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HOW MANY CRANIAL VARIATIONS WERE THERE IN EUROPE IN THE UPPER PALEOLITHIC?

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Abstract: *In the present paper a multivariate classification of 31 male and 22 female skulls from the European Upper Paleolithic were accomplished taking 10 measurements into consideration. The results of the cluster analyses of three kinds all based upon a principal component analysis were controlled by a discriminant analysis. As it was concluded skull variations constituted two basic groups. The first of these two main groups included 68 percent of males (Mladeč 1 group) and 64 percent of females (Abri Pataud group). The other main group consisted of males (Combe Capelle group) and females (Obercassel 2 group) which could be characterized by shorter and narrower brain case, lower nasal cavity, also narrower frontal bone and smaller bizygomatic arch. The similarity in the factor structures of the two sexes and their segregations of similar proportions in the main groups were striking in view of the small number of individuals, and all these could be regarded as arguments in support of the operativeness of the classification established. As a result European Upper Paleolithic appears to have been characterised by a craniological system in which the number of characteristic individuals was gradually and proportionally decreasing from the most typical groups to the solitary finds.*

Keywords: *Upper Paleolithic; Skull dimensions; Multivariate analysis.*

Introduction

During the last one hundred years a wide range of taxonomic models on the differentiation of Homo sapiens in the Upper Paleolithic have been constructed according to the different considerations of the quantitative and qualitative anatomic data base.

The multivariate analysis of Upper Paleolithic skulls is not unprecedented (Morant 1930–31, Campbell 1964, Stringer, 1974). The succeeding experiments were based upon intact skeletal finds only. Upper Paleolithic and Mesolithic samples were analysed contracted so that case-numbers can be increased (Henke 1981, 1983, 1984, 1987). However, the dissociation of the two techno-cultural levels mentioned above was reasonable with a view to both cladogenesis and anagenesis.

The present study involves the analysis of the system of Upper Paleolithic skulls exclusively, taking all the cranial finds which can furnish us with information with respect of the method in force into consideration.

Material and Method

Altogether 10 measurements of 31 male skulls and 22 female ones were used in the analysis (Table 1 and 2).

Table 1. List of male skulls examined.

No	Sign	Locality	Reference	Number of original measurements
		WEST		
1	Chan	Chancelade	Vallois 1946	10
2	ComC	Combe Capelle	Klaatsch 1910; Morant 1930-31	
3	CroM 1	Cro-Magnon 1	Vallois and Billy 1965a 1965b	10
4	CroM 3	Cro-Magnon 3		3
5	Engi 1	Engis 1	Schmerling 1833; Fraipont 1936	4
6	Goug	Goug's Cave	Seligman and Parsons 1914	4
7	LauB 4	Laugerie Basse 4	Broca 1873; Hamy 1874a	5
8	LePl	Le Placard	Hervé 1893	10
9	RocS 1	Roc de Sers 1	Martin 1927	4
10	Urti 3	Urtiaga 3	Riquet 1962; Marquer 1963	10
		SOUTH		
11	AreC 1	Arene Candide 1 (Grimaldi Caves)	Sergi et al. 1974; Verneau 1906; Legoux 1964; Riquet 1970	10
12	GBCa 1	Brama del Caviglione 1		6
13	GBGM 1	Brama Grande (Mus. Ment.) 1		3
14	GBG 2	Brama Grande 2		6
15	GBG 5	Brama Grande 5		9
16	GGEn 4	Grotte des Enfants 4		9
17	GGEn 6	Grotte des Enfants 6		9
		EAST		
18	KZam	Kostenki II, Zamiatnin	Debetz 1955	5
19	KMaG	Kostenki XIV, Markina Gora	Debetz 1955	10
20	Sung 1	Sungir 1	Zubov and Haritonov 1984	10
		CENTRAL		
21	Brno 1	Brno 1	Makowsky 1888	3
22	Brno 2	Brno 2	Jelínek et. al. 1959	3
23	Doln 1	Dolní Věstonice 1	Morant 1938	3
24	Mlad 1	Mladeč 1	Szombathy 1900	10
25	Mlad 5	Mladeč 5	Szombathy 1925	3
26	Ober 1	Obercassel 1	Bonnet1919; Henke 1984	10
27	Pade	Paderborn	Henke and Protsch 1978	4
28	Pavl 1	Pavlov 1	Vlček1961a 1961b	5
29	Pred 1	Předmostí 1	Matiegka 1934	3
30	Pred 3	Předmostí 3		10
31	Pred 9	Předmostí 9		10

Table 2. List of female skulls examined.

No	Sign	Locality	Reference	Number of original measurements
		WEST		
1	Brun 24	Bruniquel Lafaye	Genet-Varcin and Miquel 1967	10
2	CapB	Cap Blanc	Bonin 1935	8
3	CroM 2	Cro-Magnon 2	Vallois and Billy 1965a. 1965b	8
4	LauB 2	Laugerie Basse 2	Broca 1873; Hamy 1874a	3
5	LauB 3	Laugerie Basse 2		3
6	APat 1	Abri Pataud 1	Billy 1975	10
7	RocS 2	Roc de Sers 2	Martin 1927	5
8	SGer 4	Saint Germain (Riv.)	Blanchard 1935	10
9	SorD 3	Sorde, Duruthy 3	Hamy 1874b; Riquet 1970	5
		SOUTH		
		Grimaldi Caves	Veneau 1906; Legoux 1964; Riquet 1970	
10	GBG 3	Brama Grande 3		8
11	GGEn 3	Grotte des Enfants 3		2
12	GGEn 5	Grotte des Enfants 5		9
		EAST		
13	Sung 5	Sungir 5	Zubov and Haritonov 1984	9
		CENTRAL		
14	Bins	Binschof	Henke 1980	10
15	Brno 3	Brno 3	Matiegka 1929	10
16	Cioc	Cioclovina	Rainer and Simionescu 1942	3
17	Doln 2	Dolní Věstonice 2	Malý 1939	3
18	Doln 3	Dolní Věstonice 3	Jelínek 1953	9
19	Mlad 2	Mladeč 2	Szombathy 1925	3
20	Ober 2	Obercassel 2	Bonnet 1919; Henke 1984	10
21	Pred 4	Předmostí 4	Matiegka 1934	10
22	Pred 10	Předmostí 10		9

The measurements applied were used in accordance to Martin's numeration (1928): maximum cranial length (M1), maximum cranial breadth (M8), minimum frontal breadth (M9), basion-bregma height (M17), bizygomatic breadth (M45), upper facial heigth (M48), orbital breadth (M51), orbital height (M52), nasal breadth (M54) and nasal height (M55). Missing data were reconstructed by applying Dear's principal component method (Dear 1959). Thereafter the analyses were carried out by using SPSS-PC+ programme packet. As a first step, principal component analysis was applied in the light of topical selection aspects. In the second step the clustering of skulls was performed on the basis of the extracted factor scores by applying the Euclidean distance and by using the three following methods:

1) average linkage /within group/ = AL/WG/,
2) average linkage /between groups/ = AL/BG/,
3) complete linkage = CL.

In the sample all the groupings gained by cutting the cluster tree on middle level and each composed of at least three individuals were regarded characteristic. These groups determined by close connections were named after the most complete finds included. In the third step the justification of groups obtained by the concordant results of the three sorts of clustering was controlled by discriminant analysis (on the basis of the 10 measurements original or reconstructed).

Results and Discussion

Males

On surveying communalities in the course of performing principal component analysis on the sample, it was found that orbital height (M52) does not link up with the factor structure (Comm. = 0.337). On omitting this variable, communalities became satisfactory. According to unrotated factor matrix, however, the loadings of two variables (M8 and M45) in the four extracted factors were not unambiguous. After varimax rotation it was only the measurement M1 that could not be assigned to any extracted factors. (Further on it was important that each original dimension should also be estimated according to the statistics of factor scores.) Therefore it seemed that in the following step this latter variable was worth being selected rather than variables M8 and M45.

In the experiment comprising 8 variables the communalities were convenient (the lowest value being M48 = 0.743). The unrotated factor matrix only suggested indetermination in the cases of the measurements M45 and M54 primarily. After varimax rotation it was only the variable M48 that could not be assigned to the extracted factors with complete certainty.

Table 3. Results of factor analysis on the total sample of males considering 7 variables.

Eigenvalues (EV) & cumulativities (CU)			Unrotated factor matrix			
Factor	EV	CU %	Variables (Martin No.)	Factor 1	Factor 2	Factor 3
1	2.301	32.9	8	0.822	-0.008	-0.126
2	1.347	52.1	9	0.828	0.137	0.117
3	1.253	70.0	17	0.102	-0.139	0.710
4	0.990	84.2	45	0.130	0.240	0.760
5	0.516	91.5	51	0.282	0.751	-0.350
6	0.346	96.5	54	-0.051	0.891	0.256
7	0.247	100.0	55	0.754	0.055	0.341

Varimax rotated factor matrix in a sorted form and the communalities (C)

Variables (Martin No.)	Factor 1	Factor 2	Factor 3	C
9	0.828	0.137	0.117	0.717
8	0.822	-0.008	-0.126	0.691
55	0.754	0.555	0.342	0.688
54	-0.051	0.891	0.256	0.862
51	0.282	0.751	0.350	0.765
45	0.130	0.240	0.760	0.651
17	0.102	-0.139	0.706	0.528

Therefore a fourth version concerning seven measurements by omitting M1, M48 and M52 was worked out. The communalities in this case were also satisfactory. While the unrotated matrix did not show unambiguous structures, the varimax rotated matrix could be well interpreted (Table 3). Furthermore it seemed advisable to carry out the analysis of individuals on the basis of the latter.

It could be concluded that primarily the measurements of breadth of the brain case were expressed by the first factor. In the second factor the measurements of breadth of the nasal and orbital cavities were concentrated, while in the third dimension mainly the height of the brain case was of great importance.

The survey of Table 4 shows how many basic groups in the total sample should be worth separating and which finds they should be composed of.

On clustering the factor scores by AL/WG/ method, we could find that the total sample was characterised by two main groupings. One of the groups was named after the find Mladeč 1. It was striking that the bulk of them (55 %) had been excavated in Czech-Moravian territories. These were Cro-Magnon like variants and represented 67 percent of all the cranial finds in the Czech-Moravian region. The other main group was characterized by the Combe Capelle holotype. The majority of these were the variants of the classical Mediterranean type. The detached position of Cro-Magnon 1 holotype deserved special attention.

On clustering by the AL/BG/ method we could only establish significant difference from the previous results in the sense that the group marked by Mladeč 1 included a greater number of cranial finds to the detriment of Combe Capelle-like ones.

At first sight the same conclusion could be reached by clustering according to the CL method. In this case, however, a sub-cluster named after Sungir 1 could also be defined. Summing up, at least 8 individuals of Mladeč 1 type and at least 4 individuals of Combe Capelle type constituted the basis of our classification. The Cro-Magnon 1 holotype proved to be a rather extreme variant: it was only the Obercassel 1 skull which came near to that. The detachement of the grouping marked by Sungir 1 was not convincing enough.

This classification was controlled by a discriminant analysis which assorted the individuals according to the 10 original variables. Therefore the 8 finds and the 4 other ones mentioned above were placed in different groups expecting that the proper place of the additional 19 (ungrouped cases) could be determined according to the characteristic features of these.

As the results of the discriminant analysis showed, the difference between the two basic groups could be described by a function and this difference was significant on the level of 0.02 percent (Table 5). Each of the individuals considered to be characteristic showed similarity only to the parameters of its own grouping. The assortment of the individuals ungrouped was as follows:

type marked by Mladeč 1: 1, 3, 5, 7, 8, 15, 16, 20, 22, 25, 26, 27, and 30;

type marked by Combe Capelle: 11, 12, 14, 18, 19, 29.

The majority of the individuals ungrouped (that is 68 percent) showed similarity to the group marked by Mladeč 1.

Table 4. A survey of clustering on the total sample of males considering 7 variables.

Clusters	AL(WG)	AL(BG)	CL	Typical individuals of the main groups
Cluster 1	4 CroM 3	4 CroM 3	4 CroM 3	4 Cro-Magnon 3
	23 Doln 1	23 Doln 1	23 Doln 1	23 Dolní Věstonice 1
	13 GBGM 1	13 GBGM 1	13 GBGM 1	13 Brama Grande (M.Ment.) 1
	28 Pavl 1	28 Pavl 1	28 Pavl 1	28 Pavlov 1
	6 Goug	6 Goug	6 Goug	6 Goug's Cave
	24 Mlad 1	*24 Mlad 1*	*24 Mlad 1*	*24 Mladeč 1*
	31 Pred 9	31 Pred 9	31 Pred 9	31 Předmostí 9
	10 Urti 3	10 Urti 3	10 Urti 3	10 Urtiaga 3
	25 Mlad 5	25 Mlad 5	29 Pred 1	
	30 Pred 3	30 Pred 3	11 AreC 1	
	27 Pade	22 Brno 2	22 Brno 2	
		29 Pred 1	18 Kzam	
		11 AreC 1	5 Engi 1	
		25 Mlad 5	7 LauB 4	
		12 GBCa 1	12 GBCa 1	
		18 KZam		
		7 LauB 4		
Cluster 2	9 RocS 1	9 RocS 1	9 RocS 1	9 Roc de Sers 1
	21 Brno 1	21 Brno 1	21 Brno 1	21 Brno 1
	17 GGEn 6	17 GGEn 6	17 GGEn 6	17 Grotte des Enfants 4
	2 ComC	*2 ComC*	*2 ComC*	*2 Combe Capelle*
	7 LauB 4		8 LePL	
	18 KZam			
	5 Engi 1			
	12 GBG 2			
	22 Brno 2			
	29 Pred 1			
	11 AreC			
Cluster 3	*3 CroM 1*	*3 CroM 1*	*3 CroM 1*	
	26 Ober 1	26 Ober 1	26 Ober 1	
		27 Pade	27 Pade	
Cluster 4		16 GGEn 4	16 GGEn 4	
		20 Sung 1	20 Sung 1	
			25 Mlad 5	
			30 Pred 3	
Solitary finds				
	15 GBG 5	15 GBG 5	15 GBG 5	
	1 Chan	1 Chan	1 Chan	
	8 LePL	8 LePL	19 KmaG	
	19 KMaG	19 KMaG	14 GBG 2	
	14 GBG 2	14 GBG 2		
	20 Sung 1			
	16 GGEn 4			

Table 5. Classification results of discriminant analysis on the sample of males considering 10 variables.

Actual group	N	'Mlad 1'	'ComC'
'Mlad 1'	8	8 (100.0 %)	–
'ComC'	4	–	4 (100.0 %)
Ungrouped cases	19	13 (68.4 %)	6 (31.6 %)
Grouped cases correctly classified:			100.0 %

Females

Performing factor analysis on the basis of 10 variables in the total sample four factors could be extracted. The unrotated factor matrix showed uncertainty in the case of variables M48, M58 and M55 as regards loading. The varimax rotated factor matrix also showed indefiniteness concerning loading with the same variables and with an additional one: M9. Regarding the uncertainty of the loading the selection of the measurements M48 and M55 seemed to be reasonable in both respects.

Although communalities were sometimes lower than usual, the factor matrix calculated by 8 variables could be interpreted clearly even in its unrotated form (Table 6). The same could be observed in the case of the varimax rotated factor matrix. Factor extraction extended over three dimensions, which represented the 69.5 percent of the total variance. With females, similarly to the case of males, primarily measurements of breadth (M45, M9, M8) were loaded in the first dimension. Orbital cavity (M51 and M52) was characteristic of the second factor, while the third dimension was characterised rather by the height of the brain case.

Table 6. Results of factor analysis on the total sample of females considering 8 variables.

Eigenvalues (EV) & cumulativities (CU)			Unrotated factor matrix			
Factor	EV	CU %	Variables (Martin No.)	Factor 1	Factor 2	Factor 3
1	2.716	34.0	1	0.700	0.016	-0.118
2	1.525	53.0	8	0.740	-0.109	-0.010
3	1.322	69.5	9	0.756	0.365	-0.193
4	0.967	81.6	17	-0.168	0.208	0.778
5	0.679	90.0	45	0.906	-0.084	-0.000
6	0.458	95.8	51	0.209	0.906	0.225
7	0.236	98.7	52	-0.386	0.712	-0.376
8	0.102	100.0	54	0.253	-0.039	0.688

We could segregate groups composed of nearly the same components by means of clustering the individuals on the basis of their factor scores using three sorts of methods. Most individuals were included in the clusters marked by Abri Pataud 1 and Obercassel 2, respectively (Table 7).

Table 7. A survey of clusterings on the total sample of females considering 8 variables.

Clusters	AL(WG)	AL(BG)	CL	Typical individuals of the main groups
Cluster 1	3 CroM 2	3 CroM 2	3 CroM 2	3 Cro-Magnon 2
	10 GBG 3	10 GBG 3	10 GBG 3	10 Brama Grande 3
	13 Sung 5	13 Sung 5	13 Sung 5	13 Sungir 5
	11 GGEn 3	11 GGEn 3	11 GGEn 3	11 Grotte des Enfants 3
	16 Cioc	16 Cioc	16 Cioc	16 Cioclovina
	2 CapB	2 CapB	2 CapB	2 Cap Blanc
	17 Doln 2	17 Doln 2	17 Doln 2	17 Dolní Věstonice 2
	6 Apat 1	*6 APat 1*	*6 APat 1*	*6 Abri Pataud 1*
	7 RocS 2	7 RocS 2	7 RocS 2	7 Roc de Sers 2
			14 Bins	
Cluster 2	4 LauB 2	4 LauB 2	4 LauB 2	4 Laugerie Basse 2
	19 Mlad 2	19 Mlad 2	19 Mlad 2	19 Mladeč 2
	5 LauB 3	5 LauB 3	5 LauB 3	5 Laugerie Basse 3
	15 Brno 3	15 Brno 3	15 Brno 3	15 Brno 3
	20 Ober 2	*20 Ober 2*	*20 Ober 2*	*20 Obercassel 2*
Cluster 3	*1 Brun 24*	*1 Brun 24*	*1 Brun 24*	
	18 Doln 3	18 Doln 3	18 Doln 3	
	9 SorD 3	9 SorD 3	9 SorD 3	
			12 GGEn 5	
Cluster 4	*21 Pred 4*	*21 Pred 4*	*21 Pred 4*	
	22 Pred 10	22 Pred 10	22 Pred 10	
Solitary finds				
	12 GGEn 5	12 GGEn 5		
	8 SGer 4	8 SGer 4	8 SGer 4	
	14 Bins	14 Bins		

Besides, there were two other clusters consisting of smaller numbers of individuals which were also noteworthy (Dolní Věstonice 3, Předmostí 4).

This classification was controlled by performing discriminant analysis and we regarded the two main groups to be characteristic just as we could find it in the males' sample (Table 8). Thus, a significant difference between these two groups could be verified on the level of 3.5 percent. All the individuals 'grouped' were characteristic of their own groups. The ranging of cases 'ungrouped' was as follows (cf. Table 2):

type marked by Abri Pataud1: 9, 12, 14, 21, 22;

type marked by Obercassel 2: 1, 8, 18.

Consequently, the majority (63 percent) of the individuals 'ungrouped' showed similarity to the group Abri Pataud 1. This ratio seemed to be similar to that of the group Mladeč 1 (68 percent) in the case of males, which referred to a parallelism between the groups Abri Pataud 1 and Mladeč 1.

Table 8. Classification results of discriminant analysis on the sample of females considering 10 variables.

Actual group	N	'APat 1'	'Ober2'
'APat 1'	9	9 (100.0 %)	–
'Ober2'	5	–	5 (100.0 %)
Ungrouped cases	8	3 (68.4 %)	5 (62.5 %)
Grouped cases correctly classified:			100.0 %

The sequences of the canonical discriminant function coefficients of the two sexes were not entirely similar (Table 5, 8). This may have arisen from, besides the possible errors owing to the small number cases, the sexual difference which could also be manifested in covariance matrix (cf. Henke 1981 1983). It seemed that, like in the case of males, two basic variant groups served as the basis of typifying.

Bisexual parallelisms

Having classified males and females respectively, the first thing to decide was whether there existed bisexual parallelism between the two main characteristic groups. Subsequently, we had to determine which original measurements could be made of use in repeated performances of the classification specified above.

The first essential factor for answering these questions was that there were two main groups in the first factor dimensions of both sexes which differed from one another significantly on the basis of the factor scores ($0.01<P<0.05$). According to the rotated factor matrix the measurements M8, M9 and M55 in the case of males furthermore M1, M8, M9 and M45 in the case of females loaded in the first dimension.

Calculating the basic statistical parameters of all the ten original measurements in the main groups, the parallel between the groups Mladeč 1 - Abri Pataud 1 and the groups Combe Capelle - Obercassel 2 could be well discerned (Table 9). Cro-Magnon-like types (Mladeč 1 and Abri Pataud 1) are characterised by larger dimensions of the measurements of the first factor than Mediterranean-like types (Combe Capelle and Obercassel 2). These results show that the classification developed on the basis of our present knowledge can be made of good use in practice in the case of the significant unidirectional difference of three or four original measurements.

The classification positions of other skull connections smaller in number than the main groups above could not be generalized. Their formation can be explained theoretically by the genetical combinations of the individuals of the main groups.

In the case of males (Table 4) the Cro-Magnon 1 skull and the Obercassel 1 skull, besides being suggestive of the characteristic features of Mladeč 1 group, are extreme variants: they excel in their large dimensions (M45, M48 and M51).

In the case of females (Table 7) the two cranial finds from Předmostí are similar to the Abri Pataud 1 type and can be characterised by wider measurements (M8, M9 and M48) than this latter type. The individuals of the group marked by Dolní Věstonice 3 represent a transition between the two main variants though their minimum frontal breadth is narrower and their orbital and nasal dimensions are smaller than those of the main variants.

Table 9. Parameters of main groups considering also the estimated missing values.

Variables (Martin No.)	Males				Females			
	Mladeč 1 N=8		Combe Capelle N=4		Abri Pataud 1 N=9		Obercassel N=6	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	194–203	198.5*	187–198	193.3	183–197	190.2*	172–182	179.0
8	137–152	143.0*	130–139	134.8	132–142	138.0*	127–134	130.2
9	97–105	101.5*	90– 95	91.5	95–104	99.0*	92– 97	95.0
17	130–138	135.8	129–139	134.8	129–138	132.7	133–137	134.0
45	133–138	136.5	130–137	134.2	130–138	132.9*	121–128	124.9
48	67– 71	69.7	68– 70	68.8	63– 75	67.6	65– 67	65.0
51	39– 44	42.7	39– 42	40.7	41– 45	41.5	40– 42	40.5
52	26– 30	28.9	26– 28	27.6	30– 32	30.2	30– 33	30.6
54	22– 26	24.7	25– 26	25.2	23– 25	24.9	24– 25	25.0
55	49– 54	51.3*	46– 50	48.1	46– 56	51.3	44– 52	48.5

* Significance: $P<0.05$

In spite of the small number of individuals both male and female samples point to the essentials of the classification of Upper Paleolithic skulls in a strikingly similar and definite way. The similarities in the factor structures of the two sexes, which amount up to more than 70 percent of total variance, refer to the high qualitative representation of samples. Moreover, the operativeness of the classification specified in the preceding pages can be increased by the fact that the individuals are distributed similarly between the main parallel groups (Table 10): the number of Cro-Magnon-like skulls (Mladeč 1 and Abri Pataud 1) is twice as large as that of Mediterranean-like skulls (Combe Capelle and Obercassel 2). European Upper Paleolithic appears to have been characterised by a craniological system in which the number of characteristic individuals is gradually and proportionally decreasing from the most typical groups to the solitary finds.

Table 10. Distribution of individuals in the two main groups.

	Males		Females	
Individuals	Mladeč 1	Combe Capelle	Abri Pataud	Obercassel 2
Grouped	8	4	9	5
Ungrouped	11	6	5	3
Total	21	10	14	8
Percentage	67.7	32.3	63.6	36.4

*

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