

# Comparing Lithic Assemblage Edge Damage Distributions: Examples from the Late Pleistocene and Preliminary Experimental Results

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## ABSTRACT

Drawing behavioral inferences from macroscopic edge damage observations on lithic assemblages relies on linking observed damage patterns to behavioral processes identified during experimentation. Such methods have proven useful. However, critics frequently cite equifinality between different processes and wear traces on individual artifacts as well as inconsistent inter-observer agreement as problems with a ‘low-powered approach’ to lithic use-wear. One potential source of information that has received less attention is the patterns of edge damage detectable at the assemblage scale. Such patterns are only discernable by quantification of the collective distribution and frequency of edge damage on individual specimens. Here we use GIS to digitize and spatially reference artifacts to standardize and quantify edge damage. We applied this method to an assemblage of Middle Stone Age convergent flakes from Pinnacle Point Cave 13B, South Africa (165 - 90 ka) and a series of experimental flakes recreated for several tasks including use in a calibrated crossbow experiment. Assemblage results indicate that archaeological patterns of edge damage are unlikely to have a taphonomic origin. Moreover, the patterning does not appear to result from use as hafted spear armatures. Our results demonstrate the statistical and interpretive power gained by assemblage analyses compared to individual artifacts. The additional benefit of including microwear and residue analysis using a single cohesive GIS recording framework will enable rapid dissemination of results between analysts and create a record of experimental and archaeological wear-traces available to other researchers.

**R**esearchers studying lithic artifact assemblages are faced with the task of inferring past human behaviors from static artifacts that have undergone a multitude of alterations after the anthropogenic input has ended. Lithic use-wear studies seek to see beyond the taphonomic wear traces and relate edge

modification to the human component of the tools' life history. Drawing behavioral inferences from edge damage observations on lithic assemblages relies on linking observed damage patterns to behavioral processes identified during experimentation (Keeley 1980; Schiffer 1987).

Odell (2004) divides use-wear studies into 'low-power' and 'high-power' approaches based on the degree of microscopy magnification used. Low-power analyses have the advantage of documenting large samples of tools, however several blind tests have shown substantial inter-observer variation is possible (Newcomer et al. 1986; Unrath et al. 1986). In contrast, the time-intensive high-powered approach often is applied to only a small sample of the total assemblage - usually restricted to retouched formal tools or artifacts expected to be used *a priori* to test form-function hypotheses (Hardy 1994:31 or Odell 2004 and references therein). Coarse-grained raw materials also present a problem at high-magnifications due to the large grain sizes obscuring wear traces (Grace 1990; Richards 1988:6; Thackeray 2000). While most researchers agree that high and low power use-wear studies are complimentary and should be performed together, methods for merging such disparate scales of observation have not been well developed.

Here we utilize GIS software to digitize wear traces on one type of lithic tool: convergent flakes (Levallois points). GIS is used to georeference edge damage onto artifact images based on microscope observations. Once images are georeferenced, the GIS environment can be utilized to tie together many attributes of lithic tools that are of interest such as residue locations, geometric morphometric landmarks (Schoville and Otárola-Castillo 2008), and image analysis metrics such as platform area (Braun et al. 2008). Incorporating macro, micro, and residue edge-wear data within a GIS environment will enable researchers to explore patterns of edge modification across multiple scales of observation. For instance, microscopic wear locations between artifacts from different sites may be contrasted to the aggregate distribution of macroscopic edge wear on all tools from multiple assemblages when tool wear is digitally recorded. While the main objective here is to explore the assemblage distribution patterns, exploring edge damage across scales is an important area of future research since archaeological inferences of human behavior are often dependent on the researcher's scale of observation (Burger et al. 2002).

To demonstrate the methodology, convergent flakes from Middle Stone Age (MSA) layers at Pinnacle Point 13B (PP13B), South Africa were digitized into a GIS, documenting each instance of edge damage along the perimeter (Schoville in press). The possibility that convergent flakes from PP13B were used as spear point armatures prior to deposition is evaluated by comparing edge wear patterns on the archaeological assemblage to an experimental assemblage of points used as thrusting spears. A final example uses one of the few macroscopic

edge wear distribution studies from Shea (1993) to evaluate how individual Levallois points with damage patterns referable to ‘cutting’ or ‘impact’ use relate to aggregated assemblage patterns from the GIS analysis. These points were digitized based on published dorsal edge wear illustrations and compared to the set of experimental points. For this study, edge damage scars were not attributed to a specific process- only the damage size, shape, and location along the edge of the convergent flakes were documented on complete points.

### **Assemblage Distributions**

Underlying the assemblage damage approach is the argument that a distribution of tool wear traces may be more statistically representative of the population of tools than individual occurrences on individual artifacts. By comparing distributions instead of individual artifacts, observer error, sampling error, and wear-trace equifinality issues are minimized. Taphonomic and behavioral inferences may then be drawn from archaeological distributions compared to experimental ‘populations’ of edge damage. Both the high and low powered use-wear approaches could be considered to be binomial distributions in the sense that individual artifact wear traces are related to causal mechanisms of origin and the analyst is either correct or false in their attribution. The probability of correctly interpreting the original wear cause is then related to the accuracy in which the analyst may identify archaeological to experimental wear traces.

An alternative procedure is to estimate the population parameters in a probabilistic framework by analyzing patterns of edge damage at the assemblage scale. Such patterns are only discernable by quantification of the collective distribution and frequency of edge damage on individual specimens. Assemblage distributions of edge damage may be compared to a reference distribution of edge wear and the probability of a false positive (assemblage pattern attributed to wrong causation) can be derived. With this method, interpretive confidence is relative to the likelihood of an archaeological assemblage being drawn from the experimental population. Combining this approach with more traditional use-wear analysis may not only enable statistical corroboration of results, but also provide a means of comparison to published experimental and archaeological assemblage’s researchers have not physically accessed.

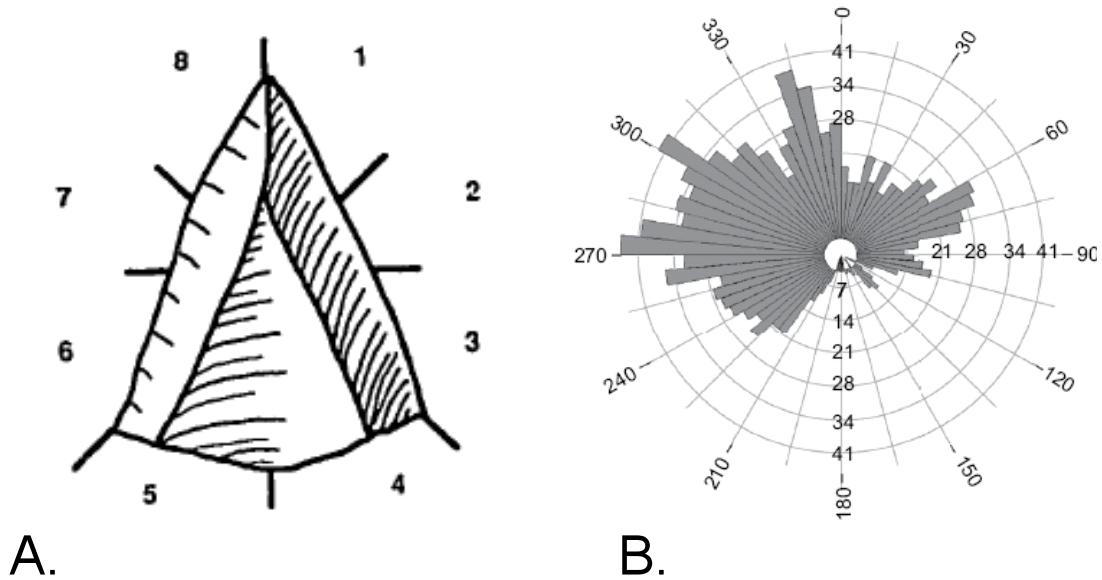
### **Background**

Triangular pointed flakes are common in many Middle Stone Age (MSA) assemblages, a fact observed by Goodwin and Van Riet Lowe (1929) in the original definition of the MSA. Recent work by Lombard and others has indicated points may have been hafted with ochre mastic and used as spear tips (Lombard 2005a; Lombard 2005b; Wadley 2005). Shea (2006) uses the tip-cross-section

area to argue that similar to many Paleolithic Levallois points, triangular MSA flakes tend to be too large to be effectively used as projectile spears or arrows, leaving open the possibility that they were hafted for use as knives or thrusting spears. Brooks et al. (2006) suggest that the decreasing point weights after 100 ka in southern Africa may indicate increasing reliance on the use of points in projectile armatures. Understanding behavioral adaptations at the site and landscape scale requires documentation of both taphonomic and cultural processes influencing artifact accumulation. Incorporating studies of lithic edge damage at the assemblage scale provides one means of evaluating not just what a sample of tools may have been used for, but of characterizing the nature of a lithic assemblage in a probabilistic framework which may be compared to other assemblages.

Within the South African record of MSA assemblages, flakes with slight lateral edge damage are common which may be attributable to taphonomic or human origin (Bird et al. 2007; Thackeray 2000; Wurz 2000). Numerous experimental studies have indicated such edge damage may form in non-random ways from use (Keeley 1980; Tringham et al. 1974; Vaughan 1985). Taphonomic edge damage on the other hand, often results in damage located randomly across tool edges (McBrearty et al. 1998; Tringham et al. 1974). Other forms of edge wear, such as hafting, result in concentrated regions of edge damage (Rots et al. 2006). Experimental studies have indicated points used as spears tips frequently show edge damage in the form of impact fractures and scarring near the point of penetration, some of which may be “diagnostic” as high-velocity impact fractures (Fischer et al. 1984; Odell and Cowan 1986; Shea et al. 2001). Flakes used as knives however, show edge damage along the utilized edge, reflective of the angle, pressure, and direction of cutting motion (Kamminga 1982; Tringham et al. 1974).

Given these differences in how edge damage forms, analyzing tools in morphologically and functionally meaningful units is essential to create distributions with inferential potential. Previous studies utilizing damage distributions tend to use categorical classifications of edge regions based on partitioning edges at defined angles from the tool centroid. The two schemes in Figure 1 from Shea (1991) and Bird et al. (2007) indicate how edge wear often is defined at polar angles of tool edges. One obstacle with this methodology is that stone tools are not circular objects; therefore the edge length is variable at angles extending from the tool centroid. In Figure 2, edge lengths of the tool on the left between 7.5° intervals are shown in the polar graph on the right. Since polar angles do not equally divide edge length, any patterning observed based on polar distributions will be obscured by the relationship between tool shape and the amount of edge available for use at polar intervals. Compounding this problem is



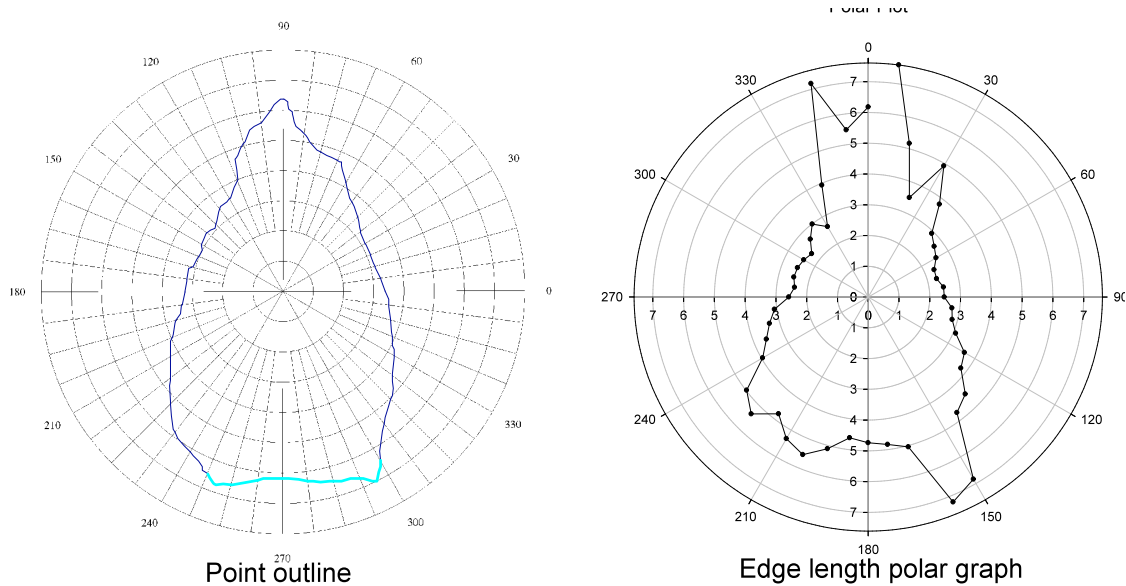
**Figure 1.** Two methods of recording edge damage location in polar segments from a) Shea (1991) and b) Bird et al. (2007).

the platform which is generally removed from analyses of lateral edge wear. When the platform is removed, even random distributions may seem patterned due only to the distribution of edge length around the perimeter of the tool. Therefore in this analysis, we attempt to use distributions of damage at homologous intervals on each tool.

We define points as unretouched convergent-flakes which consist of two faces, dorsal and ventral. With the tip up and the platform down, both faces have a left and right side. Consequently, every point has four lateral margins: dorsal left and right, and ventral left and right. Functionally, these act as two edges – one composed of the dorsal left and ventral right sides, and the other composed of the dorsal right and ventral left sides.

## Methods

Capturing edge damage data in a GIS has been previously described in Bird et al. (2007) and the method here is expanded upon in Schoville (in press) with the points from PP13B, South Africa also used here. Briefly reviewed, each artifact is photographed ventrally and dorsally and digitally traced into a GIS as a polygon vector. Each edge damage occurrence is identified through a dissection stereomicroscope (10-50x) with strong incident lighting and then defined on the specimen outline in GIS by tracing the outline of damaged edge location. The point perimeter is separated based on the extent of the platform and divided into



**Figure 2.** A typical MSA point traced on the left. Perimeter lengths at 7.5° intervals are plotted on the right, indicating “patterning” related solely to the distribution of edge length.

left and right sides. This division allows the frequency and distribution of damage on the four lateral margins to be calculated and the platform to be removed from the analysis. Edge scar frequency and distribution may then be compared to total edge length simply by summing the perimeter values or standardized to remove the effect of different tool sizes by scaling each edge to 100, with the platform edge set at 0 and the point tip set at 100.

A calibrated crossbow was constructed following Shea et al. (2001) to create experimental patterns of edge damage from thrusting spear use (Figure 3a). Experimental convergent-flakes similar to those recovered from PP13B were replicated by KB using quartzite local to the Pinnacle Point caves (n=22). Each convergent flake was hafted to a wooden dowel using a combination of *Acacia karroo* mastic and cow (*Bos taurus*) tendon (Figure 3b and c). Each experimental flake was initially thrust once and then examined for edge wear. Each surviving point was thrust until a catastrophic break occurred, up to a maximum of 6 trials. The crossbow was calibrated to 28 kg of draw force similar to Shea et al. (2001) and was kept constant for each replication. Two springbok carcasses (*Antidorcas marcupialis*) culled from a nearby ranch for the purpose of experimentation and consumption served as the target. Given the small sample size so far developed, this should be considered a preliminary result.

Published points from Shea (1993) were digitized and georeferenced into a GIS. Edge damage was digitized by tracing the extent of edge wear illustrated (Shea 1993: figure 14.3). These points come from five Middle Paleolithic sites in





**Figure 3.** Experimental “calibrated crossbow” thrusting spear and hafting preparation. a) Calibrated crossbow and springbok target; b) MSA point and dowel foreshaft; c) drying mastic and cordage hafting arrangement near fire.

the Levant (Kebara, Tabun, Hayonim, Qafzeh, Tor Faraj) which are argued to support Neandertal hafting and spear use behaviors based on impact fracture morphology and individual point edge wear distributions. While published points are not expected to reflect the complete assemblage diversity, here we are simply testing to see if the inferences by Shea based on individual artifact wear patterns are separable when aggregated, and if they are similar to the experimentally derived distributions of point function. Including the sample of points from Shea (1993) helps illustrate how the GIS framework can compare datasets from disparate sources.

## Results

A comparison of the damage patterns between single thrusting events and multiple events provides support for the method of assemblage distribution analysis advocated here. The average edge damage distribution per tool at

increasing use intensity is shown in Figure 4. Prior experimental studies have shown edges exposed to low-levels of use (i.e., light or single use events – as opposed to heavily reduced and worn edges) are unlikely to show all wear patterns necessary to refer tools to specific use and that wear frequency increases with increasing use (Odell 2004). Comparing the damage distributions at increasing use indicates single and multiple events have similar distributions of damage when aggregated such as in an assemblage analysis. In other words, *single tool* edge damage distributions may be useful when tools are extensively used such as highly curated toolkits. However, when tools are more expediently made and lightly used, *assemblage scale* edge damage distributions may be a more appropriate analysis. The similarity in damage distributions at increasing use-intensity indicates archaeological assemblage patterns should not be dependent on curation and use-intensity differences.

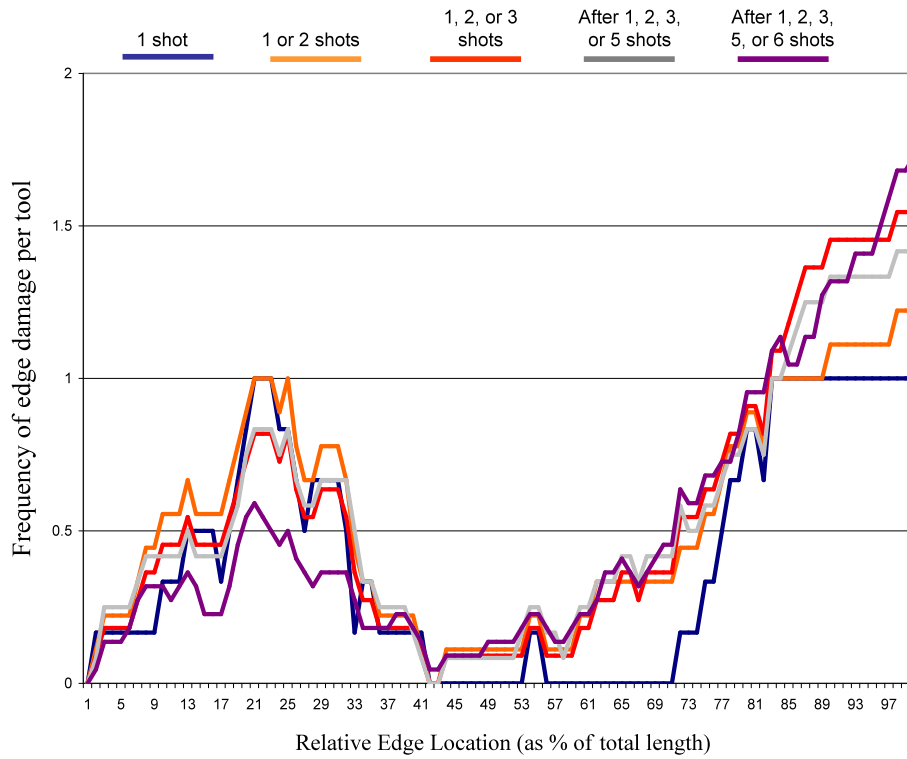
The cumulative distribution of edge damage on points from PP13B was calculated and compared to a random distribution with the Kolmogorov-Smirnov (KS) test for distribution equality (Shennan 1997) where the maximum distance between the two distributions is compared to a KS statistic. Schoville (in press) demonstrated that the distribution of damage on every edge at PP13B is significantly different from a random distribution which indicates a non-taphonomic pattern. Additionally, the left and right edges are different as are the dorsal and ventral edge damage distributions.

The preliminary set of experimental convergent-points all functioned well as thrusting spears and were capable of penetrating the carcass. All edges showed damage distributions significantly different from random except for the dorsal-left edge. The distribution of damage on dorsal and ventral edges were significantly different, however the left and right edges were not significantly different from each other and did not have significantly different frequencies of damage ( $p=0.851$ , Mann-Whitney paired means).

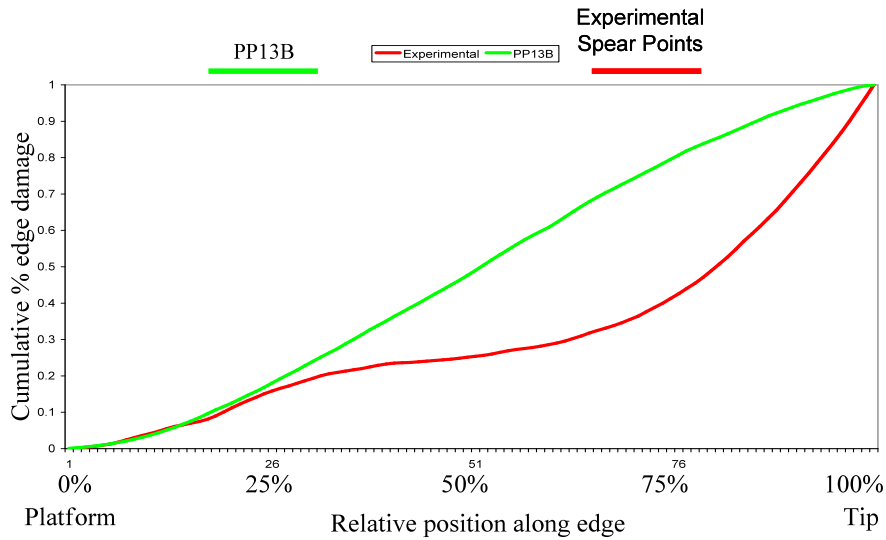
A KS test between PP13B and the experimental assemblage shows that PP13B consists of significantly different distributions of edge damage unlikely to have been drawn from the population of spear points (Figure 5;  $p<0.05$ ). The distribution of edge damage on the left and right edges of the experimental points are compared in Figure 6. The features prominent in the population of experimental thrusting points include: 1) a notable hafting ‘bump’ of damage at about 30% up the edge from the platform which corresponds to the average extent of hafting (located at 36%); 2) a trend towards high-tip damage frequency; and 3) statistically equal patterns between the left and right edges. When the left and right distributions of PP13B points are compared they show very different features (Figure 7): 1) there is no noticeable hafting ‘bump’ of edge damage near the base; 2) no trend towards heavy tip damage, and 3) the left and right edges are statistically and visually quite different.



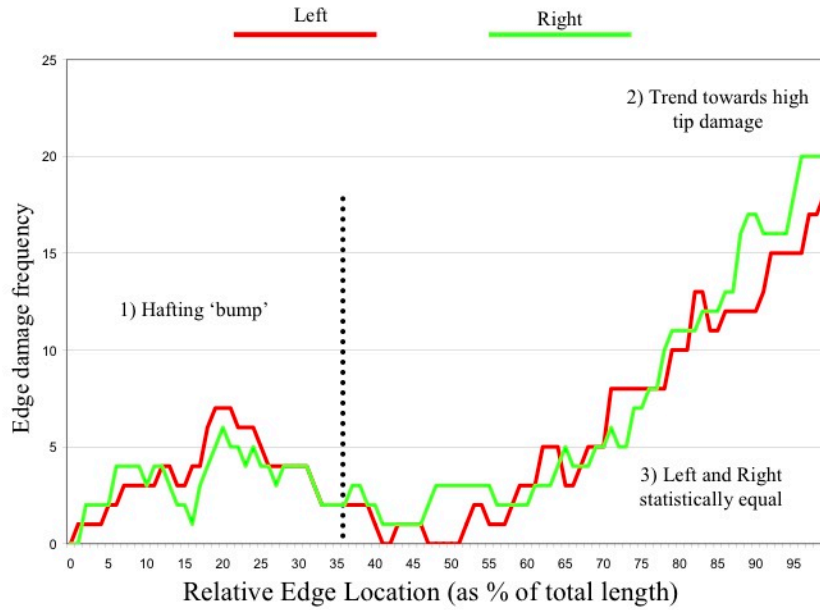
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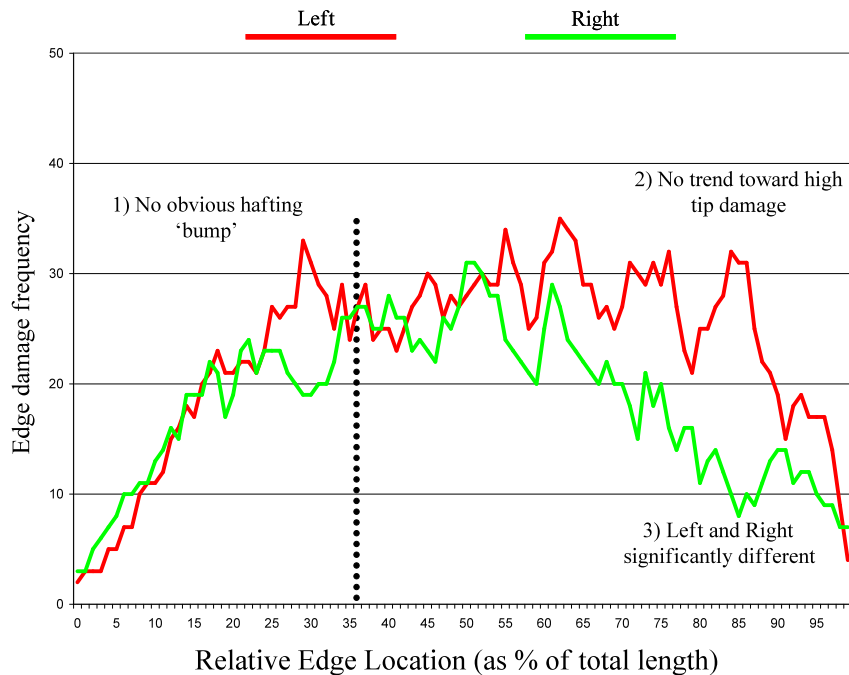
**Figure 4.** Frequency of edge damage per tool compared at increasing use-intensity.



**Figure 5.** Cumulative distribution of edge damage on points from PP13B compared to the experimental spear points. Kolmogorov-Smirnov test, Max Diff: 38.5%, KS Value: 4.6%;  $p < 0.05$ .



**Figure 6.** Edge damage frequency on the left and right sides of experimental spear points. Black dashed line indicates average extent of hafting from experimental points. Dashed line indicates average extent of hafting.



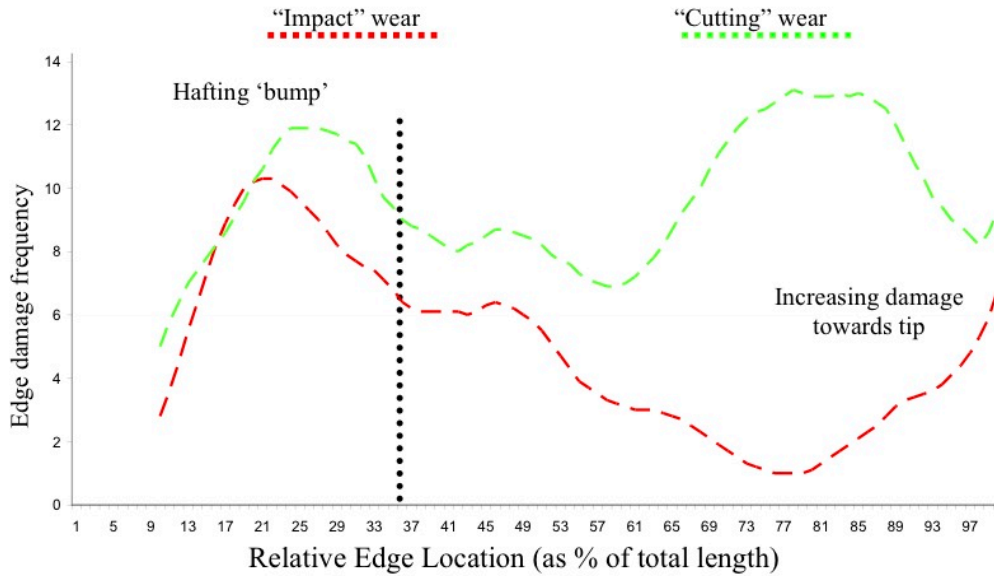
**Figure 7.** Edge damage frequency on the left and right sides of points from PP13B. Black dashed line indicates average extent of hafting from experimental points. Dashed line indicates average extent of hafting from experimental points.

Tools referable to use as “cutting” and “impact” from Shea (1993) indicate the presence of concentrated hafting damage and increased damage towards the tip (Figure 8). However, when the damage distributions are compared to the experimental assemblage of spear point damage, neither sample of inferred function appears to be drawn from the same population of tools used as spear points (Figure 9). This may be related to several factors including small sample size, only comparing the published dorsal faces, and raw material differences. It seems possible that some of the discrepancy may be due to the attribution of tools to functional classes based on individual wear patterns. While the distributions between “impact” and “cutting” tools are significantly different from each other and from random, the attribution of impact tools based on the assemblage distribution to spear use is not as well supported.

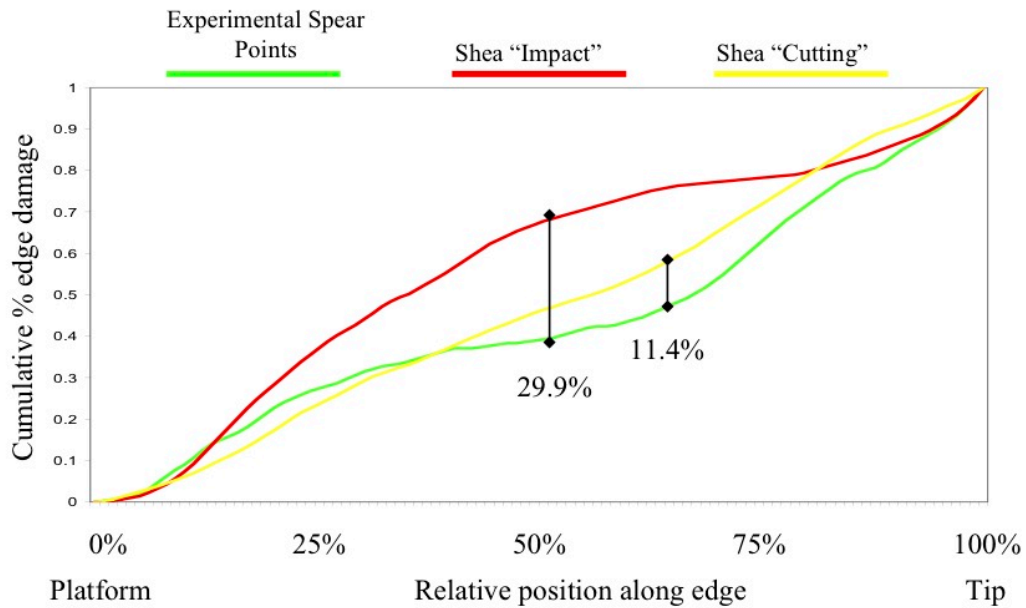
An alternative method for comparing the experimental spear points to the published set after digitization in GIS is through non-metric multi-dimensional scaling (NMDS). This is a non-parametric ordination technique appropriate for presence/absence datasets to group similar objects based on uncorrelated classification axes (Shennan 1997). The relative edge locations from 0 to 100 were used as 0/1 variables. NMDS positions objects in space to minimize distance between similar objects and maximize distance between dissimilar objects. In Figure 10, Shea’s classified points and the experimental set are plotted in two-dimensions. The experimental spear points are contained within the distribution of points described as “impact” points; which suggests some of Shea’s “impact” points are outside the range of experimental spear points in terms of damage distribution, but does confirm the interpretation that many Levantine points show wear distributions referable to use as point armatures. Perhaps more importantly, there is clear separation between points classified as cutting and the experimental spear tips.

## Discussion

Analysis of the assemblage distribution of edge damage from PP13B and Shea’s (1993) published points from the Levant provides some insight into the formation history and landscape use behaviors identifiable through assemblage edge damage enabled by GIS analysis. First, establishing that all edge damage distributions are different from a random distribution indicates that the origin of edge damage is not completely taphonomic and suggests that the patterned distributions may be behavioral. The ability to compare distributions to random is one advantage of this recording procedure that may be applied to residue analysis and other micro-wear studies. Secondly, the assemblage of points from PP13B does not show edge damage patterning suggestive of use as spear-tips prior to deposition.



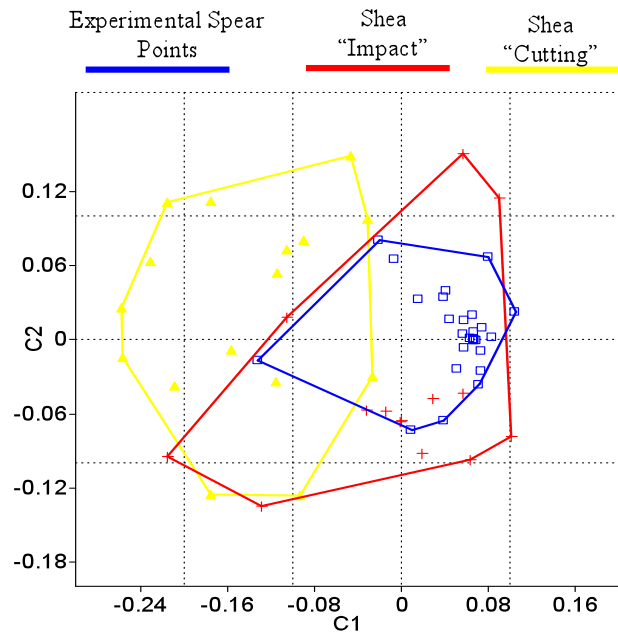
**Figure 8.** Comparison of “impact” and “cutting” edge damage frequency from points in Shea (1993). Dashed line indicates average extent of hafting from experimental points.



**Figure 9.** Distribution of edge damage of Shea’s points compared to the experimental spear points. Kolmogorov-Smirnov test, *KS Value*: 8.7%,  $p < 0.05$ .

Experimental spear points show several features not present on the assemblage distribution of edge damage at PP13B. This includes damage increasing towards the tip, concentrated hafting damage, equivalent left and right edge damage distributions, and heavier ventral edge damage. Points from PP13B instead show features that prior experimental studies suggest would be linked to use as cutting tools. These features include unequal left and right edge damage which may be related to preferential handedness, damage concentrated towards the mid-section of the flake, and lack of impact fractures on the tip. Third, support for the use of Levantine points from Shea (1993) referenced as “impact” use is limited when compared to an experimental distribution of damage from spear points, but is greater with use of NMDS ordination techniques. Analytical techniques for addressing multiple functions of morphologically similar lithic tools aggregated at the assemblage scale helps address concerns of combining functionally diverse tool patterns into a single distribution. Given that lightly used tools are unlikely to provide the more diagnostic patterns of wear on individual tools, it is possible that tool use diversity may be underestimated in many archaeological contexts when functional determination is made on individual tool edge damage patterns. As was shown in Figure 4, assemblage edge damage analysis incorporates instances of wear that may otherwise not be utilized to form a consistent picture regardless of use intensity. Estimates of ‘diagnostic impact fracture’ formation on experimental projectiles indicates such wear traces may form on ~40% of tools; however such estimates are based on multiple use events (i.e., points shot at a target *until* they broke) rather than the probability of diagnostic wear per use-event which must be considerably lower (Villa et al. 2009). Therefore, inferences based solely on diagnostic wear traces or individual tool patterns ignore a large portion (the “non-diagnostic” portion) of the point assemblage which may be included through assemblage edge damage analysis.

While this result does not suggest that all triangular convergent-flakes in the MSA were not used as spear points, it does suggest that there is variability in how these points were being used and where they were being deposited. Given the diversity of fauna at PP13B and coastal environment it may not be surprising that the lithic assemblage would reflect a range of activities rather than a predominantly hunting signature (Thompson 2008). As has been suggested for morphologically similar Middle Paleolithic Levallois points and Australian Aborigine’s knives (*Jeliras*), triangular MSA flakes likely had multiple functions (Shea 1997). Variation in the frequency of impact fractures on MSA points has been noted by Lombard to exist within some levels that post-date PP13B suggesting to her variation in hunting behavior at these sites (Lombard 2005b). The assemblage edge damage signature from PP13B may indicate that variation in use and discard of lithic technology may relate to landscape use differences as well. While other locations may see an increase in the deposition of points



**Figure 10.** Non-metric multi-dimensional scaling of Shea's points and the experimental spear points.

damaged after hunting, PP13B appears to be a location where points were deposited after cutting activities.

## Conclusion

The ability to assign statistical confidence in behavioral inferences of archaeological patterns based on experimental processes is a significant advantage with the method of edge damage analysis presented here. While the GIS method is not the only available tool for such image analyses, GIS software and training has become common in many other areas of archaeological analysis (Abe, et al. 2002; Braun, et al. 2008; McPherron and Dibble 1999). Inter-site comparisons of assemblage edge damage are one obvious extension of this method but more extensive experimental datasets will help provide the experimental linkages required to tie assemblage patterns to behavioral inferences. Future experimental research into edge damage formation should benefit from the standardized GIS recording procedure presented in Bird et al. (2007) and Schoville (in press). The additional benefit of including microwear and residue analysis using a single cohesive GIS recording framework will enable rapid dissemination of results between analysts and create a record of experimental and archaeological wear-traces available to other researchers.

## References

- Abe, Y., C. W. Marean, P. J. Nilssen, E. C. Stone and Z. Assefa  
2002. The analysis of cutmarks on archaeofauna: A review and critique of quantification procedures, and a new image-analysis GIS approach. *American Antiquity* 67:643-663.
- Bird, C., T. Minichillo and C. W. Marean  
2007. Edge damage distribution at the assemblage level on Middle Stone Age lithics: an image-based GIS approach. *Journal of Archaeological Science* 34(5):771-780.
- Braun, D. R., J. C. Tactikos, J. V. Ferraro, S. L. Arnow, and J. W. K. Harris  
2008. Oldowan reduction sequences: methodological considerations. *Journal of Archaeological Science* 35(8):2153-2163.
- Brooks, A., L. Nevell, J. Yellen, and G. Hartman  
2006. Projectile technologies of the African MSA: Implications for Modern Human origins. *In* *Transitions before the Transition: Evolution and stability in the Middle Paleolithic and Middle Stone Age*. E. Hovers and S.L. Kuhn, eds. Pp. 233-255. New York: Springer.
- Burger, O., L.C. Todd, P. Burnett, T.J. Stohlgren, and D. Stephens  
2002. Multi-scale and nested-intensity sampling techniques for archaeological survey. *Journal of Field Archaeology* 29:409-423.
- Fischer, A., P. Vemming Hansen and P. Rasmussen  
1984. Macro and micro wear traces on lithic projectile points: experimental results and prehistoric examples. *Journal of Danish Archaeology* 3:19-46.
- Goodwin, A. J. H., and C. Van Riet Lowe  
1929. The stone age cultures of South Africa. *Annals of the South Africa Museum* 27:1-289.
- Grace, R.  
1990. The limitations and applications of use wear analysis. *In* *The interpretative possibilities of microwear studies*. B. Gräslund, H. Knutsson, K. Knutsson and, J. Taffinder, eds. *Societas Archaeologica Upsaliensis*, Uppsala, Sweden.
- Hardy, B. L.  
1994. Investigations of stone tool function through use-wear, residue, and DNA analyses at the Middle Paleolithic site of La Quina, France. Ph.D. dissertation, Indiana University.
- Kamminga, J.  
1982. *Over the edge: functional analysis of Australian stone tools*. St. Lucia: University of Queensland: Anthropology Museum, Occasional papers in Anthropology No. 12.
- Keeley, L. H.  
1980. *Experimental determination of stone tool uses*. Chicago: University of Chicago Press.
- Lombard, M.  
2005a. Evidence of hunting and hafting during the Middle Stone Age at Sibidu Cave, KwaZulu-Natal, South Africa: a multianalytical approach. *Journal of Human Evolution* 48(3):279-300.  
2005b. A method for identifying stone age hunting tools. *South African Archaeological Bulletin* 60(182):115.
- McBrearty, S., L. Bishop, T. Plummer, R. Dewar, and N. Conard  
1998. Tools underfoot: human trampling as an agent of lithic artifact edge modification. *American Antiquity* 63(1):108-129.
- McPherron, S. P., and H. L. Dibble  
1999. Stone tool analysis using digitized images: examples from the Lower and Middle Paleolithic. *Lithic Technology* 24(1):38-52.
- Newcomer, M., R. Grace, and R. Unger-Hamilton  
1986. Investigating microwear polishes with blind tests. *Journal of Archaeological Science* 13(3):203-217.
- Odell, G. H.  
2004. *Lithic Analysis*. New York: Kluwer Academic/Plenum Publishers.
- Odell, G. H., and F. Cowan  
1986. Experiments with spears and arrows on animal targets. *Journal of Field Archaeology* 13:195-212.
- Richards, T. H.  
1988. *Microwear patterns on experimental basalt tools*. Oxford, England: British Archaeological Reports.
- Rots, V., L. Pirnay, P. Pirson, and O. Baudoux



2006. Blind tests shed light on possibilities and limitations for identifying stone tool prehension and hafting. *Journal of Archaeological Science* 33(7):935-952.
- Schiffer, M. B.  
1987. Formation processes of the archaeological record. Albuquerque: University of New Mexico Press.
- Schoville, B. J.  
In press. Frequency and distribution of edge damage on Middle Stone Age lithic points, Pinnacle Point 13B, South Africa. *Journal of Human Evolution*.
- Schoville, B. J., and E. Otárola-Castillo  
2008. A geometric morphometric analysis of Middle Stone Age points from Pinnacle Point 13B, South Africa. Paper presented at the 73rd Annual Meeting of the Society for American Archaeology, Vancouver, Canada.
- Shea, J., Z. Davis, and K. Brown  
2001. Experimental tests of Middle Palaeolithic spear points using a calibrated crossbow. *Journal of Archaeological Science* 28(8):807-816.
- Shea, J. J.  
1991. The behavioral significance of Levantine Mousterian industrial variability. Ph.D. dissertation, Harvard University.  
1993. Lithic use-wear evidence for hunting by Neandertals and early modern humans from the Levantine Mousterian. *Archeological Papers of the American Anthropological Association* 4(1):189-197.  
1997. Middle paleolithic spear point technology. In *Projectile Technology*. Heidi Knecht, ed. Pp. 79-106. New York: Plenum Press.  
2006. The origins of lithic projectile point technology: evidence from Africa, the Levant, and Europe. *Journal of Archaeological Science* 33(6):823-846.
- Shennan, S. J.  
1997. *Quantifying Archaeology*. Iowa City: University of Iowa Press.
- Thackeray, A. I.  
2000. Middle Stone Age artefacts from the 1993 and 1995 excavations of Die Kelders Cave 1, South Africa. *Journal of Human Evolution* 38(1):147-168.
- Thompson, J.  
2008. Zooarchaeological tests for modern human behavior at Blombos Cave and Pinnacle Point Cave 13B, Southwestern Cape, South Africa. Ph.D. dissertation, Arizona State University.
- Tringham, R., G. Cooper, G. Odell, B. Voytek, and A. Whitman  
1974. Experimentation in the formation of edge damage: a new approach to lithic analysis. *Journal of Field Archaeology* 1(1):171-196.
- Unrath, G., L. R. Owen, A. van Gijn, E. H. Moss, H. Plisson, and P. Vaughan  
1986. An evaluation of use-wear studies: a multi-analyst approach. *Early Man News* 9-11(1):117-175.
- Vaughan, P. C.  
1985. *Use-wear analysis of flaked stone tools*. Tucson, Arizona: University of Arizona Press.
- Villa, P., M. Soressi, C. S. Henshilwood, and V. Mourre  
2009. The Still Bay points of Blombos Cave (South Africa). *Journal of Archaeological Science* 36(2):441-460.
- Wadley, L.  
2005. Putting ochre to the test: replication studies of adhesives that may have been used for hafting tools in the Middle Stone Age. *Journal of Human Evolution* 49(5):587-601.
- Wurz, S.  
2000. The Middle Stone Age at Klasies River, South Africa. Ph.D. dissertation, University of Stellenbosch.

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