PRELIMINARY ANALYSIS OF FUNCTIONAL VARIABILITY IN THE MOUSTERIAN OF LEVALLOIS FACIES: A REEXAMINATION[1]

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Abstract An integral part of the *New Archeology* is a method of dealing with lithic variabilities based on a behavioral model and the use of mathematical techniques for the analysis of variance. To test some of the underlying assumptions of this paradigm a factor analysis was performed on published data for several Russian Mousterian sites. Seven factors were produced, and their content was interpreted as indicating two different types of activity: *base camp* killing and butchering and *work camp* transient food preparation.

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Binford and Binford (1966; 1968), S. R. Binford (1968), and L. R. Binford (1972) have proposed an explanation for the observed variability in lithic assemblages, based on hypothetical functional tool kits, and an analytic technique for the delineation of these functional groups. With one exception (Binford, 1972) this work has centered on the question of Mousterian variability and the results have sparked a healthy controversy.

Bordes (1961; 1972) recognized four major types of Mousterian assemblages based on a fixed typology of tool types and a technique for quantitatively defining an assemblage from the shape of a cumulative plot of these tool types. The phenomenon of more or less random alternation of these assemblage types within successive layers of one site is well established (Bordes, 1972) and has sparked considerable interest. Bordes (1961) offered three major hypotheses to explain this alternation:

1. The different types of Mousterian are associated with patterns of seasonal occupation.
2. Each type of Mousterian represents a slightly different ecological adaptation.
3. Each type of Mousterian represents a particular tribe of people characterized by a particular tradition of tool making.

Bordes reviewed these theories and rejects all but the last one. It is precisely this theory that the Binfords sought to disprove.

The Binfords applied a multivariate statistical technique of factor analysis to the question of Mousterian variability. They found five factors or tool groups which they interpreted as indicative of differing behavioral complexes (Binford and Binford, 1966). They have since expounded on the full implications of these findings within the context of the formulation of the Processural School of Archeology and have extended the analysis to Acheulean assemblages (Binfor, 1972).

Implications of the Binfords' work is revolutionizing the theoretical structure of archeology. An independent examination of the analytic techniques they employed and the assumptions involved in their approach has not, to my knowledge, been attempted. The purpose of the present study is to briefly explore the methodology proposed by the Binfords' work and its implications for paleolithic research. A preliminary analysis of selected Russian Mousterian sites has been attempted to provide a basis for comparison.

TECHNIQUES AND ASSUMPTIONS

Binford and Binford's (1966) two basic

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assumptions in their approach to the relation of artifact assemblages to human behavior are:

1. 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.
2. The minimal social processes and organizational principles exhibited by human groups today were operative in the past.

Extrapolating from these, they arrived at two propositions which are the origin of both their work and the present study:

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. 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.

Implicit in the above propositions are two probable sources of error which they assumed to have been minimized. The first proposition implies that the frequency of stone tool types from a particular site is dependent only on the activities of the persons who made and used them. It is assumed that sampling error, destructive geologic processes, taphonomic processes, and arbitrary sorting by the original users have not skewed the relative frequencies of tools found. While this may seem to be, perhaps, a bit too much to assume, it must be realized that other proposed methods of analysis (e.g., Bordes' cumulative graphs) are forced to make the same assumption. The second proposition implies that the contemporary observer can determine the function of a particular tool from its appearance. It must be remembered that the function assigned to a particular tool is entirely an educated guess on the part of the researcher and not necessarily the true function of the object.

In order to study patterns of covariance Binford proposed the use of factor analysis. This technique allows a set of variables to be represented by a smaller set of factors which take into account the covariance of the original variables. The main function of factor analysis is, therefore, one of data reduction by determining underlying patterns of covariance. (For discussion of factor analysis and its applications, see Harmann (1961), Rummel (1967), Kim and Nie (1970), and Blackith and Reyment (1971).)

MOUSTERIAN STUDY

Nine Mousterian activity levels were chosen to provide data for the present analysis. Eight of these are located in European Russia as described by Klein (1969): Molodova I–4,5; Molodova V–XI, XII; Kiik-Koba III/IV; Starosel'e; Volchij Grot; and Volgograd. The ninth site is Pech de Aze II–4 which was described by Bordes (1972). The assemblages from all sites were classified according to Bordes typology.

Molodova I and V and Volgograd are open-air stations located in the Dnestr and Prut basin, and near the city of Volgograd respectively. Kiik-Koba, Starosel'e, and Volchij Grot are all cave sites located in the Crimea. Pech de Aze is a cave site located in southwestern France. The latter was included because Binford's analysis of Near Eastern Mousterian also incorporated a French site, Houpeville.

Published tool lists from the above sites were compiled and percentage values for each variable were entered into the computer. Bordes' list of 63 tool types was condensed to 46 variables after the manner of Binford and Binford (1966). Table 1 lists these 46 variables, their number in Bordes' type list and in the Binfords' analysis, and their postulated function. It should be noted that whereas the Binfords had 40 variables, the present study employs 46. This is due to the presence of significant numbers of tools in categories which were relatively empty in Binford's data. No categories were combined except those combined by the Binfords.

The theory of factor analysis is based on the assumption of a normal frequency distribution which requires, among other things, a large sample size. The usually accepted lower limit of the number of cases required to assume a normal distribution is 40 (Ingram, 1974). It has been suggested, however, that a normal multivariate distribution requires a sample size significantly larger than this (Blackith and Reyment, 1971). Obviously the present sample of 9 cases is rather small and the results are questionable. It must be stressed that this is a preliminary exploratory study and the results should not be pushed too far. In this regard, it should be noted that Binford's sample sizes, 17 in the case of the Mousterian study (Binford, 1968) and 32 in the Acheulean study (Binford, 1972) suffer the same deficiency.

RESULTS AND DISCUSSION

The data were submitted to subroutine FACTOR of the Statistical Package for the Social Sciences (SPSS) and a quartimax rotation was performed (see Binford 1972). The output (summarized in table 2) shows that 7 factors were produced which had eigenvalues greater than 1 (factor 7 eigenvalue = 1.89303); and these 7 cumulatively accounted for 100% of the variability. The variables for each factor are those diagnostic of the particular rotated factor and are those which have the highest loading for that factor. The suggested activity associated with each factor was arrived at by comparison with the Binfords' results (Binford and Binford 1966), and by extrapolation from the functions listed in table 1.

The most obvious difference between the results of the present study and those

TABLE 1

Classification of artifact types and input variables

No. Bordes' type list*	Binfords' variable index**	Prior's variable index	Artifact name	Binford's functional interpretation
1	1	1	Typical Levallois flake	Delicate cutting
2	2	2	Atypical Levallois flake	Delicate cutting
3	3	3	Levallois point	Spear point
4	4	4	Retouched Levallois point	Spear point
5	5	5	Pseudo-Levallois point	Perforating (?)
6	6	6	Mousterian point	Spear point
7	7	7	Elongated Mousterian point	Spear point
8	—	8	Limace	——
9	8	9	Simple straight side-scraper	Cutting-scraping, non-yielding surface
10	9	10	Simple convex side-scraper	Cutting-scraping, non-yielding surface
11	10	11	Simple concave side-scraper	Scraping cylindrical objects
12–17	11	12	Double side-scrapers	
18–20	12	13	Convergent side-scrapers	
21	—	14	Canter side-scrapers	
22–24	13	15	Transverse side-scrapers	
25	14	16	Scrapers on the ventral surface	Push plane
26	15	17	Scrapers with abrupt retouch	
27	—	18	Side-scrapers with thinned back	
28	—	19	Side-scrapers with bifacial retouch	
29	—	20	Side-scrappers with alternate retouch	
30	16	21	Typical end-scrapers	
31	17	22	Atypical end-scrapers	
32	18	23	Typical burin	Deep incising
33	19	24	Atypical burin	Heavy cutting
34	20	25	Typical borer	Perforating

TABLE 1. *Continued*

No. Bordes' type list*	Binfords' variable index**	Prior's variable index	Artifact name	Binford's functional interpretation
35	21	26	Atypical borer	Perforating
36	22	27	Typical backed knife	Heavy cutting
37	23	28	Atypical backed knife	Heavy cutting
38	24	29	Naturally backed knife	Heavy cutting
39	25	30	Raclette	—
40	26	31	Truncated flake	—
41	—	32	Mousterian Tranchet	—
42	27	33	Notched piece	Gut-stropper, small objects
43	28	34	Denticulate	Sawing
44	29	35	Bec	Perforating
45	30	36	Ventrally retouched piece	?
46–47	—	37	Piece with coarse, abrupt or alternate retouch	—
48–49	31	38	Utilized flakes	—
50	32	39	Pieces with bifacial retouch	—
51	—	40	Tayac point	—
52	—	41	Notched Triangle	—
53	—	42	Pseudo-Microburin	—
54	33	43	End-notched piece	Scraping cylindrical objects
55	—	44	Hachoir	—
61	35	45	Chopping tool	Heavy-duty cleaving
62	36	46	Miscellaneous	—

*See Bordes 1961 and 1972.
**See Binford and Binford, 1966.

of Binford is the number of factors they contain. There are three possible reasons for the increased number of factors resulting from this analysis:

1. The factor structure is unstable due to small sample size and some of the factors are redundant.
2. There is a difference in the level of cultural complexity between the sites sampled by Binford and those represented here.
3. The results reflect the presence in the sample of different types of activity centers, i.e. base camps and work camps.

While the first reason cannot be ruled out, as mentioned previously, the second is probably unlikely inasmuch as the types of functions being considered reflect a general level of cultural development and would be expected to be constant within a particular time level. The third point seems the most reasonable based on the current data. Our results require a careful, in-depth study of a significant sample for their verification.

Factors III and VI (table 2) represent tool kits which are comparable in function, but differ in complexity. The data suggests what Binford has described as functionally analogous factors. Based on a presence-relative absence correlation, factor III seems to be most strongly related to the Russian cave sites while factor VI is related to the open-air sites (with the exception of Volgograd which seems to correlate better with factor III). Based on the factor structure, it would appear that factor III represents a "base camp" type of killing and butchering kit while factor VI serves the same function but is correlated with more transient "work camps". Factors IV and V seem to be similarly related.

The technique of factor analysis would seem to be well suited for the task of analyzing lithic assemblages with the following restrictions:

1. The mathematical requirements necessary for factor analysis to be valid must be met (*e.g.*, a

normal density function, which implies, among other things, a large sample size).
2. The indeterminancy of factors under rotation must be taken into account.
3. The limits of the assumption that tool frequencies reflect behavior must be recognized.
4. The fact that tool functions are *a posteriori* assumptions and not necessarily accurate representations of reality must be considered.

TABLE 2

Factor analysis of Mousterian variability

Number	Diagnostic variable	Factor loading*	Suggested activity
I	Notched triangle	.32097	Manufacture of non-flint tools
	Pseudo-microburin	.32097	
	Hachoir	.32097	
	Miscellaneous tools	.29987	
	Ventrally retouched pieces	.27315	
	Typical burin	.27280	
	Typical borer	.25906	
II	Pieces with bifacial retouch	.30757	(Hide preparation)
	Atypical end-scrapers	.30622	
	Typical end-scrapers	.29239	
	Simple straight side-scrapers	.28942	
	Side-scrapers with thinned back	.27868	
	Side-scrapers with bifacial retouch	.27198	
	Double side-scrapers	.25764	
	Side-scrapers with alternate retouch	.25652	
	Simple concave side-scrapers	.25444	
	Utilized flakes	−.21721	
	Convergent side-scrapers	.20720	
III	Elongated Mousterian points	.38081	Killing and butchering (cave sites)
	Tayac points	.37493	
	Atypical borers	.33693	
	Canted side-scrapers	.32308	
	Retouched pieces—coarse	.27790	
	Mousterian points	.27290	
	End-notched tools	.26463	
	Denticulates	.22527	
	Notched tools	.20021	
IV	Chopping tools	.48657	Food processing —vegetables (open air sites)
	Typical backed knives	.45438	
	Alternate borinating bees	.36360	
	Ventral side-scrapers	.23614	
V	Limace	.51440	Food processing —vegetables (cave sites)
	Mousterian tranchets	.50710	
	Atypical backed knives	.34906	
	Transverse side-scrapers	.22273	
VI	Pseudo-Levallois points	.41225	Killing and butchering (open air sites)
	Scrapers with abrupt retouch	.41143	
	Atypical burins	.38797	
	Levallois points	.22608	
VII	Retouched Levallois flakes	.56123	Cutting and incising —food processing
	Raclette	.32637	
	Naturally backed knives	−.30675	
	Atypical Levallois flakes	.29213	
	Truncated flakes	.27799	
	Simple convex side-scrapers	.24960	
	Typical Levallois flakes	.22777	

*See Harmann, 1961 for details.

Even with these restrictions, however, the factor analytic technique and the behavioral paradigm would seem to provide the most useful and valid analysis currently available.

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