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Experimental evaluation of Kuhn's geometric index of reduction and the flat-flake problem

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Abstract

This paper presents the results of an experiment designed to explore the performance of Kuhn's Geometric Index of Unifacial Reduction [S. Kuhn, A geometric index of reduction for unifacial stone tools, Journal of Archaeological Science 17 (1990) 585—593] in measuring the amount of material removed over a sequence of retouching events for a population of 30 flakes. The index provides a reliable absolute measure of reduction under experimental conditions, and does so irrespective of blank cross-section, suggesting that the "flat-flake" problem is not necessarily a serious difficulty for the index. Furthermore, Kuhn's Index provided a more sensitive and robust measurement of the extent of reduction than any of the alternative techniques proposed in recent years.

Keywords: lithics; reduction; experiment; Kuhn

1. Introduction

Archaeological investigations of Palaeolithic artefact assemblages now regularly attempt to understand the complexity of reduction processes. This concern reflects recognition that the pattern and amount of reduction are mechanisms frequently and powerfully affecting the composition of lithic assemblages. Explorations of assemblage variation on all continents have shown the value of characterising differences in the level and kind of retouching to which flakes have been subjected (e.g. [1], [2], [3], [6], [7], [8], [9], [11], [12], [13], [14], [16], [17], [18], [20] and [23]). Consequently we argue that our capacity to explain assemblage differences is enhanced by analyses aiming to quantify the extent, nature and variability of reduction. However, such a goal challenges archaeologists to find quantitative measures of the rate and nature of changes to stone artefact morphology that occur during flaking. Consequently, one of the consuming methodological questions in studies of stone artefacts is to identify robust and reliable measures of the intensity with which stone was reduced. A large number of methods have been suggested and employed but only a few archaeological or experimental evaluations of these methods have been published (e.g. [3], [5], [9], [10], [19] and [22]). In this paper we provide an experimental review of one measure, the reduction index proposed by Kuhn [19]. Although this measure has been commonly used (e.g. [15] and [16]), it has been criticised as unreliable in some conditions, and alternative measures of the extent of retouch advocated by a number of archaeologists (see [9] for a review). An appraisal of the accuracy and robustness of Kuhn's Index, in comparison to competitors, is imperative. In this paper, we use experimental data to provide a quantitative description of the relationship between the index and the rate of change to retouched flakes during reduction. This experimental evidence supplies the basis for a revised comparison of the different methods of measuring the intensity of retouching on retouched flakes.

2. Kuhn's Index of reduction

A measure suited to estimating the amount of reduction on marginally and unifacially retouched flakes was proposed in 1990 by Kuhn [19]. The index calculates the extent of retouch by the relative "height" (ventral–dorsal) of retouch scars. Kuhn presented two different methods for calculating what he named the geometric index of reduction. The first method quantifies edge attrition by dividing the height of retouch scars above the ventral face (t) by the maximum thickness of the flake (T). Both measurements were taken at right angles to the ventral surface and at the same point on the retouched edge (Fig. 1). Both t and T can be measured directly using calipers, the technique we have employed in this paper. Kuhn [19] also suggested a second way of measuring the height of retouch scars (t) involving a trigonometric calculation in which retouch scar length is multiplied by the sine of the retouch angle.

We have not used this variant simply because the imprecision of standard methods for measuring edge angle is likely to make this technique less accurate (see [21]).

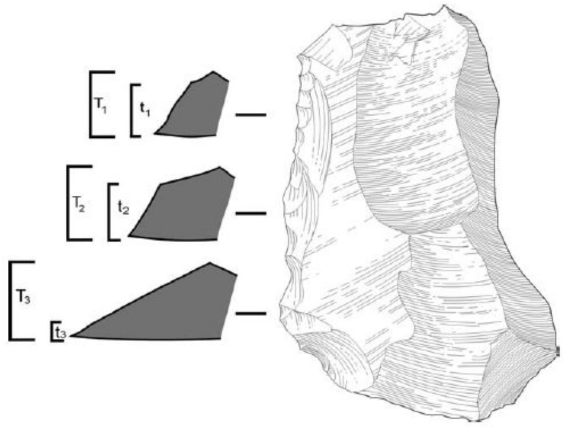

Fig. 1. Illustration of the measurement of Kuhn's [19] Geometric Index of reduction on a unifacially retouched flake.

Kuhn's geometric index of reduction yields values ranging from 0 to 1. A value of 0 represents no retouch and a value of 1 indicates that retouch scars have intersected with, or crossed, the point of maximum thickness. The index therefore provides a straightforward and relatively simple way of measuring the amount of edge lost from a retouched flake. The nature of the index means that it is not restricted to a particular shape of retouched edge and it potentially offers a versatile measure for a wide range of assemblage types. However, the index has been criticised on a number of grounds. One limitation that was acknowledged by Kuhn [19] was that the index could only be measured on unifacially retouched flakes on which blows were applied to the ventral face and created scars on the dorsal face. Because both *t* and *T* are oriented to and measured from the ventral face, any retouching onto the ventral surface will make calculation of the index at that point impossible. Consequently where ventral and dorsal retouch exists on different edges of a single specimen, the Kuhn Index will express the amount of retouch on only some edges. Furthermore, unifacial implements with ventral retouch and bifacially flaked specimens cannot have a Kuhn Index calculated. This restricts the proportion of an implement assemblage that can be assessed using the index, although in many parts of the world dorsally flaked unifaces are the dominant category of implement. Regions in which implements are typically bifaces may have limited use for the index. While this limitation may create an inconvenience for some researchers it is not a fault with the index. The primary criticism of Kuhn's Index is in relation to what we call the "flat-flake problem".

3. The "flat-flake" problem

The most extensively developed critique of Kuhn's Index was provided by Dibble [9, p. 330], who argued that while the index functioned as designed on flakes with triangular cross-sections it was unresponsive to retouching on flakes with flat dorsal surfaces parallel to the ventral face. Using the illustration we reproduce in Fig. 2, Dibble explained this "flat-flake problem" as follows:

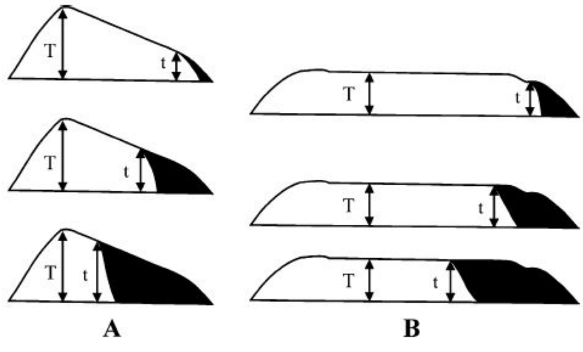

Fig. 2. Dibble's [9, p. 329] illustration of the "flat-flake problem". "A" represents the reduction of a flake without a flat cross-section, while "B" represents the reduction of a flake with a flat cross-section.

A problem occurs in the case of very flat flakes, however, where this ratio will approach the maximum much more quickly (i.e., after fewer resharpening episodes) than it will on more highly convex flakes… Thus, while Kuhn's Reduction Index can reflect the amount of retouch that is applied, it will also be affected by the exterior morphology of the flake. Though more objective than the previous technique, it is still not an unambiguous measure of how much material was removed.

This theory that the rate at which the index changes is probably related to flake cross-sectional shape is correct, we argue, and an appreciation of that effect should be built into interpretations of the Kuhn Index. However, Dibble's flat-flake critique fails to acknowledge that even flakes with very flat dorsal faces may often have cross-sectional variation caused by curvature of the ventral face, or that the identification and exclusion from analysis of specimens with very flat surfaces might facilitate valid assessments of the extent of reduction using the Kuhn Index. Furthermore, the magnitude of this effect has not been empirically measured and its impact on the interpretation of retouch intensity using Kuhn's Reduction Index has not been established. While Dibble's critique is technically correct, it has not been shown to create a significant problem for interpretation of most archaeological assemblages.

Another critique of the Kuhn Index sometimes offered is that it is insensitive to the amount of retouching that takes place at the distal end of a flake. This proposition is based on the idea that values of the index may be less altered by distal retouch reworking than retouch positioned on the lateral margins. This could occur because it may take less retouch to attain the maximum value of 1 at the distal end than on a lateral margin. For this reason some archaeologists argue that the Kuhn Index is most viable on laterally retouched implements (see comments in [19]). We suggest such a position is an over-reaction to the effects of cross-sectional shape, and we will return to this issue later in the paper. This concern with distal end measurement is in fact a special form of the "flat-flake problem" already described; in this case relating values of the index to the shape of longitudinal cross-sections rather than transverse cross-sections.

We argue that in their present state these criticisms are not refutations of the usefulness or reliability of the Kuhn Index. Indeed specific investigations of the robustness of the index in different situations, including the magnitude of variation induced by differences in cross-section, must be undertaken before the implications of these issues can be assessed. Experimental programs, in which changes to the index with known increments in reduction can be quantified, are likely to be the most profitable means of assessing the affect of blank variables such as cross-sectional shape. To evaluate the robustness of the index, and examine the likely impact of the "flat-flake problem" we proceed to a re-evaluation and experimental testing of the Kuhn Index. Our specific goals in this paper are to provide answers to the following questions about the Kuhn Index:

1. Is the index invariably positively correlated with the intensity of reduction?
2. Is that correlation linear or non-linear?
3. How is variation in those patterns related to blank shape?

4. Experimental methods

Kuhn [19] originally performed a series of experiments to demonstrate the effectiveness of his index. His experiments involved retouching 22 flakes; each flake being worked on a number of occasions, called "events", to simulate maintenance of a working edge. On the basis of these experiments Kuhn observed that although there was a positive relationship between number of events and size of the index, the interpretation of the index is complicated by a curvilinear relationship that created considerable variation in the magnitude of change between retouching "events". Our main concern about Kuhn's experiments is his use of the "retouching event" to measure reduction. Despite the care that he took in conducting the experiments, Kuhn's choice of this unit of observation was a poor one, since there is no reason to believe that these events were of equivalent magnitude to each other; either within or between experimental specimens. Hence, while we accept that Kuhn's experiments demonstrate that the reduction index displays a unidirectional relationship with the extent of reduction, his experiments are not an adequate demonstration of the linear or non-linear nature of the relationship. We argue that an exploration of the linearity of the relationship between the extent of reduction and Kuhn's Reduction Index should be conducted using weight of rock removed and/or number of flakes removed during retouching. To this end we conducted an experiment that was very similar to Kuhn's but in which we measured changes to mass as well as numbers of flakes struck.

The methods chosen to evaluate Kuhn's Index are similar to those undertaken by Clarkson [3], and involved tracking changes in the rate of increase in index values against numbers of retouch blows and the percentage of weight lost from each specimen. By establishing the nature of the relationships between these variables, we hope to determine the degree of linearity, the actual as opposed to theoretical range of the index, and the limitations of this approach to measuring retouch.

Experiments involved unifacial percussion flaking of thirty flakes. Blows were applied to the ventral face of one lateral margin, removing flakes from the dorsal face to create a straight retouched edge. This was done in a number of episodes, each comprising ten flake removals more than 3 mm in length positioned along the entire length of the specimen, and at the end of each retouching episode a number of attributes were recorded on each specimen. This provided a record of the progressive changes in morphology for each specimen during reduction, and gave a total of 348 data points. The approach to reduction was conservative, with the authors aiming to remove enough of the edge to effectively resharpen or rejuvenate it, but without removing unnecessary mass. To avoid judgements on functionality, retouching was continued until the specimen broke.

A summary of the experimental results is given in Table 1. The amount of reduction varied, with as little as 68 flakes and as many as 203 flakes being removed before specimens broke. This resulted in an average weight loss of approximately half the original weight of flakes, although the percentage of weight removed varied between specimens. All specimens had attained high Kuhn Reduction Index values before they were broken.

TABLE 1. Summary of experimental results

	N	**Minimum**	**Maximum**	**Mean±SD**
Number of flakes	30	68	203	111.90±31.73
Kuhn Reduction Index	30	0.79	1.00	0.95±0.06
Percentage weight loss	30	15.0	82.3	51.73±16.65

This experiment held many factors constant, including raw material (mudstone), the technique of retouching (direct hand held percussion), the face retouched (dorsal), the number of margins retouched (one), the shape of the retouched edge (straight), the interval between measurement (10 blows), and the weight of hammer stones (two hammers weighing 82 g and 55 g were used throughout). The main factor that was varied was the flake blank, as a way of evaluating the effect of flake morphology on the development of high values of the Kuhn Reduction Index. We created a number of flakes that were broadly similar in size to those retouched in many prehistoric assemblages. As summarised in Table 2, these flakes were quite varied in weight (27–344 g), width (29–89 mm), thickness (8–33 mm), cross-section (steep triangle to flattish trapeze, see Fig. 3), relative thickness index (calculated as thickness/width), number of ridges (1–4), and edge angles (32°–104°).

Approximately half (14 of 30) of our specimens have two dorsal ridges, giving the flake a trapezoidal cross-section. These specimens yielded 163 data points during experimental flaking. To describe the cross-sectional variation of these trapezoidal flakes we can refer to several characteristics:

• The proportion of flake width found between the two dorsal ridges. This percentage may be high on the kinds of flat flakes likely to cause non-responsiveness in the Kuhn Index as reduction continues. In our experimental sample the percentage of width between ridges varies from 9.5% to 90.0%, with the mean at 53.7±23.2%.

• Height difference between the two ridges, calculated by measuring the difference in ridge heights relative to the ventral surface and expressing that as a percentage of maximum flake thickness. This “ridge height difference %” may be low on the kinds of flat flakes likely to cause non-responsiveness in the Kuhn Index as reduction continues. In our experimental sample this value varies from 20% to 71%, with the mean at 51.2±17.9.

• Five specimens, representing 56 data points, have trapezoidal cross-sections with percentage of width between ridges exceeding 70% and ridge height differences <25%. In Dibble’s [9] discussion of the flat-flake problem these are the kinds of cross-sectional shapes that were suggested to pose the greatest problem for the application of the Kuhn Index as a reliable measure of continued reduction. In the following analysis these specimens are singled out for analysis in addition to the complete experimental set.

We intend to explore the relationship of these aspects of flake morphology to changing values of the Kuhn Reduction Index on another occasion; here our only purpose is to evaluate those trends in the Kuhn Index that are so robust they exist despite this massive variation in blank morphology.

TABLE 2. Summary of experimental flake blanks

	N	**Minimum**	**Maximum**	**Mean±SD**
Weight	30	27.3	344.2	75.11±67.37
Length	30	49.2	119.7	72.45±15.82
Width	30	28.9	88.5	45.74±13.82
Thickness	30	8.0	32.7	16.11±6.46
Relative thickness (T/W)	30	0.19	0.59	0.35±0.09
Number of ridges	30	1	4	1.93±0.58
Average edge angle	30	32.3	103.7	51.50±15.6

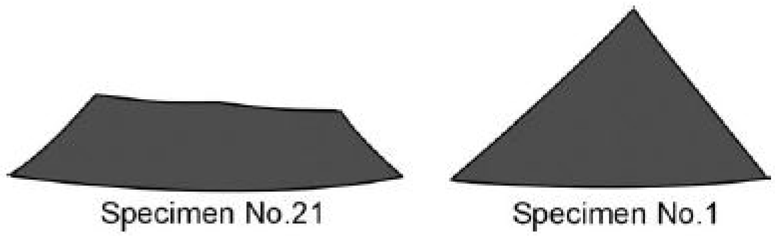

Fig. 3. Examples of the range of flake cross-sections used in the reduction experiment. Specimen No. 21 has a flattish trapezoidal-like cross-section similar to Dibble's "flat flakes", while Specimen No. 1 has a steep triangular cross-section.

5. Experimental results

The number of blows had a complex relationship with the Kuhn Reduction Index. Low reduction index values were reached in only a few blows but high index values were attained with both large and small numbers of flakes, reflecting wide differences in the number of flake removals required to achieve large Kuhn values. While the correlation is statistically significant the coefficient reveals that the relationship is only moderately strong (r=0.716, r^2=0.513, r_s=0.748, N=348, P<0.001). The primary cause of this pattern is the variation between flakes in mass removed. A more robust description of the relationship of reduction and the Kuhn Index is therefore achievable by focusing on mass removed.

The relationship between the Kuhn Index and the percentage of weight of the original flake that has been lost during retouching is a positive one that is log-linear in nature, as shown in Fig. 4. Flake geometry is partly responsible for the non-linear nature of this association. On many flakes the increase in thickness away from the lateral margin means that similar blows will remove less mass from the margins of the flake, early in the retouching process, than from the centre of the flake, later in the process. The nature of reduction also changes as retouching continues, with the creation of steep angles and step terminated scars compelling the knapper to rejuvenate the edge by striking bigger and more invasive flakes, creating longer scars. Furthermore, since the Kuhn Index, by definition, has a maximum value of 1 and reduction can continue after that value is reached, the relationship must become non-linear as retouching continues, because on heavily retouched specimens mass is lost without altering the Kuhn Index.

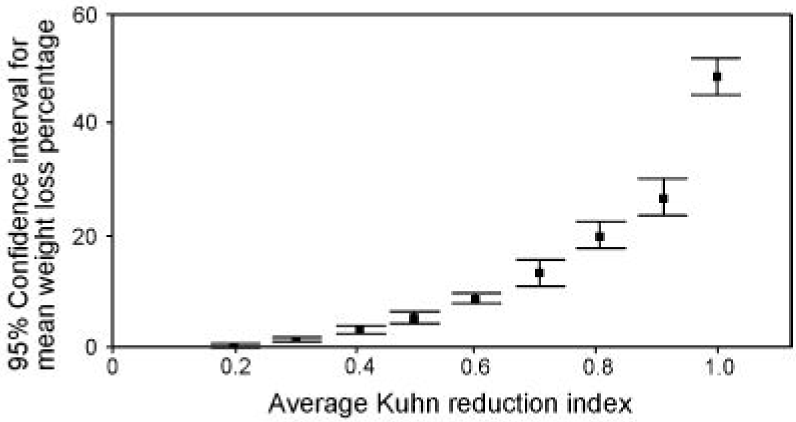

Fig. 4. Illustrations of the relationship between the Percentage of original mass lost and Kuhn's Index of reduction for our experimental specimens, showing bars displaying the 95% confidence interval for the mean of each 0.1 of the Kuhn index.

The curvilinear relationship of the Kuhn Index to mass reduction is significant for interpretations of the index. Since relatively more weight is lost later in the flaking sequence than early in the retouching process, not all increments in the Kuhn Index are equivalent. For example, in terms of mass lost the interval between 0.8 and 0.9 is substantially greater than between 0.2 and 0.3. Consequently, comparisons between assemblages and sections of assemblages that have different values of the Kuhn Index should be couched in terms or relative rather than absolute differences in the extent of retouch, unless a relevant calibration is available.

Furthermore, the minimum value recorded for the Kuhn Reduction Index, on specimens with minimal retouch, was 0.14. This demonstrates that even in the initial phase of retouching values less than 0.2 may be rare, and values less than 0.1 may not be found in many assemblages and/or recognised as retouch; a pattern congruent with the results of Kuhn's own experiments [19].

On some specimens mass continues to be lost through retouching after a value of 1 has been reached. Twelve specimens, 40% of the experiments, reached Kuhn values of 1 before breaking. Those specimens reaching values of 1 did so when weight loss was 57.1±8.3% of the original flake (N=12). For those specimens 13.1±7.7% of the original flake weight was removed after values of 1 were recorded. It should be emphasised that the conditions of our experiments exaggerate this effect, because all specimens were reduced until they were broken.

The implications of these findings are:

1. Although in theory the index is scaled from 0, in practice the range of values will usually be less, starting between 0.1 and 0.2 in our experimental setting

2. While the maximum value of the Kuhn Index is typically reached when 50–65% of original mass has been removed, specimens with values of 1 represent varying levels of reduction and should not necessarily be interpreted as a maximum or near maximum amount of retouch

3. In relation to the change in the relative mass of each flake produced by retouching the Kuhn Reduction Index is not linearly scaled and should not be interpreted as though it was. The reduction index can reliably be used as a relative measure of the amount of mass removed, but a further analytical step is required to "calibrate" it and allow it to be used as an absolute measure.

Our experiments indicate that in some instances the transformation of variables may be sufficient to create a strong linear relationship, thereby providing a basis for absolute statements of different levels of reduction. For our experimental data it is a simple matter to re-express the percentage of original flake weight lost through retouch on a logarithmic scale, as log(%weight loss), thereby transforming the relationship of mass loss and the Kuhn Index into a linear one. The bivariate plot resulting from this transformation is illustrated in Fig. 5. A linear regression of these data, calculated with a constant, gives a correlation coefficient of 0.933 (N=348, p<0.001), which can be interpreted as 87% of the variation in mass loss being expressed by values of the Kuhn Index (r^2=0.871). A similar analysis, without constant, gives a coefficient of 0.993 (N=348, p<0.001), a remarkably high value that indicates that approximately 98% of mass loss is explicable in terms of the Kuhn Reduction Index (r^2=0.985). With coefficients of these strengths it is reasonable to assert that, at least in single margin reduction of the type experimentally tested, the percentage of weight lost could be reliably predicted from the value of the Kuhn Reduction Index that can be measured on specimens. The robustness of this relationship was also indicated by an analysis of variance demonstrating a significant response in log(%weight loss) with changing values of the Kuhn Index (F=410.5, p<0.001), with little response to cross-sectional traits of dorsal ridge number (F=0.217, p=0.885), relative thickness (F=2.86, p=0.494), or the percentage of width between ridges on trapezoidal cross-sections (F=0.314, p=0.584). The relationship of log(%weight loss) and Kuhn's Index therefore appears to hold despite variation in blank cross-section.

To further demonstrate this inference we note that a similar analysis using only flakes with trapezoidal cross-sections yields similarly strong relationships between the percentage of weight lost and the Kuhn Reduction Index. For example, a linear regression of these data, calculated with a constant, gives a correlation coefficient of 0.907 (N=163, p<0.001), which can be interpreted as 82% of the variation in mass loss being expressed by values of the Kuhn Index (r^2=0.823). The bivariate plot shown in Fig. 5 depicts the two-ridge specimens as dark data points, and reveals a similar dispersion of observations to that observed for flakes with triangular cross sections. Even when we analyse only the four flattest flakes in our experiments, those with more than 70% of flake width positioned between the two ridges, steep marginal angles and little height difference between the two ridges, we obtain a correlation coefficient of 0.898 (N=42, p<0.001; r^2=0.807) for the relationship of percentage weight lost and the Kuhn Reduction Index. Consequently for the kinds of flakes used in our experiments even relatively flat flakes could have the percentage of weight lost reliably predicted from the value of the Kuhn Reduction Index that can be measured.

6. Kuhn as a predictor of extent of reduction

The experiments we have described here indicate that the Kuhn Reduction Index is a poor predictor of the number of flakes removed, but is a robust indicator of the progressive loss of weight from a retouched flake worked on a single lateral margin. The relationship between loss of mass and the Reduction Index is non-linear, with relatively more weight lost later in the retouching process per measured interval. This pattern must be considered in deriving interpretations based on the Kuhn Reduction Index, and we suggest that inferences can be based on the principle that the value of the index measures log(%weight loss). Treated in this way the Kuhn Index is a reliable description of the amount of flake retouching. We particularly note that the flakes we retouched were selected to represent a large variety of cross-sections, ranging from very flat to steeply triangular. The strong non-linear correlation displayed by our experimental data therefore provide grounds for concluding that the flat-flake problem discussed by Dibble [9] may exist but need not create an obstacle to employing the Kuhn Reduction Index as a powerful way of measuring the extent of flake reduction.

7. Comparing measures of reduction

An evaluation of Kuhn's Index would not be complete without a comparison of its performance to alternative measures. To provide a basis for comparing different kinds of measurements we have calculated, from our experimental data a number of the different reduction measures discussed by Dibble [9] and other authors. For each measure we have calculated its linear correlation with changing weight loss. Table 3 provides regression coefficients for five measures of reduction, including the Kuhn Index, determined using the percentage of weight lost from each specimen as the independent absolute measure of reduction. We have chosen linear regression as a way of studying the strength of significant positive relationships between each reduction measure and mass lost, an approach that requires certain conditions including linearity. Where appropriate we have therefore corrected for non-linear relationships by applying a data transformation; the last column in Table 3 indicates the type of transformation that obtains the highest coefficient for each measure. To develop a ranking system that in some ways approximates those used by Dibble [9] and Gordon [11], but excludes any measure of retouch distribution, we have used a ranking system that incorporates only the relevant attributes of those ranking systems; that is, edge angle, scar length and frequency of step terminated retouch. To calculate this index, the range of values recorded in each variable over the sequence of reduction was divided into four equal intervals (ranks) and assigned to each specimen for each retouching event. The mean of these three rankings was calculated for each specimen, providing an overall ranking that was regressed against log percentage of original weight lost to determine the performance of these attributes as a measure of reduction over the experimental sequence.

TABLE 3. Comparison of regression correlation coefficients for various measures of reduction on experimental observations, ranked in order of coefficient value

Measure	**Coefficient (*r*)**	r^2	**Probability**	**Transformation**
Kuhn Index	0.933	0.871	<0.001	Log(% weight lost)
Surface area/thickness	0.727	0.529	<0.001	None
Retouch scar length	0.697	0.486	<0.001	Log(% weight lost)
Ranked scar characteristics	0.674	0.454	<0.001	Log(% weight lost)
Surface area/platform area	0.259	0.067	<0.001	None

Calculated in this way the coefficients provided in Table 3 allow a comparative judgement of the effectiveness of different measures of reduction in the circumstances of our experiment: highly variable blank forms reduced in a standard way by unifacial retouching one lateral margin. Note that because of the large number of observations available all tests show a decidedly non-random pattern, as measured by $p<0.001$ in every case. These significance values alone cannot be employed as an indication of the relative differences in predictive strength of the different measures, and we therefore adopt the simple practice of emphasising the coefficient as the apposite means of comparing the predictive power of each measure. We have ordered the various measurements by the size of the calculated coefficients, making the order in Table 3 a rank-order list of the effectiveness of the different measures in describing the proportion of original flake weight that had been lost. The Kuhn Index performs extremely well compared to other indices, and explains at least 35% more variation than other measures (as revealed in an r^2 calculation). In contrast, some indices performed very poorly, such as Dibble's [9] surface area to platform area index which explains as little as 6.7% of variation. In the kind of situation represented by our experiment, such as assemblages of dorsally retouched side scrapers, we would strongly recommend caution in the use of a surface area to platform area index, and advocate researchers employ other more powerful measures. Interestingly, a variant of the surface area to platform area index devised by Holdaway et al. [18] that uses thickness rather than platform area as the estimator of original flake size is far superior, explaining 53% more of the variation. That conclusion is also consistent with the correlation analyses presented by Dibble [9]. Close's [4] retouch scar length and the retouch ranking system also achieve only moderate success with both explaining less that 50% of variation.

In the framework of our experiments the Kuhn Reduction Index out-performed other published measures of the amount of retouching by a considerable margin. However, when analysing other patterns of reduction of the kind not represented by our unifacial reduction experiments, such as when retouching removes flakes from the ventral face of a flake, measures such as a surface area to platform area index may be more reliable than the Kuhn Reduction Index. Clearly further experimental evaluations of the efficacy of reduction indices in different patterns of flake retouching, for different flake blanks and perhaps for different raw materials, is warranted. Further experiments may also explore the way multiple reduction indices could be used to provide composite estimates of the extent of flake retouching.

8. Conclusion

In these experimental circumstances the Kuhn Index is the most powerful of the measures, and should be employed as a robust indicator of the extent of reduction when retouching patterns are suited to the calculation of the index. The experimental framework adopted constrains retouching patterns beyond what might reasonably be expected in archaeological assemblages, and we encourage further experimental investigations into the conditions under which reduction measures operate adequately. However, the use of rigid retouching patterns in this experiment has also provided an opportunity for a number of reduction indices to perform without interference from complicating factors, and to compare those performances. In these conditions, and for the kinds of flake cross-sections employed in our experiments, it is apparent that for unifacially retouched flakes Kuhn's Index is the most robust and precise measure of the amount of reduction currently available, both for individual specimens and assemblage-wide comparisons. By showing that Kuhn's Index is strongly positively related to log(%weight loss) and that variation in blank cross-section has minimal impact on that capacity of the index to predict mass loss these experiments suggest that archaeologists should have confidence when using the index in analyses of archaeological reduction sequences, and should employ the Kuhn Index in appropriate circumstances, even in preference to many other measures, unless assemblage specific contraindications are forthcoming.

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