TESTING THE FUNCTIONAL UTILITY OF HANDAXE SYMMETRY: FALLOW DEER BUTCHERY WITH REPLICA HANDAXES

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ABSTRACT

The Acheulean handaxe has been described by Wymer (1982) as the enigma of the Lower Palaeolithic. Whilst most now agree that it fulfilled a role as a heavy duty butchery tool there is still considerable debate concerning the significance of its distinctive morphology and, in particular, the presence of symmetry, often in more than one plane. This paper reports on experiments designed to empirically test one of the theories for the presence of symmetry, namely that a high degree of symmetry improves the handaxe's effectiveness as a butchery tool. Two fallow deer carcasses were butchered using eight handaxes of varying degrees of symmetry, and the artefacts' effectiveness for butchery was measured in a variety of ways. Results show that there does not appear to be a clear relationship between degree of symmetry and the effectiveness of a handaxe for butchery and that the most important handaxe attribute where butchery is concerned is a multi-purpose cutting edge.

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Key words: Acheulean handaxe, function, symmetry, experimental butchery, cutting edge

INTRODUCTION

Whilst there is still much disagreement regarding the function of the Acheulean handaxe it appears to be almost universally agreed that one, although not necessarily the only, function was that of a heavy duty butchery tool. Use wear analyses of artefacts (e.g. Keeley 1980; Mitchell 1996), the associations between tools and cut marked bone (e.g. Roberts & Parfitt 1999) and experimental butchery using replica handaxes (e.g. Jones 1980, 1981; Mitchell 1996) have confirmed both the handaxe's suitability for this task and its actual use as such. However, whilst accepting this utilitarian aspect of the handaxe's role, some have argued that the artefacts often appear to be over-engineered for this task alone. Both Gamble (1998) and Kohn & Mithen (1999) identify the Acheulean as a social technology and posit a role for the handaxe within a social context, either as a manifestation of individual or group identity or as an extended phenotype, used as a form of display in the competition for mates. In particular, this latter theory refers to the high degree of symmetry exhibited in many handaxes, sometimes in two or more planes, and suggests that it was intentionally imposed to exploit a sensory bias towards symmetry. There is now robust evidence for the assessment of symmetry as a mate choice criteria in many species including humans (e.g. Møller 1992; Grammer & Thornhill 1994; Møller & Thornhill 1998), and Kohn & Mithen (1999) extended this criteria to extinct hominins with reference to the handaxe. Both Pelegrin (1993) and Edwards (2001) also refer to the presence of symmetry within the handaxe as support for their arguments for its non-utilitarian role, although they regard the intentional imposition of symmetry as

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evidence of a nascent aesthetic sense. Whilst Kohn & Mithen (1999) and Pelegrin (1993) may differ in their suggestions for the ultimate role of symmetry in the Acheulean handaxe what they both imply is that the presence of symmetry is not required to increase the suitability of the handaxe for heavy duty butchery tasks. The purpose of the experiments reported here was to explicitly test this assumption: that the degree of symmetry within an Acheulean handaxe is not related to the effectiveness of that tool for a series of butchery processes.

METHODOLOGY

The set of experiments detailed in this paper were carried out in November 2004. The "effectiveness" of a handaxe for butchery was assessed in terms of the total amount of time to carry out a complete butchery task (t), the amount of time to carry out each butchery process (cutting skin, cutting skin from flesh, cutting meat, cutting joints and cutting ligaments), the number of times the handaxe was rotated to identify a more effective cutting edge, and the subjective scores awarded by the butcher in relation to usefulness and ease of use for butchery. The use of time as a measurement of effectiveness was selected upon the assumption that each completed butchery process would take the same period of time if the same handaxe were used on the same portion of a carcass of the same species.

The Handaxe Assemblage

Twenty three flint handaxes were produced, of varying degrees of frontal and side symmetry, by John Lord. These were then digitally photographed in plan view and profile and their degree of frontal and side symmetry was calculated, using Saragusti *et al.'s* (1998) Continuous Symmetry Measure (CSM), from the resultant images using software originally designed for the Acheulean Biface Database (Marshall *et al.* 2002). The CSM provides an actual rather than comparative measure of symmetry. Therefore, absolute symmetry is zero and increasing values represent increasing asymmetry. Eight handaxes of similar length were then selected, to control for size of handaxe as measured by length. These eight handaxes covered the broadest possible range of frontal symmetry (Figure 1 & Table 1).

Handaxe	*Length (mm)*	*Frontal symmetry*	*Side symmetry*
I	105.0	0.0018	0.0010
N	128.2	0.0028	0.0110
J	128.2	0.0049	0.0153
P	128.3	0.0092	0.0256
H	134.8	0.0104	0.0753
T	125.5	0.0118	0.0292
F	133.0	0.0133	0.0673
R	148.9	0.0162	0.0214

Table 1: Length and symmetry measures for the experimental sample (n=8)

Butchery Technique

The butchery was carried out by David John, a professional butcher from the Covered Market in Oxford, on fallow deer carcasses. Employing David John to carry out the experiments ensured that:

1. The variable of increasing skill as butchery skills were learnt was controlled for as the requisite butchery skills were in place prior to the experiment.

2. The variable of pre-existing archaeological knowledge and/or assumptions regarding handaxe function and symmetry was controlled for (David John had no prior experience of using stone tools for butchery).

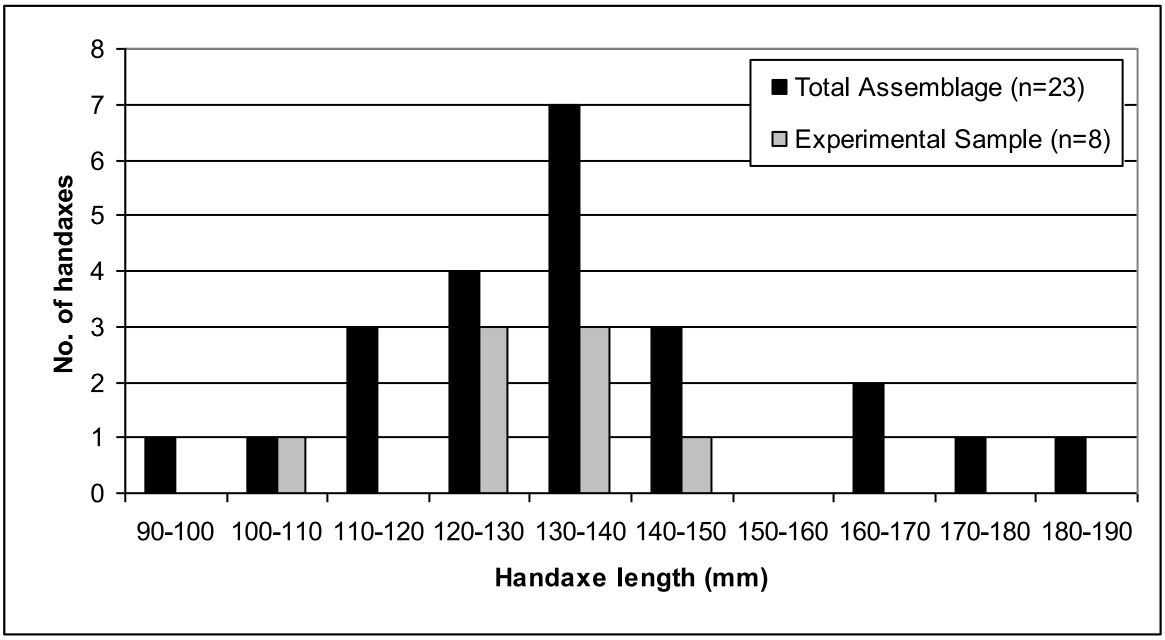

Figure 1: Histogram of handaxe lengths for the total assemblage (n=23) and the experimental sample (n=8)

It was acknowledged that David John's lack of experience with stone tools might lead to a variable factor of increasing skill, and hence speed, with experience of stone tool use which could distort any relationship between handaxe symmetry and effectiveness. However, a subjective video analysis of the resultant experiments did not indicate any initial hesitancy followed by an increase in skill and confidence as the experiment proceeded. A further consideration of the impact of increasing skill on the experimental results is detailed below.

The Butchery Experiment

The butchery experiments took place within a two hour period. David John was presented with each handaxe in turn, commencing with the most symmetrical, in terms of frontal symmetry, first and asked to butcher one quarter of the deer carcass. The use of the handaxes in order of decreasing frontal symmetry dictated that the experiments tested the following hypotheses:

1. Where t (butchery time) is stable either:
    a. Decreasing symmetry does not influence handaxe effectiveness for butchery or;
    b. Decreasing symmetry does negatively influence handaxe effectiveness for butchery but has been counter-balanced by increasing skill and experience.
2. Where t is decreasing either:
    a. Decreasing symmetry leads to an increase in handaxe effectiveness for butchery or;
    b. Decreasing symmetry does not influence handaxe effectiveness for butchery but there has been a marked increase in skill due to experience.

3. Where t increases decreasing symmetry does have an effect on handaxe effectiveness for butchery; as symmetry decreases effectiveness decreases.

The animal was butchered in quarters, each quarter consisting of either a hind or fore leg, to ensure, as far as is practicable, that each handaxe was being used for a comparable butchery process in terms of the order of butchery stages and the characteristics, size and distribution of skin, meat, sinew and joints. However, whilst all eight handaxes were used for the purpose of removing meat from the leg bones of the animal the characteristics of the carcass, and in particular the skin and the joints, differed between the hind and front legs as did, to some extent, the order of the stages of butchery (Table 2).

Following the use of each handaxe David John was asked to score the handaxe on seven, five point, ordinal data scales (Table 3).

Data Collection

The collection of data involved logging the video footage, collating the scores awarded by David John to each handaxe and recording and transcribing David John's subjective comments made during the course of the experiment.

In total one hour and sixteen minutes of footage covering the use of the eight handaxes was video-taped and logged using a series of activity categories (Table 4). The start and end times of each period of activity were noted and the total amount of time for each butchery phase calculated. The numbers of individual episodes of each period of activity were also counted, an episode being defined as a continuous period of a specific activity without pause. Comments from the butcher and discussions between the butcher and Anna Machin were also recorded verbatim from the video record. In addition, an assessment was made of which handaxe edge was being used at any time, for how long, for what process and in what order edges were used. To allow comparison between handaxes each handaxe circumference was split into ten sectors (Figure 2). Sectors a and e relate to use of the tip and butt respectively, sectors h and b use of the edges on the side of the tip, sectors f and d use of the edges on the side of the butt and sectors g and c use of the lateral edges of the handaxe. Sectors x and y incorporate b, c, and d and h, g and f respectively and edge use was categorised using one of these two sectors when long cuts using the entirety of the handaxe edge, with the exception of the tip or butt, were used.

RESULTS

The results of the video logging and scoring are summarised in Tables 5–8. Due to the small overall sample size and the potential effect on results of the use of two carcasses and two carcass body areas for the butchery, as evidenced by the consistent difference in total time to butcher the hind as opposed to fore legs, it was not possible to carry out statistically robust analyses of the results. However, the data visualisation allowed a series of tentative conclusions to be drawn regarding the relationship between handaxe symmetry and effectiveness for butchery.

Carcass Area	*Fore Leg*	*Hind Leg*	
Stage 1	Cutting skin/cutting flesh	Cutting skin	
Stage 2	Cutting skin from flesh	Cutting skin from flesh	
Stage 3	Cutting skin (at ankle)	Cutting ligament	
Stage 4	Cutting flesh (to expose shoulder joint)	Cutting skin from flesh/cutting flesh	
Stage 5	Cutting joint	Cutting skin (at ankle)	
	-	**Route B** (Removal of leg bones in one stage)	**Route A** (Removal of leg bones in two stages)
Stage 6	Cutting flesh (to expose ligament)	Cutting flesh (to remove both leg bones)	Cutting flesh (to remove lower leg bone)
Stage 7	Cutting ligament	Cutting joint	Cutting joint
Stage 8	-	-	Cutting flesh (to remove upper leg bone)

Table 2: Stages of butchery for fore and hind leg

Overall usefulness as a butchery tool	**1** Not at all useful	**2**	**3** Adequate	**4**	**5** Perfect/Ideal
Usefulness for skinning	**1** Not at all useful	**2**	**3** Adequate	**4**	**5** Perfect/Ideal
Usefulness for filleting	**1** Not at all useful	**2**	**3** Adequate	**4**	**5** Perfect/Ideal
Usefulness for dismemberment	**1** Not at all useful	**2**	**3** Adequate	**4**	**5** Perfect/Ideal
Overall quality of cutting edge	**1** Not at all efficient as a cutting edge	**2**	**3** Adequate	**4**	**5** Perfect cutting edge
Weight distribution	**1** Not at all ideal	**2**	**3** Adequate	**4**	**5** Perfect weight distribution
Overall ease of use	**1** Very difficult to use	**2**	**3** Adequate	**4**	**5** Very easy and comfortable to use

Table 3: Scoring categories

Phase	*Definition*
Butchery Processes	
Cutting skin	Cutting through the hide
Cutting skin from flesh	Cutting the seams between the hide and the flesh
Cutting flesh	Cutting flesh and gristle
Cutting joint	Cutting between jointed bones
Cutting ligament	Cutting ligaments and tendons
Handaxe Movements	
Rotate handaxe	*Either* flip the handaxe over to use the other lateral edge *or* use another area of the handaxe edge on the same side e.g. moving from the point to the butt
Clean handaxe	Cleaning the handaxe
Movements of/on deer	
Applying pressure to joint	*Either* applying pressure to a joint *or* pulling apart skin *or* pulling skin from flesh *or* articulating a joint
Shifting carcass/leg/shoulder/ meat	Moving the deer or sections of the deer
Other	
Pausing	To answer question, think, realign self, indicate areas on handaxe etc.

Table 4: Categories of action for video logging

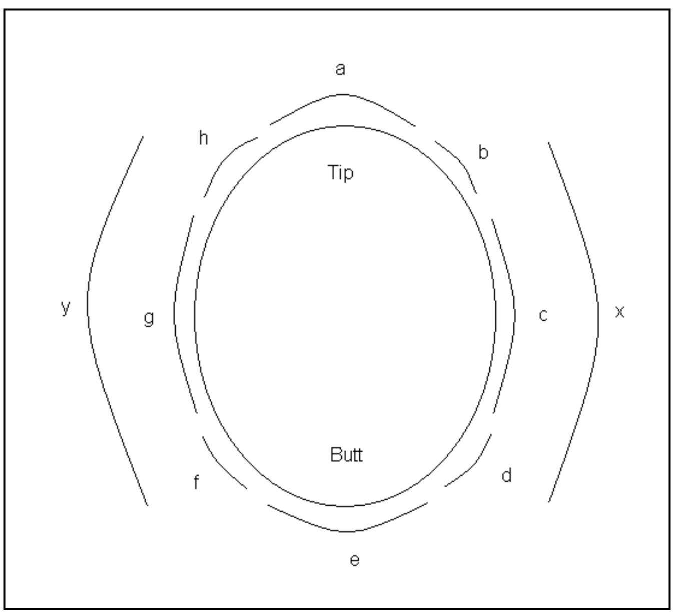

Figure 2: Handaxe diagram illustrating the ten edge sectors used in the edge use analysis

The initial impression is that there is not a strong correlation between either frontal or side symmetry and the effectiveness of a handaxe for butchery (Figures 3 & 4, Tables 5–7). Indeed, overall the most effective handaxe, in terms of total time to butcher (t) and handaxe rotation time, was that exhibiting the lowest degree of frontal symmetry, namely handaxe R. In addition, when considering the hind leg data alone, handaxe H, the handaxe exhibiting the second lowest degree of frontal symmetry and the most asymmetrical value for side symmetry within the "hind leg" group, proved to be the most effective handaxe when considering total butchery time and the number of handaxe rotations. Both results appear to provide support for hypothesis two; namely that either decreasing symmetry leads to increasing effectiveness or that decreasing symmetry has no effect but there has been a marked increase in skill on the part of the butcher. This latter conclusion is supported when plotting cumulative butchery time, as a measure of experience, against t (butchery time) for each individual handaxe (Figures 5 & 6), as individual butchery time appears to decrease with accumulated overall butchery time. However, this conclusion is countered, firstly, by the lack of evidence in the video log for an initial hesitancy followed by an increase in confidence, and secondly, by the following results promoting the paramount importance of the cutting edge.

The results for butchery time achieved by handaxes R and H are backed up by the subjective comments made by David John during the butchery process:

- For R he commented that the edge was "*very sharp*" and capable of cutting through bone. Unlike the other handaxes which took several seconds and multiple strokes to cut a ligament, handaxe R took less then one second and only one stroke.
- Handaxe H was described as "*quite good and effective*". David John particularly liked the long edge which enabled him to take longer strokes, a comment also made for handaxe N.

What is overwhelmingly striking about David John's comments is that they focus on the nature of the cutting edge; its length, characteristics and sharpness. For both handaxes J and F he commented in a positive vein upon the grooved nature of the cutting edges, likening them to a serrated knife. He only rotated the handaxes to find a better edge, not to use the entire edge for the sake of it as has been suggested for some ovates (Mitchell 1996; White 1998), and was not bound by the perceived convention of holding the handaxe with the butt towards the palm and utilizing the lateral edges towards the point.

However, whilst David John's comments indicate that some edges may be better for one particular task than others, an analysis of the edge use data indicates that those edges which received the most use were mainly used for all butchery tasks rather than one edge being assigned to a certain task. This would suggest that an effective edge is one which is capable of being used for multiple butchery tasks. For example, for handaxe N (Figure 8) edges a and b were only briefly used for a single task and were not returned to during the later stages of the butchery to test their appropriateness for other tasks, possibly because they had already been assessed as being ineffective. In contrast, edges c and g, which between them were used for over 88% of the time, were utilized during all stages of the butchery. Similar results were achieved, albeit for different edges, for handaxes J, P, H, T, F and R.

				All butchery	Cutting skin		Cutting skin from flesh		Cutting flesh		Cutting joints		Cutting ligaments	
Handaxe	***Frontal symmetry***	***Carcass***	***Area***	***T (s)***	***T (s)***	***Ep.***	***T (s)***	***Ep.***	***T (s)***	***Ep.***	***T (s)***	***Ep.***	***T (s).***	***Ep.***
I	0.0018	1	Hind leg	953	181	24	183	18	269	42	97	26	2	1
N	0.0028	1	Hind leg	917	160	29	227	22	267	32	77	15	5	1
J	0.0049	1	Fore leg	382	96	13	66	8	84	15	23	5	3	2
P	0.0092	1	Fore leg	375	74	12	43	2	97	9	68	20	4	1
H	0.0104	2	Hind leg	539	72	11	117	15	162	19	71	14	3	1
T	0.0118	2	Hind leg	809	136	19	159	23	270	31	43	8	4	2
F	0.0133	2	Fore leg	315	79	11	65	3	48	13	60	13	7	2
R	0.0162	2	Fore leg	246	56	11	42	7	39	9	45	4	1	1

Table 5: Results of butchery processes for each handaxe (in order of decreasing frontal symmetry). T (s): butchery time; Ep.: Number of episodes

			Handaxe rotations		***Cleaning handaxe***		***Shifting carcass***		***Applying pressure to joints***	
Handaxe	***Carcass***	***Area***	***Time (s)***	***Episodes***	***Time (s)***	***Episodes***	***Time (s)***	***Episodes***	***Time (s)***	***Episodes***
I	1	Hind leg	39	34	2	3	126	45	29	16
N	1	Hind leg	18	22	18	10	110	48	20	12
J	1	Fore leg	3	1	2	1	81	25	6	3
P	1	Fore leg	17	9	0	0	46	24	10	6
H	2	Hind leg	5	5	0	0	59	25	25	9
T	2	Hind leg	20	12	11	4	89	32	13	3
F	2	Fore leg	6	3	0	0	45	20	4	4
R	2	Fore leg	1	2	0	0	28	11	18	10

Table 6: Results of other activities for each handaxe (in order of decreasing frontal symmetry)

Handaxe	Overall usefulness as a butchery tool	Usefulness for cutting skin	Usefulness for cutting flesh	Usefulness for cutting joints and ligaments	Overall quality of cutting edge	Weight distribution	Overall ease of use
I	3	2	3	2	2	3	2
N	2	3	2	3	2	2	1
J	4	4	4	4	4	3	4
P	1	4	1	1	2	2	1
H	3	4	2	2	3	2	2
T	1	2	1	1	1	1	1
F	2	3	3	3	3	3	2
R	4	4	3	4	4	3	3

Table 7: Results of the butcher's scorings for each handaxe

Handaxe	Number of sectors utilised	Order edges utilised (for edge codes see Figure 2)	Sectors	Number of episodes in sector	Time utilised (s)	%	Time (s) for cutting skin	%	Time (s) for cutting skin from flesh	%	Time (s) for cutting flesh	%	Time (s) for cutting joint	%	Time (s) for cutting ligament (s)	%
I	6	bfdadbfdhehbfdebh	a	1	2	0.21	2	1.10	0	0.00	0	0.00	0	0.00	0	0.00
		efdfdfdfhedhedhed	b	4	128	13.21	22	12.15	11	6.01	74	27.41	0	0.00	0	0.00
		h	d	10	276	28.48	39	21.55	148	80.87	45	16.67	0	0.00	2	100.00
			e	6	39	4.02	9	4.97	0	0.00	4	1.48	11	11.34	0	0.00
			f	7	167	17.23	92	50.83	3	1.64	29	10.74	0	0.00	0	0.00
			h	7	357	36.84	17	9.39	21	11.48	118	43.70	86	88.66	0	0.00
N	6	hgcgbgfhfhcgcgcac	a	2	12	1.32	0	0.00	0	0.00	12	4.49	0	0.00	0	0.00
		gcga	b	1	3	0.33	2	1.25	0	0.00	0	0.00	0	0.00	0	0.00

			c	6	274	30.18	54	33.75	79	34.80	70	26.22	15	19.48	5	100.00
			f	2	74	8.15	1	0.63	62	27.31	0	0.00	0	0.00	0	0.00
			g	7	529	58.26	90	56.25	84	37.00	185	69.29	62	80.52	0	0.00
			h	3	16	1.76	13	8.13	2	0.88	0	0.00	0	0.00	0	0.00
J	2	yx	x	1	276	76.67	96	100.00	66	100.00	64	74.42	0	0.00	0	0.00
			y	1	84	23.33	0	0.00	0	0.00	22	25.58	23	100.00	3	100.00
P	3	xyxyxydy	d	1	5	1.33	0	0.00	0	0.00	0	0.00	4	5.88	0	0.00
			x	3	208	55.32	56	75.68	43	100.00	69	71.13	5	7.35	1	20.00
			y	4	163	43.35	18	24.32	0	0.00	28	28.87	59	86.76	4	80.00
H	3	yxaxyx	a	1	3	0.55	0	0.00	0	0.00	2	1.23	0	0.00	0	0.00
			x	3	312	57.67	2	2.78	5	4.27	134	82.72	71	100.00	0	0.00
			y	2	226	41.77	70	97.22	112	95.73	26	16.05	0	0.00	3	100.00
T	4	yxyfydydfy	d	2	12	1.48	0	0.00	0	0.00	4	1.48	0	0.00	0	0.00
			f	2	12	1.48	0	0.00	3	1.89	8	2.95	0	0.00	0	0.00
			x	1	7	0.86	0	0.00	6	3.77	0	0.00	0	0.00	0	0.00
			y	5	779	96.17	136	100.00	150	94.34	259	95.57	43	100.00	4	100.00
F	3	cyby	b	1	4	1.27	0	0.00	0	0.00	3	6.25	0	0.00	0	0.00
			c	1	29	9.24	25	31.65	0	0.00	0	0.00	0	0.00	0	0.00
			y	2	281	89.49	54	68.35	65	100.00	45	93.75	60	100.00	7	100.00
R	2	hbh	b	1	162	66.67	50	89.29	42	100.00	28	71.79	0	0.00	0	0.00
			h	2	81	33.33	6	10.71	0	0.00	11	28.21	45	100.00	1	100.00

Table 8: Estimation of handaxe edge use

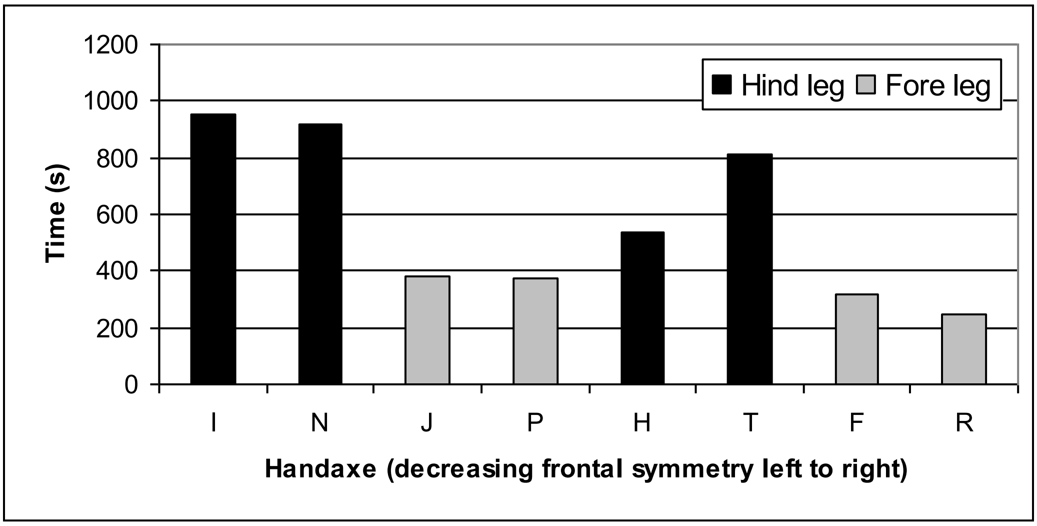

Figure 3: Total time per butchery episode (handaxes ordered by decreasing frontal symmetry)

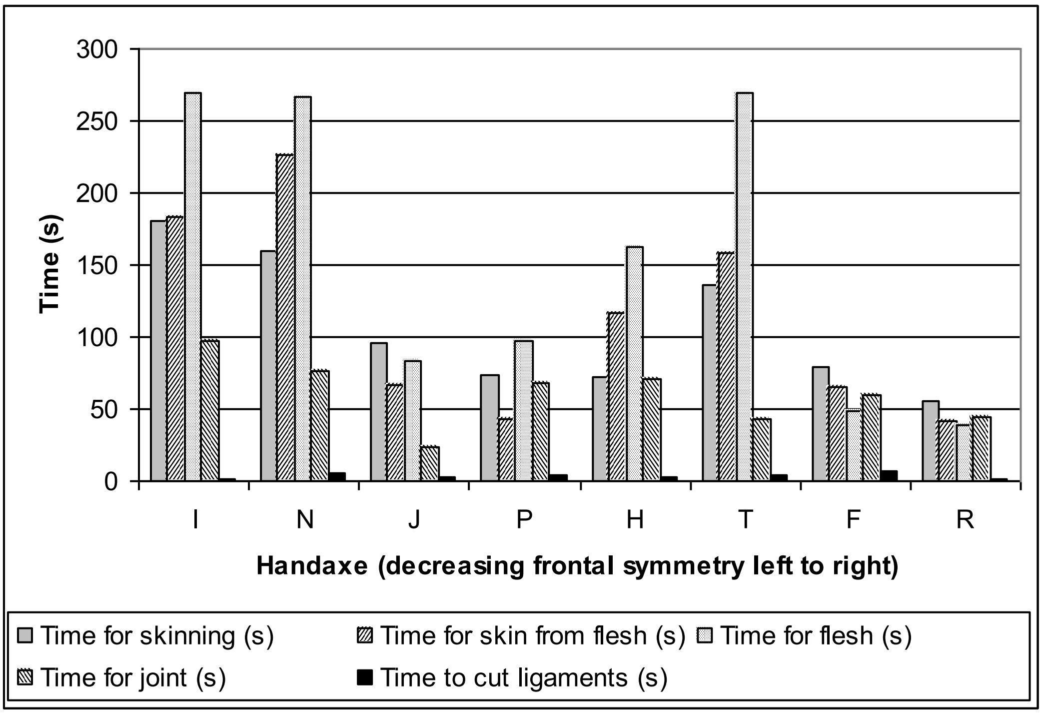

Figure 4: Time per individual butchery stage (handaxes ordered by decreasing frontal symmetry). Time for skinning (s) = Time (s) for cutting skin; Time to skin from flesh (s) = Time (s) for cutting skin from flesh; Time for flesh (s) = Time (s) for cutting flesh; Time for joint (s) = Time (s) for cutting joints; Time for cut ligaments (s) = Time (s) for cutting ligaments.

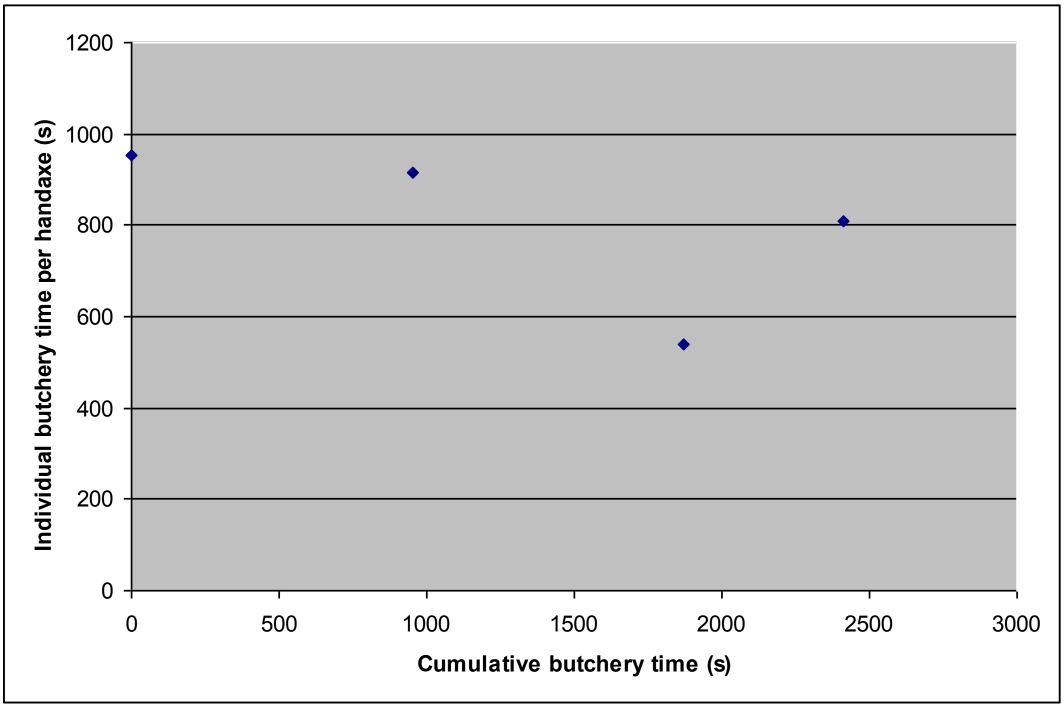

Figure 5: Cumulative butchery time versus individual butchery time per handaxe (hind leg experiments)

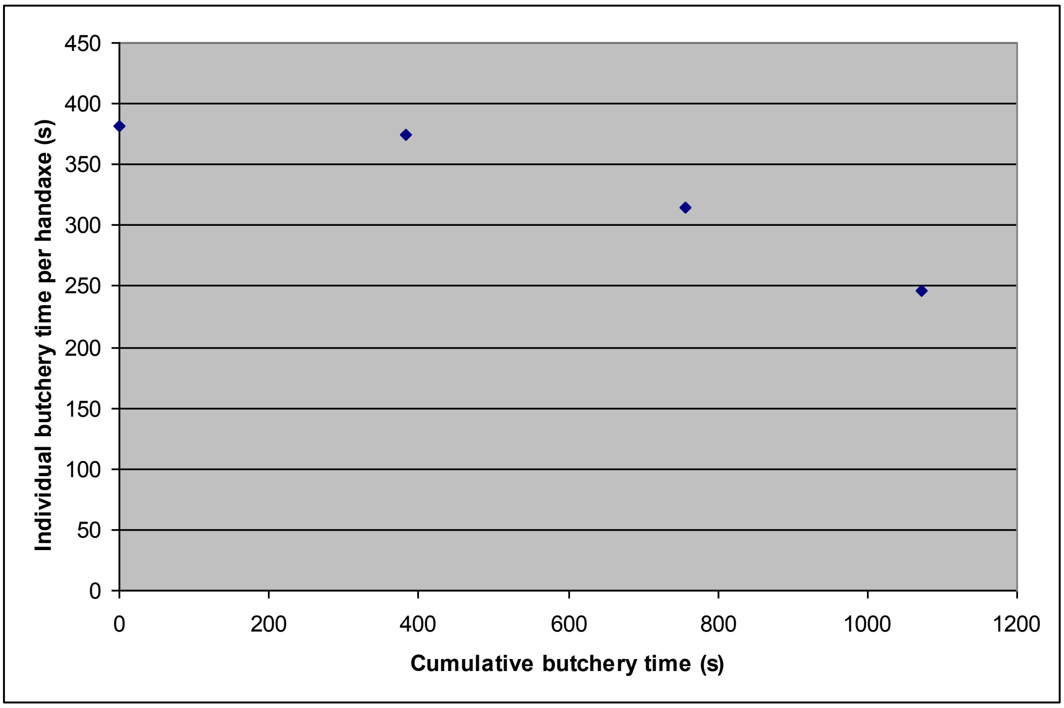

Figure 6: Cumulative butchery time versus individual butchery time per handaxe (fore leg experiments)

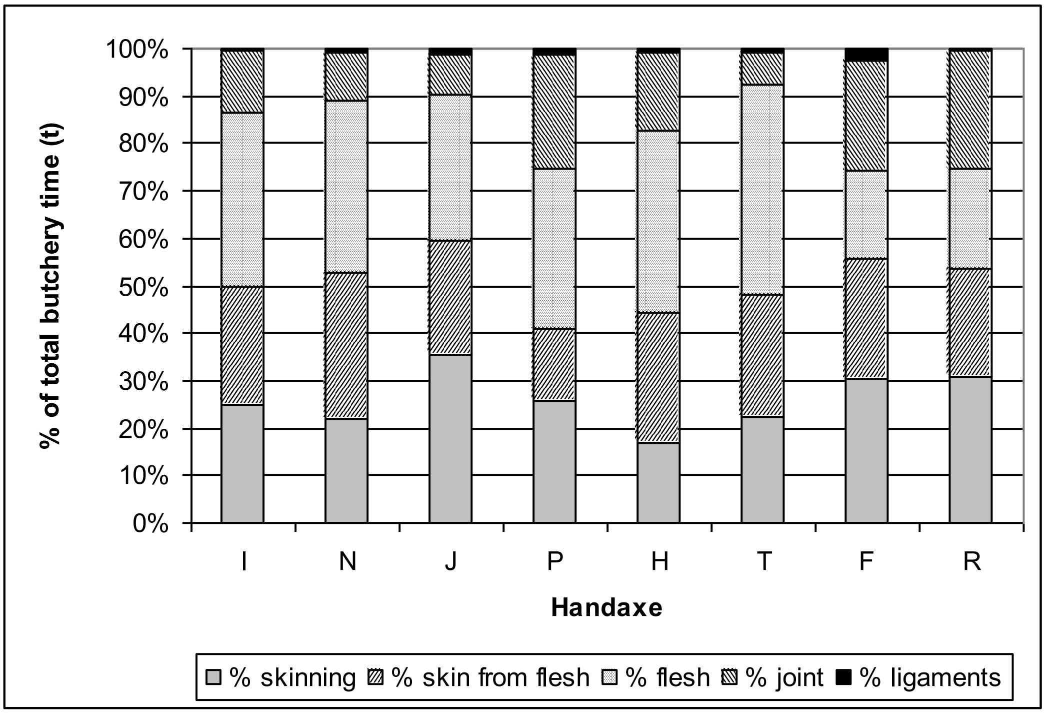

Figure 7: Percentage of total butchery time (t) represented by each butchery phase. % skinning = % time for cutting skin; % skin from flesh = % time for cutting skin from flesh; % flesh = % time for cutting flesh; % joint = % time for cutting joints; % ligaments = % time for cutting ligaments.

CONCLUSIONS

Whilst the scale of the experiment did not allow for robust statistical analysis, the visualisation of the data has indicated the lack of a clear relationship, either positive or negative, between the degree of symmetry and the effectiveness of a handaxe for butchery. Analysis of the logged and scoring data in fact indicates that, when using the handaxe for butchery, it is the nature of the cutting edge which is of paramount importance, a multi-purpose cutting edge being the desired goal even if this should involve using the butt. As such our results support the conclusions of Ashton & McNabb (1994) and White (1998) with respect to handaxe form being the result of a compromise between raw material form and the desire for the most effective cutting edge. Therefore, our results lead us to the tentative conclusion that symmetry is present for some other reason. Combined with the results of other work which indicates that raw material is not a controlling factor for symmetry, thus removing another variable from the list of possibilities (Machin & Marshall in prep.), this would suggest that this reason was, in all probability, non-utilitarian. Therefore, future work will focus not only on repeating the reported experiment on a wider scale to ensure replicability of results but also on testing the robusticity of those theories which link the presence of symmetry to social behaviour or cognitive development amongst the multiple hominin species of the Lower Palaeolithic.

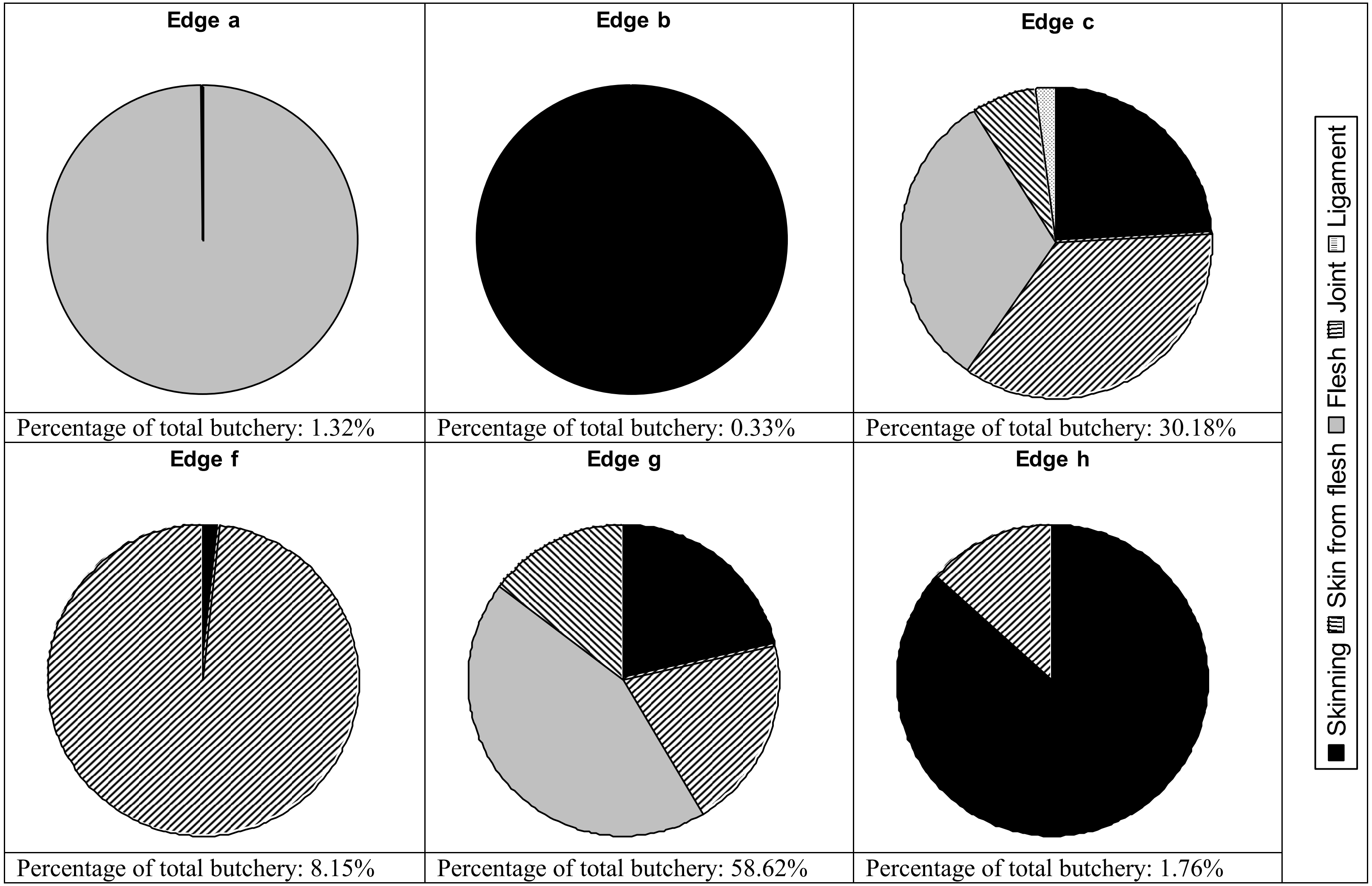

Figure 8: Edge use data for handaxe N. Skinning = cutting skin; Skin from flesh = cutting skin from flesh; Flesh = cutting flesh; Joint = cutting joints; Ligament = cutting ligaments.

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