Scraper reduction at the Early Neolithic site of Hurst Fen, Suffolk, England

Andrew P. McLaren [1,2], Adam Brumm [3,4]

1. AECOM Australia Pty Ltd, Level 5, 420 George Street, Sydney, New South Wales, Australia.
Email: andrew.mclaren@aecom.com
2. Department of Archaeology, School of Philosophical and Historical Inquiry, Faculty of Arts and Social Sciences, University of Sydney, Sydney, New South Wales, Australia.
3. Australian Research Centre for Human Evolution, Griffith University, Brisbane, Queensland, Australia.
Email: a.brumm@griffith.edu.au
4. School of Environment and Science, Griffith University, Brisbane, Queensland, Australia.

Abstract:

Prior analyses of Neolithic flaked stone assemblages in Britain have tended to focus on the relative abundance of different implement types as a basis for inferring the structure of settlement and subsistence patterns during this period, with dorsally retouched 'scrapers' dominating the retouched components of most assemblages. Here we investigate the relationship between scraper morphology and reduction intensity at the classic Early Neolithic site of Hurst Fen in Suffolk, England. We hypothesize that the morphological variability underpinning the distinction between formal scraper types at Hurst Fen is largely a product of increasing reduction intensity. To test this hypothesis, we apply a range of quantitative measures of reduction intensity to a sample of 175 complete scrapers from the site, including: Kuhn's (1990) Geometric Index of Unifacial Reduction (GIUR), Hiscock and Attenbrow's (2002; 2005) retouch curvature and retouched zone indices, perimeter of retouch, and retouched edge angle. Correlation statistics and descriptive plots of the relationship between Kuhn's GIUR and the remaining retouch characteristics reveal universally positive and statistically significant relationships, albeit with the correlation between the GIUR and retouched edge angle markedly weaker than for the other retouch characteristics. Collectively, the results of our analyses support the hypothesis that the extent to which scrapers were reduced throughout their respective use-lives was a critical factor in the creation of morphological and, by extension, typological variability in the Hurst Fen scraper assemblage. At the same time, our data suggest that Early Neolithic knappers at Hurst Fen habitually knapped and resharpened scrapers in such a manner that a relatively low edge angle of around 60° was continually reproduced, raising the possibility of preconceived 'designs' that were primarily expressed in the morphological features of retouched edges. We propose a model of scraper reduction that accounts for most of the differences in scraper morphology at Hurst Fen and evaluate the analytical utility of Clark's hugely influential typological scheme in view of this. We also consider the implications of our findings for interpretations of morphological patterning in British Neolithic scraper assemblages more broadly.

Keywords: Hurst Fen; scraper; reduction intensity; typology; Early Neolithic; Grahame Clark

Journal of Lithic Studies (2025) vol. 12, nr. 1, 30 p. DOI: https://doi.org/10.2218/jls.9629

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

1. Introduction

To echo a point made by Brown (1995) almost thirty years ago, few studies in the history of archaeological lithic analysis have had as great and enduring an impact as Grahame Clark's description of the struck flint assemblage recovered from the Early Neolithic site of Hurst Fen in Suffolk, England, excavated in the mid-to-late 1950s (Clark *et al.* 1960). Although published over half a century ago, Clark's approach to the description of the Hurst Fen assemblage, characterised by Brown (1995) as a three-stage sequence moving from raw materials, to formed objects (*sensu* Moore 2000: 28) and 'affinities', continues to be routinely replicated by British Neolithic lithic specialists, albeit with flake debitage analyses now also included in the process. At the same time, the typological scheme developed by Clark for the retouched component of the Hurst Fen assemblage remains, in only slightly modified form, the cornerstone of virtually all modern investigations of Neolithic lithic technology in Britain (see, *e.g.*, Ballin 2021; Butler 2005). Much like Bordes' (1961b) pioneering typological scheme for the European Middle Palaeolithic, Clark's typology was primarily morphological in nature, with retouch location and plan outline comprising the primary determinants of a tool's 'type'. As with his equally influential typology for the microlithic industries of the British Mesolithic (Clark 1932), underpinning Clark's typological scheme for the Hurst Fen assemblage was his belief in flaked stone tool assemblages as one of the key archaeological manifestations of different prehistoric cultures, and, more specifically, the economic responses of these groups to differing ecological contexts (Brown 1995: 27; Fagan 2001: 33). Implicit within Clark's typology was the notion that different stone artefact types are real, discontinuous and immutable entities that directly reflect shared intentional designs in the minds of their manufacturers.

Viewed in its historical context, Clark's morphological typology for the Hurst Fen assemblage, and the assumptions underpinning it, are far from unique. Indeed, both are typical of the culture-historical archaeology of the late 19th and early-to-mid 20th centuries. As alluded to above, perhaps the best-known parallel for Clark's typology is Bordes' (1961b) typology for the European Middle Palaeolithic, premised as it was on this scholar's belief in both the intentionality of types and their corresponding archaeological significance, namely, as markers of different ethnic groups (Bordes 1961a). However, unlike Bordes' typological scheme, which has been the focus of much debate and review over the past six decades (*e.g.*, Binford 1973; Binford & Binford 1966; Bisson 2000; Bordes & de Sonneville-Bordes 1970; Dibble 1995; 1984; 1987b; 1987a; 1989; 1991b; 1991a; Dibble & Rolland 1992; Hiscock & Clarkson 2008; 2015; Rolland 1977; 1981; Rolland & Dibble 1990), Clark's model has received little in the way of critical scrutiny. Indeed, while questions have been raised over the utility of Clark's general approach to lithic analysis (*e.g.*, Brown 1995), the typological scheme upon which this approach is based has yet to be seriously critiqued. This is surprising given the profusion of so-called 'reduction thesis' studies that have been published in recent decades (*e.g.*, Andrefsky 2006; Bischoff 2023; Blades 2003; Brumm & McLaren 2011; Bustos-Pérez & Baena 2019; Bustos-Pérez *et al.* 2024; Clarkson 2002a; 2002b; 2005; 2006; 2007; 2008; Douze & Delagnes 2016; Hashemi *et al.* 2021; Hiscock & Attenbrow 2003; 2011; 2002; Hiscock & Clarkson 2005a; 2005b; 2008; 2015; Holdaway *et al.* 1996; Lerner 2015; Lombao *et al.* 2020; 2023; Maloney 2020; Maloney *et al.* 2017; Marwick 2008a; 2008b; Marwick *et al.* 2016; McPherron 1995; Morales 2016; Morrow 1997; Morrow & Morrow 2002; Muller *et al.* 2018; Nguyen & Clarkson 2013; 2016; Shott 2017; Shott & Seeman 2015; Shott & Weedman 2007). Central to this ever-growing body of applied archaeological research is the notion that the final forms of chipped stone artefacts need not indicate cognitive intent but rather the influence of a potentially wide range of variables in the reduction process, with reduction intensity and differences in the morphology of blanks selected for retouch identified as key variables. Notably, while the validity of the reduction thesis has gained broad acceptance amongst lithic specialists (for a recent review, see Shott 2024), in Europe, published applications of the reduction thesis outside of the Palaeolithic remain scarce, a situation that stands in contrast to some other parts of the world (*e.g.*, Australia and North America).

The present study contributes to existing research on the meaning of morphological patterning in Holocene flaked stone tool assemblages in Britain by investigating the relationship between scraper morphology and reduction intensity in the Neolithic technology of Hurst Fen. We have chosen to focus on scrapers, as these implements not only dominate the retouched component of the Hurst Fen assemblage but most British Neolithic assemblages. A primary objective of this study is to test the hypothesis that the morphological variability underpinning the distinction between scraper types in the Hurst Fen assemblage is, to a considerable degree, causally linked to increasing reduction intensity. To do this, we use an array of quantitative methods of lithic analysis not previously applied to the Hurst Fen material, nor, to our knowledge, to any other British Neolithic scraper assemblage. We use our results to develop a model of scraper reduction that accounts for most of the differences in scraper morphology at Hurst Fen and evaluate the analytical utility of Clark's typology in view of this.

2. The Hurst Fen site: Background

The Early Neolithic site at Hurst Fen is located in the Mildenhall parish of Suffolk, approximately 2.4 kilometres north of the river Lark (Figure 1). The site, which occupies a low Breckland hillock, was excavated over three seasons in the mid-to-late 1950s. Preliminary investigations by Lady Grace Briscoe in 1954 (Briscoe 1954) were followed by two seasons (1957-58) of excavations directed by Grahame Clark (Clark *et al.* 1960). Together, these investigations revealed an artefact-rich 'cultural layer' and associated subsoil features covering an area of approximately 3,500 m^2 (Figure 2). Subsoil features comprised 200 pits containing variable quantities of pottery, struck and burnt flint, animal bone and worked stone, as well as a small though unquantified number of postholes. No definite structures were identified. However, the distribution of pits across the site was not uniform, with several distinct clusters of pits discernible, particularly around its periphery. These features were interpreted by Clark as belonging to separate households, each with its own cluster of grain storage pits (but see Pollard 1999 for a different interpretation based on power relations and the temporality of occupation). No absolute dating evidence is available for the Hurst Fen site. Nonetheless, as the type-site for Early Neolithic 'Mildenhall Ware' pottery in East Anglia, a date range of approximately 3,700-3,400 cal. BC is broadly accepted (for comparable Mildenhall Ware sites in East Anglia see Garrow *et al.* 2006; Harding 2017; Healy 1988; 2013; Hummler 2005; Tabor *et al.* 2016; Wainwright 1972; Wilkinson *et al.* 2012).

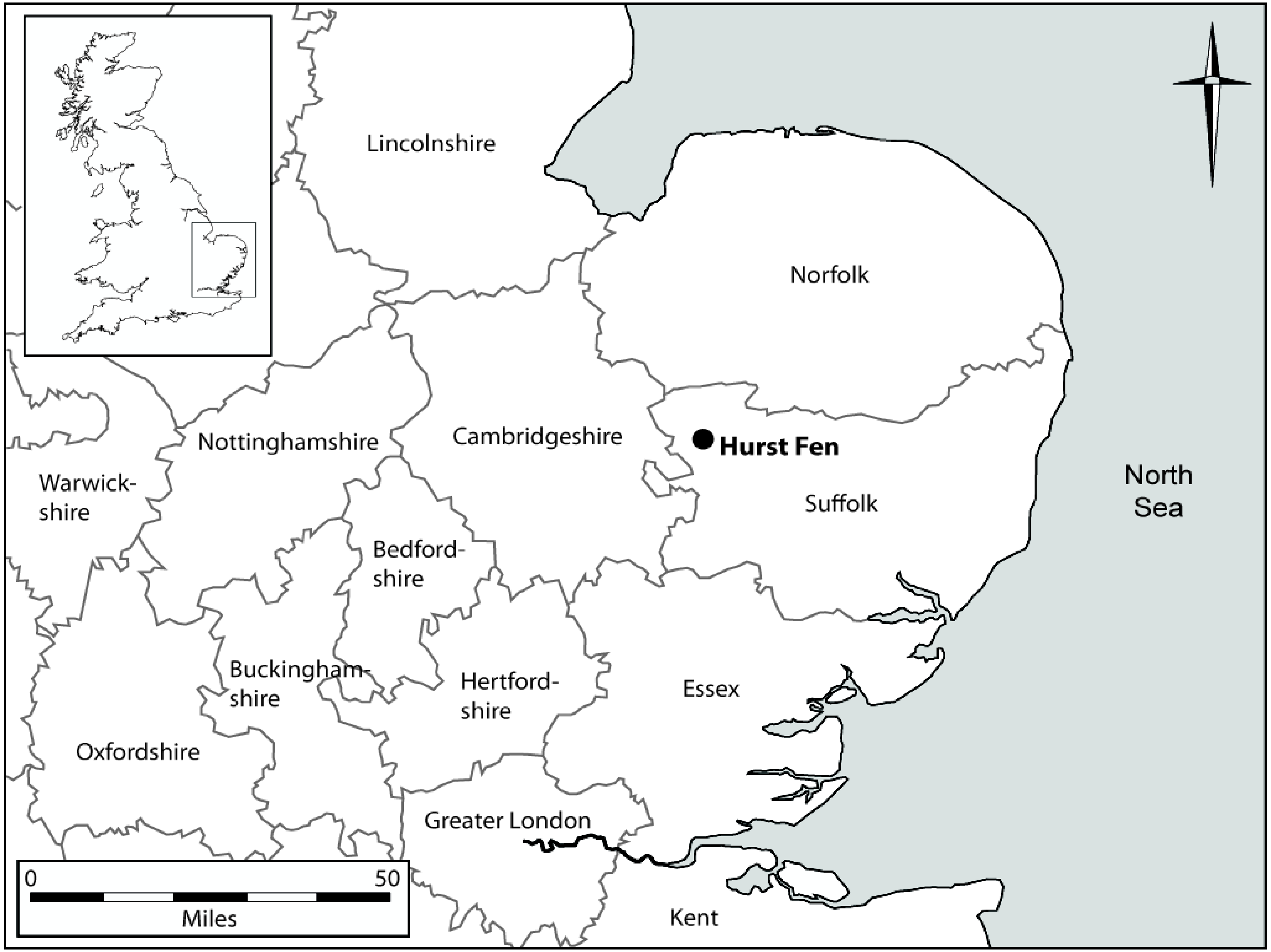

Figure 1. Map of southeastern England showing the location of the Hurst Fen site in Suffolk

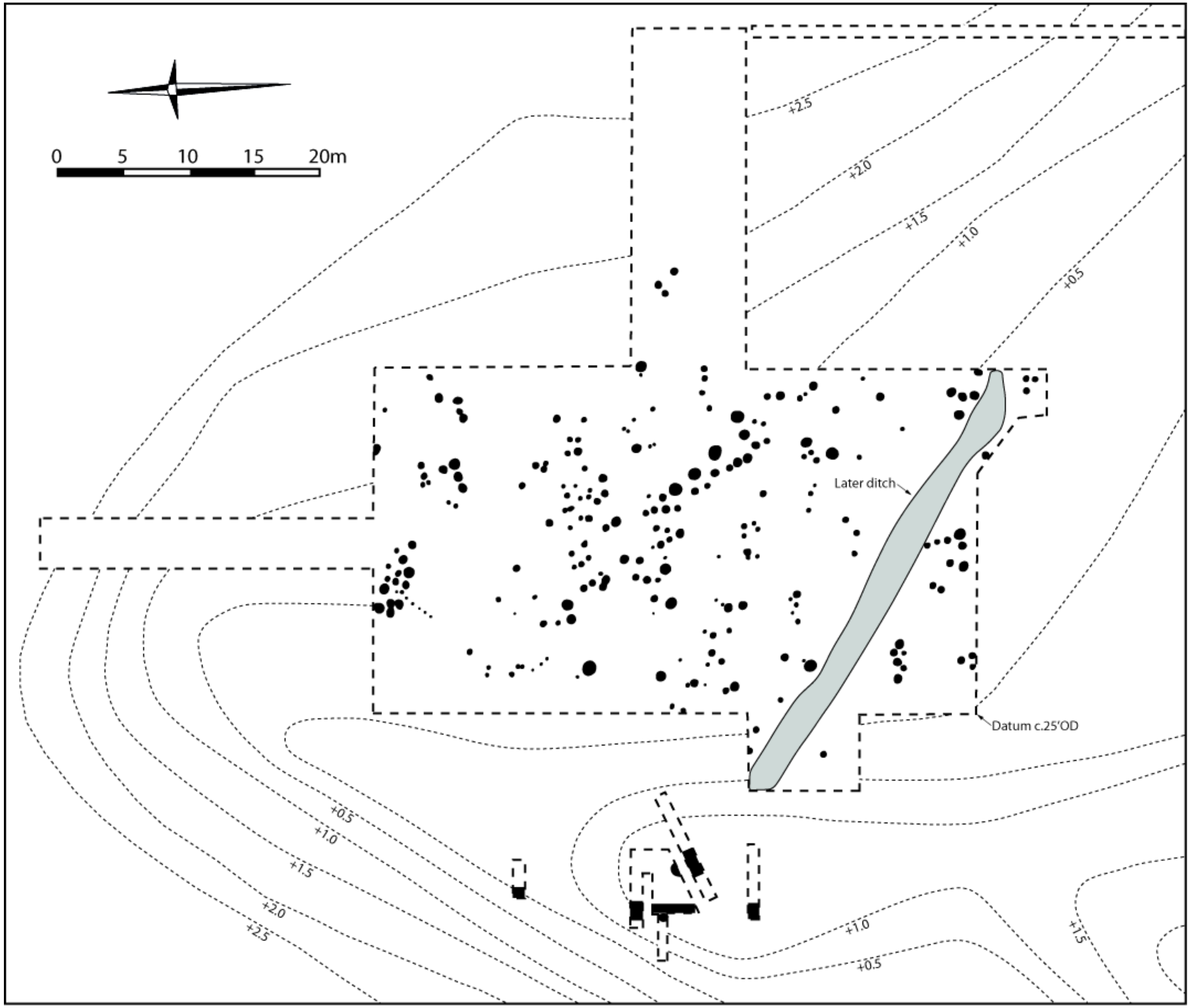

Figure 2. Hurst Fen excavation plan (redrawn from Clark *et al.* 1960: 204, fig.1 & plate 26)

The total number of flaked stone artefacts recovered from formal archaeological investigations at Hurst Fen is unavailable in published records for the site. However, Clark *et al*. (1960: 214) report an assemblage of *c*.16,500 pieces from the first season of excavation alone. Clark *et al.*'s (1960: 214, fig. 7) published typological breakdown of this sub-assemblage reveals a more-or-less standard technological profile for a British Neolithic lithic assemblage, with cores, unmodified utilised flakes and retouched implements poorly represented in comparison to unmodified 'waste' flakes. A typological breakdown of the site's combined retouched tool assemblage (Table 1), meanwhile, attests to the strong representation of scrapers at Hurst Fen, with 58.2% (n = 736) of all quantified implements (n = 1264) from the site classified as such. Other numerically significant tool types include serrated or denticulated flakes (n = 356, first season only), leaf-shaped arrowheads (n = 70, all seasons) and small, bifacially flaked implements known as laurel-leaves (n = 44, all seasons). Cortical surfaces indicate a near exclusive reliance on locally occurring and abundant secondary (non-mined) flint, which appears to have been of generally good knapping quality.

Table 1. Typological breakdown of the retouched component of the Hurst Fen assemblage. [1] Note that the number of serrated flakes presented here is a *minimum value* as it relates only to the first season of excavation at Hurst Fen. Counts for the second and third seasons are not provided in Clark *et al.*'s (1960) excavation report.

Type	**Number**	**%**
Scraper	736	58.2
Serrated flake[1]	356	28.2
Leaf-shaped arrowhead	70	5.5
Laurel-leaf	44	3.5
Awl	18	1.4
Burin	11	0.9
Blunted-back knife	10	0.8
Fabricator	10	0.8
Polished axe	6	0.5
Sickle	1	0.1
Polished knife	1	0.1
Petit tranchet arrowhead	1	0.1
Total	**1,264**	**100**

Most scrapers at Hurst Fen were manufactured on flakes produced via direct hard hammer percussion. However, scrapers made on blades, including some struck by soft-hammer percussion (evidenced by diffuse bulbs and platform lipping), as well as thermal spalls, are also present in the assemblage. For those manufactured on 'struck flakes' (n = 626), Clark classified each specimen into one of five types - denoted type A through E - based principally on the location of their retouch but also plan outline and the presence or absence of a bulb of percussion. The five discrete scraper types are: *end* (A), *double-ended* (B), *disc* (C), *side* (D) and *broken flake* (E) (Table 2). In Clark's classificatory scheme, 'end' scrapers dominate the Hurst Fen scraper assemblage (80.2%, n = 502), with 'double-ended', 'disc', 'side' and 'broken flake' scrapers comparatively poorly represented at 1.3% (n = 8), 2.2% (n = 14), 3% (n = 19) and 13.3% (n = 83), respectively (see Table 2). However, it should be noted that Clark's 'end' scraper category incorporates a significant - though as yet unquantified - number of specimens that most modern British Neolithic and Bronze Age lithic specialists would classify as 'end and side' scrapers (*i.e.*, scrapers exhibiting retouch across their distal end and along one or both lateral margins).

Table 2. Clark's (1960) typological breakdown of Hurst Fen scrapers made on 'struck flakes' (n = 626).

Scraper Type	Number	%
End	502	80.2
Broken flake	83	13.3
Side	19	3
Disc	14	2.2
Double-ended	8	1.3
Total	**626**	**100**

3. Methodology

The analytical methodology adopted for this study follows that employed by Hiscock and Attenbrow (2002; 2003; 2005) in their seminal investigation of early Aboriginal implement variation at the Capertee rockshelter in New South Wales, Australia, as well as Clarkson's (2005) investigation of scraper reduction continuums in the eastern Victoria River region of Australia's Northern Territory. A primary objective of this study, as indicated, is to test the hypothesis that the morphological variability underpinning the distinction between the various scraper types in the Hurst Fen assemblage is largely a product of increasing reduction intensity. At the same time, following Clarkson (2005), we seek to evaluate the analytical utility of Clark's influential typology in two key respects; firstly, to investigate the degree to which it provides an accurate depiction of the nature of scraper morphology at Hurst Fen; and secondly, to assess the boundedness of Clark's types. Our sample for this study consists of 175 complete scrapers from the Hurst Fen excavation archive, with implements selected for inclusion on a non-random basis following a visual assessment of the archived scraper assemblage at large. All four of Clark's complete scraper types are represented in our sample (Table 3, Figure 3), with the addition of the now standard 'end and side' category. Importantly, care was taken during sampling to select a morphologically diverse range of scrapers within each typological category. Accordingly, we have confidence in the representativeness of our sample.

Table 3. Relative frequency of scraper types in the sample employed in this study.

Scraper Type	Number	%
End	96	54.9
End and side	51	29.1
Side	16	9.1
Disc	8	4.6
Double-ended	4	2.3
Total	**175**	**100**

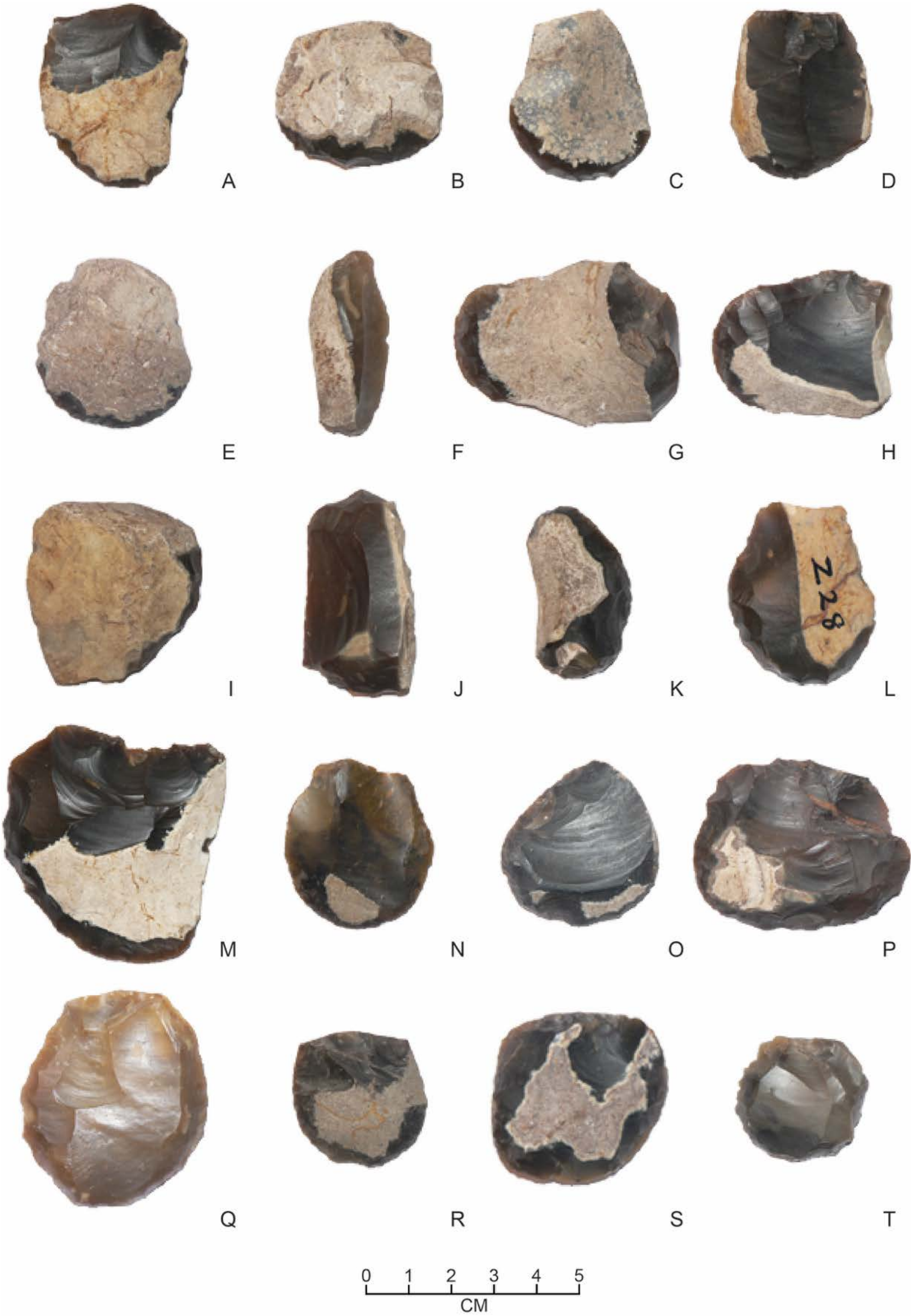

Figure 3. Selection of scrapers from Hurst Fen. Types, as classified by the authors, as follows: end (A-F), side (G-I), double-ended (J-K), end and side (L-R), disc (S-T).

In the first section of this paper, we examine changes in scraper morphology in response to increased reduction using a range of quantitative measures and indices, including: Kuhn's (1990) Geometric Index of Unifacial Reduction (GIUR), Hiscock and Attenbrow's (2002; 2005) retouch curvature and retouched zone indices, perimeter of retouch, retouched edge angle, and retouch termination type. Results are used to develop a hypothetical reduction model for Hurst Fen scrapers. Descriptions of employed measures and indices, as well as associated recording protocols are provided in Supplementary Information (SI) File #1. While acknowledging the potential for alternate avenues of reduction analysis for the Hurst Fen assemblage, including, for example, 2D and 3D geometric morphometric analyses (*e.g.*, Bischoff 2023; Bustos-Pérez *et al.* 2024; Hashemi *et al.* 2021), we emphasise that the attributes selected for use in this study have been shown, both individually and in combination, to comprise robust measures of reduction intensity (see, *e.g.*, Brumm & McLaren 2011; Clarkson 2002b; 2002a; 2005; 2006; 2007; 2008; Hiscock & Attenbrow 2003; 2011; 2002; Hiscock & Clarkson 2005a; 2005b; 2008; 2015; Maloney 2020; Maloney *et al.* 2017; Marwick 2008a; 2008b; Marwick *et al.* 2016; Nguyen & Clarkson 2013; 2016).

In the second part of the paper, we assess the analytical utility of Clark's typology using bivariate plots and comparison of means tests. Plots of Clark's scraper types against various measures of reduction intensity are accompanied by the results of independent t and Mann-Whitney U tests for changes in implement morphology between these types. Results from these analyses provide insight into both the accuracy of Clark's typology and the extent to which the various scraper types identified in the Hurst Fen assemblage can be considered discrete and tightly bounded entities.

Data throughout were analysed using IBM SPSS Statistics 29, with a conventional significance threshold of 0.05 employed. Assumptions for normality were checked by examining histograms and Q-Q plots, as well as Shapiro-Wilk tests, while those for variance were checked via Levene's test. Where appropriate, non-parametric tests (*e.g.*, Mann-Whitney U, Spearman's Rho) were used. To facilitate replicability and future research use, all recorded attribute data for this study are available in Supplementary Information (SI) File #2.

4. Results

4.1. Characterising scraper reduction at Hurst Fen

Descriptive statistics for the size and shape of the 175 scrapers employed in this study are provided in Table S1 in SI File #1, while those for assessed retouch characteristics are presented in Table S2. Correlation statistics (Table 4) and plots (Figure 4) of the relationship, in our scraper sample, between Kuhn's GIUR and four other key retouch characteristics - perimeter of retouch, number of retouched zones, retouched edge curvature and retouched edge angle - reveal universally positive and statistically significant relationships. A Spearman's rank correlation of GIUR and perimeter of retouch reveals a strong correlation between these two characteristics (r_s([173]) = [.72], p = < .001), a finding consistent with the prediction that as greater amounts of retouch were applied to the edges of Hurst Fen scrapers, the total length of retouched margins increased concomitantly. Unsurprisingly, a similarly strong correlation (r_s([173]) = [.66], p = < .001) exists between the GIUR and the number of retouched flake 'zones' or segments on Hurst Fen scrapers, a result that provides further evidence for the progressive expansion of retouch around flake perimeters throughout the reduction process. Analysis also indicates that retouched scraper edges became progressively more curved with increased reduction, with the scrapers in our sample revealing a strong correlation between the GIUR and retouched edge curvature (r_s([173]) = [.65], p = < .001). Notably, the correlation between the GIUR and retouched edge angle in our sample is markedly weaker (r_s([173]) = [.25], p = < .001) than the preceding retouch characteristics. We observe that average edge angles remain unexpectedly low and acute throughout the majority of the reduction process (~60°, see Table 5), increasing only in its final stages. We discuss this pattern in further detail below. Finally, ordinal logistic regression indicates a significant positive relationship between the GIUR and the frequency of aberrant terminations on the edges of Hurst Fen scrapers ($\beta = 5.68$, S.E. = .95, Wald's $\chi^2(1) = 36.1$, $p = < .001$), a finding consistent with the experimentally-demonstrated association between increasing retouched edge angles and the frequency of aberrant terminations on those edges (*e.g.*, Cotterell & Kamminga 1987; Macgregor 2005).

Table 4. Correlation statistics for relationship between GIUR and other reduction measures/indices.

Comparison	**Spearman's rank correlation coefficient**	**Df**	**Significance**	**N**
GIUR vs. perimeter of retouch (%)	.72	173	<.001	175
GIUR vs. retouched zone index	.66	173	<.001	175
GIUR vs. index of retouch curvature	.65	173	<.001	175
GIUR vs. retouched edge angle	.25	173	<.001	175

Table 5. Relationship between increasing GIUR and mean retouched edge angle on Hurst Fen scrapers. [1] *Std Dev* = Standard Deviation; [2] *CV* = Coefficient of Variation.

	GIUR Interval				
Retouched Edge Angle	**0.19-0.33 (n = 33)**	**0.34-.50 (n = 56)**	**.51-0.67 (n = 54)**	**0.68-0.80 (n = 26)**	**0.81-1 (n = 6)**
Mean	57.3	57.9	60.8	60.9	68.9
Std Dev[1]	12.2	9.2	7.6	8.9	4.7
CV[2]	21.3	15.9	12.5	14.6	6.9
Median	57.3	56.3	60.2	62.3	69.2
Min	45.1	48.7	53.3	52	64.2
Max	69.4	67.1	68.4	69.8	73.7

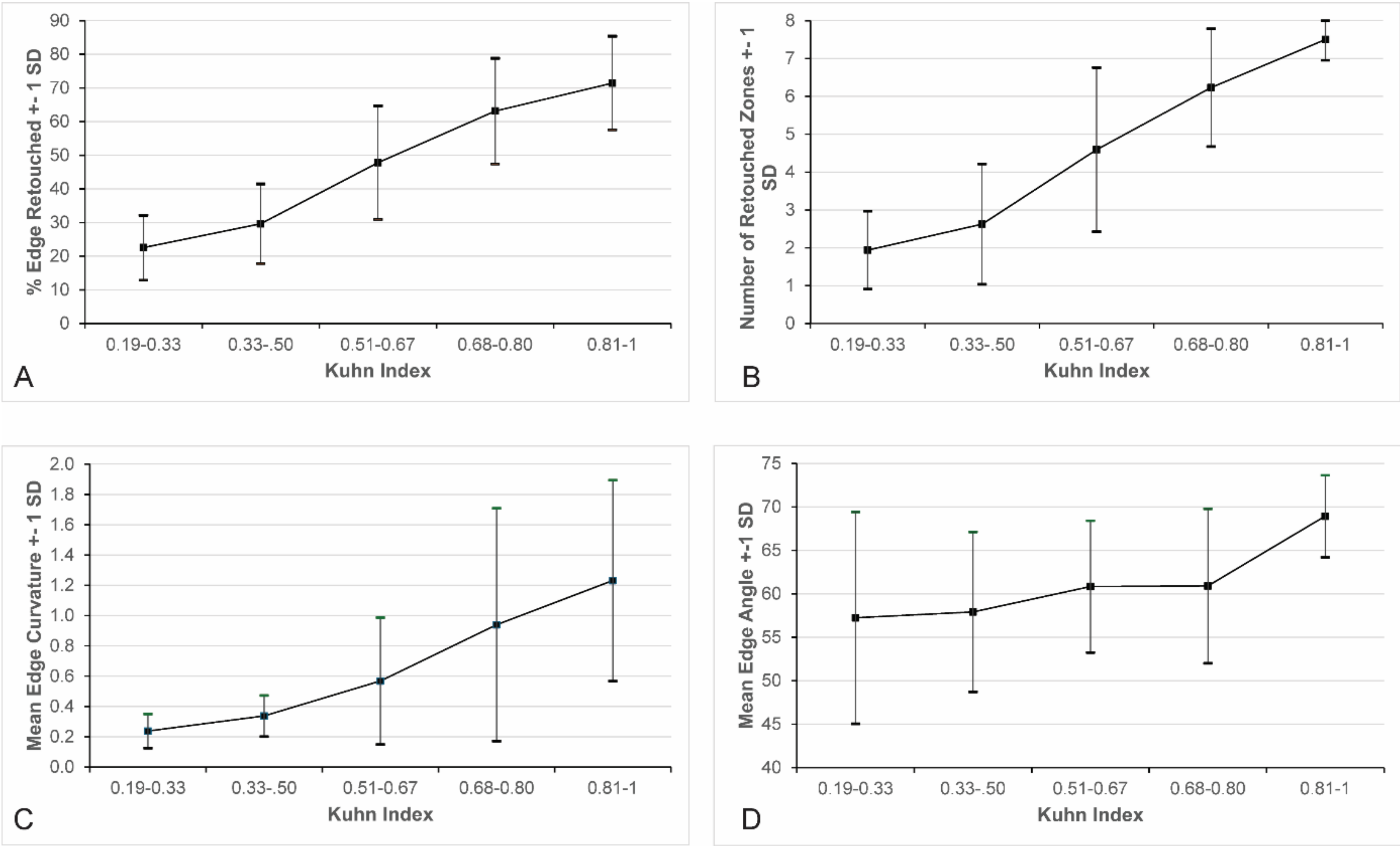

Figure 4. Graphs showing the relationship between Kuhn's GIUR and perimeter of retouch (A), number of retouched zones (B), retouched edge curvature (C) and retouched edge angle (D).

Further insight into the character of scraper reduction at Hurst Fen can be attained though a consideration of the distribution of retouch throughout the reduction process. Changes to the frequency and evenness with which retouch is distributed across the scrapers in our sample are presented graphically in Figure 5. As shown, there is a marked difference in the frequency of retouch on the distal and proximal ends of scrapers in the <0.33 and 0.34-0.66 GIUR classes, with the earliest phase(s) of scraper retouch clearly concentrated on the former. At the same time, there is a notable difference in the frequency of retouch on the distal portions of the left and right lateral margins of scrapers in the same classes (45.5% versus 21.2% and 67.3% versus 51.9%). Differences in the frequency of retouch between the medial and proximal segments are not as pronounced. Nonetheless, a slight preference for the left margin is evident. Our interpretation of this patterning is that retouch blows were most commonly delivered first to the distal ends of flakes, with subsequent resharpening episodes typically involving blows to the left lateral margin (moving distal to proximal) followed by the right (also distal to proximal). Sequences of retouch, of course, will have varied between individual specimens, as will the location of initial retouch blows, with individual blank morphology undoubtedly influencing the selection of margins for retouch (see Section 4.2 below; also Beadsmore (2006: 64) for a similar argument in a British Early Neolithic context). However, on the basis of available evidence, the dominant trend at Hurst Fen appears to be one of an early, uneven distribution of retouch focused on distal flake segments, transforming over the course of the reduction process, to a later, more even distribution around most, if not all, of the flake's perimeter. Average GIUR and retouched zone index values for the 'end', 'end and side' and 'disc' scrapers in our sample, presented in Table 6, are explicable by way of this trend. Clark's 'side' and 'double ended' types represent different, less common retouch trajectories, with average GIUR and retouched zone index values for these types placing them in the earlier and later stages of the reduction process respectively.

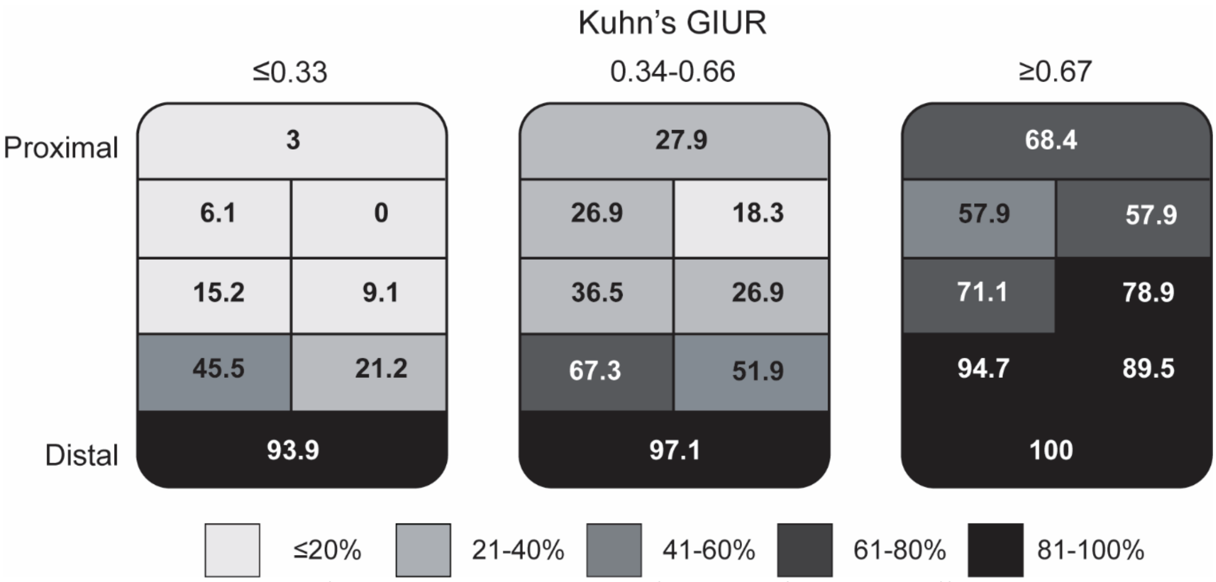

Figure 5. Graphic depiction of the relationship between the frequency of retouch at different locations on Hurst Fen scrapers and reduction intensity, as measured by Kuhn's GIUR.

Table 6. Descriptive statistics for GIUR and retouched zone index values for the ‘end’, ‘side’, ‘end and side’, ‘double-ended’ and ‘disc’ scrapers in our sample, ranked (left to right) by mean GIUR.

		Scraper type				
		Side (n = 16)	**End (n = 96)**	**Double-ended (n = 4)**	**End and side (n = 51)**	**Disc (n = 8)**
GIUR	Mean	0.40	0.42	0.61	0.64	0.76
	Std Dev	0.14	0.13	.06	0.13	0.11
	CV	34.9	30.1	9	19.9	14.5
	Median	0.40	0.41	0.60	0.66	0.78
	Min	0.19	0.19	0.56	0.31	0.57
	Max	0.62	0.78	0.69	0.83	0.92
Retouched zone index	Mean	4.1	2.4	4.3	6.4	7.5
	Std Dev	0.9	1.2	1.7	1.4	0.8
	CV	22.9	50.9	40.2	21.3	10.1
	Median	4	2	4.5	7	8
	Min	2	1	2	3	6
	Max	5	5	6	8	8

Taken together, the results of the analyses described above support the hypothesis that the extent to which scrapers were reduced throughout their respective use-lives was a critical factor in the creation of morphological and, by extension, typological variability in the Hurst Fen scraper assemblage. They also strongly suggest that scraper reduction at Hurst Fen was a continuous, as opposed to discontinuous process, a proposition that can be further demonstrated through univariate analysis. If, as we are suggesting, morphological variability in the Hurst Fen assemblage is causally linked to increasing reduction intensity, the assemblage should contain a series of intermediate shapes, with increased reduction producing an unbroken range of morphological variation. Histograms of observed values for the GIUR and the index of retouch curvature (Figure 6) reveal unimodal distributions with no evidence for groupings that might signify the existence of discrete types. Together with the results of the correlation analyses presented above, such evidence supports the argument that typological variation in the Hurst Fen assemblage is not reflective of imposed form, as per Clark *et al.* (1960), but rather is closely tied to variable retouch intensity.

 DOI: https://doi.org/10.2218/jls.9629

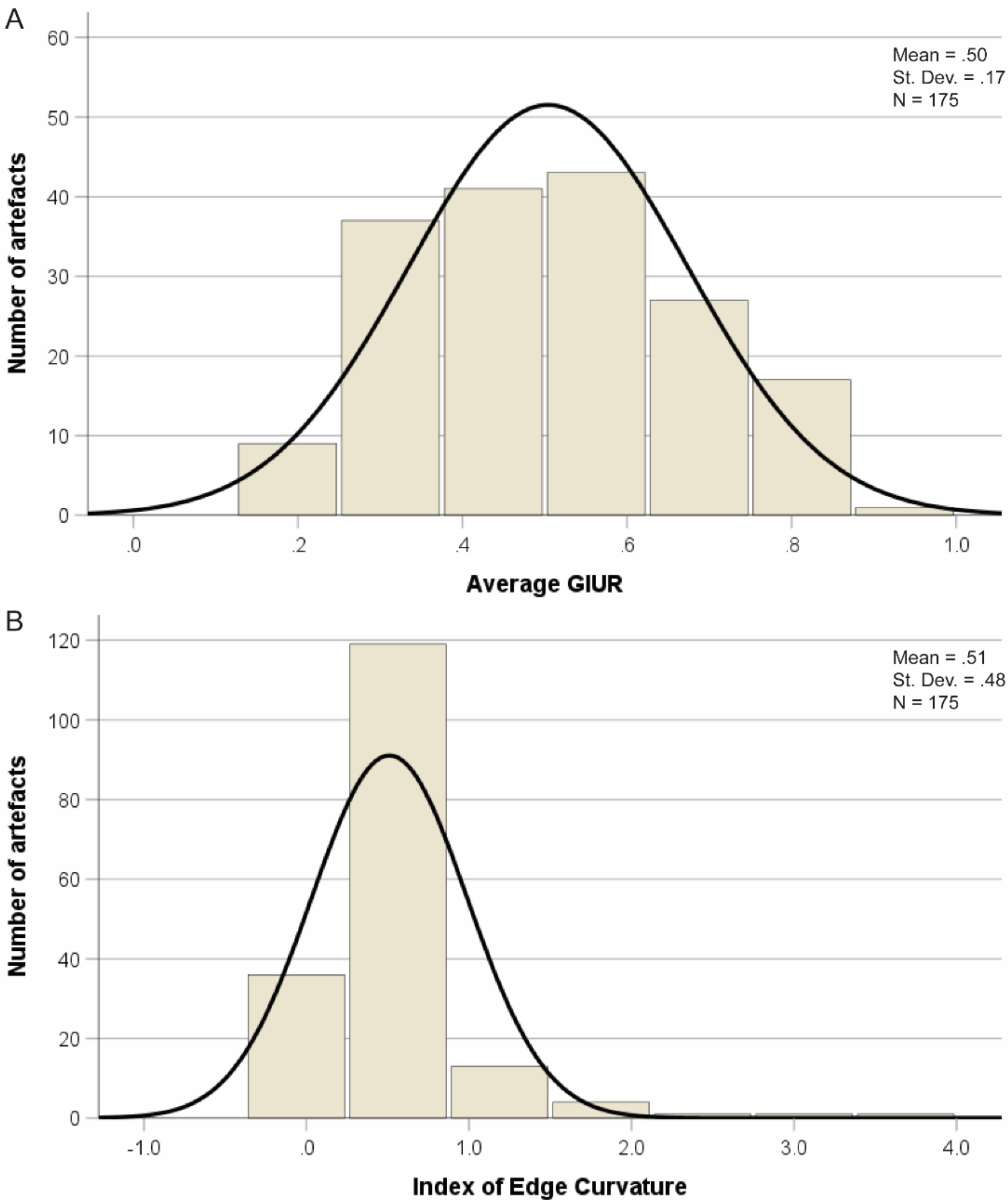

Figure 6. Histograms of observed values for the average GIUR (A) and the index of retouch curvature (B)

4.2. A reduction model for Hurst Fen scrapers

Figure 7 presents a hypothetical reduction model for the Hurst Fen scraper assemblage. Our model suggests that scraper retouch at Hurst Fen usually began with a series of blows to the distal end of a flake. The result of this initial phase of retouch was a minimally modified 'end' scraper with a reasonably convex, low-angled (*i.e.*, around 60º) working edge. Most scrapers appear to have been discarded at this early stage of the reduction process, with end scrapers particularly well represented in our sample (see Table 3). If reduction did continue, average retouch length and retouched edge curvature values for adjacent GIUR interval classes (Table 7) indicate significant, progressive increases in both the length and convexity of retouched scraper edges, with near uniformly significant comparison of means test results for adjacent GIUR intervals (Table 8). While acknowledging the potential for multiple reduction pathways at Hurst Fen, in typological terms, it would appear that Hurst Fen scrapers most commonly began their respective use-lives as 'end' scrapers before transforming, via increased reduction, into 'end and side' and, finally, 'disc' scrapers. It is worth noting that retouched edge angles exhibit a markedly different pattern to retouch length and edge curvature. Differences between adjacent GIUR intervals are generally negligible and not statistically significant (Tables 4 and 8). These data suggest that the reproduction of a low angled working edge was of particular importance to Early Neolithic knappers at Hurst Fen. They also suggest that these knappers were adept at maintaining such edges throughout the reduction process.

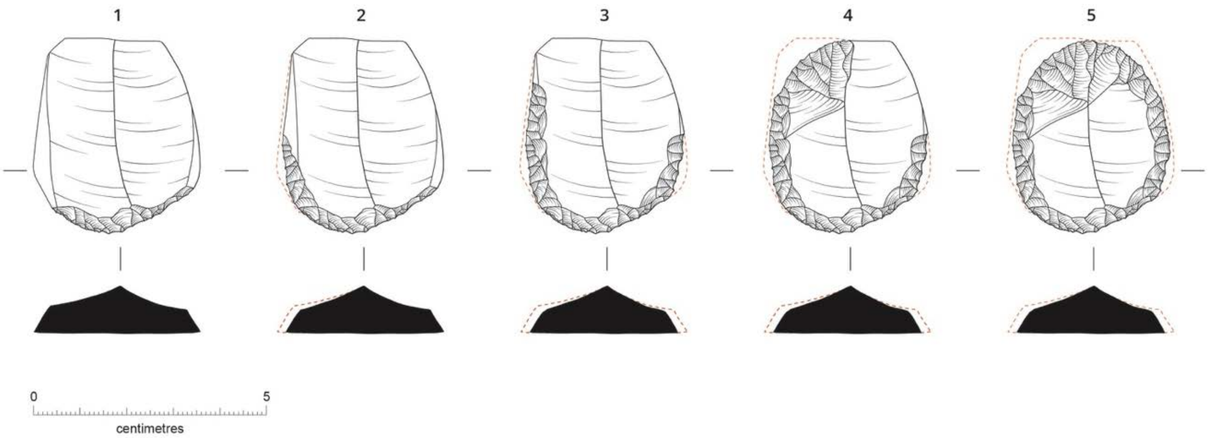

Figure 7. Hypothetical reduction model for the Hurst Fen scraper assemblage. (Scale bar is 5 cm wide.)

Table 7. Average retouch length and index of retouch curvature for adjacent GIUR classes.

		GIUR Interval				
		0.19-0.33 (n = 33)	**0.34-.50 (n = 56)**	**0.51-0.67 (n = 54)**	**0.68-0.80 (n = 26)**	**0.81-1 (n = 6)**
Retouch length (mm)	Mean	29.8	38	61	77.7	90.1
	Std Dev	14	19	24.5	22.3	21.4
	CV	47	50	40.2	28.7	23.7
	Median	23.9	32.4	56.5	79.3	94.1
	Min	5.6	8.7	23.2	38.9	62.9
	Max	58.4	107.7	150.7	128.4	113.7
Edge curvature	Mean	0.2	0.3	0.6	0.9	1.2
	Std Dev	0.1	0.1	0.4	0.8	0.7
	CV	47.5	40.3	73.8	81.8	53.9
	Median	0.2	0.3	0.5	0.7	1.2
	Min	-0.1	0.1	0.2	0.3	0.5
	Max	0.5	0.9	2.9	4.0	2

Table 8. Means comparison test results for morphological changes between adjacent GIUR intervals.

	Test result	Significant difference?
Retouch length		
0.19-0.33 versus 0.34-0.50	U = 633, Z = -2.472, p = .013	✓
0.34-0.50 versus 0.51-0.67	U = 593, Z = -5.495, p = <.001	✓
0.51-0.67 versus 0.68-0.80	U = 404, Z = -3.061, p = .002	✓
0.68-0.80 versus 0.81-1	t = -1.230, df = 30, p = .228	×
% Perimeter retouched		
0.19-0.33 versus 0.34-0.50	U = 583, Z = -2.896, p = .004	✓
0.34-0.50 versus 0.51-0.67	U = 531, Z = -5.866, p = <.001	✓
0.51-0.67 versus 0.68-0.80	U = 370, Z = -3.410, p = <.001	✓
0.68-0.80 versus 0.81-1	t = -1.195, df = 30, p = .242	×
Retouch curvature		
0.19-0.33 versus 0.34-0.50	U = 504, Z = -3.568, p = <.001	✓
0.34-0.50 versus 0.51-0.67	U = 836, Z = -4.042, p = <.001	✓
0.51-0.67 versus 0.68-0.80	U = 414, Z = -2.958, p = .003	✓
0.68-0.80 versus 0.81-1	U = 52, Z = -1.255, p = .209	×
Retouched edge angle		
0.19-0.33 versus 0.34-0.50	t = -.299, df = 87, p = .766	×
0.34-0.50 versus 0.51-0.67	t = -1.808, df = 108, p = .073	×
0.51-0.67 versus 0.68-0.80	t = -.034, df = 78, p = .973	×
0.68-0.80 versus 0.81-1	t = -2.128, df = 30, p = .042	✓

Notably, descriptive statistics for the size and shape of Hurst Fen scrapers, presented in Table 9, provide broad support for the proposed reduction model. For example, when considered alongside mean GIUR values (Table 6), data for Clark's end, side, end and side and disc types indicate a general inverse relationship between reduction intensity and maximum length. At the same time, disc scrapers exhibit both the smallest mean area (1320.7±281.8 mm^2) and highest mean thickness (14.1±3.3 mm) of the different scraper types, values consistent with these implements representing the most intensively retouched specimens. Data presented here also provide insight into the probable influence of original blank form on the location of initial retouch blows. In contrast to side scrapers, for example, which appear to have been routinely manufactured on squat flakes, evidenced by a mean elongation ratio of 0.9±0.2, ratios for Clark's end and double-ended types are substantially higher (1.4±0.4 and 1.7±0.3 respectively), pointing, in the case of more elongate blanks at least, to initial retouch blows focused on the distal and proximal ends of these blanks.

Table 9. Descriptive statistics for size and shape of Hurst Fen scrapers by type, ranked (top to bottom) by mean GIUR.

	Scraper type	N	Mean	*Std Dev*	*CV*	Min	Max
Max Length (mm)	Side	16	42.3	11.2	26.4	27.3	78.5
	End	96	43.9	9.2	20.9	27.3	82.3
	Double-ended	4	48.0	5.3	11.1	43.3	54.4
	End and side	51	41.0	8.8	21.4	28.0	68.8
	Disc	8	35.3	4.5	12.6	27.8	39.6
Max Width (mm)	Side	16	44.9	7.7	17.1	30.0	56.5
	End	96	33.3	6.9	20.8	18.8	52.8
	Double-ended	4	28.7	4.7	16.5	23.9	35.2
	End and side	51	39.1	7.0	17.8	27.0	57.5
	Disc	8	37.1	4.4	11.9	29.5	43.5
Max Thickness (mm)	Side	16	12.9	3.5	26.9	5.1	18.2
	End	96	11.8	2.9	24.9	6.0	18.8
	Double-ended	4	13.6	1.7	12.6	12.0	15.2
	End and side	51	12.2	3.2	26.0	6.9	24.0
	Disc	8	14.1	3.3	23.3	9.3	18.7
Area (mm^2)	Side	16	1942.7	768.3	39.5	818.1	4240.6
	End	96	1482.3	553.7	37.4	623.7	3646.6
	Double-ended	4	1374.8	230.4	16.8	1035.4	1543.9
	End and side	51	1646.7	647.9	39.3	870.6	3956.5
	Disc	8	1320.7	281.8	21.3	819.8	1722.6
Elongation	Side	16	0.9	0.2	21.1	0.7	1.5
	End	96	1.4	0.4	26.6	0.8	3.2
	Double-ended	4	1.7	0.3	18.8	1.2	2.0
	End and side	51	1.1	0.2	14.7	0.8	1.5
	Disc	8	1.0	0.1	9.4	0.8	1.1

5. Evaluating Clark's typology

Having established that reduction intensity provides a parsimonious explanation of scraper form in the Hurst Fen assemblage, we turn now to the implications of our reduction model for Clark's typological scheme. Following Clarkson (2005), plots of Clark's scraper types against three key measures of reduction intensity (*i.e.*, Kuhn's index, % perimeter retouch and edge curvature) facilitate an assessment of the degree to which Clark's typology accurately reflects the nature of scraper variation at Hurst Fen, as well as the boundedness of his types. Figure 8A depicts the relationship between Kuhn's index and the percentage perimeter of retouch for each of Clark's types, while Figure 8B depicts the relationship between edge curvature and percentage perimeter of retouch. As one might expect for a typological scheme based principally on the location of retouched margins, both plots reveal that Clark's types reflect, to certain extent, the relationships previously established for the intensity of scraper reduction at Hurst Fen. However, as in other contexts (*e.g.*, Clarkson 2005: 27), we maintain that this patterning is equally explicable via the number of retouched margins created throughout the reduction process, with scrapers sharing the same number of retouched margins (*e.g.*, 'side' and 'end' scrapers), for example, exhibiting similar or identical mean and standard deviation values for average GIUR (0.40±0.14 versus 0.42±0.13), % perimeter retouched (28.1±10.5% versus 27.3±9.2%) and edge curvature (0.3±1 versus 0.3±1). Comparison of means tests for morphological changes in adjacent scraper types (Table 10) confirm that, in comparison to those obtained for adjacent GIUR classes (Table 8), Clark's types are poorly differentiated, with statistically significant differences revealed for only 43.8% of type comparisons, versus 62.5% for adjacent GIUR classes. In combination with the substantial typological overlaps and intra-type variance evident in Figures 8A and 8B, these provide support for the argument that Clark's typology provides a poor measure of scraper reduction intensity at Hurst Fen.

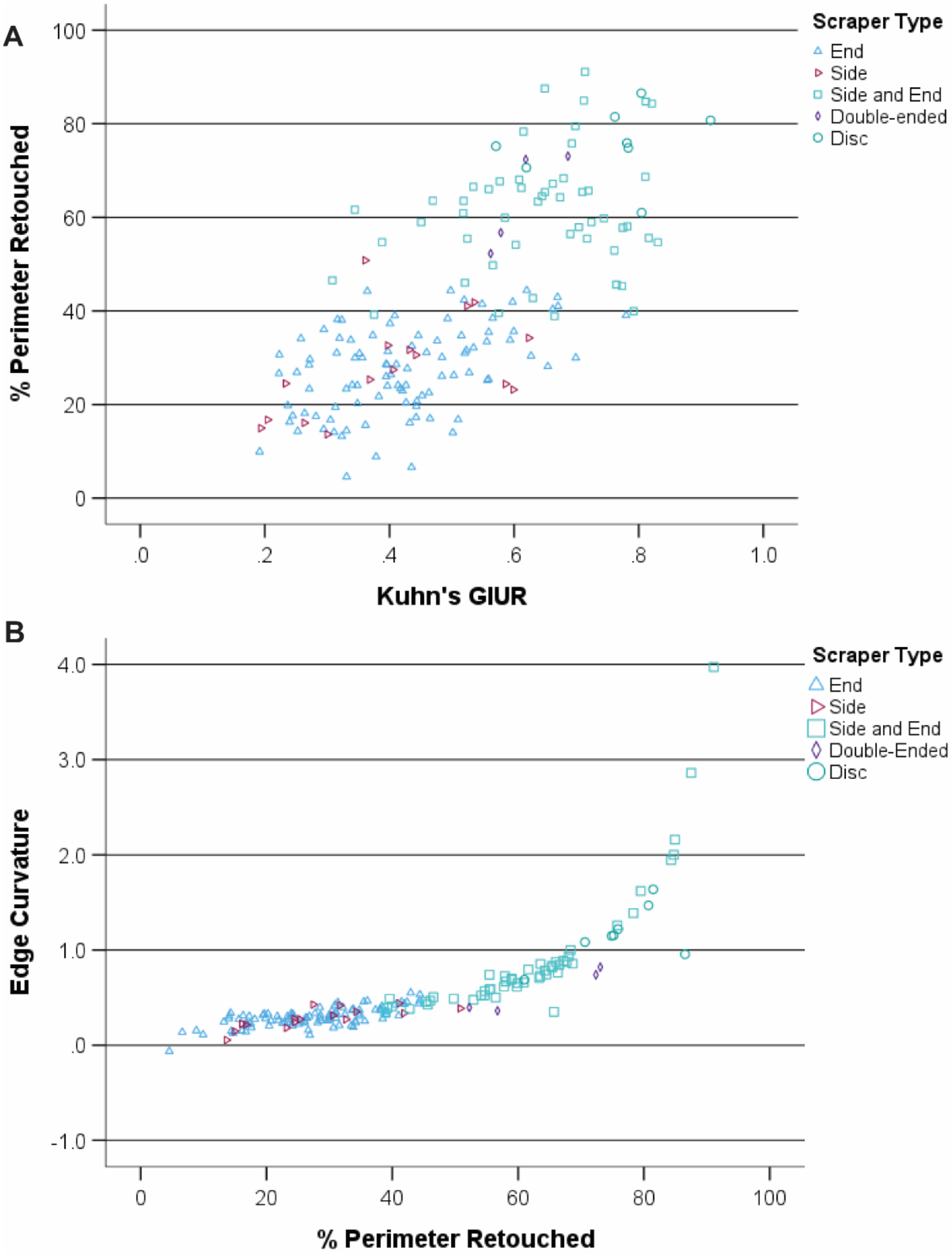

Figure 8. Scattergrams showing the relationship between: A) Kuhn's GIUR and % perimeter retouched; and B) between % perimeter retouched and edge curvature.

Table 10. Means comparison test results for morphological changes between adjacent scraper types, ranked (top to bottom) according to mean GIUR values.

	Test result	Significant difference?
Retouch length		
Side versus end	U = 675, Z = -.773, p = .439	×
End versus double-ended	t = -7.252, df = 98, p = <.001	✓
Double-ended versus end and side	U = 88, Z = -.454, p = .650	×
Side and end versus disc	U = 132, Z = -1.594, p = .111	×
% Perimeter retouched		
Side versus end	t = -.317, df = 110, p = .752	×
End versus double-ended	t = -.7.692, df = 98, p = <.001	✓
Double-ended versus end and side	t = -.347, df = 53, p = .730	×
Side and end versus disc	t = -3.100, df = 57, p = .003	✓
Edge curvature		
Side versus end	t = .252, df = 110, p = .802	×
End versus double-ended	t = -5.299, df = 98, p = <.001	✓
Double-ended versus end and side	U = 68, Z = -1.102, p = .290	×
Side and end versus disc	U = 79, Z = -2.768, p = .006	✓
Retouched edge angle		
Side versus end	t = 4.165, df = 110, p = <.001	✓
End versus double-ended	t = -.757, df = 98, p = .451	×
Double-ended versus end and side	t = -.1.072, df = 53, p = .289	×
Side and end versus disc	t = -2.277, df = 57, p = .027	✓

6. Discussion

Following Clark *et al.* (1960), British Neolithic lithic specialists routinely subdivide excavated and surface-collected scraper assemblages from this period into several distinct and formally recognised types (*e.g.*, ‘end’, ‘side’, ‘end and side’) (see Ballin 2021), an approach rooted in the assumption that these classes represent discrete and immutable categories made according to fixed designs. However, at Hurst Fen, the site that gave rise to Clark’s highly influential typological scheme, our results suggest that the morphological variability underpinning the distinction between scraper types was generated principally by differences in the amount of retouch applied to individual scrapers prior to discard. In this sense, at least, our results are consistent with a range of comparable scraper reduction studies from other time periods and parts of the world (*e.g.*, Blades 2003; Brumm & McLaren 2011; Dibble 1984; 1987b; 1995; Dibble & Rolland 1992; Hiscock & Attenbrow 2002; 2003; 2011; Hiscock & Clarkson 2015; 2008; Morales 2016; Morrow 1997; Shott 1995; Shott & Seeman 2015; Shott & Weedman 2007), which have made the case that, alongside original blank form, reduction intensity comprises one the key determinants of morphological patterning in prehistoric scraper assemblages. In common with these studies, our results provide further support for the now well-established argument that depictions of morphological variation in prehistoric scraper assemblages based on segmented, rather than continuous, models of implement variation are invariably inaccurate. Notably, however, our analysis has revealed some evidence for ‘imposed form’ in the Hurst Fen Assemblage, albeit in a non-traditional sense.

As described above, our data suggests that Early Neolithic knappers at Hurst Fen habitually knapped and resharpened scrapers in such a manner that a relatively low edge angle of around 60˚ was continually reproduced, with edge angles rising only in the final stages of the reduction process. Statistical analysis shows that this same acutely angled edge was consistently achieved largely regardless of how intensively individual scrapers were reduced and how much implements changed in size and shape throughout the reduction process. As acutely retouched edges on a scraper approach the thickest section of the flake it is expected that overall edge angle will increase exponentially. However, this trend is not evident in the majority of scrapers at Hurst Fen. Rather, Early Neolithic knappers at the site appear to have made conscious efforts during reduction to overcome contingencies presented by the continually shifting geometric and volumetrical properties of retouched scrapers in order to consistently produce a distinctive edge configuration on the tools. Thus, while the overall morphology of Hurst Fen scrapers changed continuously throughout reduction, retouched edge angles remained relatively constant.

How should this pattern be interpreted? One possibility is that Early Neolithic Knappers at Hurst Fen did indeed impose form on their scrapers but that the loci of intent resided not within the plan form of these implements but rather the particular shape characteristics of retouched *edges* (*c.f.* Barton 1990). Early Neolithic knappers, it could be argued, were capable of shaping stones according to preconceived 'designs'. However, the resulting patterns are primarily expressed in the morphological features of retouched edges. Together with the lack of use-wear data currently available for the Hurst Fen assemblage, existing ambiguities in the literature surrounding the relationship between different edge angle classes and scraper functions (*c.f.* Siegel 1985; Wilmsen 1970) preclude detailed comment on the functional significance of the remarkably consistent edge angle (*i.e.*, around 60˚) that appears, in most cases at least, to have been maintained by Early Neolithic knappers at Hurst Fen. Following Siegel (1985), however, we tentatively propose that the majority of scrapers at Hurst Fen were employed in activities based upon transverse motion (*e.g.*, scraping, planning, and adzing) as opposed to those based upon longitudinal motion (*e.g.*, cutting, sawing, whittling and carving), with the latter linked to low range edge angles (*i.e.*, ≤35°). This suggestion remains to be demonstrated through use wear analysis. Nonetheless, our results suggest that there may be some merit to reducing the basic unit of quantitative analysis of variability in Neolithic lithic assemblages to artefact *edges* (*i.e.*, 'edge units'), an argument made elsewhere on the basis of ethnoarchaeological research (see, *e.g.*, Hayden 1977; White 1967).

Although limited to a single site, it is anticipated that the model of scraper reduction proposed in this paper will, with inevitable site-specific variations, be broadly applicable to other British Neolithic scraper assemblages. If, as our results suggest, reduction intensity is the primary driver behind morphological variability in Neolithic scraper assemblages in Britain, how might we use the results of reduction analyses such as ours to obtain a better understanding of human behavior during this period? Following Clarkson (2002b; 2005; 2007) and others (*e.g.*, Blades 2003; Dibble 1995; Hiscock & Attenbrow 2003; 2005; 2011; Kuhn 1995; Marwick 2008b; 2008a; Morales 2016; Shott 1996; 1995; Shott & Ballenger 2007; Shott & Weedman 2007), we would argue that the answer to this question lies with the ability of such analyses to quantify, on an intra- and inter-site basis, spatial and chronological variability in extent of tool reduction (curation), variability tied to factors such as residential mobility and raw material availability (*sensu* Andrefsky 1994). As highlighted elsewhere (*e.g.*, Bamforth 1986; Bamforth & Bleed 1997; Bleed 1986; Bousman 1993; 2005; Kuhn 1994; 1995) extending the use-lives of retouched implements through repeated resharpening is one of several technological strategies, each with its own advantages and disadvantages, that can be employed by stone-tool-using groups to increase energetic efficiency and reduce risk (see also Jeske 1992). Kuhn (1992; 1995; 2004) has linked extensive tool resharpening to his strategy of the *provisioning of individuals*, one of two "idealised systems for making finished tools and/or necessary raw materials available when and where they are needed" (Kuhn 2004: 432), the other being the *provisioning of places*. These systems are not mutually exclusive phenomena, a point Kuhn has stressed (2004: 433). Nonetheless, translated into broader land use strategies, it has been suggested that residentially organised hunter-gatherers will tend to provision individuals whereas logistically organised, or more sedentary, groups will focus on the provisioning of places (*e.g.*, Graf 2010; Kuhn 1995; 2004; Riel-Salvatore *et al.* 2008; Riel-Salvatore & Barton 2004).

To return to Hurst Fen, the apparent dominance of ‘end’ scrapers in the site’s lithic assemblage might reasonably be explained as a product of basic raw material availability, with locally abundant secondary flint nodules, ostensibly of good knapping quality, all but eliminating the need to maximize scraper use-lives through extended sequences of retouch. That this was the only factor conditioning the intensity of scraper retouch at the site seems unlikely, however. For example, as argued by Garrow *et al.* (2005) and others (*e.g.*, Tabor *et al.* 2016), a convincing case can be made for the extended occupation of large pit-dominated Early Neolithic sites such as Hurst Fen, a situation that is likely to have encouraged the provisioning of places, with its attendant lack of emphasis on raw material conservation, and, by extension, intensive tool retouch. The prevailing view of Early Neolithic settlement in Britain continues to be one of impermanence, with many researchers, for example, pointing to the lack of substantial buildings on sites of this period as evidence of a relatively mobile way of life (*e.g.*, Pollard 2000; Thomas 1999; Whittle 1997; 1999). Despite this, there now exists a substantial body of evidence for the persistent and repeated occupation of certain locales, albeit on a non-permanent basis; in Cumming’s (2017: 86) words, evidence for “tethered mobility, with people congregating at particular places at certain times of the year”. If Hurst Fen was one such locality, it seems possible to conclude that what the relative abundance of scraper types at this site is capturing is not, as Clark’s (1960) traditional typological approach would imply, Neolithic people’s cultural preferences, but rather the extent to which the inhabitants of this site had to conserve available raw materials to ensure that tools were available where and when they were needed. Applied to the British Neolithic more broadly, our results suggest that investigations of spatial and temporal variability in the intensity of scraper at Neolithic sites offer a powerful analytical tool for investigating landscape-scale habitation, mobility and land use patterns during this period.

7. Conclusion

In this study we have made the case that retouch intensity provides a parsimonious explanation for scraper form in the Hurst Fen assemblage. While revealing some noteworthy, edge-specific evidence for ‘imposed form’ at this iconic site, our results present an interpretive challenge to the traditional typological approach that continues to inform British Neolithic lithic studies. Given the formative role of the Hurst Fen assemblage in shaping the direction of modern British Neolithic lithic research, the argument we have made that the scraper assemblage at this site displays continuous, as opposed to discontinuous, variation has important implications for the analysis and interpretation of Neolithic chipped stone assemblages beyond this site. *Contra* Clark, it may be questionable to assume that the different implement types that make up the retouched components of these assemblages reflect the deliberate imposition of particular forms. In the case of scrapers in particular, it seems likely that the morphological variability used to subdivide scraper assemblages from this period was ultimately generated by factors such as raw material availability and occupation duration. Consequently, the analyses presented in this paper may prove useful for promoting further research into the behavioral significance of morphological patterning in British Neolithic scraper assemblages, as well as other retouched tool types. In particular, there may be value in emphasizing technological, rather than typological, approaches to the description of retouched implements from this period.

Acknowledgements

The authors thank Anne Taylor, former Curatorial Assistant for Archaeology at the University of Cambridge's Archaeology and Anthropology Museum, for arranging access to the Hurst Fen assemblage, and providing facilities for our analysis. We also thank Amber Steele for specialist statistical advice, as well as the two anonymous reviewers for their helpful comments and feedback, which greatly strengthened the overall manuscript. Figure 7 was prepared by Vicki Herring of Vicki Herring Illustration.

Data accessibility statement

The authors confirm that the data of this study are available within the article and its supplementary materials without any restriction

List of supplementary files

Supplementary file 1
"McLaren_Brumm_Supplementary File 1.docx"
Word document containing descriptions of the quantitative measures and indices of reduction used in this study, as well as associated recording protocols.

Supplementary file 2
"McLaren_Brumm_Supplementary File 2.csv"
Spreadsheet containing all recorded attribute data for the scraper sample analysed by the authors.

References

Andrefsky, W. 2006, Experimental and archaeological verification of an index of retouch for hafted bifaces. *American Antiquity*, 71: 743-758. DOI: https://doi.org/10.2307/40035887

Andrefsky, W. 1994, Raw-material availability and the organization of technology. *American Antiquity*, 59(1): 21-34. DOI: https://doi.org/10.2307/3085499

Ballin, T. B. 2021, *Classification of lithic artefacts from the British Late Glacial and Holocene periods*. Archaeopress, Oxford, 87 p.

Bamforth, D. B. 1986, Technological efficiency and tool curation. *American Antiquity*, 51: 38-50. DOI: https://doi.org/10.2307/280392

Bamforth, D. B., & Bleed, P. 1997, Technology, flaked stone technology, and risk. In: *Rediscovering Darwin: evolutionary theory and archaeological explanation* (C.M. Barton, C.M. & Clark, G. A, Eds.), Archaeological papers of American Anthropological Association Vol. 7, American Anthropological Association, Arlington: p. 109-139.

Barton, C. M. 1990, Beyond style and function: a view from the Middle Paleo-lithic. *American Anthropologist*, 92: 57-72. DOI: https://doi.org/10.1525/aa.1990.92.1.02a00040

Beadsmore, E. 2006, Earlier Neolithic flint. In: *Excavations at Kilverstone, Norfolk: an episodic landscape history* (Garrow, D., Lucy, S. & Knight, M., Eds), Cambridge Archaeological Unit, Cambridge: p. 53-70.

Bischoff, R.J. 2023, Geometric morphometric analysis of projectile points from the southwest United States. *Peer Community Journal*, 3: e80. DOI: https://doi.org/10.24072/pci.archaeo.100315

Binford, L. R. 1973, Interassemblage variability: the Mousterian and the “functional argument.” In: *The explanation of cultural change: models in prehistory* (Renfrew, C., Ed.), Duckworth, London: p. 227-254.

Binford, L. R., & Binford, S. R. 1966, A preliminary analysis of functional variability in the Mousterian of Levallois facies, *American Anthropologist*, 68: 238-295. DOI: https://doi.org/10.1525/aa.1966.68.2.02a001030

Bisson, M. S. 2000, Nineteenth century tools for twenty-first century archaeology? Why the Middle Paleolithic typology of Francois Bordes must be replaced, *Journal of Archaeological Method and Theory*, 7:1-48. DOI: https://doi.org/10.1023/A:1009578011590

Blades, B. S. 2003, End scraper reduction and hunter-gatherer mobility. *American Antiquity*, 68(1): 141-156. DOI: https://doi.org/10.2307/3557037

Bleed, P. 1986, The optimal design of hunting weapons: maintainability or reliability. *American Antiquity*, 51: 737-747. DOI: https://doi.org/10.2307/281295

Bordes, F. 1961a, Mousterian cultures in France, *Science*, 134: 803-810. DOI: https://doi.org/10.1126/science.134.3473.803

Bordes, F. 1961b, *Typologie du Paléolithique ancien et moyen*. Publications de L’In-stitut de Préhistorie de L’Université de Bordeaux; Mémoire Vol. 1. Imprimeries Delmas, Bordeaux, 85 p. (in French) ("Typology of the Early and Middle Palaeolithic")

Bordes, F., & de Sonneville-Bordes, D. 1970, The significance of variability in Palaeolithic assemblages, *World Archaeology*, 2: 61-73. DOI: https://doi.org/10.1080/00438243.1970.9979400

Bousman, C. 1993, Hunter-gatherer adaptions, economic risk and tool design, *Lithic Technology*, 12: 59-96. DOI: https://doi.org/10.1080/01977261.1993.11720897

Bousman, C. 2005, Coping with risk: Later Stone Age technological strategies at Blydefontein rock shelter, South Africa. *Journal of Anthropological Archaeology*, 24: 193-226. DOI: https://doi.org/10.1016/j.jaa.2005.01.001

Briscoe, G. 1954, A Windmill Hill site at Hurst Fen Mildenhall. *Proceedings of the Cambridge Antiquarian Society*, 47: 13-24. DOI: https://doi.org/10.5284/1072900

Brown, A. G. 1995, Beyond Stone Age economics: a strategy for a contextual lithic analysis. In: *Lithics in context: suggestions for the future direction of lithic studies*, (Schofield, A.J., Ed.), Lithic Studies Society Occasional Paper Vol. 5. Lithic Studies Society, London: p. 27-36.

Brumm, A., & McLaren, A. P. 2011, Scraper reduction and “imposed form” at the Lower Palaeolithic site of High Lodge, England. *Journal of Human Evolution*, 60(2), 185-204. DOI: https://doi.org/10.1016/j.jhevol.2010.10.006

Bustos-Pérez, G., & Baena, J. 2019, Exploring volume lost in retouched artifacts using height of retouch and length of retouched edge. *Journal of Archaeological Science*: Reports, 27: 101922. DOI: https://doi.org/10.1016/j.jasrep.2019.101922

Bustos-Pérez, G., Gravina, B., Brenet, M. & Romagnoli, F. 2024, The contribution of 2D and 3D geometric morphometrics to lithic taxonomies: testing discrete categories of backed flakes from recurrent centripetal core reduction. *Journal of Paleolithic Archaeology*, 7(5). DOI: https://doi.org/10.1007/s41982-023-00167-7

Butler, C. 2005, *Prehistoric flintwork*. Tempus, Stroud, 223 p.

Clark, J. G. D. 1932, *The Mesolithic Age in Britain*. Cambridge University Press, Cambridge, 222 p.

Clark, J. G. D., Higgs, E., & Longworth, I. 1960, Excavations at the Neolithic site at Hurst Fen, Mildenhall, Suffolk (1954, 1957 and 1958), *Proceedings of the Prehistoric Society* 26: 202-245. DOI: https://doi.org/10.1017/S0079497X00016315

Clarkson, C. 2002a, An Index of invasiveness for the measurement of unifacial and bifacial retouch: A theoretical, experimental and archaeological verification. *Journal of Archaeological Science*, 29(1): 65-75. DOI: https://doi.org/10.1006/jasc.2001.0712

Clarkson, C. 2002b, Holocene scraper reduction, technological organization and landuse at Ingaladdi rockshelter, northern Australia. *Archaeology in Oceania*, 37(2): 79-86. DOI: https://doi.org/10.1002/j.1834-4453.2002.tb00508.x

Clarkson, C. 2005, Tenuous types: scraper reduction continuums in the eastern Victoria River region, Northern Territory. In: *Lithics "Down Under": Australian approaches to lithic reduction, use and classification* (Clarkson, C. & Lamb, L., Eds.), BAR International Series Vol. 1408. Archaeopress, Oxford: p. 21-33.

Clarkson, C. 2006, Explaining point variability in the Eastern Victoria River Region, Northern Territory. *Archaeology in Oceania*, 41(3): 97-106. DOI: https://doi.org/10.1002/j.1834-4453.2006.tb00632.x

Clarkson, C. 2007, *Lithics in the land of the Lightning Brothers: The archaeology of Wardaman Country, Northern Territory*. Terra Australis Vol. 25. ANU Press, Canberra, 221 p.

Clarkson, C. 2008, Changing reduction intensity, settlement, and subsistence in Wardaman Country, Northern Australia. In: *Lithic technology: measures of production, use, and curation* (Andrefsky, W, Ed.). Cambridge University Press, Cambridge: p. 286-316.

Cotterell, B., & Kamminga, J. 1987, The formation of flakes. *American Antiquity*, 52(4): 675-708. DOI: https://doi.org/10.2307/281378

Cummings, V. 2017, *The Neolithic of Britain and Ireland*. Routledge, London, 295 p.

Dibble, H. L. 1984. Interpreting typological variation of Middle Paleolithic scrapers: function, style, or sequence of reduction? *Journal of Field Archaeology*, 11: 431-436. DOI: https://doi.org/10.1179/009346984791504526

Dibble, H. L. 1987a, Reduction sequences in the manufacture of Mousterian implements of France. In: *The Pleistocene Old World: regional perspectives* (Soffer, O., Ed.). Plenum Press, New York: p. 33-45.

Dibble, H. L. 1987b, The Interpretation of Middle Paleolithic scraper morphology. *American Antiquity*, 52(1): 109-117. DOI: https://doi.org/10.2307/281062

Dibble, H. L. 1989, The implications of stone tool types for the presence of language during the Lower and Middle Palaeolithic. In: *The human revolution: behavioural and biological perspectives on the origins of modern humans* (Mellars, P. & Stringer, C.. Eds.). Edinburgh University Press, Edinburgh: p. 415-432.

Dibble, H. L. 1991a, Local raw material exploitation and its effects on Lower and Middle Paleolithic assemblage variability. In: *Raw material economies among prehistoric hunter-gatherers* (Montet-White, A. & Holen, S., Eds). University of Kansas Press, Lawrence: p. 33-47

Dibble, H. L. 1991b, Mousterian assemblage variability on an interregional scale. *Journal of Anthropological Research*, 47(2): 239-257. DOI: https://doi.org/10.2307/3630327

Dibble, H. L. 1995, Middle Paleolithic scraper reduction: background, clarification, and review of the evidence to date. *Journal of Archaeological Method and Theory*, 2(4): 299-368. DOI: https://doi.org/10.1007/BF02229003

Dibble, H. L., & Rolland, N. 1992, On assemblage variability in the Middle Paleolithic of western Europe. In: *The Middle Paleolithic: adaptation, behavior, and variability* (Dibble, H.L. & Mellars, P., Eds). University of Pennsylvania Museum, Philadelphia: p. 1-28.

Douze, K., & Delagnes, A. 2016, The pattern of emergence of a Middle Stone Age tradition at Gademotta and Kulkuletti (Ethiopia) through convergent tool and point technologies. *Journal of Human Evolution*, 91: 93-121. DOI: https://doi.org/10.1016/j.jhevol.2015.11.006

Fagan, B. 2001, *Grahame Clark: An intellectual biography of an archaeologist*. Westview Press, Boulder, 304 p.

Garrow, D., Beadsmore, E., & Knight, M. 2005, Pits clusters and the temporality of occupation: An earlier Neolithic Site at Kilverstone, Thetford, Norfolk. *Proceedings of the Prehistoric Society*, 71: 139-157. DOI: https://doi.org/10.1017/S0079497X00000980

Garrow, D., Lucy, S., & Gibson, D. (Eds) 2006, *Excavations at Kilverstone, Norfolk: An Episodic landscape history*. East Anglian Archaeology Vol. 113. Cambridge Archaeological Unit, Cambridge, 257 p.

Graf, K. 2010, Hunter-gatherer dispersals in the mammoth-steppe: technological provisioning and land-use in the Enisei River Valley, South-Central Siberia. *Journal of Archaeological Science*, 37: 210-223. DOI: https://doi.org/10.1016/j.jas.2009.09.034

Harding, P. 2017, Excavations of Reydon Farm: Early Neolithic pit digging in East Suffolk. *Proceedings of the Suffolk Institute of Archaeology & History*, 44(1): 1-18. URL: https://suffolkinstitute.pdfsrv.co.uk/customers/Suffolk%20Institute/2021/07/30/wetransfer-024246/SIAH%202017%20002%20Reydon%20Farm.pdf

Hashemi, S.M., Nasab, H.V., Berillon, G. & Oryat, M. 2021, An investigation of the flake-based lithic tool morphology using 3D geometric morphometrics: A case study from the Mirak Paleolithic Site, Iran. *Journal of Archaeological Science: Reports*, 37(June): 102948. DOI: https://doi.org/10.1016/j.jasrep.2021.102948

Hayden, B. 1977, Stone tool functions in the Western Desert. In: *Stone tools as cultural markers* (Wright, R.V.S., Ed.). Australian Institute of Aboriginal Studies, Canberra: p. 178-188.

Healy, F. (Ed) 1988, *Spong Hill part VI: 7th to 2nd millennia BC*. East Anglian Archaeology Vol. 39. The Norfolk Archaeological Unit, Dereham, 118 p.

Healy, F. 2013, In the Shadow of hindsight: pre-Iron Age Spong Hill viewed from 2010. In *Spong Hill, Part IX: Chronology and Synthesis* (Hills, C. & Lucy, S., Eds.). McDonald Institute, Cambridge: p. 12-26

Hiscock, P., & Attenbrow, V. (2002). Morphological and reduction continuums in eastern Australia: measurement and implications at Capertee 3. In: *Barriers, borders, boundaries: proceedings of the 2001 Australian Archaeological Association annual conference* (Ulm, S., Westcott, C., Reid, J., Ross, A., Lilley, I., Prangnell, J. & Kirkwood, L., Eds.), Tempus Vol. 7. Anthropology Museum, University of Queensland, Brisbane: p. 167-174.

Hiscock, P., & Attenbrow, V. 2003, Early Australian implement variation: A reduction model. *Journal of Archaeological Science*, 30(2): 239-249. DOI: https://doi.org/10.1006/jasc.2002.0830

Hiscock, P., & Attenbrow, V. 2005, *Australia's Eastern Regional Sequence revisited: technology and change at Capertee 3*, BAR International Series Vol. 1397. Archaeopress, Oxford, 151 p

Hiscock, P., & Attenbrow, V. 2011, Technology and technological change in eastern Australia: the example of Capertee 3. In: *Keeping your edge: recent approaches to the organisation of stone artefact technology* (Marwick, B. & Mackay, A., Eds), BAR International Series Vol. 2273. Archaeopress, Oxford: p. 21-32.

Hiscock, P., & Clarkson, C. 2005a, Measuring artefact reduction - an examination of Kuhn's Geometric Index of Reduction. In: *Lithics "Down Under": Australian approaches to lithic reduction, use and classification* (Clarkson, C. & Lamb, L., Eds.), BAR International Series Vol. 1408. Archaeopress, Oxford: p. 7-20.

Hiscock, P., & Clarkson, C. 2005b, Experimental evaluation of Kuhn's Geometric Index of Reduction and the flat-flake problem. *Journal of Archaeological Science*, 32(7): 1015-1022. DOI: https://doi.org/10.1016/j.jas.2005.02.002

Hiscock, P., & Clarkson, C. 2008, The construction of morphological diversity: a study of Mousterian implement retouching at Combe Grenal. In: *Lithic technology: measures of production, use, and curation* (Andrefsky, W, Ed.). Cambridge, Cambridge University Press: p. 106-135.

Hiscock, P., & Clarkson, C. 2015, Retouch intensity on Quina scrapers at Combe Grenal: a test of the reduction model. In *Taxonomic tapestries: the threads of evolutionary, behavioural and conservation research* (Behie, A. M. & Oxenham, M. F., Eds.). ANU Press, Canberra: p. 103-128.

Holdaway, S., McPherron, S., & Roth, B. 1996, Notched tool reuse and raw material availability in French Middle Paleolithic sites. *American Antiquity*, 61(2): 377-387. DOI: https://doi.org/10.2307/282432

Hummler, M. 2005, Before Sutton Hoo: the prehistoric settlement (c.3000 BC to c.AD 550). In: *Sutton Hoo: a seventh-century princely burial ground and its context* (Carver, M., Ed.). British Museum Press, London: p. 391-458.

Jeske, R. J. 1992, Energetic efficiency and lithic technology: an Upper Mississippian example. *American Antiquity*, 57(2): 467-481. DOI: https://doi.org/10.1017/S0002731600054366

Kuhn, S. 1992, On planning and curated technologies in the Middle Paleolithic. *Journal of Anthropological Research*, 48: 185-214. DOI: https://doi.org/10.2307/3630634

Kuhn, S. 1994, A formal approach to the design and assembly of mobile toolkits. *American Antiquity*, 59(3): 426-442. DOI: https://doi.org/10.2307/282456

Kuhn, S. 1995, *Mousterian lithic technology: an ecological perspective*. Princeton University Press, Princeton, 209 p.

Kuhn, S. 2004, Upper Paleolithic raw material economies at Ucagizli Cave, Turkey. *Journal of Anthropological Archaeology*, 23: 431-448. DOI: https://doi.org/10.1016/j.jaa.2004.09.001

Lerner, H. 2015, Dynamic variables and the use-related reduction of Southern Huon projectile points. In: *Works in stone: contemporary perspectives on lithic analysis* (Shott, M., Ed.) The University of Utah Press Salt Lake City: p. 143-161.

Lombao, D., Cueva-Temprana, A., Mosquera, M., & Morales, J.I. 2020, A new approach to measure reduction intensity on cores and tools on cobbles: the Volumetric Reconstruction Method. *Archaeological and Anthropological Sciences*, 12(222). DOI: https://doi.org/10.1007/s12520-020-01154-7

Lombao, D., Rabuñal, J., Cueva-Temprana, A. & Morales, J.I. 2023, Establishing a new workflow in the study of core reduction intensity and distribution. *Journal of Lithic Studies*, 10(2): 25 p. DOI: https://doi.org/10.2218/jls.7257

Macgregor, O. J. 2005, Abrupt terminations and stone artefact reduction potential. In: *Lithics "Down Under": Australian approaches to lithic reduction, use and classification* (Clarkson, C. & Lamb, L., Eds.), BAR International Series Vol. 1408. Archaeopress, Oxford: p. 57-65.

Maloney, T. R. 2020, Experimental and archaeological testing with 3D laser scanning reveals the limits of I/TMC as a reduction index for global scraper and point studies. *Journal of Archaeological Science: Reports*, 29: 102068. DOI: https://doi.org/10.1016/j.jasrep.2019.102068

Maloney, T. R., O'Connor, S., & Balme, J. 2017, The effect of retouch intensity on mid to late Holocene unifacial and bifacial points from the Kimberley. *Australian Archaeology*, 83: 42-55. DOI: https://doi.org/10.1080/03122417.2017.1350345

Marwick, B. 2008a, Beyond typologies: the reduction thesis and its implications for lithic assemblages in Southeast Asia. *Indo-Pacific Prehistory Association Bulletin*, 28: 108-116. DOI: https://doi.org/10.7152/bippa.v28i0.12023

Marwick, B. 2008b, What attributes are important for the measurement of assemblage reduction intensity? Results from an experimental stone artefact assemblage with relevance to the Hoabinhian of mainland Southeast Asia. *Journal of Archaeological Science*, 35(5): 1189-1200. DOI: https://doi.org/10.1016/j.jas.2007.08.007

Marwick, B., Clarkson, C., O'Connor, S., & Collins, S. 2016, Early modern human lithic technology from Jerimalai, East Timor. *Journal of Human Evolution*, 101: 45-64. DOI: https://doi.org/10.1016/j.jhevol.2016.09.004

McPherron, S. P. 1995, A re-examination of the British biface data. *Lithics*, 16: 47-63. DOI: https://doi.org/10.1016/j.jhevol.2016.09.004

Moore, M. W. 2000, Technology of Hunter Valley microlith assemblages, New South Wales. *Australian Archaeology*, 51: 28-39. DOI: https://doi.org/10.1080/03122417.2000.11681678

Morales, J. I. 2016, Distribution patterns of stone-tool reduction: establishing frames of reference to approximate occupational features and formation processes in Paleolithic societies. *Journal of Anthropological Archaeology*, 41: 231-245. DOI: https://doi.org/10.1016/j.jaa.2016.01.004

Morrow, J. E. 1997, End scraper morphology and use-life: an approach for studying Paleoindian lithic technology and mobility. *Lithic Technology*, 22: 70-85. DOI: https://doi.org/10.1080/01977261.1997.11721069

Morrow, J. E., & Morrow, T. A. 2002, Exploring the Clovis Gainey-Folsom continuum: technological and morphological variation in Midwestern fluted points. *Lithic Technology*, 2: 141-157. DOI: https://doi.org/10.4324/9781315428338-9

Muller, A., Clarkson, C., Baird, D., & Fairbairn, A. 2018, Reduction intensity of backed blades: blank consumption, regularity and efficiency at the Early Neolithic site of Boncuklu, Turkey. *Journal of Archaeological Science: Reports*, 21: 721-732. DOI: https://doi.org/10.1016/j.jasrep.2018.08.042

Nguyen, D. T. & Clarkson, C. 2013, The organisation of drill production at a Neolithic lithic workshop site of Bai Ben, Cat Ba Island, Vietnam. *Journal of Indo-Pacific Archaeology*, 33: 24-39. DOI: https://doi.org/10.7152/bippa.v33i0.14508

Nguyen, D. T. & Clarkson, C. 2016, Typological transformation among Late Paleolithic flakes core tools in Vietnam: an examination of the Pa Muoi assemblage. *Journal of Indo-Pacific Archaeology*, 40: 32-41. DOI: https://doi.org/10.7152/jipa.v40i0.14963

Pollard, J. 1999, 'These places have their moments': thoughts on settlement practices in the British Neolithic. In: *Making places in the prehistoric world: themes in settlement archaeology* (Bruck, J. & Goodman, M., Eds.). University College Press, Dublin: p. 76-93.

Pollard, J. 2000, Neolithic occupation practices and social ecologies from Rinyo to Clacton. In: *Neolithic Orkney in its European context* (Ritchie, A., Ed.). McDonald Institute, Cambridge: p.363-369.

Riel-Salvatore, J., & Barton, C. M. 2004, Late Pleistocene technology, economic behaviour, and land-use dynamics in southern Italy. *American Antiquity*, 69(2): 257-274. DOI: https://doi.org/10.2307/4128419

Riel-Salvatore, J., Popescu, G., & Barton, C. M. 2008, Standing at the gates of Europe: human behavior and biogeography in the southern Carpathians during the Late Pleistocene. *Journal of Anthropological Archaeology*, 27: 399-417. DOI: https://doi.org/10.1016/j.jaa.2008.02.002

Rolland, N. 1977, New aspects of Middle Palaeolithic variability in Western Europe. *Nature*, 266: 251-252. DOI: https://doi.org/10.1038/266251a0

Rolland, N. 1981, The Interpretation of Middle Palaeolithic variability. *Man*, 16(1): 15-42. DOI: https://doi.org/10.2307/2801973

Rolland, N., & Dibble, H. L. 1990, A new synthesis of Middle Paleolithic variability. *American Antiquity*, 55(3): 480-499. DOI: https://doi.org/10.2307/2801973

Shott, M. J. 1995, How much is a scraper? Curation, use rates, and the formation of scraper assemblages. *Lithic Technology*, 20: 53-72. DOI: https://doi.org/10.1080/01977261.1995.11720899

Shott, M. J. 1996, An exegesis of the curation concept. *Journal of Anthropological Archaeology*, 52: 259-280. DOI: https://doi.org/10.1086/jar.52.3.3630085

Shott, M. J. 2017, Stage and continuum approaches in prehistoric biface production: a North American perspective. *PLoS ONE*, 12(3): e0170947. DOI: https://doi.org/10.1371/journal.pone.0170947

Shott, M. J. 2024, Dibble's reduction thesis: implications for global lithic analysis. *Journal of Paleolithic Archaeology*, 7, 12. DOI: https://doi.org/10.1007/s41982-024-00178-y

Shott, M. J., & Ballenger, J. A. M. 2007, Biface reduction and the measurement of Dalton curation: a southeastern United States case study. *American Antiquity*, 72: 153-175. DOI: https://doi.org/10.2307/40035302

Shott, M. J., & Seeman, M. F. 2015,. Curation and recycling: estimating Paleoindian endscraper curation rates at Nobles Pond, Ohio, USA. *Quaternary International*, 361: 319-331. DOI: https://doi.org/10.1016/j.quaint.2014.06.023

Shott, M. J., & Weedman, K. J. 2007, Measuring reduction in stone tools: an ethnoarchaeological study of Gamo hidescrapers from Ethiopia. *Journal of Archaeological Science: Reports*, 34(7): 1016-1035. DOI: https://doi.org/10.1016/j.jas.2006.09.009

Siegel, P. E. 1985, Edge angle as a functional indicator: a test. *Lithic Technology*, 14(2): 90-94. DOI: https://doi.org/10.1080/01977261.1985.11754508

Tabor, J., Billington, L., Healy, F., & Knight, M. 2016, Early Neolithic pits and artefact scatters at North Fen, Sutton Gault, Cambridgeshire. *Proceedings of the Prehistoric Society*, 82: 161-191. DOI: https://doi.org/10.1017/ppr.2016.2

Thomas, J. 1999, *Understanding the Neolithic*. Routledge, London, 266 p.

Wainwright, G. 1972, The excavation of a Neolithic settlement on Broome Heath, Ditchingham, Norfolk. *Proceedings of the Prehistoric Society*, 38: 1-97. DOI: https://doi.org/10.1017/S0079497X00010925

White, P. J. 1967, Ethno-archaeology in New Guinea: two examples. *Mankind*, 6(9): 409-414. DOI: https://doi.org/10.1111/j.1835-9310.1967.tb00357.x

Whittle, A. 1997, Moving on and moving around: Neolithic settlement mobility. In: *Neolithic Landscapes* (Topping, P., Ed.), Neolithic Studies Group Seminar Paper Vol. 2. Oxbow Books, Oxford: p. 15-22.

Whittle, A. 1999, The Neolithic period. In: *The archaeology of Britain: an introduction from the Upper Palaeolithic to the Industrial Revolution* (Hunter, J. & Ralston, I., Eds.). Routledge, London: p. 58-76.

Wilkinson, T. J., Murphy, P. L., Brown, N., & Heppell, E. M. (Eds.) 2012, *The archaeology of the Essex Coast, volume II: excavations at the prehistoric site of the Stumble*, East Anglian Archaeology Vol. 144. Essex County Council, Historic Environment, Chelmsford, 150 p.

Wilmsen, E. N. 1970, *Lithic analysis and cultural inference: A Paleo-Indian case*. Anthropological Papers of the University of Arizona Vol. 16. University of Arizona Press, Tucson, 87 p.