. 4

complexity in the diagnostics for Factor II, suggest several interpretive questions. Does this situation represent:

(a) change through time in hunting activities?
(b) differentiation of hunting methods in terms of kinds of game exploited by contemporaneous groups?
(c) regional variability in hunting practices?
(d) increasing specialization of tools in performing essentially the same tasks?

TABLE VII. SUMMARY OF FACTORS

Factor Number	Diagnostic Variables	Suggested Activity	Type of Activity	Analogy to Bordes' Types
I	Typical borer Atypical borer Bec Atypical burin Typical end-scraper Truncated flake Notches Miscellaneous tools Simple concave scraper Ventrally retouched piece Naturally backed knife	Manufacture of toolsfrom non-flint materials	Maintenance tasks	Typical Mousterian (concave graph)
II	Levallois point Retouched Levallois point Mousterian point Convergent scrapers Double scrapers Simple convex scrapers Simple straight scrapers Bifacially retouched piece Typical Levallois flake Unretouched blade	Killing and Butchering	Extractive tasks	Ferrassie (convex graph)
III	Typical backed knife Atypical backed knife Naturally backed knife End-notched piece Typical Levallois flake Atypical Levallois flake Unretouched flake	Cutting and incising (food processing)	Maintenance tasks	Mousterian of AcheulianTradition (concave graph)
IV	Utilized flakes Scrapers with abrupt retouch Raclettes Denticulates	Shredding and cutting (of plant materials?)	Extractive tasks	Denticulate (concave graph)
V	Elongated Mousterian point Simple straight scrapers Unretouched blade Scraper with retouch on ventral surface Typical burin Disc	Killing and butchering	Extractive tasks	Ferrassie (convex graph)

These questions can be answered only by analyzing the temporal and spatial correlates of the materials at the sites; such an analysis is attempted in the following section.

REDESIGN OF THE CUMULATIVE GRAPH IN LIGHT OF THE FACTOR ANALYSIS

Five groups of artifacts have been isolated that differ in the determinant of the relative percentages of artifacts occurring with each group. We wished to present this information in graphic form, along with information pertaining to the percentages of individual tool types in each assemblage sample. The artifacts most diagnostic of each factor were grouped and arranged in a descending order of relative frequency in the population studied. A curvilinear plot was then drawn which, when placed in series with the other factor diagnostics, has five different steps or plateaus, corresponding to the five factors. In designing the arrangement of factor groups on the horizontal coordinate, those factors sharing the greatest number of artifact forms were placed next to each other, while the most discrete factors were separated.

The cumulative percentage graph presented here (Figure 5) also differs from the conventional Bordean graph in that several artifact forms omitted from Bordes' "essential" counts have been included—Levallois points, ventrally retouched pieces, and bifacially retouched pieces. We have included them since in our analysis they showed regular modes of variation and because they are highly diagnostic of some factors.

Artifacts not included in the graph but included in the study are: typical and atypical Levallois flakes, utilized flakes, unretouched flakes and blades, and waste flakes. These seem to be associated with flint-working, a discussion of which follows in the next section.

Table VIII shows the proposed arrangement of the artifacts for Figure 5 and provides the expected percentages of each factor block of artifacts if a single factor were the only determinant of the composition of an assemblage. In addition, the expected percentages of the "nonessential" artifact classes are given, together with the expected ratios of essential to "nonessential" artifacts.

The general order of artifacts in Figure 5 is the reverse of that in a normal Bordean graph; scrapers and points are at the end of the type list rather than at the beginning. The result of this reversal is that curves that are concave in Bordes' system will, in this arrangement, generally be convex.

Inspection of the graphs in Figure 5 shows that there are three types of graph: first, that represented by Factors II and V which yield a concave curve; second, Factors I and III, which form a low-stepped convex curve; and third, the high-stepped convex curve of Factor IV. The relationships between the factors can be seen in Figure 6, where the percentages of the total assemblage contributed by the diagnostics for each factor are presented. It is evident from Figure 6 that Factors I and III represent very similar assemblages which differ in detail rather than in the general class of artifacts represented.

TABLE VIII. EXPECTED PERCENTAGES FOR VARIABLES INCLUDED IN THIS STUDY ARRANGED ACCORDING TO THE REVISED ORDERING OF TYPES SUGGESTED BY THE FACTOR ANALYSIS

Factor	No. in Bordes' List	Variable Name	IV %	I %	III %	V %	II %
I. *Essential Graph*							
	43	Denticulate	43.28	16.69	12.75	4.98	7.03
	5	Pseudo-Levallois Point	1.79	.82	.98	1.29	.69
IV	39	Raclette	3.81	.00	.00	.57	.06
	26	Scraper-abrupt retouch	.89	.00	.39	.17	.01
	42	Notches	13.65	14.32	17.63	.00	1.87
	62	Misc. Tools	1.23	11.33	12.50	2.96	1.95
	38	Naturally backed knife	.00	8.97	13.95	.00	.48
	45	Ventrally retouched piece	.00	7.25	7.53	.00	1.00
	33	Atypical burin	.00	5.50	.00	7.01	1.66
	40	Truncated flake	6.24	4.76	.00	.38	1.07
I	11	Simple concave scraper	.00	3.02	2.13	.86	.42
	31	Atypical end-scraper	1.64	2.48	1.40	.35	.65
	30	Typical end-scraper	.00	1.65	.76	1.16	.09
	44	Bec	.00	1.51	.13	.00	.04
	22–24	Transverse scrapers	.60	.66	.89	.79	.49
	35	Atypical borer	.00	1.02	.10	.00	.00
	34	Typical borer	.43	.39	.00	.00	.00
	61	Chopping tool	.00	.03	.00	.00	.00
	37	Atypical backed knife	.20	.08	4.51	.00	.13
III	54	End-notched piece	.42	1.09	2.10	.51	.12
	36	Typical backed knife	.32	.28	2.16	.55	.05
	32	Typical burin	3.53	3.41	.00	12.42	4.04
	7	Elongated Mousterian point	.00	.17	1.09	6.18	.77
V	—	Disc	.27	.00	.00	4.63	.13
	25	Scraper with ventral retouch	.00	.00	1.18	3.93	.57
	56	Rabot	.00	.01	.00	.33	.00
	3	Levallois point	12.46	.00	8.11	10.48	25.92
	10	Simple convex scraper	5.47	5.61	.00	14.80	23.69
	9	Simple straight scraper	.45	4.76	6.10	16.44	9.17
II	12–17	Double scrapers	.00	3.31	.87	4.76	5.63
	4	Retouched Levallois point	3.11	.00	2.09	1.25	4.57
	18–20	Convergent scrapers	.00	.00	.00	2.92	4.50
	6	Mousterian point	.00	.28	.54	.00	2.57
	50	Bifacially retouched piece	.21	.55	.00	.14	.64
Total			99.99	99.99	99.99	99.99	99.99
II. *"Nonessential" percentages*							
	2	Atypical Levallois flake	9.19	28.66	20.82	14.50	16.70
	1	Typical Levallois flake	1.04	10.63	20.79	29.09	22.02
	48–49	Utilized flake	39.83	13.42	1.07	0.00	.69
	—	Unretouched flakes	42.21	44.92	48.49	4.00	48.55
	—	Waste flakes	0.00	1.83	1.59	7.42	0.00
	—	Unretouched blades	7.72	.51	7.20	44.98	12.02
III. *Ratios of essential to "nonessential"*							
		Percentage of total-essential	27.29	30.78	15.14	40.36	30.67
		Percentage of total-nonessential	72.71	69.22	84.86	59.64	69.33
		Index of Essential/nonessential	.37	.44	.18	.69	.44

We have suggested that these two factors are related to maintenance activities conducted in a relatively permanent location—activities involving the preparation of food and the manufacture of tools for the processing of nonflint raw materials.

Factor IV diagnostic artifact percentages are higher in Factors I and III than in Factors II and V. The frequency of Factor I diagnostics is higher in Factor IV than in Factors II or V (see Figure 6). This pattern suggests that

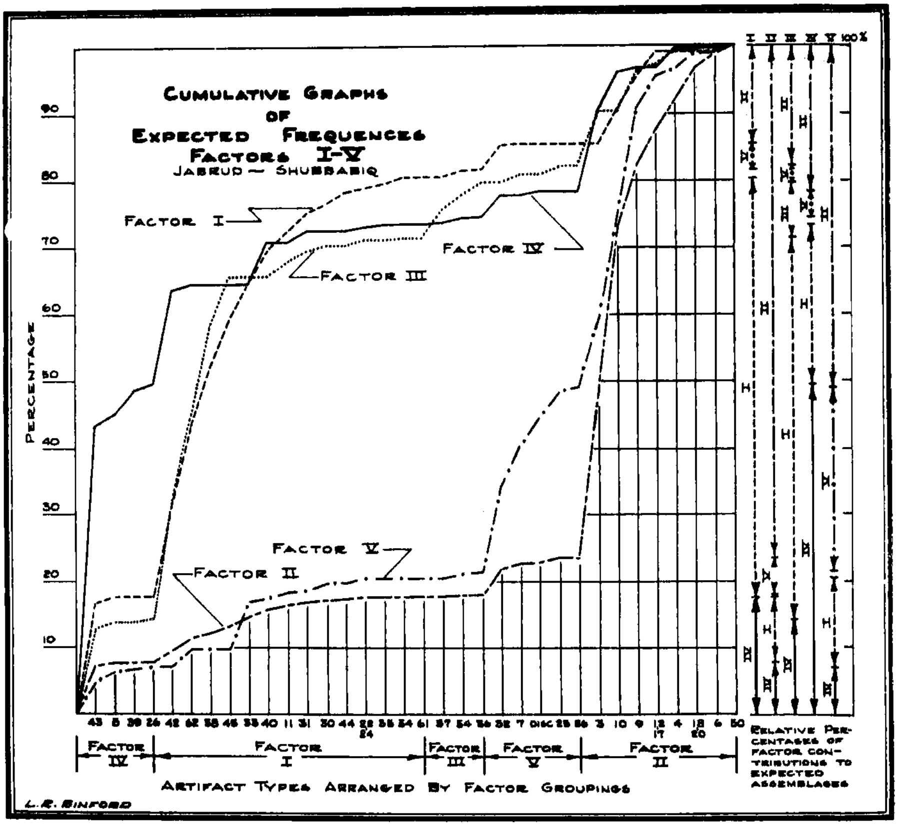

FIG. 5

the activities represented by Factor IV are related more to Factors I and III than they are to Factors II and V. Nevertheless, Factor IV exhibits a higher frequency of Factor II diagnostics than does Factor I or III, suggesting a minor overlap of activities not appearing in Factors I and III.

If we are correct in inferring that Factor IV represents the procurement and processing of plant products, then it, along with Factors II and V, can be said to have a primary extractive function. On the other hand, if such activities were conducted by women, on the assumption of a primary division of labor by sex, then the correlations with Factors I and III (the maintenance factors) is

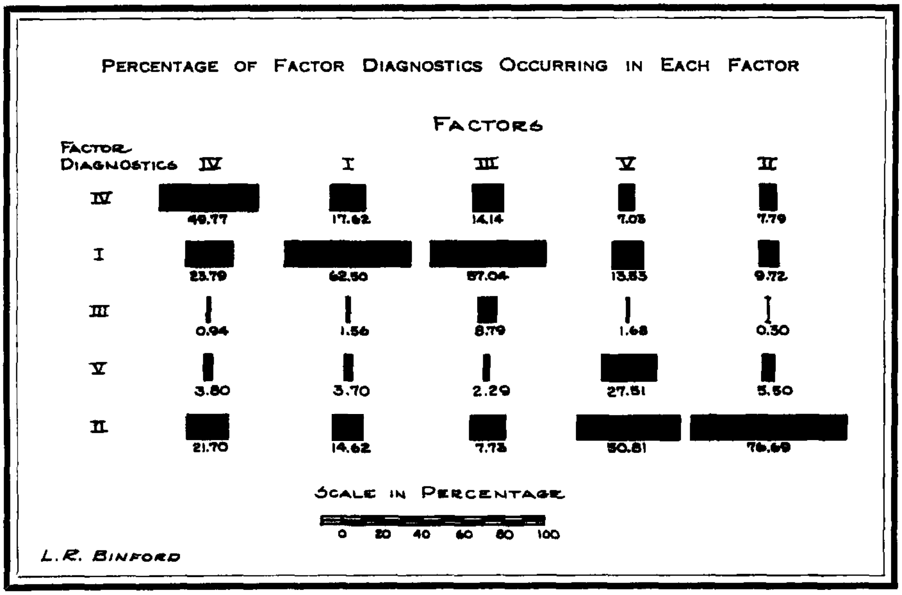

Fig. 6

not surprising. The division of labor would have involved women preparing food and working in the immediate area of the settlement, while the men hunted at more distant locations and did not engage much in the gathering and processing of plant materials. If we could isolate variability in Mousterian assemblages that reflected a basic sexual division of labor, we would have a powerful tool for considering problems of marriage and residence patterns (for example, see Longacre 1963).

Another major point to be noted in Figure 5 is that none of the curves describes a "diagonal" pattern (this is also true of Figure 2). The "diagonal" form of cumulative graph is characteristic of assemblages classified by Bordes as Typical Mousterian. None of the factors is identifiable as Typical, suggesting that these assemblages may possibly be composed of tool kits (factors) which separately would describe convex and concave curves; their combined result would be a "diagonal" graph. This point will be treated more fully in the section dealing with the analysis of site samples.

FLINT-WORKING

Artifact forms not included in Bordes' essential graph and believed to be associated with flint-working are of five general classes:

(1) pieces made by Levallois technique, believed to represent blanks intended for eventual modification or use as tools (typical and atypical Levallois flakes);

(2) pieces made by non-Levallois technique which probably also represent blanks (unretouched flakes and blades);

(3) cores, or prepared forms from which blanks and incidental biproducts were derived;
(4) waste flakes, or those biproducts believed to be primarily derived from shaping cores;
(5) utilized flakes.

Members of the last group were excluded from the essential graph because they are not diagnostic and because their quantity is such that they tend to distort the graph. All of the other groups were included in the factor analysis (see Table VIII) with the exception of cores, which were excluded because of possible typological inconsistencies. The data on cores from Jabrud were obtained from Rust's report, while those from Shubbabiq were typed by the junior author under Bordes' direction.

TABLE IX

Factors	Expected Ratios					
	(1) C/LB	(2) C/Bi	(3) C/T	(4) LB/T	(5) LB/Bi	(6) Bi-non LB/T
I	?	?	?	.88	.86	1.02
II	?	?	?	.87	.63	1.04
III	?	?	?	2.33	.74	3.12
IV	?	?	?	.28	.21	1.32
V	?	?	?	.64	.89	.72

The internal variability of groups of artifacts that we believe to be associated with flint-working is quite probably different from the variability discernible in the factors clusters. The latter represent, in our opinion, unit activities, and their determinants are of a different order than those that condition flint-working, which cannot really be thought of as a unit activity. What is suggested by our study is that flint-working was broadly related to the logistics of tool production; the conditions affecting the presence or absence of flint-working may be generalized as follows:

(1) location and disposition of available raw material;
(2) location and spatial distribution of loci of tool use;
(3) the necessity of transporting products of flint-working from locations of manufacture to locations where they will be used.

The combination of these conditions may vary greatly at any given habitation site and in conjunction with activities related to group maintenance or extraction of subsistence products. Thus we envision flint-working as a series of production steps which may or may not be carried out at a single location. For this reason the biproducts of flint-working vary more in terms of the five factors than they do mutually (see Table VIII).

Since we are interested in flint-working as an index of economizing behavior and as a clue to site utilization on the part of Neanderthal populations, the "nonessential" artifacts have been analyzed by means of ratios which hopefully inform about the degree to which several independent phases of tool production were executed at a single location.

Table IX presents the expected ratios for the following pairs of items:

(1) *Ratio of cores to Levallois blanks:* This is obtained by dividing the total number of cores by the total number of Levallois blanks (typical and atypical Levallois flakes).

(2) *Ratio of cores to non-Levallois blanks and/or biproducts:* This is obtained by dividing the total number of cores by the combined counts for unretouched flakes and blades. In assemblages of Levallois facies, this ratio is probably primarily a measure of the amount of core preparation, independent of the degree to which Levallois blanks were removed from the site (see Bordes 1953b:478–479). In non-Levallois assemblages, this ratio probably more closely approximates the ratio of blanks to cores.

(3) *Ratio of cores to finished tools:* This is obtained by dividing the total number of cores by the total number of tools in the "essential" category. A low value indicates that activities other than flint-working were dominant; a high value signifies that the knapping of cores was a major activity.

(4) *Ratio of Levallois blanks to tools:* This value is obtained by dividing the sum of typical and atypical Levallois flakes by the sum of the tools in the "essential" category. A low value would reflect a primary emphasis on tool use as opposed to tool production. This situation could result from either the modification on the site of blanks into tools (resulting in there being more tools than blanks), or the removal of blanks from the site for subsequent modification elsewhere. A high value signifies either on-the-spot production of Levallois blanks or their introduction into the site from another flint-working locality.

Another useful element to measure the degree to which blanks were modified into tools in any given site would be the relative quantity of secondary and tertiary chipping debris. This element was not included in our study since we had no way of knowing how much of this class of material was kept at Jabrud.

(5) *Ratio of Levallois blanks to biproducts of core modification:* This ratio is particularly important in assemblages of Levallois facies. It is obtained by dividing the sum of typical and atypical Levallois flakes by the sum of unretouched non-Levallois flakes and blades. This ratio should

measure the degree to which cores were being worked on the location for the production of Levallois blanks. A low value would indicate that Levallois blanks were being produced on-the-spot; a high ratio would mean that blanks produced elsewhere were introduced into the site.

(6) *Ratio of non-Levallois blanks and/or core biproducts to tools:* This ratio is obtained by dividing the sum of unretouched flakes and blades by the sum of tools in the "essential" group. A low value would indicate that the use of already manufactured tools dominated the activities at the site, to the general exclusion of the production of Levallois blanks from cores. This interpretation is predicated on the relatively high frequency of Levallois over non-Levallois cores. Where non-Levallois cores are much more numerous, the production of non-Levallois blanks might as easily be inferred. A high ratio value would suggest that on-the-spot processing and production of both Levallois and non-Levallois blanks from cores was a major activity.

Table IX presents the expected values of the ratios for assemblages that were determined solely by the activities indicated by the five recognized factors.

Inspection of Table IX reveals that there is a great difference between the factors with respect to flint working and its various phases. Factors I, II, and V are quite similar in the ratio of Levallois blanks to tools (ratio #4), suggesting that the Levallois technique was important in the production of tools used in all three sets of activities. Factor III is strikingly different in the very high value of ratio #4; this could indicate that the production of Levallois blanks was an important component of the activity we infer for Factor III. Factor IV is remarkably low in the value exhibited for ratio #4; this could mean either that Levallois technique was relatively unimportant in the production of tools utilized, or that the production of Levallois blanks was not a component of the activity represented by Factor IV.

With respect to ratio #5, Factor IV is again distinctive. The ratio has a very low value, suggesting that the manufacture of Levallois blanks was unimportant but that the working of cores was a major component. The other factors are fairly similar in the proportion of Levallois blanks to unretouched flakes and blades.

Ratio #6 shows that Factors I, II, and IV are similar in the frequencies of non-Levallois blanks and/or flint-working biproducts as compared to tools. Factor II has a high ratio value, indicating that flint-working (as opposed to tool use) was probably a major component of the activities. On the other hand, the low value of the ratio in Factor V suggests that flint-working was not generally associated with the activities defined by that factor.

ANALYSIS OF SITES AND SITE SAMPLES

Five factors have been recognized, each of which represents a different set of conditions which determined the mutual frequency variation of the variables included in the study. Comparisons were made between the factors in terms of:

(a) the configuration of mutual co-variation between the variables;

(b) the general appearance of a factor when expressed in terms of the expected percentages for an assemblage inventory;

(c) the pattern of distribution of determinancy among the variables when two factors were compared.

Functional interpretations of the factors were based on tool morphology and on the similarities in levels of mutual determinancy for classes of artifacts. Two kinds of interpretations were made: first, the kinds of activities inferred for each factor; second, the social context in which the suggested activities would be most likely to have occurred.

The following expansion of the interpretive framework is formulated to aid in the development of an explanatory model for understanding the observed variation. We are restating, and in some cases slightly modifying, the useful material presented by Phillip Wagner in *The Human Use of the Earth* (1960).

All known groups of hunters and gatherers live in societies composed of local groups, regardless of the way they may be internally organized (Steward 1955, Service 1962). The local group is invariably partitioned into subgroups which function to carry out different tasks. Sex and age criteria frequently are the basis for the partitioning of the local group, with subunits generally composed of individuals of the same age or sex who cooperate in work forces. For example, young male adults often cooperate in hunting, while women may work together in gathering plant materials and preparing food.

At other times the group breaks up along different lines in order to form reproductive and/or residence units—i.e., family groups—which are, unlike the work groups, more permanent and self-sustaining.

Although we have no idea about the specific ways in which Neanderthal groups were socially partitioned and segmented, it is reasonable to assume that their societies were organized flexibly and included both work and family subgroups. If this assumption is granted, we would expect this organization to be reflected in the variability both between assemblages at a given site and between different sites.

Geographical or spatial variability would be expected since the total sum of activities engaged in by a given society is not conducted at a single location. This is the result of differential distribution in the environment of game, plant material, appropriate living space, and raw materials for tool manufacture. We would anticipate that certain locations in the territory of a society would be occupied for the performance of certain tasks, while other tasks would be carried out in other parts of the territory. Spatial variability would also be affected by the kinds of organizational principles outlined above. For example, one site might be a favorable hunting location where groups of young males killed and partially butchered animals before returning to the site where the local group was living. Another site might have been used by a group of females while gathering and partially processing plant materials while away from the location where the larger group was "housed."

Thus, we might generalize that the composition of archeological assemblages from various locations will be determined by: (a) the kinds of tasks performed, and (b) the size and composition of the social unit performing the tasks.

The form of the archeological remains of a stable society might vary temporally for several reasons. Differential availability of plant and animal resources in the annual climatic cycle is primary and results from the correlated reproductive cycle of the plants and animals themselves. In addition, the society itself varies throughout the course of an annual cycle and goes through a number of *structural poses* (see Gearing 1962). The ways in which various members of a society are organized and how they cooperate at different times of the year vary with the characteristics of activities performed at different times of the year. Other considerations which modify the group's behavior during a yearly cycle concern the integrative problems the society must solve as a result of maturation of the young, death of members, relations with other groups, etc.

Temporal variation (within an annual cycle) within the archeological remains of a stable society is determined by: (a) the kinds of tasks performed, and (b) the size and composition of the social units performing the tasks.

In addition to the factors discussed above which can affect the spatial and temporal variability of archeological assemblages, there exist other determinants which profoundly modify site utilization. The kinds of locations utilized for different activities and the way these specialized locations are related are referred to respectively as *settlement type* and *settlement system.* (An excellent example of these concepts as applied to the data of North American prehistory can be found in H. D. Winters' *Survey of the Wabash Valley* [1963]).

For technologically simple societies we can distinguish between two broad classes of activities: extraction and maintenance. Extractive activities are those that center around the direct procurement of subsistence items or of raw materials to be used in the manufacture of artifacts. Maintenance activities are related to the preparation and distribution of subsistence goods already on hand and to the processing of on-hand raw materials in the production of tools. The distribution of resources in the environment bears no necessary relation to the distribution of locations affording adequate life-space and protection, and we would therefore expect differential distribution in the territory of a group of locations for extractive and maintenance activities. We would expect there to be *base camps* selected primarily in terms of adequate life-space, protection from the elements, and central location with respect to the distribution of resources. The archeological assemblages of base camps should reflect maintenance tasks—the preparation and consumption of food as well as the manufacture of tools for use in other locations.

Another settlement type would be a *work camp*, a location occupied while subgroups were carrying out extractive tasks—e.g., kill sites, collection stations, and quarries for usable flint. In these locations we would expect the archeological assemblages to be dominated by the tools used in the specific extractive tasks. The degree to which maintenance activities may be represented at work camps would be a direct function of the length of time a given social unit was there and of the size of that unit.

The way in which these two general classes of camps are utilized by a single society defines the settlement system. In the settlement system of hunters and gatherers who are relatively sedentary, base camps would exhibit little discrete seasonal variability since we would expect them to have been occupied for a longer period and over a greater span of the seasonal cycle. If, on the other hand, the society went through a sequence of structural poses common to many hunters and gathers—i.e., living in relatively large aggregates part of the year and dispersing into smaller familial units during other parts of the year—we might expect to find more than one type of base camp for a given society, and these types should exhibit some seasonal correlates.

We would anticipate a greater variety in the types of work camps of a given society since each location would have been occupied for a shorter time, and the activities conducted there would have been more specifically correlated with the kinds of resources being exploited. Further variability in the composition of work camp assemblages would be related to the degree to which resources exploited there could be transported. For example, in the case of the killing of very large mammals or the successful hunting of large numbers of animals, the local group might come to the kill site to partially consume and process the animals. In such a case we would expect to find large numbers of artifacts related to processing and consumption at the work camp, although the variety of tasks represented would be less than would be associated with a base camp.

We might also suggest that the degree to which maintenance tasks are represented at work camps will be directly related to the distance between the work and base camps. If the work camp and the base camp are close together, we would not normally expect to find evidence of maintenance activities at the work camp. However, as the distance between the work and base camp increases, an increase in maintenance activities could be anticipated in the work camp assemblages.

This consideration of the mobility of groups and their travel through the territory leads us to suggest another type of settlement we might expect to find: the *transient camp*. At such a location we would have the remains of the minimal maintenance activities of a travelling group, possibly representing no more than an overnight stay.

We have discussed certain minimal types of spatial and temporal variability which we might expect to occur in the archeological remains of a simple group of hunters and gatherers whose social organization was based on principles of internal partitioning and segmentation. These models, together with our postulates as to the functional significance of clusters of artifacts isolated by the factor analysis, led to our suggestions as to the possibility of relating types of activities to types of settlement. We turn now to the more specific discussion of the sites and assemblages in this study.

In our study there were three different sites from three different geographical regions. Two of these sites provide slightly different types of control with regard to variability within assemblages. Jabrud provides data on a sequence of occupations, while Shubbabiq provides data on a number of samples from what is believed to represent a single kind of occupation. By studying the patterns of variation between the samples from the three locations we hope to determine the following:

(1) Does the composition of assemblages from different occupations correspond to unit factors, or do they represent various combinations of factors?
(2) Do the types of Mousterian industries defined by Bordes always correspond to the same assemblage composition defined by factor analysis?
(3) Is there any regularity in the composition of assemblages at a given location which can be interpreted in terms of regular patterns of past human behavior?
(4) Is there directional change through time evidenced in assemblages from a single location which suggests evolutionary or situtational changes in human behavior?

These four questions will guide the analysis of the separate samples from the several sites.

In comparing the results from the several sites we hope to determine to what degree the assumptions and postulates set forth in the preceding arguments have been supported, and what testable hypotheses can be offered on the basis of our analysis and comparison.

JABRUD

The Jabrud shelters are located on the eastern edge of the anti-Lebanon range, near Damascus (Syria). Two of the shelters were excavated by Rust during the 1930's and reported several years later (Rust 1950). The samples included in this study are from the upper 2 meters of the deposits in Shelter I. This rockshelter is on the side of a small valley and at a considerable elevation above the valley floor; it is approximately 35 meters long and is oriented in a north-south direction, opening to the east. At the time of excavation, there was a heavy rockfall in the center of the shelter, leaving only the north and south ends available for entry. It could not be determined from Rust's report if the rockfall had been present during the full span of occupation of the shelter. However, Dr. Ralph Solecki's (1964) recent findings indicate that it was in fact present during the occupations represented in our samples and can therefore be taken as a boundary on the space available within the shelter.[3]

Rust's excavations exposed approximately 22.5 meters along the shelter wall, roughly centered with respect to the total length of the shelter. The excavation was, on the average, 3 meters wide. Judging from Rust's report, the excavated area would represent about half of the living space available in the shelter at the time of the occupations of Levels 2–8.

The artifactual remains were originally published by Rust (1950) and subsequently analyzed by Bordes (1955). Our study has made use of Bordes' analysis of the artifacts but also includes the totals for cores as reported by Rust.

LEVEL 8 (SHELTER I)

This level occurred between 1.5 and 1.7 meters below the surface, and was continuous over the entire portion of the excavated area. The recovered materials came from a matrix of approximately 13.5 cubic meters of deposit, and included 784 artifacts reported by Bordes plus 19 cores reported by Rust. This represents a density of 59.4 artifacts per cubic meter of matrix.

In the original report Rust (1950:49) interpreted the assemblage as a culture derived from a mixture or blending of Jabrudian and Acheulian, and he termed it "Upper Jabrudo-Mousterian." Bordes (1955:494) compared this level with Level 10 of the same shelter (not included in this study) and identified it as the Ferrassie type of Charentian Mousterian.

Figure 7 is a summary cumulative graph of Levels 2–8 with the artifacts arranged by factor groupings. Figure 8 is a cumulative graph of expected and observed frequencies for three levels of Shelter 1, with the expected frequencies based on varying assumptions about the composition of the assemblages. With respect to Level 8, the expected frequency curve is on the assumption that 33 per cent of the determinance of the assemblage was controlled by Factor I, and 67 per cent by Factor V. This assumption on the nature of the controlling determinants allows us to reproduce the observed frequencies with remarkable accuracy.

Thus, we interpret the assemblage from Level 8 as representing a combination of artifact groups utilized in two major activities: maintenance and secondary tool manufacture (Factor I) and rather specialized hunting and butchering (Factor V).

Inspection of the ratios of "nonessential" artifacts shows that, while the correspondences between observed and expected frequencies in the essential category are very close, they are much less so in this case. It appears that the discrepancies are primarily a function of the amount of flint-working as compared to other activities.

The lowest ratio values of any level studied from Jabrud were with the first three ratios (see Table X), suggesting that cores were relatively rare and that, once introduced, they were reduced to blanks and waste. Such an interpretation is supported by ratios #4 and #5. The expected index for the essential to non-essential components of the assemblage is .60; the observed index is .44, indicating that flint-working was more frequently carried out than would have been predicted from the range of variation in the total population of artifacts.

We may conclude that Level 8 at Jabrud was an example of an occupation representing mainly hunting and butchering (extractive tasks) and secondarily flint-working. We suggest, in terms of our discussion of settlement types, that this is a *work camp*.

LEVEL 7 (SHELTER I)

This occupation occurred between 1.3 and 1.5 meters below the surface and was continuous over the entire excavated portion of the shelter. 774 artifacts

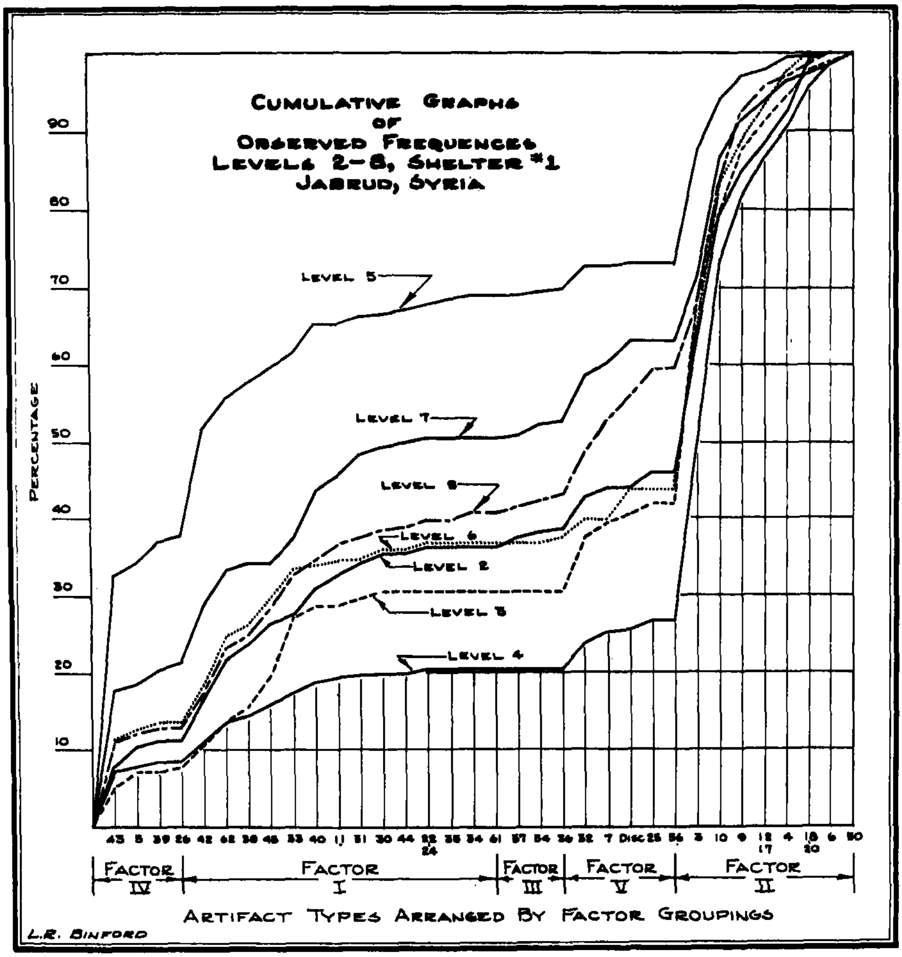

FIG. 7

were reported by Bordes (1955) and 64 cores by Rust (1950), representing a density of 62.1 artifacts per cubic meter of matrix. This is only slightly greater density than in Level 8. In his original analysis, Rust interpreted the Level 7 assemblage as being derived historically from the "pre-Aurignacian" but blended with the local Mousterian tradition of the region. The size of the implements is somewhat smaller than the average for the site; for this reason

Rust related this assemblage to that of Level 5 which also yielded some implements of reduced size. He therefore designated these materials "pre-micro-Mousterian."

Bordes (1955:494) comments that while the assemblage from Level 7 is

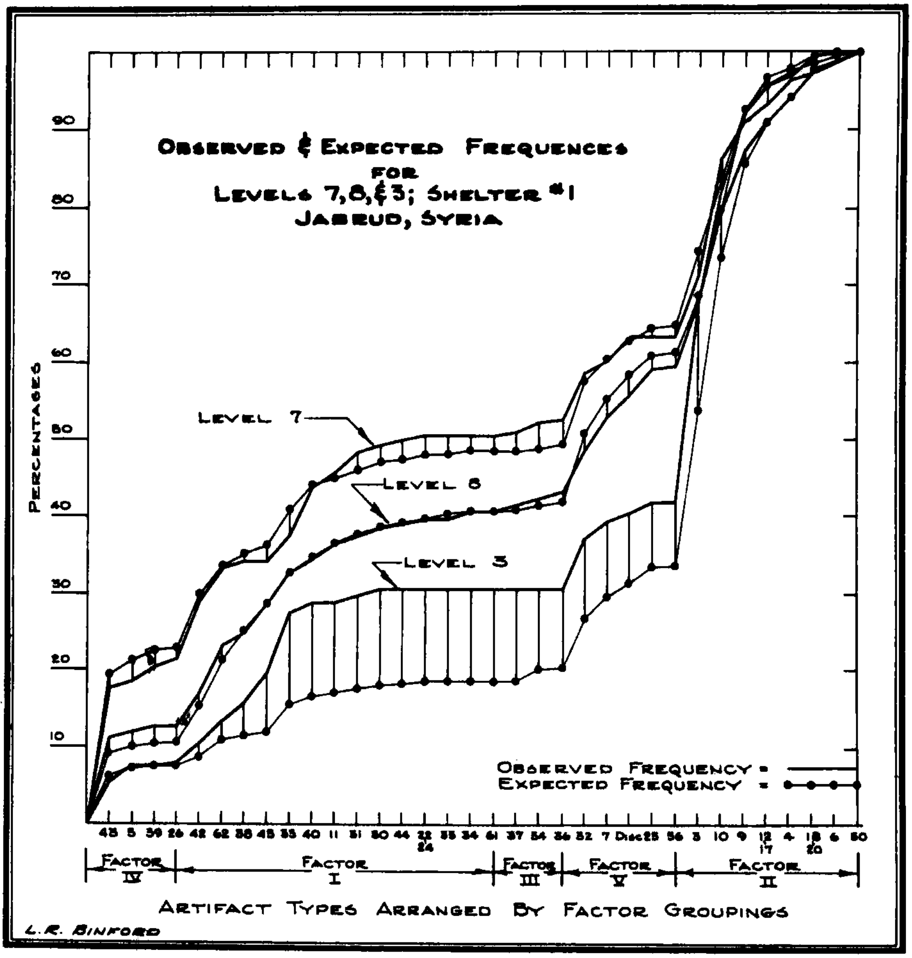

Fig. 8

identifiable as Typical Mousterian as known in France, that this sample contains more blades, burins, and denticulates than are normally found.

Of all the levels analyzed from Jabrud, our analysis indicates that this is the most complex. The cumulative graph for the assemblage can be duplicated only by postulating that three distinct factors determined the composition—50 per cent Factor V, 33 per cent Factor IV, and 17 per cent Factor I (see Figure 8). The fact that in combination the factors yield a graph identifiable as Typical Mousterian can be understood in terms of the individual graphs of each component factor. One half of the assemblage is determined by Factors I and IV together (convex graph) and the other half by Factor V (concave graph). When combined these yield a cumulative graph roughly halfway between the two, approximating a diagonal with, as Bordes noted, more denticulates, burins, and blades.

TABLE X. RATIOS

		(1) C/LB	(2) C/Bi	(3) C/T	(4) LB/T		(5) LB/Bi		(6) Bi/T		Ess/Non		Density / Cu M.
		Jabrud			o	e	o	e	o	e	o	e	
Levels	2	.21	.18	.21	1.02	*1.36*	*.87*	.66	1.17	*1.73*	*.43*	.35	52.7
	3	.29	.27	.25	*.87*	.73	*.93*	.78	*.93*	.85	.48	*.58*	93.0
	4	.18	.09	.11	.64	*.87*	.54	*.63*	*1.20*	1.04	*.50*	.44	149.9
	5	.82	.34	.41	.50	*.68*	*.41*	.32	1.22	*1.27*	.33	*.39*	511.0
	6	.20	.12	.17	*.83*	.70	*.62*	.59	*1.34*	1.01	.39	*.48*	44.2
	7	.39	.24	.28	*.73*	.56	.62	*.66*	*1.18*	.97	.41	*.54*	62.1
	8	.10	.08	.07	*.76*	.72	.76	*.88*	*1.00*	.82	.44	*.60*	59.4
		Shubbabig											
Units	100	.51	.31	.34	.81	*1.17*	.73	*.79*	1.11	*1.44*	*.42*	.39	•
	100A	1.01	1.15	.58	.57	*1.17*	*1.13*	.79	.50	*1.44*	*.79*	.39	•
	103–109	.37	.20	.27	*1.42*	1.17	*1.05*	.79	1.35	*1.44*	.32	*.39*	•
	113	1.14	.50	.37	.33	*1.17*	.44	*.79*	.74	*1.44*	*.75*	.39	•
	115–116	.65	.45	.47	*1.10*	1.09	*1.05*	.72	1.05	*1.38*	*.39*	.38	•
	117	1.04	2.08	.72	.70	*1.07*	*2.00*	.71	.34	*1.36*	*.76*	.38	•
	300–10	.42	.29	.39	1.00	*1.17*	.76	*.79*	1.31	*1.44*	.31	*.39*	•
	200–8	.28	.24	1.47	*4.95*	2.11	*.74*	.72	*6.00*	2.81	.05	*.21*	•
		Houppeville											
	1	.?	.?	.?	1.28	*1.71*	*.65*	.64	1.95	2.33	*.29*	.27	•

o=observed ratio.
e=expected ratio.

Factor V, accounting for half the assemblage, is interpreted as a specialized hunting and scraping factor. Contributing 17 per cent and 33 per cent respectively were activities believed to be related to the production of nonflint artifacts (Factor I) and to the as yet poorly understood activity represented by the denticulate factor (Factor IV), presumably related to scraping and shredding and to the procurement and processing of plant materials.

As was pointed out above, Level 7 (along with Level 5) is distinctive in the small size of some tools and in the raw material used for tool manufacture. Rust (1950:50) reported that the material used was a brown patinated flint available at the site but of poor quality. It is probably more than coincidence that both Levels 5 and 7 are distinctive in (a) the size of some tools, (b) the raw material used, and (c) the representation of the denticulate factor (Factor IV). We therefore suggest that the expedient use of relatively poor raw material in these levels is associated with Factor IV. We are *not* implying that the morphology and size of the artifacts were *determined* by the nature of the raw material, but that this particular raw material was expediently utilized for the manufacture of these implements.

Turning to the "nonessential" ratios, we note that this level is quite similar to Level 8 except that there are more cores and slightly greater number of core-working biproducts and/or non-Levallois blanks as compared to finished tools (see Table X).

We suggest that this level represents an occupation of the same general type we inferred for Level 8—a work camp specifically related to hunting tasks sufficiently distant from the base camp that tools for hunting were prepared here. In addition, in this assemblage there are represented the activities related to Factor IV, possibly the procurement and processing of plants.

If we wish to put ourselves further out on an interpretive limb, we might ask if the differences in raw materials and technique associated with Factor IV represent a basic sexual division of labor—with men making and using the hunting tools while women made and used the tools for processing plant materials.

Level 7 exemplifies one of the significant findings of our study. The assemblage was identified as Typical Mousterian by univariate statistical analysis, but multivariate analysis indicates that the assemblage might well be understood in terms of the operation of three distinct factors which, in combination, determine the form of the assemblage.

LEVEL 6 (SHELTER I)

This occupation occurred at between 1.00 m. and 1.20 m. below the surface and was continuous over the entire excavated portion of the shelter. The recovered artifacts were in a matrix of approximately 13.5 cubic meters of soil. A total of 570 artifacts are reported by Bordes (1955) plus 27 cores by Rust (1950), representing a density of 44.2 artifacts per cubic meter of matrix. This density is considerably lower than that calculated for Levels 7 and 8.

Rust (1950:53–54) described this assemblage as composed of unusually large implements that were strongly Levallois, and added that the raw materials were of high quality and available in adjacent valleys but not on the site itself.

In his analysis of the lithic materials Bordes (1955:494) found this assemblage comparable to those of Levels 8 and 10 (the latter not included in this study) and found it analagous to the Ferrassie type of Mousterian in France.

According to our analysis, this assemblage is the result of three determining factors, one of which (Factor V) also is related to the assemblage from Level 8. If we assume 60 per cent determinance by Factor II and 20 per cent each for Factors IV and V, the cumulative graph which results is almost identical to

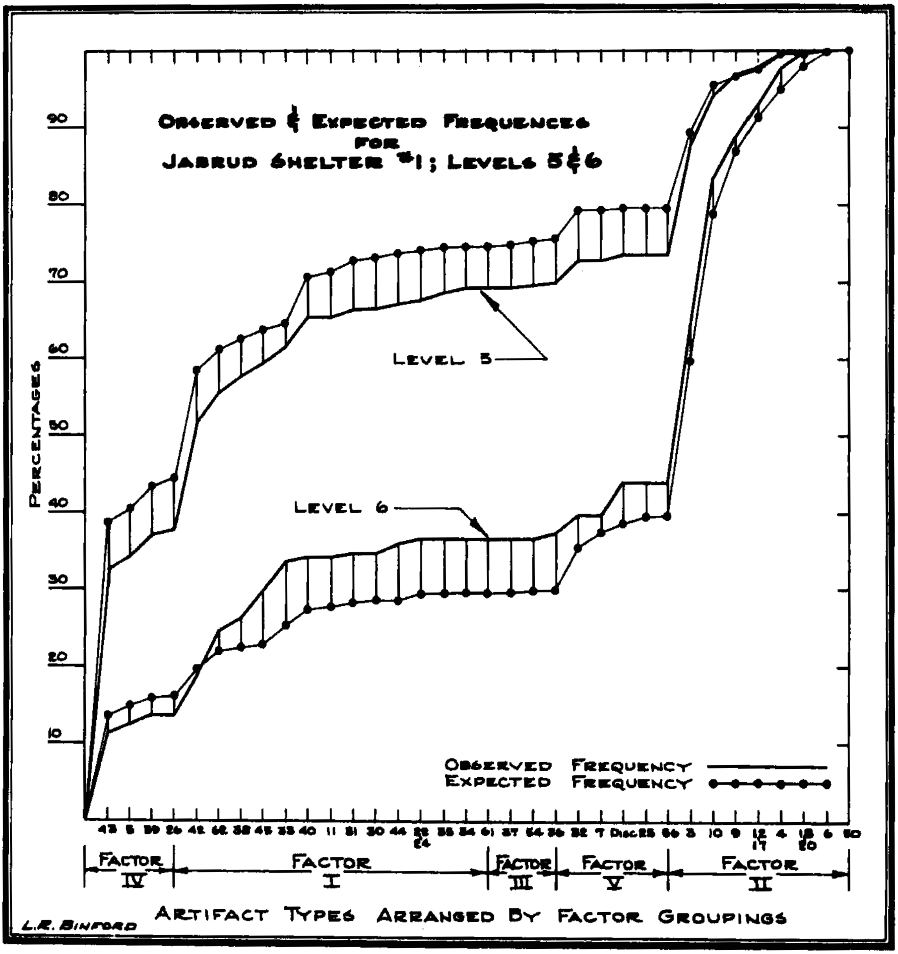

Fig. 9

that observed for Level 6 (see Figure 9). The differences between the observed and expected frequencies are in three types diagnostic of Factor I—miscellaneous tools (#62), naturally backed knives (#38), and ventrally retouched pieces (#45).

The three factors that determine this assemblage have been interpreted as representing hunting and butchering (Factors II and V) and possibly procurement and processing of plants (Factor IV). All of these factors are believed to be related to extractive tasks, and this assemblage does not reflect the maintenance tasks inferred for Levels 7 and 8.

Examination of the "nonessential" ratios shows that there is a lower relative frequency of cores than in Levels 7 and 8. For those ratios whose expected values could be calculated, the observed exceed the expected in all cases. This means that there were more Levallois blanks and biproducts and/or non-Levallois blanks than expected, and further, there were more Levallois blanks than non-Levallois blanks or biproducts. This suggests that Levallois blanks were introduced and that for the number of finished tools observed there was more evidence of flint-working than expected. This observation is also supported by the fact that the ratio of essential to nonessential classes of artifacts is lower than expected.

This situation might be interpreted as reflecting expediency in tool production because of either poor advanced preparation of tools or loss or discarding of tools at another location. In any event, the indications are that the flint-working was related to the production of tools used directly in the extractive tasks represented. Rust observed that the flint materials in this level were introduced into the site but that the material was available in neighboring valleys. This, taken together with the fact that the density of artifacts is lower for this level than for the two previously discussed, forms a picture of a small group of people primarily engaged in hunting and in making tools for the hunt. The absence of factors related to maintenance, together with the relatively low density of artifacts, suggests that the length of occupation was shorter than those in Levels 7 and 8.

LEVEL 5 (SHELTER I)

This occupation occurred between 0.8 and 1.0 meters below the surface. Unlike the other levels, this assemblage was concentrated in a very restricted area of not more than 10 square meters of horizontal distribution at the south end of the rockshelter (Rust 1950:54–56). Bordes (1955) reports 946 artifacts, and Rust's core count is 98, making a total of 1,044 artifacts in about 10 cubic meters. The density here is enormously higher than in any of the other levels—511 artifacts per cubic meter. This unique concentration makes comparisons with other levels very difficult. Taken together with the horizontal concentration, all we can say is that it represents exceedingly intensive use of a small area of the shelter.

Rust noted that this assemblage was quite distinctive in the small size of the implements, which averaged between 2 and 4 cms. in length. In addition, they were manufactured of the rather poor quality brown flint that we described for Level 7.

Rust termed this assemblage "micro-Mousterian." Bordes (1955:494–496, 1962:48) saw similarities between this assemblage and the Denticulate Mousterian of France.

We can best reproduce the observed frequencies of this assemblage on the assumption that its composition was determined by two factors—83 per cent by Factor IV and 17 per cent by Factor I (see Figure 9). In terms of activities, this would represent scraping and shredding possibly of plant material (Factor IV) and some secondary tool manufacture (Factor I).

Inspection of the "nonessential" artifacts (see Table X) shows that cores were common when compared to Levallois blanks (ratio #1) and that the ratio of tools to biproducts and/or non-Levallois blanks is high, suggesting an economical use of flint. This interpretation is supported by other ratios—those of tools to Levallois blanks (#4), of Levallois blanks to biproducts and/or non-Levallois blanks (#5), and of biproducts and/or non-Levallois blanks to tools (#6).

This occupation appears to represent a very short-term but intensive use of part of the shelter by a small group engaged in a restricted range of extractive activities, possibly the procurement and processing of plant materials. The economical and expedient use of local flint suggests a situation in which the group was apparently poorly equipped in advance. Because of the distinctive nature of the tasks represented by this assemblage and the use made of immediately available flint, we tentatively suggest that the composition of the social unit responsible for this assemblage might have been somewhat different from that of the groups occupying Levels 6 and 8.

LEVEL 4 (SHELTER I)

This occupation occurred between .6 and .7 meters below the surface and was presumably distributed over the entire excavated portion of the shelter with a slightly higher concentration in the south section (Rust 1950:61). The recovered artifacts came from a matrix of approximately 6.8 cubic meters of deposit. Bordes (1955) analyzed a total of 977 artifacts, and 36 cores were reported by Rust (1950), yielding a density of 148.9 artifacts per cubic meter, making the density in this level second only to that of Level 5.

Rust (1950:57) viewed this assemblage as representing a cultural break with preceding assemblages, noting that it was as a whole somewhat smaller. He suggested further that many of the points present were intended for further modification into more "specialized" tools. The raw material used was a fine quality flint available in the neighboring valleys and was introduced into the site.

Although our analysis does not make use of any of the specific data cited by Rust in support of his suggested cultural break, our results also indicate that Level 4 marks a general change in the nature of the occupations (see Figure 10).

Bordes (1955:496) sees likenesses between this assemblage and those of Levels 10, 8, and 6 but with a much greater number of side-scrapers. He adds that the assemblage resembles that from the site of La Ferrassie and Aïn Métherchem (Tunisia).

According to our analysis, this is the only one of the levels analyzed from Jabrud which can be accounted for by a single factor. On the assumption that Factor II determined the composition of the assemblage, there is a strong correspondence between the observed and expected frequencies (see Figure 10). This factor is believed to represent hunting and butchering.

In comparing the ratios of the "nonessential" artifacts, a basic difference is seen between this assemblage and the others previously discussed (see Table

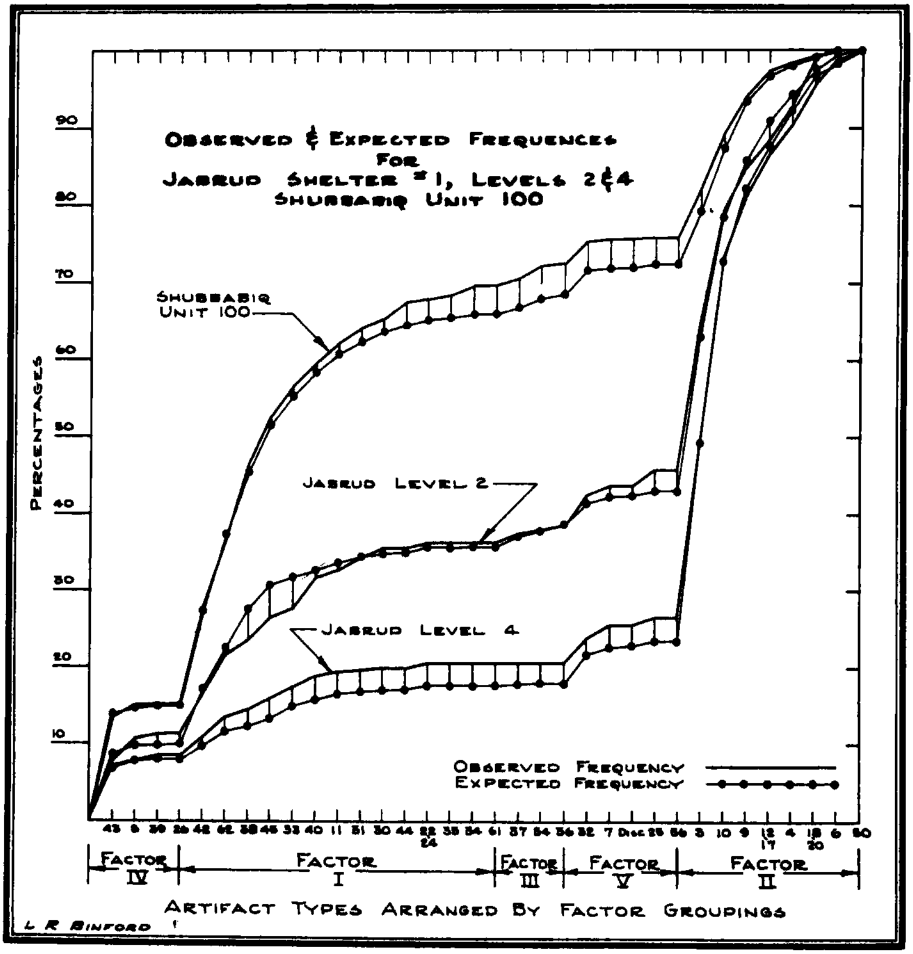

FIG. 10

X). In Levels 8 through 5 the observed ratios of essential to nonessential classes were less than expected, suggesting a greater amount of flint-working than expected, given the activities represented. The case in this level is the reverse—less evidence of flint-working than expected.

In addition, in both the ratios of Levallois blanks to tools (#4) and of Levallois blanks to biproducts and/or non-Levallois blanks (#5) the values are lower than expected, suggesting that Levallois blanks are being deleted from the assemblage, possibly lost at other locations or being taken away by the occupants. Another possible interpretation is that more of the Levallois blanks are being modified into tools.

On the other hand, the observed ratio of biproducts and/or non-Levallois blanks to tools (#6) is higher than expected. This lends support to the idea that tools were being removed from this site. The ratio of essential to nonessential components is greater than expected (*N.B.:* Levallois blanks are categorized here within the essential class), suggesting also that there are more tools than biproducts and/or non-Levallois blanks than could be expected for the inferred activity.

The picture from these varying lines of evidence is one of a relatively small group of well-equipped hunters (i.e., equipped with blanks for points and scrapers) occupying the site while carrying out a highly restricted range of extractive tasks (hunting and butchering of game). In addition, some tools were manufactured here which were either lost at other locations or carried away when the group moved on. This level is interpreted as a *work camp* of a more specific type than those represented in Levels 7 and 8 and functionally very different from those in Levels 5 and 6.

LEVEL 3 (SHELTER I)

This occupation occurred at a depth of .4 meters below the surface and was apparently more concentrated near the south end of the shelter (Rust 1950: 61). Although the exact depth of the layer is not clear from the report, we estimate that the density of artifacts was probably about 93 per cubic meter. Rust reports that the raw material was a low-grade reddish-brown transparent flint available in deposits in the plateau and around the site. Rust compares this assemblage with that of Level 4 but notes that the burins are larger and cruder (1950:59).

Bordes (1955:496) interprets the assemblage as belonging to the same series as those from Levels 10, 8, 6, and 4, exhibiting analogous typological and technical characteristics, despite the greatly higher burin count.

We were best able to reproduce the observed frequencies by assuming 40 per cent determination by Factor II and 60 per cent by Factor V (see Figure 8). Both of these factors are interpreted as representing hunting and butchering, with Factor II employing rather specialized tools. The discrepancies between observed and expected frequencies are associated with miscellaneous, naturally backed knives, ventrally retouched pieces, and atypical burins.

Inspection of the "nonessential" ratios (Table X) indicates that this level is similar to Levels 6 and 8 in that there is more flint-working present than would be expected for the activities. In addition, the greatest discrepancy between observed and expected ratios occurs in ratio #5, or in a higher frequency of Levallois blanks.

The density of the artifacts, their restricted distribution, the lack of maintenance activities all suggest a *work camp* occupation specifically concentrating on hunting and butchering.

LEVEL 2 (SHELTER I)

This level occurs between .2 and .3 meters below the surface at the south end of the shelter; however, it rises to the north end and has been partially eroded. This deposit is a breccia which can be traced by fragments adhering to the wall in the north end. Despite this lack of continuity, the artifacts were observed to be more concentrated in the northern portion of the shelter—a fact which distinguishes this level from the others studied.

Estimation of artifact density is difficult for this layer since no longitudinal sections were given by Rust; however, it seems likely that the density did not exceed 52.7 artifacts per cubic meter of matrix. This figure is most like those obtained for Levels 8 and 6, and these are the levels said by Rust to be most like this one. His comparison was based on the size of the artifacts, the presence of handaxes, and on the relatively large size of cores (1950:61).

Bordes (1955:496) finds strong similarities between this assemblage and that of Level 3, except for the reduced frequencies of burins and the presence of handaxes.

The best correspondence between observed and expected artifacts frequencies in the assemblages is obtained on the assumption that Factors II and III determine the composition, by 67 per cent and 33 per cent respectively (see Figure 10). We have suggested that these factors are associated with Ferrassie and Mousterian of Acheulian Tradition, and presumably the handaxes in this level are related to the latter. It should be noted that the discrepancy between the observed and expected graphs is due to the counts of naturally backed knives, ventrally retouched pieces, and atypical burins—types that behaved the same way in the assemblages from Levels 3, 5, and 6.

Factors II and III probably bear some functional relationship to one another, since the former is believed to be related to hunting and the latter to the preparation of meat. In the case of Factor III, the interpretation is supported by the occurrence of fire lenses in this layer, the only one in which Factor III plays a role.

In examining the "nonessential" component of the assemblage (Table X) we find that there were in general fewer Levallois blanks and biproducts and/or non-Levallois blanks than expected from the range of activities represented. Nevertheless, there are more Levallois blanks observed per tool than in any other level studied. This suggests that blanks might have been introduced into the site.

The presence of Factor III as a determinant singles this assemblage out as distinct from all the others. However, it is still identified as a work camp with primary emphasis on hunting with some consumption of game on the spot.

SUMMARY OF ANALYSIS: LEVELS 2–8

In our analysis we hoped to gain information on four questions posed above (see p. 270). We will therefore summarize the results in terms of these questions. (1) *Does the composition of the observed assemblages correspond to unit factors as isolated by the factor analysis?* We may answer this question in the negative.

Six of the seven levels analyzed were *compounds* of two or more factors; that is, the gross behavior represented by any given assemblage generally represents varying combinations of demonstrable subgroups of artifacts. This implies that we must be able to isolate the factors (subgroups of artifacts) in order to make regular inferences as to past behavior.

(2) *Do the types of Mousterian assemblages isolated by Bordes always correspond to the same combination of factors?* Once again, we may answer in the negative. Five assemblages classified as Ferrassie appear to be composed of different combinations of factors. Levels 3, 4, and 6 all have in common a dominance of Factor II or V as determinants along with an absence of Factors I or III. Although there is internal variability between these three assemblages, they all appear to be distinct from those of Levels 2 and 8 (also classified as Ferrassie). These latter two are alike in the presence of Factors I or III, which, as seen in Figure 6, are quite different from Factors II and V. Thus, we find that the five assemblages classified as Ferrassie display a considerable range of variability with respect to the groups of artifacts (factors) present in each, and that these five can be said to represent two generic types of assemblage on the basis of the presence or absence of Factors I or III.

With respect to Level 5 (classified as Denticulate) and Level 7 (classified as Typical), there is less variability in the factor contributions of these two assemblages than there is between the assemblages classified as Ferrassie. For example, Level 7 (classified as Denticulate) is more like Level 8 in factor determinants than Level 8 is like Level 2 (also classified as Ferrassie).

We therefore conclude that the use of multivariate analysis allows us to discriminate between assemblages which, with the use of univariate statistics, appear to be similar, as well as allowing us to recognize common factors in assemblages thought to be different. This should allow us to re-examine the problem of correlations between seasonal phenomena, types of game represented, and environmental variables and to formulate new hypotheses about past behavior.

(3) *Is there regularity in the composition and form of assemblages at a given location which can be interpreted in terms of regular patterns of past human behavior?* We may answer this question affirmatively. First, it should be noted that all the assemblages were dominated by Factors II, IV, or V, all of which have been interpreted as reflecting extractive activities. In only one case (Level 5) was Factor IV dominant, all the others being determined principally by Factors II or V, the hunting and butchering factors. We may therefore generalize that all seven levels studied reflect extractive tasks, principally hunting and butchering, and on this basis we interpret the occupations as representing work camps.

In addition to this overall regularity in site use, we would like to point out certain provocative patterns of association between factors. In levels where Factor IV is a major contributor (Levels 5 and 7) exploitation of similar raw material was observed. Immediately available flint was used, whereas in all the "hunting" levels flint was obtained from a broader geographical area. This observation coincides with that of Freeman (1964), who observed that in the northern Spanish Mousterian assemblages denticulates were characterized by an inordinately high frequency of medium grades of quartzite. Bordes (1962: 44) also notes that the workmanship in denticulate assemblages is "often mediocre." Our observations, taken in conjunction with those of Bordes and Freeman, suggest that there is something special about the raw materials and techniques employed for production of Factor IV diagnostics. There is apparently an expedient use of local material, as well as an areal limitation of the sources exploited. Could it be that what is being reflected is a primary difference in terms of social division of labor between males and females? The model we have in mind is that of women carrying out restricted tasks close to the site, making use of local flint sources, and making tools by slightly different techniques than did the men. The men, in this scheme of things, are envisioned as engaging in more far-ranging tasks like hunting, and working flint with techniques better suited to the production of points, scrapers, and knives.

Another regularity in these assemblages is the fact that in no case were Factors I and II observed to co-occur as determinants, whereas all other possible combinations of the factors were observed. When Factor I was present, Factors IV and/or V were associated. Keeping in mind that Factor I has been interpreted as representing maintenance activities, the following hypotheses are offered:

(a) Factor V represents a special kind of hunting of particular game which necessitates a longer stay away from the base camp, and hence more maintenance tasks in the work camp.
(b) The differences between Factors II and V reflect differences in the logistics of hunting—i.e., whether or not the game was butchered before returning to the base camp. Such an interpretation fits the major observable differences between Factors II and V but would not explain the association of Factors V and I, since it is Factor II which has the greater number of artifacts which can be inferred as butchering tools. We must, therefore, also assume that there were differences in the number of animals taken at one time. If they were being taken singly and were also small, we might anticipate the need for more maintenance activities to cover a longer period of hunting.
(c) The third alternative is that the sample from Jabrud is not representative of the kinds of sites included in the settlement systems of the late Typical Mousterian and that the failure to observe coincidence between Factors II and I is due to sampling error.

(4) *Is there regular change through time in the assemblages that might indicate either general evolutionary or specific situational changes in the activities of the occupants?* With a number of qualifications, we may answer this question in the affirmative. It has been demonstrated that Factor II tends to replace Factor V through the Jabrud sequence (see Figure 11). We may ask if this replacement of one hunting assemblage by another is a function of (a) general culture

change, or (b) a shift in the way this specific location was utilized through time. Since Factors II and V are differently related to Factor I, we tend to favor the latter interpretation. The total configuration of variability of the levels suggests essentially different types of occupations. Those of the lower levels are interpreted as work camps, some distance from the base camp of the local group, involving the exploitation of local resources. The occupations of the

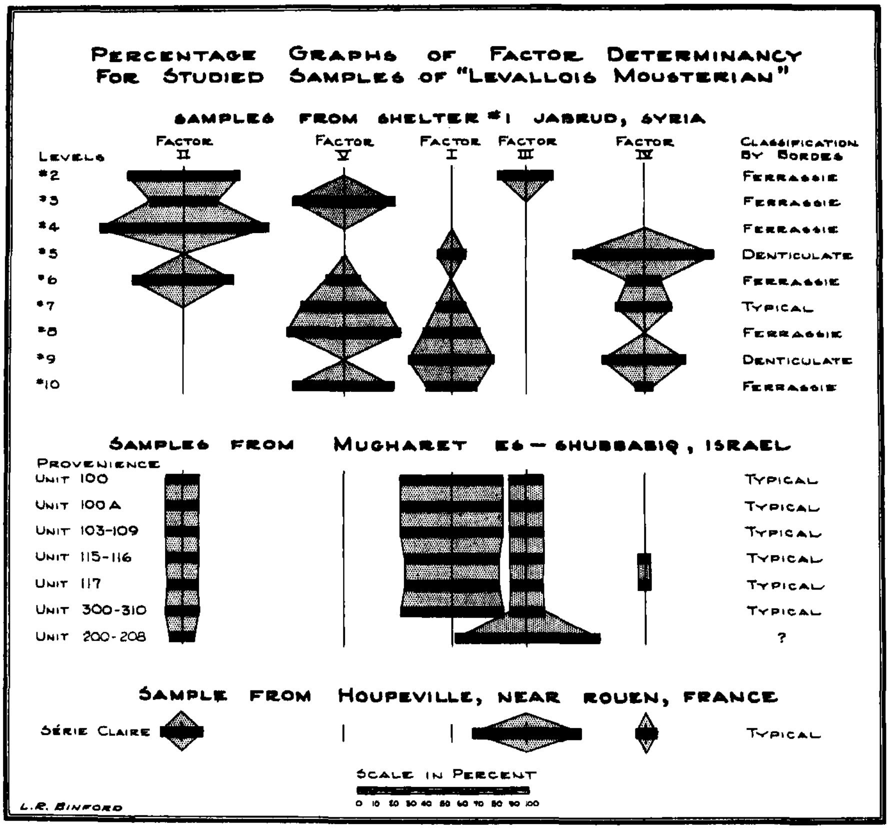

FIG. 11

upper levels, on the other hand, suggest more specific work groups occupying the shelter for shorter periods of time. These observations do not rule out the possibility of there having been a major change in the cultural systems represented; however, given these data alone, such a change cannot be demonstrated.

We may summarize the findings from Jabrud as follows:

(1) The Mousterian assemblages represented are not made up of single factors; on the contrary, they are generally composites of two or more factors.

(2) The use of multivariate statistics in analyzing assemblages allows us to

distinguish between types of assemblage which appeared similar when univariate statistics were used.

(3) There is apparent regularity in the utilization of the shelter of Jabrud in that:

(a) all the occupations appear to have been work camps;
(b) the major activity represented seems to have been hunting;
(c) Factor IV appears to be associated with an expedient use of immediately available sources of flint. We have further tentatively suggested that the activities represented by Factor IV may reflect a primary (sexual) division of labor.

(4) There was a regular shift in the activities in the occupations of the shelter—from work camps with a minor element of maintenance tasks to hunting and butchering without maintenance activities being represented.

MUGHARET ES-SHUBBABIQ

This site was excavated by the junior author in 1962 (S. R. Binford 1966); it is located in the Wadi Amud, a few kilometers northwest of the Sea of Galilee, Israel. The site is a cave in a dolomitic limestone cliff, and its opening stands approximately 40 meters above the present level of the wadi. The cave is a large one (ca. 295 square meters of floor space within the limits of natural light, with an additional 53 square meters in the rear chamber beyond the limits of natural light). The roof of the cave is a domed vault, about 20 meters above the cave floor over much of the area within the limits of natural light.

Although the exact floor space of Shelter I at Jabrud is not known, it is estimated from the published floor plan to have been approximately 178 square meters (Rust 1950; plate 3). Both the shelter of Jabrud and the cave of Shubbabiq face east and are lightest in the morning hours. In Shubbabiq the light inside the cave is sufficient for reading until about 3 p.m., after which the light diminishes rather rapidly. Presumably at Jabrud more light would have been available later in the day, because of the open nature of the site.

The main chamber of Shubbabiq is well protected from both wind and rain; even during the height of the rainy season in 1962, this portion of the cave remained completely dry. In short, the cave provides excellent living space with ample requirements of light and protection from the elements.

Unfortunately the archeological deposits in the main chamber of Shubbabiq were removed by later inhabitants; the only traces remaining are in crevices in the bedrock and in semiconsolidated deposits just outside the cave entrance. Undisturbed deposits, highly brecciated, did occur in the rear chamber; these most certainly represent a dump or midden deposit rather than living-floors. Eight samples from the site were used in this analysis; they are:

Unit 100: disturbed soft deposits, about an average of 1.4 meters thick, in the rear chamber.
Unit 100A: undisturbed soft deposits, directly underlying 100 in most places.

Unit 103–9: the first 5 cm. of depth of the undisturbed breccia in the rear chamber, 50–54 m. line.

Unit 113: the first 3–5 cms. of depth of the undisturbed breccia in the rear chamber, 55–57 m. line.

Unit 115–116: material from a lateral cut (N-S) in the breccia of the rear chamber, from the top to bedrock (1.3 m. thick), across the 1 m. test trench.

Unit 117: material from a section in the breccia at right angles to the one described above (E-W), along the side of trench from the 57–58.80 m. line.

Unit 300–310: material from an unconsolidated, undisturbed deposit which lay between the breccia and a fault crevice formed by the floor and the north wall of the cave, along an area 1.2 m. long and averaging .75 m. wide.

Unit 200–208: material from the semiconsolidated remnant deposit several meters to the east of the cave entrance.

Analysis of the factor content of the samples from Shubbabiq (Figure 11) shows that there are only three recognizably different kinds of assemblages present. The material from Unit 115–116 and Unit 117 exhibited some variation from the others in that Factor IV was represented. Since these two samples were derived from vertical cuts in the breccia and included artifacts from stratigraphically lower levels than did the other samples from the rear chamber, we may possibly have reflected here a differential in tools through time—i.e., there might have been a heavier use of denticulates in the earlier occupation period. However, the variation seen in the factor analysis is not great enough to suggest a major change in occupation type.

The sample from Unit 200–208, from the remnant deposit outside the cave entrance, does differ markedly from the other samples. Due to the small size of the sample, it was not possible to partition it as reliably into the factors contributing to its composition. But it is evident (Figure 11) that Factor III contributes over 50 per cent of its determinancy. This area was the only one at Shubbabiq that yielded traces of fire lenses; it will be recalled that Level 2 at Jabrud in which Factor III was present also had evidence of fires. The most reasonable interpretation of the distinctive nature of this sample is that it represents a localization of activity on the site.

The remaining samples are all essentially alike. They were originally analyzed using Bordes' methods and checked by Chi Square tests (S. R. Binford 1966) and were identified as Typical Mousterian of Levallois facies. The factor analysis indicates that these samples are composed of three major components, each factor representing a set of activities. Factor I is the dominant one at the site, with 60 per cent of the variability accounted for by the activities represented by this factor. Factors II and III each contribute 20 per cent to the total determinancy of the assemblage composition.

Factor I is believed to be associated primarily with maintenance activities—the manufacture of tools and processing nonflint raw materials into usable items. Factor II is interpreted as a tool kit used in the killing and butchering of animals, and Factor III is seen as a specialized group of implements used for cutting and incising, possibly related to the preparation and consumption of food. This particular set of factors is very different from the combinations observed in the samples from Jabrud. In none of the levels studied from Jabrud did Factors I and III occur together; in none of the Jabrud levels was either Factor I or III a prime determinant of an assemblage. It seems that the occupation at Shubbabiq is well outside of the range of settlement types represented at Jabrud.

The nature of the factors and their inferred activities at Shubbabiq suggests that the occupation here represents a central and more permanently occupied location. The major activities represented (Factor I) appear to be associated with maintenance, rather than extractive, tasks. The assemblages at Jabrud, on the other hand, suggest occupations of differentially constituted social groups primarily engaged in exploiting local resources. The character of the Shubbabiq assemblage suggests the site might have served as a *base camp* for work groups analogous to those responsible for the occupations at Jabrud.

Further support for the hypothesis that Shubbabiq represents a base camp settlement type in a more complex settlement system is found in our growing understanding of the minimum numbers of persons capable of maintaining a self-sustaining human society. It has been suggested that the minimum size of a local group within such a population is of the order of 20 to 24 individuals (Howells 1960:179–180). Such an estimate does not imply that a group of this size would necessarily remain together throughout an entire seasonal cycle; rather, that only during certain phases of a cycle would the aggregation live together. If we take this observation as a point of reference, we may then propose that the site where the larger social unit was localized during the annual period of aggregation must have had sufficient life space to allow for daily living of a group composed minimally of 20 to 24 individuals. A recent study suggests that there is a constant in the numbers of people living together and the amount of necessary sheltered space, the minimum being of the order of 10 square meters per individual (Naroll 1962).

Given this figure, we can argue that the 178 square meters of floor space estimated for Levels 2–8 at Jabrud could not have accommodated more than 18 people for any extended period of time. On the other hand, Shubbabiq with its 295 square meters of floor space could have provided adequate living space for about 25 persons, and possibly for as many as 30. This argument, taken together with the demonstrable differences in the composition of the assemblages from the two sites, leads us to conclude that we are dealing with two basically different types of locations in a differentiated settlement system.

There are also interesting differences in the "nonessential" artifact ratios for the two sites. Table X presents the summary indices for the "nonessential" artifacts from the various provenience units at Shubbabiq. Units 100A, 113, and 117 all have a large number of cores, with no indication of their having been worked on the spot; blanks also appear to have been introduced. The ratios involving completed tools indicate a primary emphasis on tool use rather than on tool production. These three units are interpreted as derived from areas where tool use, rather than tool production, was primary.

Units 100, 103–9, 115–16, and 300–10 suggest a different situation, one in which there are a great many blanks and biproducts from flint working and fewer tools. It is suggested that these samples were derived from areas where blanks and tools were being produced in higher frequencies than were finished tools.

Unit 200–8 is distinctive in that it is exceedingly high in those indices reflecting primary flint-working. It will be recalled that this deposit lies outside the present cave entrance and toward the south wall, an area which would have been both well-lighted and yet away from the center of living activities.

These samples demonstrate that the various phases of tool manufacture were conducted at different locations and independently of the particular tool-using activities conducted in the same locations.

In summarizing our findings from Shubabbiq, we again return to the four questions for which we originally sought answers:

(1) *Does the composition of the observed assemblages correspond to unit factors as isolated by the factor analysis?* As in the findings from Jabrud, our answer is negative. The samples from Shubbabiq are minimally constituted of two factors and maximally of four.

(2) *Do the types of Mousterian assemblages isolated by Bordes always correspond to the same combination of factors?* Our response here is also in the negative. The total assemblage from Shubbabiq was classified by Bordes' techniques as Typical Mousterian and was found to have strong resemblances to Level 7 of Jabrud. However, when the two assemblages are analyzed in terms of factor content, they are seen to be quite distinct. The material from Shubbabiq is dominated by Factor I, with Factors II and III as minor contributors, while Level 7 from Jabrud was primarily controlled by Factor V, with minor determinancy by Factors I and IV.

(3) *Is there regularity in the composition and form of assemblages at a given location which can be interpreted in terms of regular patterns of past human behavior?* This question can be answered affirmatively. The overall similarity between seven of the eight samples from Shubbabiq suggests that although the occupation of the cave may have spanned a considerable period of time, the location was utilized in essentially the same way by its occupants. The data specifically indicate use of the cave as a base camp.

(4) *Is there regular change through time in the assemblage which might indicate either general evolutionary or specific situational changes in the activities of the occupants?* This question must be answered negatively. The slightly larger loading on denticulates in the two samples certainly is not of an order to suggest any major difference in occupation type.

By comparing our results from Shubbabiq and Jabrud, a number of testable hypotheses can be offered:

Base camps, identifiable by a major determinancy of the statistical form of the assemblage by Factors I or III, will have the following characteristics:

(a) they will offer good shelter and protection from the elements;
(b) they will be relatively large locations and, if they are caves or bounded areas, will have at least 250 square meters of floor space;
(c) there will probably be a wider range of activities represented than at work camps, as indicated by the number of factors contributing to the assemblages;
(d) the fauna will probably exhibit a wider range of forms available over a longer period of the seasonal cycle.

HOUPPEVILLE

The material from Houppeville is not directly relevant to a study of the Mousterian of the Near East; Houppeville is a quarry in the Seine basin, near Rouen, France (Bordes 1952:431). This assemblage was included in the computer run for two reasons: first, to increase our sample size; and second, because there appeared to be strong resemblances between this material and that from Shubbabiq when analyzed by Bordes' methods.

When studied by factor analysis, the assemblage appears to be the result of a combination of determinants (see Figure 12). Factor III was dominant, with an appreciable amount of variance accounted for by Factor II, and a minor role played by Factor IV. In terms of the activities represented, based on our interpretation of the factors, we have represented at Houppeville food preparation, hunting and butchering, and processing of plant material. The ratios derived from the "nonessential" flint materials suggest that tool production was also an important activity at this site (see Table X).

In view of the difference in environmental setting from the other sites analyzed plus the fact that this was an open-air location, we do not feel it possible to make an interpretation as to the type of settlement represented nor the nature of the settlement system, on the basis of this one site.

SUMMARY AND CONCLUSIONS

The purpose of this paper was the presentation of alternative testable hypotheses for the observed variation and alternation of Mousterian industries demonstrated by Bordes. The value of our results lies chiefly in the realm of methodology, and these methodological developments are inextricably predicated on a theoretical position, which we summarize here.

We argue that culture is most usefully defined as man's extrasomatic means of adaptation (White 1959:8) and that a major component of man's adaptive success has been his ability to behave rationally. We would therefore expect differences and similarities in cultural remains to be relatable, at least in part, to the rational use of cultural means for the maintenance and perpetuation of human groups. We suggest that variability in archeological assemblages should be investigated from this point of view, that such variability presents analytical problems which the prehistorian must solve before he can make inferences concerning behavior in the past. This research has been directed toward the development of techniques which make possible the explanation of differ-

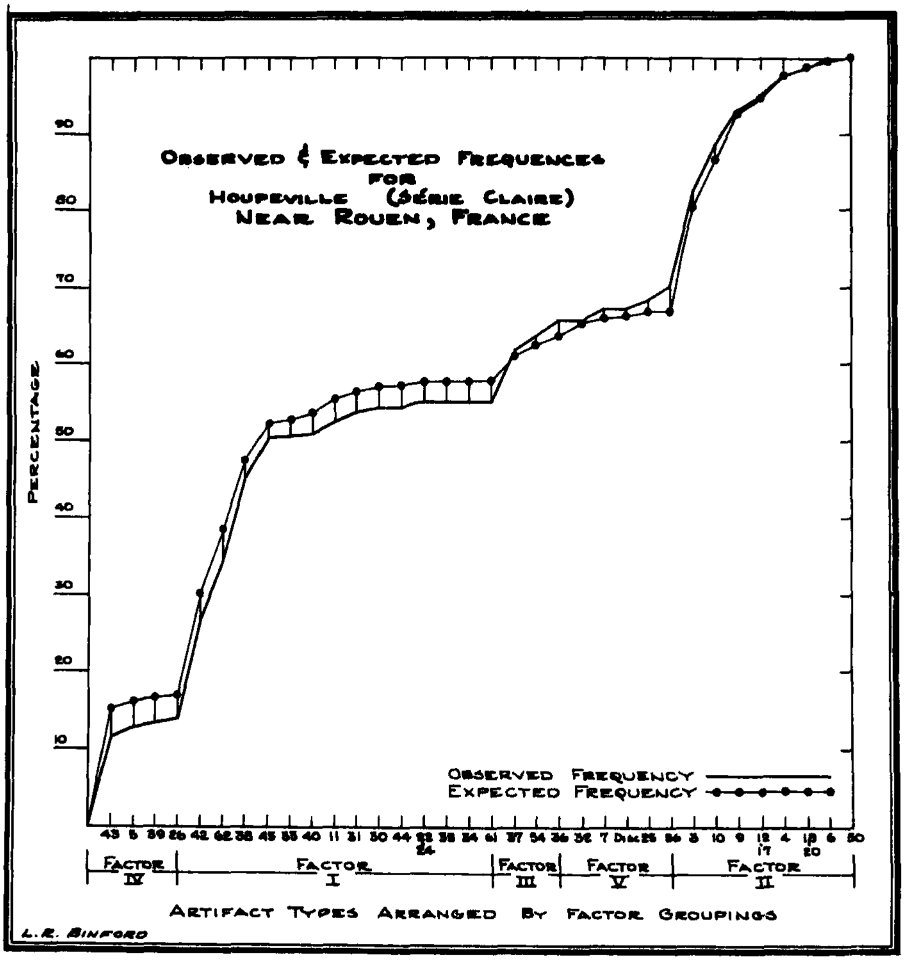

Fig. 12

ences and similarities, without reference to "migrations" or unalterable "traditions," and expressed as hypotheses which can be tested by future work.

Our analytical methods must allow us to determine: 1) when variability does in fact reflect past behavior and is not simply the product of sampling error, and 2) what differences and similarities in archeological assemblages signify in terms of past behavior. The first problem can be solved by the use of research designs planned to control sampling error (L. R. Binford 1964) and by the use of standard statistical tests (Spaulding 1960). It is toward the solution of the second problem that the methods developed here have been directed.

Our approach to the solution of this problem involves certain assumptions and postulates concerning the nature of human activities and their relation to (a) the composition of any given archeological assemblage, and (b) the cultural systems which were the context of these activities. The basic assumption allowing us to deal rationally with archeological assemblages is: *The form and composition of assemblages recovered from geologically undisturbed context are directly related to the form and composition of human activities at a given location.*

A second assumption we make is that: *The minimal social processes and organizational principles exhibited by human groups today were operative in the past.*[4] Given these assumptions we can advance the following propositions:

(1) An undifferentiated mass of archeological data can, by the use of methods designed to reveal patterns of covariation, be partitioned into subunits of artifacts which we can infer were used in a related set of activities.

(2) These groupings of artifacts that exhibit mutual determinancy should also share morphological characteristics which, on the basis of simple mechanics, can be reasonably inferred to have been used in a set of related mechanical tasks.

The first step in the study was the application of factor analysis to a series of Mousterian assemblages that had been summarized as counts of various artifact types using identical typological methods. The factor analysis yielded five *factors*—groups of artifacts that exhibited a high order of mutual covariance—which shared common determinants for the relative quantitative variability of the included artifacts. These findings supported our first proposition. Further, there was a high degree of consistency in the form of artifacts diagnostic of each factor, a finding that lent support to our second proposition.

The second step in the study was the analysis of the various samples of artifacts from the sites of Jabrud, Shubbabiq, and Houppeville. On the basis of the two major assumptions stated above, we suggested that we would expect assemblages, as the product of human activity, to vary in terms of (a) the form of the social unit—e.g., social segments or cooperating groups organized along age and/or sex lines, and (b) the specific tasks performed. It was argued that the differential distribution of resources and advantageous living sites would lead us to expect both spatial and temporal variability in both the form of the social unit and the specific tasks performed by a given group.

A distinction was made between *maintenance* and *extractive* tasks, the former involving activities related primarily to the nutritional and technological requirements of the group, and the latter activities related to the direct exploitation of environmental resources. It was suggested that these two types of activities were not isomorphic in their distribution, extractive tasks more commonly being performed by work groups and minimal segments of the society at locations determined by the distributions of resources within a territory. Maintenance activities, on the other hand, would tend to occur at locations selected principally in terms of space and shelter requirements of the residence group. We proposed that, on the basis of these arguments, we should be able to distinguish *base camps* and *work camps*, as two settlement types within a settlement system.

The detailed analysis of the samples from Levels 2–8 at Jabrud (Shelter I) in terms of the models suggested above shows that all of the levels appear to represent work camps, and primarily hunting camps. Variability was noted between the several levels in both the combinations of factors present and the relative presence or absence of those factors which were interpreted as reflecting maintenance activities. This variability was interpreted as related to (a) the length and intensity of occupation, and (b) the range and nature of tasks represented. Kinds of data not available for our study such as animal bone, features, pollen and plant remains, etc., might be profitably investigated and should provide confirmation or refutation of our interpretive hypotheses.

The analysis of samples from Shubbabiq revealed a very different situation. The factors contributing to the variability of the assemblage suggest a dominance of activities related to maintenance, and the composition of the various samples indicate the consistent use of the site for similar purposes—for use as a base camp. (No settlement type interpretation was offered for Houppeville; see p. 289 above.)

Our findings suggest that a great deal of the variability in Mousterian assemblages can be interpreted as *functional variability.* Further, the nature of this functional variability strongly suggests that the social systems represented were culturally based and that the principles of organization of these social systems were similar to those known from contemporary hunters and gatherers.

Our findings also suggest some possible solutions to the problem of interpreting the alternation of Mousterian assemblages demonstrated by Bordes. The following points are relevant:

(1) The use of multivariate statistics allows us to partition Mousterian assemblages into subunits of artifacts which can reasonably be interpreted as representing tool-kits for the performance of different sets of tasks.

(2) These subunits of artifacts vary independently of one another and may be combined in numerous ways.

The significance of these findings is that correlations must be sought not for total assemblages but for these independently varying factors. This can be implemented in the field by the following methods of data collection:

(1) Excavation of sites so as to reveal their internal structure (e.g., digging wide, contiguous areas), thus allowing us to study the spatial clustering of activities at a given location.

(2) Excavation of as wide a range as possible of different forms of sites

(e.g., open-air stations, caves, and rockshelters) to obtain information on the relationship between settlement type and range of activities.

(3) Excavation of sites from different environmental zones to test the relationship between extractive tasks and the differential distribution of resources in a region.

(4) Observation of a number of attributes not generally studied in detail:

(a) the degree of correlation between kinds of raw materials and groups of artifacts to evaluate the differential use of local and distant flint sources for artifacts used in various activities,

(b) the degree of correlation between different sets of activities (as defined by factors) and the form and composition of faunal assemblages;

(c) degree of correlation between types of activities and the form and composition of floral assemblages (pollen and macroplant remains).

(d) degree of correlation between kinds of activities and the physical characteristics of sites (extent of living area, degree of protection, etc.).

The provocative results of our study suggest to us that the methods of analysis used here are potentially useful for formulating testable hypotheses about social organization and evolutionary culture change within prehistoric communities.

NOTES

[1] An early attempt to develop analytical means for the isolation of functional variability is exemplified by the work of James Brown and Leslie Freeman (1964) in their use of linear regression models in the analysis of ceramics from a site excavated under the direction of Dr. Paul Martin of the Chicago Natural History Museum.

William Longacre conducted the pioneer study using multiple regression techniques in his study of ceramic design elements from materials obtained from the same site, Carter Ranch (Longacre 1963). The first application of multivariate analysis to Old World Paleolithic data was done by Robert C. Whallon (1963) as a Master's thesis.

Leslie Freeman (1964) used a factor analysis model in his study of Mousterian materials from Cantabrian Spain, his results serving as the major portion of his doctoral dissertation at the University of Chicago. At the same time James Hill conducted a more elaborate factor analysis study of ceramics, design elements, stone and bone tools, and animal bones recovered from the Broken K site in eastern Arizona (Hill 1965). This analysis constitutes a large portion of his doctoral thesis, submitted to the faculty of the University of Chicago in spring 1965.

[2] Prof. Bordes graciously provided us with copies of his work-sheets on Houppeville and Jabrud. The data from Shubbabiq were obtained during the tenure of a Postdoctoral National Science Foundation Fellowship by the junior author. The factor analysis was conducted at the Institute for Computer Research, University of Chicago, whose facilities were made available through the kindness of Professor Allan Addleman and through the consistent encouragement and assistance of Prof. Benjamin Wright, Advisor for the Social Sciences, at the computer center. The actual calculations were performed on the 7090 IBM computer, using a University of California program (Mesa 83) modified at the University of Chicago (Mesa 84); the program was supplied through the Social Science Computer Program Library at the University of Chicago.

[3] At the time this study was undertaken, Dr. Solecki's first season of work at Jabrud was just beginning. At this writing the first season's work is completed but the results have not been com-

pletely analyzed. These new data should make possible the testing of some interpretive hypotheses we have offered here, based on Rust's data.

[4] This is not to say that we believe that social units of the Lower and Middle Pleistocene were organized along the same lines as are living social units; rather, we take these units as baselines against which to compare social units of the past.

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