

Usewear and Functional Analysis of Bronze Weapons and Armor

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Abstract: The functionality of bronze weapons and armor has been downplayed since the 1960's due to early experimental work and impressionistic claims by scholars. Recently, however, these claims have been called into question by a new but growing body of experimental and functional research. Methods in this field are still somewhat eclectic, but recent efforts make a good case for rejecting earlier interpretations. These studies and their conclusions are important due to their central importance in debates over the prevalence of warfare during the Bronze Age and their ability to inform us about the nature of practices like hoarding and ritual deposits.

Introduction

The subject of warfare has become something of a hot topic in archaeology following publications for general audiences (Keeley 1996; LeBlanc 2003; Otterbein 2004), and several conferences on the subject leading to edited volumes (Carman 1997; Martin and Frayer 1997; Rice and LeBlanc 2001; Guillane and Zammit 2001; Otto, Thrane, and Vandkilde 2006). In European prehistory specifically, the Bronze Age has often been identified as the beginning era of a warrior elite class (Harding 2000; Kristiansen 1999), and changes in European warfare beginning in the late Bronze Age have been identified as being critical in understanding wide reaching change in Europe and the Near East (Drews 1994). The development of a warrior ethos, identified by analogy with Homer, the presence of new weapons and armor, or through iconographic sources has, for well or ill, contributed to a perception of the Bronze Age as a heroic era (Demakopoulous 1999; Harding 2000; Osgood 2001; Harrison 2004).

If warfare did suddenly become more prevalent in the Bronze Age and our contemporary perspective of its role in this era is justified, a functional understanding of the weapons and armor of the period is needed. While there is a history of experimental archaeology with regards to the Bronze Age, much largely pushed forward by Coles

(1973) and his colleagues, this work has only been expanded upon eclectically in the period since. Most archaeometallurgical analysis has been concerned with the process of manufacture (e.g. Tylecote 1987), element ratios in alloys and compounds (Spoto 2003:7-8), or trace element analysis for sourcing (e.g. Hancock, Pavlish, and Salloum 1991). Experimental work of a sort has continued outside academia among re-enactors and amateur enthusiasts, but this generally lacks the necessary rigor of scientific inquiry.

This situation is unfortunate as the interpretations of several key elements of the Bronze Age require a functional understanding. The interpretation of hoards and “votive” depositions, for instance, changes radically if the items deposited are functional weapons or ceremonial duplicates, and yet again if those weapons which are functional show signs of usewear or not. The role of warrior elites changes quite markedly as well if they are viewed as ceremonial positions, armored in useless bronze, or actual combatants, protected differentially on the field based on social class. Even when warfare is still assumed to take place with organic counterparts to bronze items, the era is interpreted differently due to the large emphasis on the manufacture of bronze items, and whether this emphasis is militant or aggrandizing (or both) in its character.

Despite the importance of understanding the functional capacity of bronze weapons and armor, most scholars estimate function from formal characteristics or rely on older experimental studies which have recently been called into question (e.g. Harrison 2004:68). Subjective, impressionistic assessment of use is often relied upon and experimental tests are not considered a necessity in determining how successfully a Bronze item could have been employed for its purpose. Even though the Bronze Age is the first period in Europe in which a large amount of artifacts appear which have no apparent purpose besides the killing of other human beings (Harding 2000:154), in some

cases, academic thought has produced an image of a Bronze Age in which warriors mainly clash in ceremonial combat, wearing useless armor and flimsy shields (Coles 1962), and wielding swords which are heavy and unsuited for the battlefield (Harding 1999:166)

In recent years a group of younger scholars (Bridgford 1997; Malloy 2004; Roberts and Ottaway 2003) and at least one older, established scholar (Kristiansen 2002) have critically re-evaluated some of the earlier results of these functional analyses. These re-evaluations have been more methodologically rigorous than previous analyses, but slow to disseminate throughout the literature. Their findings, the application of this more rigorous methodology, and a willingness to involve interested members of the public have resulted in a small but growing body of work which demonstrates the inadequacy of the older approaches and calls into question the inadequately equipped Bronze Age warrior model that has become prevalent. These studies lay the groundwork for reinterpreting several aspects of the European Bronze Age.

History of Methodology

While there are horror stories involving 18th and 19th century antiquarians swinging Bronze swords around the lawns of their respective national museums (Moedlinger 2006; Bridgford 1997), experimentally based analysis of Bronze weapons was much slower coming than metallurgical description. The functions of various items were generally inferred from formal analogy with medieval and renaissance weaponry known from historic times, and the resulted in the various typologies which are still in use, including classes such as rapier, dagger, dirk, sword, spear, and halberd (*stabdolche* or *dolchstab* in German). This is also possibly the cause of a lack of a dart / javelin

formal type for bronze points intermediately between arrow heads and spear heads, a case Drews (1993:180-181) laments. The early typologies may not be as best suited to the function of the materials, but the names, such as the *Naue* Type II sword, seem to be long-lived regardless. Some rare experiments did occur during this period, including the only experimental test documented which resulted in the death of the archaeologist (he burst a blood vessel while blowing too hard on bronze horns [MacAdam 1860]).

The functional properties assigned to items throughout the early 20th century were not entirely fanciful, but were based as well on speculation and formal analogy. Much of it was well grounded in common knowledge – certain improvements to fastening at the hilt were likely to result in a sword with a more stable hilt (Benton 1931). Ribbing and a longer, more substantial tang were likely to result in a sturdier all around weapon. An understanding of the general mechanical principles involved justified most of these more superficial analyses, and assumptions about the relative efficiency of different forms of metal were largely unquestioned. While a few scholars in isolation were interested in experimental studies and functionally understanding (Coles 1973:13; Oakeshott 1960), the majority were concerned more with typology and questions of artifact distribution, chronology, and diffusion.

This was in contrast, however, to the developments being made in experimental archaeology in the field of lithics, ceramics, and comparisons being made between stone and metal items. Flint knapping is one of the oldest areas of experimental archaeology (Smith 1893), and comparisons of stone and steel axes for tree clearance have occurred frequently in the last century (Matthieu and Meyer 1997). A functional understanding of obsidian and chert became more common in this period through ethnographic analogy

and the application of the direct historical method and set the groundwork for studies on usewear which were to come later (Semenov 1976:13).

Around the time that the New Archaeology was beginning to take hold among Anglo-American academics, a large body of experimental work began to appear. The majority of that which was associated with prehistoric Europe and the Bronze Age in particular was compiled by or performed in association with John Coles (1962; 1973). It is to this body of work that the majority of Bronze Age scholars refer to when describing the functional properties of bronze arms and armor and evaluating whether or not such items were used in combat (Coles and Harding 1979; Bradley 1990; Harding 1999; Bridgford 1997). Coles connected this development with that being made elsewhere with living history and textiles, and his text *Archaeology by Experiment* (1973) encompasses a wide geographic range. Lithic use wear studies were being pioneered by Semenov (1964) around the same time that the focus on experimental archaeology as part of the New Archaeology took hold, and paralleled the increasing level of scientific rigor being applied in social sciences as a whole, though this rigor was not always necessarily merited by the sought after results.

The use of experiment, however, did not result in the abandonment of impressionistic evaluations. The majority of classical archaeologists dealing with finds in the Near East continued to use analogy or historical description of weapons as reliable indicators of their use (though it should be noted that this may have prevented some of them from joining the useless weapons and armor camp), and weapons were not generally subjected to a set of standard evaluations for function, but for chemical composition (Drews 1993). Descriptions of use were left within the realm of what

seemed logical, rather than what could be proven, and this trend has continued until recently, with Harding providing an example of a typical assessment:

I also believe that the effectiveness of Bronze Age cut-and-thrust swords has been exaggerated. I have not experimented with striking an object, let alone a living body, with such a sword, but I have waved a few around, and find it hard to believe that a slashing blow landing on a clothed body would have done more than produce bruising. Even freshly sharpened, it is hard to see how they could have produced more than superficial cuts where the skin was protected. Thrusting blows, delivered in a moment of inattention.... are much more likely to have been effective (Harding 1999:166).

Weinberger (2002) as well relies on a quick impressionistic judgment to exclude bronze knives and *stabdolche* (halberd blades) from having had any functional significance, in her thesis, which argues for warfare having had little role in the Early Bronze Age of Central Europe.

What is frustrating about this long account given by Harding and the shorter dismissal by Weinberger is that the claims they make would be very easily experimentally evaluated – one would only need a replica of a Bronze Age cut and thrust sword or *dolchstab*, a cut of meat or animal carcasses (comparable to “animal targets” used in lithic experiments [e.g. Odell and Cowan 1986]), and some appropriate textile or leather garments. Such an evaluation would be cheaper in terms of materials than travel to an international conference and would easily fit into the budget of many institution-specific undergraduate and graduate supplemental research grants. Yet experimental archaeology is not sought after for the solution of this problem by them or by the majority of the scholars in the field.

More recent work has begun to fly in the face of the earlier conclusions of experimental and impressionistic archaeology alike. Experimental work by Malloy (2004) has challenged Coles’ conclusions regarding Bronze shields, and work by Bridgford (1997) and Roberts and Ottaway (2003) has found proof that sword and

socketed axes were used for cutting in combat. These findings are even more significant as they attest to a common use among those specimens which occur in some “votive” contexts, lending support to Randsborg’s (1999) position that some hoard examples represent the complete arms of defeated units in combat, deposited ritually by the victors of the combat.

While Coles’ original position was that experimental archaeology was better equipped to handle what prehistoric peoples could not have done than what they could have done, the use of his experiments seems a cautionary tale. One is reminded of early atlatl experiments which concluded that atlatls would have been impossible to hunt with as the weights and leverage did not aid in the force of the projectile (Peets 1960). It is important to keep in mind the fact that archaeologists are not always capable of properly reproducing “primitive” technologies, nor do they necessarily possess the skills to use them properly, much less evaluate the efficiency of that use. Basic assumptions about the improvements of iron over bronze in general use have proven false with new methods (Mathieu and Meyers 1997) and common assumptions regarding prehistoric knowledge are continually being called into question. As such it is necessary to expand beyond the limits of what we think people may have been able to do and explore a fuller range of what it is possible for people to think and do in prehistory. In many areas prehistoric people certainly had more knowledge than present scholars.

As it now stands, the defense of Bronze weapons as functional is paving the way for more usewear oriented analyses. Bridgford (1997), Kristiansen (2002), Roberts and Ottaway (2003), and Kienlen (2006) have done much of the pioneering work in pushing forward usewear evaluations, and their methods are open to improvement. The future of archaeometallurgical usewear is not certain, as it is being conducted by a small group of

scholars associated with a limited number of universities – most of the more avid participants are in the UK and studied at Sheffield. The situation is worsened by the fact that many scholars do not presently feel the need to cite use wear studies in discussing prehistoric contexts in which the function of artifacts is critical (Kristiansen 2002: 319), but there is hope that recent efforts will help this condition to change. The increasing role of digital photography in such studies may help to expand their base as well.

Experimental Methodology and Case Studies

Experimental archaeology with Bronze Arms and Armor has essentially followed the same basic formula generally used in other areas of experimental work:

- 1) Duplicate, as closely as possible, the items being tested using authentic methods from the period to produce the object when available, or at least compare hardness and other characteristics when such methods are not available.
- 2) Set up the experiment in such a way as to minimize the number of variables that might affect results while being as consistent with each item being tested as possible.
- 3) Form some objective means of measuring the results of the experiment and identifying differences between the objects being tested.
- 4) Run the experiment and record results.

While much of this seems common sense, often there are real world barriers to neatly following each of these steps. For example, bronze sheet of the suitable thickness wasn't available during the time of the original Coles (1962) experiment, and with several tree clearing experiments using axes, the experimenters ran out of time or resources, didn't

have access to a set of trees with a consistent girth, or timing devices failed and time had to be estimated at some points rather than accurately measured (Matthieu and Meyer 1997:335).

There is also an ongoing debate regarding the appropriate means of being objective. Some tests which can be employed rely more upon motion sensors and devices which measure force of impact, while others emphasize simply reproducing the likely tasks (a favorite demonstration of the utility of swords by re-enactors is slicing up meat carcasses). Some tests advocated for the cutting capacity of bronze edged weapons involve a robotic device which strikes objects at a set velocity (Malloy 2004). While both tests seem to have their uses, many of the questions being posed can be best answered by tests duplicating close to authentic conditions, and so mechanically objective tests using sensors, robotic arms, and the like are not quite necessary in this context.

The tests utilized by Malloy (2004) and Coles (1962; 1973) both involve “authentic” use conditions. Replica bronze weapons and replica bronze shields, produced by modern smiths working with simulated prehistoric technology are employed by both, and in both cases human beings strike the shields with the replica bronze weapons, attempting to cause damage. The shield is assessed after a set number of strikes or period of time of strikes to check its condition, photographed, and then it is struck more until an overall assessment of its capacity to endure damage can be reached. An exact numerical assessment (ie. A leather shield can take on average 15 blows” is not sought after – instead, a more general impression of whether or not a shield could “hold up in combat” is the goal of such studies.

Coles describes the process of preparing both a water-hardened leather shield and a beaten metal shield in detail, though one detail makes the test suspect: “The copies were made of copper sheet, as bronze sheet was unobtainable at the time” (Coles 1973:146). The copper shield was beaten around the boss and ribs to help increase the hardness, which “approached that of the genuine articles” with a Vickers Pyramid hardness of 88-92 for the copies, compared to a original shield of hardness 93 (no wider range of original hardnesses is given). The leather shield was a replica of one found in an Irish bog, and its replication is recounted in detail by Coles (1973:145-146). The shield was essentially soaked in cold water, held in a mold by “wooden round-ended punches” then a few examples were treated with either wax or hard water. The shield treated with wax was less flexible, although both shields proved water resistant.

The actual test of the materials is described in less detail, although the findings certainly don’t allow for a long-winded account. The first strike with a bronze spear punctured the “bronze” (read: copper) shield and a bronze sword cut the shield “almost in two,” as compared with the leather shield chosen for the experiment – which was barely even perforated by the thrust from the spear and withstood 15 blows with only slight damage (Coles 1973:147).

There are a number of problems with Coles’ methodology, besides the obvious use of a copper shield in place of a bronze shield. First, in setting up the experiment, no analogies are made with thicknesses of armor used in different periods of metal, such as iron or steel, so the description of the shields as thin is only by comparison with organic materials. Second, despite a range of thickness in metal shields, only one thickness (3 mm) is subjected to the test. Third, the leather shield was chosen from a variety of preparation methods, whereas the metal shield was selected from only a single

preparation method. These factors, along with the fact that the shield was copper rather than bronze, should have made Coles' effort an exploratory one, to be followed up on by the application of a more rigorous methodology. Instead, for around forty years it has stood as holy writ in Bronze Age studies, and reported on with free license, such as when Harding refutes the idea that Bronze armor appeared to negate advances in weaponry with: "experiments have demonstrated unequivocally that sheet-bronze shields are significantly less useful than leather or wooden examples" (1999:287) later falsely referring to the Coles experiment as making use of "beaten sheet-bronze shield" (*ibid*, 287) rather than a copper shield.

Barry Malloy (2004) performs a similar test to Coles, but comes to a radically different conclusion. In his test he compares the capacity of three different shields – one bronze with 10% tin content and a thickness of 1.5 mm, one sheet copper of a .9 mm thickness backed with leather, and one only of leather in their abilities to withstand blows. He justifies the backing of the copper shield with leather by comparison with the Lough Gur shield, which Coles dismissed as misidentified by antiquarians, but Malloy finds this dismissal suspect. Each of the items used was custom made for Malloy by Bronze Age Foundries. The swords used to strike the shields belong to the Irish Type IVA classification and were also purchased by Malloy from Bronze Age Foundries (2004).

The copper shield backed with leather held up well, though it bent at the rim. Malloy cautions that deliberate strikes against the rim, rather than glancing blows forced off line are not the best predictor of an exact number of strikes a shield could bear as shields are used in a more "live" fashion. The boss caved in slightly after repeated sword blows, but spear points were unable to pierce through the copper into the leather. Finally,

a javelin thrown into the shield resulted in the blade of the javelin entering the shield, but only up to the socket, so that no significant damage would have been inflicted on the user. Malloy found the leather shield to be as effective as Cole had found it, though after forty strikes it became seriously bent and there would have been a danger of the blade still coming into contact with the user, despite a successful block. It was also penetrated partially, but not entirely by a javelin throw (Malloy 2004:32-33).

The bronze shield was the major source of deviation from Coles' experiment as Malloy found it to hold up the best of the three shields tested. It received only the slightest nicks from being beaten by a bronze sword, except in the area of the boss which again sustained minor damage, the spear thrust glanced off the surface, and both javelin and spear throws bounced off (though Malloy does caution that a more experienced or stronger thrower may come across different results). Malloy's conclusion is that bronze shields were quite functional, although some thin non-functional examples do exist. He contends that the thin examples are votive versions of the functional shields, rather than only elaborate duplicates of leather or wood shields (Malloy 2003:33-34).

Kristiansen (2002) provides a less rigorous but still worthwhile examination of the functional capacities of bronze swords in the first half of an article that examines the social context of swords in the Bronze Age. The initial portion of his examination is focused on debunking the myth that bronze swords were not practical to use due to awkward hilt size or weights. He argues that the size of the hilt caters to a different grip that was better for controlling for the center of gravity which was more distal in bronze swords than in those of iron or steel (2002:320). While he makes the inaccurate claim that bronze swords are heavier than historical rapiers, despite the fact that most bronze swords weigh in between 600 and 800 grams (Grancsay 1949) and most rapiers were

over 1200 grams (Oakeshott 1960), he does argue successfully that different gripping styles suited bronze swords better and shows that when gripped in the way he advocates, they cant inwards, much as modern fencing weapons.



Fig. 1 – Proper grip of bronze sword, after Kristiansen (2002)

Kristiansen then gives a cursory overview of the sort of scars bronze swords accumulate through their use – predominantly consisting of nicks on the lower third of the blade (called the strong or forte of the blade in historical and present day fencing literature, due to it being the area of the sword most leverage can be applied to) which occurs when a sword parries blows, and damage to the tip leading to regular re-sharpening, due to the tip being deflected by shields or armor. He provides examples of swords which have undergone extensive resharping, including a close up of fresh edge scars in a sword occurring in a hoard deposit. After discussing other forms of damage that can occur to swords, including hilts being knocked loose from their rivets, he demonstrates that typological shifts in swords from the early to middle and finally to late Bronze Age demonstrate an active effort of sword manufacturers to guard against these problems.

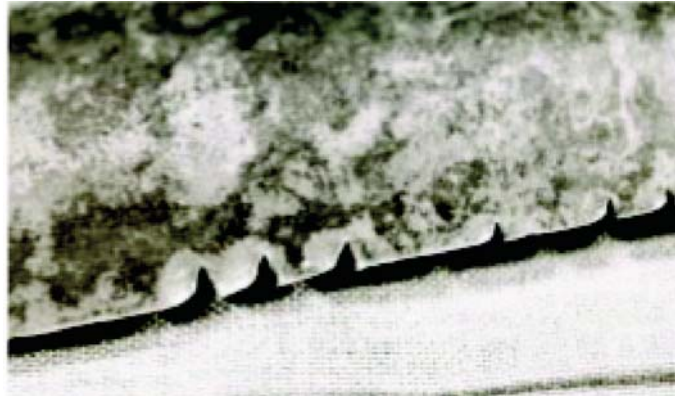


Fig. 2, notches in edge of bronze sword occurring due to perpendicular strikes, after Kristiansen (2002).

With his discussion of armor, rather than refuting Coles, Kristiansen relies on evidence for leather padding or support for bronze armor and evidence that several Bronze helmets had sustained blows. He also adds that swords are unique as weapons in that they have a larger potential for defensive use than axes or spears, and discusses the role of the warrior's skill in protecting himself, adding that wooden replicas (also called "wasters") were present during the Bronze Age (Stevenson 1960; after Kristiansen 2002). If we accept the results of Malloy's (2004) test, it seems that the evidence for padding is probably more comparable to historic gambesons – padded or quilted garments which were worn under mail or plate armor in the medieval period to absorb some of the mechanical shock of blows, but which could also be worn as a form of armor by those lacking the wealth for better protection – rather than the actual armor worn under a useless bronze outer layer which simply signified rank.

Tests utilizing authentic conditions such as these are beneficial in that they produce usewear marks which can be analyzed. Roberts and Ottaway's (2003) study, for example, takes advantage of this feature for socketed axes in Ireland. There is a large literature on standards of use wear analysis for lithics, but this is not the case for metal artifacts, and Roberts and Ottaway adapt usewear techniques to archaeometallurgical

cases (2003:120). Much of this is comparable to the sort of experimental work done with bone and chert by Semenov (1976) in that the items are used for a set amount of time and then examined microscopically for striations, nicks and scratches, and other signs of use. Roberts and Ottaway test the socketed axes against wood and metal targets to differentiate between different forms of use before comparing these results with a set of socketed axes from a museum, with the end aim being to group axes from the museum into those used for cutting wood or combat based on their use wear (Roberts and Ottaway 2003:120).

While casts have been used previously in analyzing samples, Roberts' and Ottaway's comparison is also quite methodical. Each axe was examined under a variable light source at 10 x magnification, measured, weighed, photographed, and drawn to scale. A system of marks was created to indicate each type of sign of use that might occur – nicks, cuts, etc (Roberts and Ottaway 2003:121). Axes were excluded if post-depositional corrosion was too significant, or if the porosity was higher, or if there was any reason to believe that taking an impression of the axe would cause damage to the artifact. After the exclusions, dental impression material was used to make a cast of each axe (Roberts and Ottaway 2003:122). The same nicks, etc. located by the initial photographs were then indicated on the casts. Much of the impression process will not necessarily need to be repeated in future studies, however, as Roberts and Ottaway found that advances in digital photography have made high resolution photos much more effective than impressions when dealing with actual artifact usewear (Roberts and Ottaway 2003:123).

Roberts and Ottaway's (2003) work is largely based on preliminary examinations by Kienlen (1995) and Bridgford (2000) in their unpublished masters and doctoral work. Prior to their own experimental evaluation they compare these earlier findings to the axes

in their reference collection but find some scratches and marks difficult to identify. The major complication they describe as the possibility that axes were used for more than one function, and that opportunistic forms of use might result in usewear patterns not discernible by comparison with repeated single-use experimental studies (2003:123). This is a problem common to all experimental studies, and not just those concerned with metal objects, and as it is rather difficult to control for it, objects which cannot be identified as single-use are often excluded from such studies.

Figure 5. The wear traces produced by the experimental befted axe cutting the wood after 15 minutes

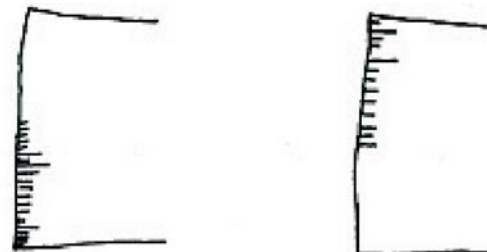


Figure 6. The wear traces produced by the experimental befted axe cutting the wood after 50 minutes

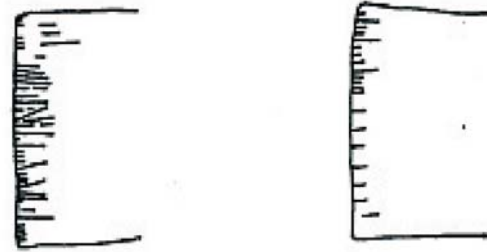


Figure 7. The wear traces produced by the experimental befted axe cutting the wood after 120 minutes

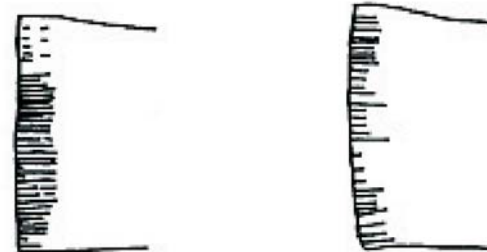


Figure 8. The wear traces produced by the experimental befted axe cutting the wood after 240 minutes



Fig. 3 – Usewear marks sketched out by Roberts and Ottaway (2003)

With each step of the reconstruction of the bronze axes, Roberts and Ottaway give a large amount of attention to the accuracy of particular methods and choices. They discuss the use of ash for the hilt (and contrast it with the possibility of using oak), referring to known archaeological examples, and after bronze axe heads were cast they examined them for traces of seams or other marks of manufacture (2003:125). A coppiced hazel tree was cut for four hours by one of the softer axe heads without much difficulty (the axe only needed slight resharping in the last hour). One axe blade was used for debarking another section of tree but this produced no noticeable characteristic usewear. The wear on the axe used in coppicing was sketched out and compared with the collection, along with comparison made previously by Bridgford (2000) for striking against metal, and while some axes were capable of now being sorted into having been used for woodwork and striking metal, a reasonable majority still remained in the “variable light use” and “variable heavy use” categories. While their article sets a high standard for rigor in experimental methodology, it is only an initial exploratory step, and they discuss the need for usewear studies to expand beyond the small group currently engaged, the majority of which are students at Sheffield College in England.

Bridgford’s (1997) analysis of bronze swords in Ireland differs by applying usewear and functional analysis to a large set of unprovenanced swords of Irish types in Dublin and Oxford (1997:95-96). Despite the variable treatments of swords in museums (she describes that “some were, it would seem, used in anger quite recently” [1997:96]), she was able to examine a set which also had samples removed for archaeometallurgical analysis and was able to confirm that 10% Sn (tin) content was the median value for the sample. This alloy represents an ideal hardness and its presence as the median values implies that smithing efforts sought to produce this alloy with some consistency.

By comparing the mean distance from the center of gravity to the widest part of the blade, she determines that the swords were weighted as cutting blades (method of analysis after Oakeshott [1960]). She also compares the turning moment (weight x distance from center of gravity) for the blades in an effort to create an objective standard for quality of weight and compares this with her subjective assessment of the blades' weight. The grip she uses follows Oakeshott (1960) as well, and is similar, though not perfectly identical to that described by Kristiansen above. After using this grip she determined that none of the swords examined felt awkward (Bridgford 1997:104-105).

The next part of her examination concerned marks of use. As with previous authors, she notes the presence of "torn rivet holes" which were mainly typical of Class 1 swords yet "continued to appear in the butt wings of other classes" (Bridgford 1997:106). Tangs were a weak point, likely to break, as were blade tips, as well as the narrow section above the leafing portion of blades with wider cutting edges, despite the mid rib having been constructed thicker, probably for the purpose of preventing breakage in the region (Bridgford 1997:106). Looking for edge notching, characteristic of use in cutting and parrying, she determined that 90% of the blades in her sample had sustained damage of this type. She also noticed that notches on Class 5 swords were smaller, due to superior casting.

There are common threads throughout all the studies and a cohesive methodology can be developed from these commonalities. It is difficult to apply scientific rigor to the subject of how awkward or natural it felt to wield a bronze sword, but Harding's impressionistic assessment is clearly inadequate when compared with Bridgford's (1997) and Kristiansen's (2002) studies which identify both why bronze swords seem inadequate to those in Harding's camp and how changing the grip corrects for this. Kristiansen's

examination would probably benefit from the addition of indices of weight distribution and the location of the center of gravity, such as those Bridgford employs, to further solidify his analysis. The fact that Malloy's (2004) analysis of bronze shields differs from Coles (1962; 1973) is easily traced to the difference in materials employed in the studies, and Malloy's comparable results with the leather shield form an anchor for comparison. The emphasis Roberts and Ottaway place on digital photography may allow for the standardization of forms of photographs, such as those from Kristiansen (2002), which will allow for more discourse and comparison and for the field of experimental archaeometallurgy to expand.

Conclusions

Despite the eclectic nature of experimental and functional analysis of bronze arms, it is clear that employing a rigorous methodology is capable of producing worthwhile results, even if the results are in difficult to quantify categories, such as how useful an item may have been in combat. An examination of the literature, and how far it runs askew in its reliance upon Coles and Harding's interpretations of bronze items demonstrates clearly that such studies are needed if we hope to meaningfully describe the bronze age as a real past and understand the contexts of and significance of its conflicts. Very likely, results found concerning the functional capacity of weapons and armor is likely to extend into our understanding of their significance on stelae and other representations (e.g. Harrison 2004).

The situation will only be able to improve if scholars offer more of a willingness to include archaeometallurgical usewear research in their efforts to understand prehistory. Much of it is undertaken presently without significant grant support, and by younger

scholars working in relative isolation. Most of the 'big picture' work being done on the Bronze Age relies more heavily on outdated experimental studies or impressionistic evaluations of weaponry than it does on recent excavations in constructing an overall synthesis, yet a comprehensive update of these earlier findings has not been financially supported, even though it could be carried out for less than 5% of the cost of a full scale three stage field project. It can only be hoped that as newer research brings older assumptions into contention, significant effort and research support will be applied towards solving these problems.

Works Cited

- Benton, Sylvia. 1931. An Unlucky Sword: The Leaf-Shaped Blade from Mycenae. *Man*, Vol. 31 (Jul., 1931):127-128.
- Bradley, Richard. 1990. *The Passage of Arms*. Cambridge: Cambridge University Press.
- Bridgford, Sue D. 1997. Mightier than the Pen? (an Edgewise Look at Irish Bronze Age Swords) in *Material Harm: Archaeological Studies of War and Violence*, edited by John Carman. 95-115. Glasgow: Cruithne Press.
- Bridgford, Sue D. 2000. Weapons, warfare, and society in Britain 1250-750 BC. Unpublished PhD Dissertation: Sheffield University.
- Carman, John, (ed.). 1997. *Material Harm: Archaeological Studies of War and Violence*. Glasgow: Cruithne Press.
- Carman, John and A. F. Harding (ed.). 1999. *Ancient Warfare: Archaeological Perspectives*. Gloucestershire: Sutton Publishing.
- Coles, John M. 1962. European Bronze Age shields, *Proceedings of the Prehistoric Society* 28:50-98.
- Coles, John M. 1973. *Archaeology by Experiment*. London: Hutchinson University Library.
- Coles, John M. and A. F. Harding. 1979. *The Bronze Age in Europe: An Introduction to the Prehistory of Europe c. 2000-700 B. C.* London: Thames and Hudson.
- Demakopoulous, K. (ed.). 1999. *Gods and Heroes of the European Bronze Age*. London: Thames and Hudson.
- Drews, Robert. 1994. *The End of the Bronze Age: Changes in Warfare and the Catastrophe*. Princeton: Princeton University Press.
- Grancsay, Stephen V. 1949. Irish Bronze Age Weapons. *The Metropolitan Museum of Art Bulletin*, New Series, 7(7):181-185.
- Guillane, Jean and Jean Zammit. 2001. *The Origins of War: Violence in Prehistory*. London: Blackwell.
- Hancock, R.G.V., L.A. Pavlish, R.M. Farquhar, R. Salloum, W.A. Fox, G. C. Wilson.

1991. Distinguishing European trade copper and northeastern North American native copper. *Archaeometry* **33**, 69-86.
- Harding, A. F. 1999. Warfare: a Defining Characteristic of Bronze Age Europe? In *Ancient Warfare: Archaeological Perspectives* edited by John Carman and Anthony F. Harding, 157-17. Gloucestershire: Sutton Publishing.
- Harding, A. F. 2000. *European Societies in the Bronze Age*. Cambridge: Cambridge University Press.
- Harrison, Richard. 2004. *Symbols and Warriors: Images of the European Bronze Age*. Bristol: Western Academic and Specialist Press, Ltd.
- Keeley, Lawrence. 1996. *War Before Civilization*. Oxford: Oxford University Press.
- Keinlen, Tobias. 1995. Flanged axes of the North-Alpine region: an assessment of the possibilities of usewear analysis on metal artifacts. Unpublished MSc dissertation, Sheffield University.
- Kristiansen, Kristian. 1998. The Emergence of Warrior Aristocracies in Later European Prehistory and their Long-Term History. In *Ancient Warfare: Archaeological Perspectives*. Edited by John Carman and Anthony F. Harding, 157-173. Gloucestershire: Sutton Publishing.
- Kristiansen, Kristian. 2002. The Tale of the Sword: Swords and Sword-fighters in Bronze Age Europe. *Oxford Journal of Archaeology* 21(4):319-332
- LeBlanc, Steven A. 2003. *Constant Battles: The Myth of the Noble, Peaceful Savage*. New York: St. Martin's Press.
- MacAdam, R. 1860. Ancient Irish Trumpets. *Ulster Journal of Archaeology* 8:99-110.
- Malloy, Barry. 2004. Experimental Combat with Bronze Age Weapons. *Archaeology Ireland* 18(1):32-34.
- Martin, Debra L. and David W. Frayer, (eds.). 1997. *Troubled Times, Violence and Warfare in the Past*. London: Gordon and Breach Publishers.
- Matthieu, James R. and Daniel Meyer. 1997. Comparing Axe Heads of Stone, Bronze, and Steel: Studies in Experimental Archaeology. *Journal of Field Archaeology* 24(3):333-351.
- Moedlinger, Marianne. 2006. Natural History Museum in Vienna, Personal Communication.
- Oakeshott, Ewart. 1960. *The Archaeology of Weapons*. London: Lutterworth.
- Odell, George H. and Frank Cowan. 1986. Experiments with Spears and Arrows on

- Animal Targets. *Journal of Field Archaeology* 13(2):195-212.
- Osgood, Richard and Sarah Monks. 2001 *Bronze Age Warfare*. Gloucestershire: Sutton.
- Otterbein, Keith. 2004. *How War Began*. College Station: Texas A&M University Press.
- Otto, Ton, Henrik Thrane, and Helle Vandkilde (eds.). 2006. *Warfare and Society: Anthropological and Archaeological Perspectives*. Aarhus: UP.
- Randsborg, Klavs. 1999. Into the Iron Age. In *Ancient Warfare: Archaeological Perspectives*. Edited by John Carman and Anthony F. Harding, 190-202. Gloucestershire: Sutton Publishing.
- Rice, Glenn and Steven A LeBlanc (eds.). 2001. *Deadly Landscapes: Case Studies in Prehistoric Southwestern Warfare*. Salt Lake City: University of Utah Press.
- Roberts, Ben and Barbara Ottaway. 2003. The Use and Significance of Socketed Axes during the Late Bronze Age. *European Journal of Archaeology* 6(2):119-140
- Peets, Orville H. 1960. Experiments in the Use of Atlatl Weights. *American Antiquity*, 26(1):108-110.
- Semenov, S. A. 1964. *Prehistoric Technology*, first edition, Monroe Township: Barnes & Noble.
- Semenov, S. A. 1976. *Prehistoric Technology*, second edition, Monroe Township: Barnes & Noble.
- Smith, G. V. 1893. The use of flint blades to work pine wood, *Annual Reports of the Smithsonian Institute*. 1891:601-605.
- Spoto, Giuseppe. 2003. Chemical Methods in Archaeology. In *Kirk-Otmer Encyclopedia of Chemical Technology*. Hoboken: John Wiley & Sons, Inc.
- Tylecote, R. F. 1987. *The Early History of Metallurgy in Europe*. New York: Longman.

Additional Figures (after Demakapoulous, K. ed. et al. 1999)



Crested Helmet, Blainville-la-Grande, Meurthe-et-Moselle, France, Late Bronze Age, 12th–9th centuries BC
(Cat. No. 153) (Demakapoulos 1999:94)



Shield, Sorup, Eskilstrup, Maribo, Denmark. Late Bronze Age. 11th-10th centuries BC (Cat. No. 149)

(Demakapoulos 1999:97).



Armor, Petit Marais, Marmesse, Haute Marne, France. Late Bronze Age, 9th-8th centuries BC

(Demakapoulous 1999:91)