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There's Method in the Fragments: A Damage Ranking System for Bronze Age Metalwork

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Broken and damaged Bronze Age metalwork has long been studied, but there is no methodology for identifying signs of intentional versus *unintentional action. Past approaches have tended to rely on assumptions about how such finds were damaged. Drawing on the material properties of copper alloys, as well as on recent research into wear-analysis and experimental fragmentation of bronze implements, this article presents a working methodology for identifying deliberate damage. Seven 'Destruction Indicators' are presented, with associated criteria, for making informed interpretations about archaeological artefacts. These contribute to a 'Damage Ranking System', an index for ranking damage on Bronze Age copper alloy objects based on the likelihood that damage was intentional. Two case studies illustrate how this system can be applied.*

Keywords: Bronze Age, damage, destruction, fragmentation, metalwork

Introduction

The deliberate destruction and deposition of Bronze Age metalwork is a well-recognized phenomenon, often interpreted according to ritual or utilitarian theories. Yet, to date, no comprehensive methodology has been developed for assessing and interpreting the cause of this damage, with researchers generally relying on obvious features, such as excessive bending or extreme fragmentation. But when can a bent sword be considered 'deliberately bent'? How can we distinguish an intentionally fragmented axehead from one broken through use? The proliferation of newly-discovered broken and damaged metalwork in excavations and metal-detecting activities across Europe makes it increasingly necessary to determine accurately whether damage on metalwork was the result of deliberate prehistoric agency if we are to interpret this material with confidence.

By considering the material properties of prehistoric copper alloys in combination with recent experimental research, I propose in this article a methodology for a systematic approach to interpreting damage on Bronze Age metalwork, focusing predominantly on British copper alloy objects. Key indicators of intent observed on metalwork are categorized, followed by a set of criteria from which one might consider damage to have been caused by human action. This leads to a simple, coded index, a Damage Ranking System (hereafter DRS) underpinned by an informed rationale. Since studying damage is inherently subjective, it is impossible to achieve total objectivity. However, I conclude this paper by presenting two case

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studies that exemplify how the DRS can be applied in practice and what potential it offers.

Here, the terms 'destruction' and 'decommission' (and their variations) refer to rendering an artefact unusable, based on its presumed function, e.g. a sword as a thrusting or slashing weapon or an axehead as a chopping implement. Damage may be intentional, unintentional, or a combination of the two, which may in turn change its function (e.g. a broken sword may become raw material for recycling). However, the purpose of the framework presented here is not to interpret intentional damage as 'ritual' or 'utilitarian'. Intentional damage can be both; what is important is to first assess whether what is being interpreted shows signs of intent.

Classifying Damage

In her study of Bronze Age metalwork from the River Thames, York (2002: 80) considered deliberate destruction 'probable' when an artefact had been:

- 'chopped across at right angles to its length once or more';
- 'struck and crushed in a manner inconsistent with its primary use';
- 'bent to breaking point (always a sword)';
- 'burnt and maybe twisted, distorted and fused to other objects'.

This broad method of identification characterizes the approach often taken, focusing on 'obvious' features of damage. Nebelsick (2000), for instance, presents numerous case studies of Late Bronze Age hoards from Central Europe selected for the exaggerated nature of the damage. Likewise, objects considered intentionally damaged include crushed and/or plugged socketed axeheads in hoards from Britain (Turner, 2010; Dietrich & Mörtz, 2019), as well as numerous bent, burnt, broken, and/or notched swords from different contexts across Britain, Ireland, and France (Bridgford, 2000; Quilliec, 2008). In his recent analysis of the Late Bronze Age hoard from Oltárc Márki Hill in Hungary, Tarbay (2017) goes further in separating ancient from modern damage and accidental/use-related from deliberate damage to identify what represented a true prehistoric manipulation and what was caused by other processes. A thorough set of criteria is, however, not presented in any of the examples cited above.

Patterns of damage on similar objects have often been used as a way of identifying intent, including the presence of different parts of weapons and tools in hoards across Europe (Bradley, 2005: 151–55; Čivilytė, 2009) or the careful fragmentation of Late Bronze Age gold bracelets in Britain and Iberia (Gwilt et al., 2005; Perea, 2008). Alternatively, patterns of damage have been used to identify changes in practice over time. In his study of Late Bronze Age hoards in the Carpathian Basin, Rezi (2011) recorded fragmentation on different object types. Although this study relied on fragmentation rather than other forms of damage, it allowed Rezi to identify an increase in the extent of damage sustained on objects in hoards from 'Bronzezeit D' (*c.* 1325–1200 BC) to Hallstatt A1 (*c.* 1200–1125 BC). Rezi used this data-led approach to assess whether sacred or profane interpretations for fragmentation were applicable on a wide scale to hoards in his study region; he concluded that, while some breakage may have been linked to a pre-monetary function, not all hoards nor even every object within a hoard indicated that this was the sole reason for the fragmentation and deposition of objects. Thus, we can begin to see the advantages of developing a methodology for identifying deliberate damage.

While obvious indicators of damage are no doubt important, what of evidence that is initially inconclusive? It is reasonable to consider bent and broken weapons in a hoard to be the result of intentional action, but this is less clear when an isolated fragment of an axehead is found. Moreover, studies focused on the deliberate damage of metal objects rarely draw upon wear-analysis that could indicate how different types of damage were sustained (though see Horn & Karck, 2019). A more cohesive approach is, therefore, desirable, as well as a system of identification and classification building on past studies.

Destruction Indicators

To develop a methodology for identifying intentional damage, we must first assess what might be reasonably considered an indicator of deliberate damage or destruction, hereafter a Destruction Indicator (DI) (Table 1). Seven DIs are proposed, encompassing the most common forms of deliberate damage observed on metalwork. Qualifying criteria are discussed and suggested, but should be considered indicative rather than absolute, and based on our present understandings as informed by material science and wear-analysis. Consequently, aspects of material science, use-related damage and post-depositional effects are inherent to the discussion but they have yet to be widely considered for deliberately damaged metalwork. Importantly, the criteria are starting points that may be subject to revision in the future. Although each listed DI may have been the result of intent, the potential for several indicators having been caused by use or accident must also be considered. Research into these aspects is presented below to determine the criteria for quantifying damage. An awareness of the contexts in which the objects were found, as well as associated objects and damage that can strengthen or weaken the determination of intent, is clearly important for all DIs. Nevertheless, the criteria laid out are designed to be used even when no further information is available. Linked to this is the initial assessment of whether damage is ancient or not. A simple method for identifying ancient damage consists of assessing the consistency between the corrosion of the object and the corrosion of the damage sustained (York, 2002: 79; Roberts & Ottaway, 2003; Horn & von Holstein, 2017). There are caveats to this method, as corrosion can form quickly post-recovery and obscure differences in the age of damage. Nonetheless, assessing the consistency of corrosion remains one of the best ways of ascertaining the antiquity of damage, especially when combined with knowledge of post-depositional processes and post-recovery history.

Table 1. *Destruction Indicators observed on copper alloy objects.*

Destruction Indicator	Description
Bending/folding	Transverse plastic deformation from the expected trajectory of an object
Twisting/torsion	Lateral plastic deformation along the longitudinal axis
Crushing	Compression of an object
Notching	Plastic deformation of an edge or surface resulting in an indentation
Breakage	Separation of two or more pieces of an object
Burning	Exposure of an object to high temperatures
Plugged sockets	Filling of a socket with other objects

DI 1: Bending and folding

Bending refers to transverse plastic deformation of an object from the expected trajectory (e.g. a sword that is no longer straight). Folding, an extreme form of bending, refers to plastic deformation resulting in an object being bent to about 180°; it is considered a deliberate act. Objects bent less than this require greater consideration to determine whether the observed damage was intentional. Four aspects should be considered in this assessment: composition, object thickness, angle of bend, and position of the bend. Here, I mainly concentrate on swords and spearheads as the artefacts most commonly found bent but also consider factors relevant to all object types.

Composition

British Bronze Age copper alloys typically consist of copper alloyed with up to ten to twelve per cent tin, and by the later Bronze Age lead is also added (Brown & Blin-Stoyle, 1959). The quantity of tin and lead alloyed with copper will affect the plasticity of the resulting object. For instance, the tensile strength of a tin-copper alloy (i.e. the maximum stress an object can withstand before breaking) will increase until around thirteen per cent, at which point the higher levels of tin will result in a more brittle material, indicating why certain alloy percentages were favoured (Scott, 2012: fig. 9.4; Knight, 2019: 252). The inclusion of lead (particularly over 5 per cent) will increase the plasticity and ductility of the copper alloy, allowing greater plastic deformation. Quantifying the effects of composition is difficult as other factors play a part, but one should be aware and use this information where possible.

Thickness

The thicker an object is, the more force is required to bend or fold it and hence it becomes less likely that plastic deformation might occur accidentally. An experiment trying to bend and break a tin-bronze dagger (containing 10 per cent tin) confirmed that a 3 mm-thick tip could be bent when struck with a granite hammerstone, whereas, at 9 mm thick, the hilt only suffered surface damage and limited plastic deformation (Knight, 2018: Appendix C). Furthermore, a study of bent metalwork with associated damage indicating human action (e.g. hammer blows) found that most objects were less than 5 mm thick (Knight, 2018). Similarly, Moyler's (2007: 144–49) attempts to break a replica Early Bronze Age flat axehead with steel tools caused bending and associated cracking, but no breakage. Moyler does not give the thickness of this replica, but it can be compared to bent archaeological examples (see below). Of course, archaeological examples of thick, bent objects are known, for example the large Middle Bronze Age dirk from East Rudham (Norfolk), which must have been twisted and bent while heated, probably by a skilled metalworker with appropriate tools and material knowledge (Wilkin, 2016). Attempts to deliberately bend replica swords without breaking them came to similar conclusions for the Italian Late Bronze Age (Bietti Sestieri et al., 2013: 167–9) and the British Late Bronze Age (Knight, 2019). Therefore, we can suggest that extreme force and/or specific skills would have been needed to bend thicker objects; by extension it is less likely they would have bent by accident.

Conversely, thinner objects are more prone to plastic deformation, which is supported by recent use experiments. The thin tip of a replica Middle Bronze Age dirk bent when struck against synthetic skeletal tissues (Faulkner-Jones, 2016: 3–4), and combat experiments involving replica swords (Crellin et al., 2018: 295; Gentile & van Gijn, 2019) have repeatedly caused some bending of the weapons, although not to the extent of destruction experiments. Such damage need not decommission an object as the blade can be quickly and easily straightened (Knight, 2019: 259). Slighter objects, including tools and ornaments, might similarly bend through accident. Bent awls, knives, pins, and razors are often encountered; given their thinness and the inherent use exerting pressure on the tips, it is hard to determine when damage was deliberate rather than the result of accident or post-depositional processes.

Here, I suggest that bent objects showing no associated signs of damage (e.g. tool marks) but which are thicker than 7.5 mm at the point of the bend could be the result of intentional human action. This figure offers a starting point for categorizing damage and for eliminating the possibility that bending occurred accidentally; further research and experimentation are required to refine this figure. One must also be aware of modern processes, such as dredging or ploughing, both of which could strike and bend bronze objects.

Angle of bend

The angle to which an object is bent is another important indicator of intent. The combat experiments cited earlier indicate that swords might bend up to 20° through use (Gentile & van Gijn, 2019; Knight, 2019: fig. 8), offering a starting point for quantifying bending on archaeological blades. In my own experiments, swords did not bend further than approximately 10°, and an analysis of swords from south-western England found that those displaying bending greater than *c.* 15° were also broken (Knight, 2018: 160, 2019: table 2). Similarly, Anderson (2012: 104–5) notes that deliberately decommissioned weapons from northern Britain were bent more than 50°, while those bent through post-depositional activity were rarely bent more than 30°. The angle of bending caused through use is consequently unlikely to be extreme; it is proposed here that any sword with a transverse bend of 30° or more could be considered intentional damage. This does not exclude bladed objects bent to less than 30° from being intentionally bent, but additional damage is necessary to conclusively surmise intent.

Determining an angle of bend for objects other than swords is problematic as there have been fewer experiments and no data recorded. Such information would be most useful for spearheads, which often present bent tips and, for earlier forms, bent tangs (see examples in Davis, 2012, 2015). Christian Horn (2013: 13; Horn & Karck, 2019) suggests that spearheads, like swords, might bend from force exerted on the tip. This may occur if the spear was thrust or used for stabbing, but the action failed or was deflected (Bridgford, 2000: 145). However, Anderson (2011: 604) found that replica spearhead tips did not bend when thrown or thrust. It is, thus, unclear whether a spearhead might bend through use.

Deliberate hammering of a spearhead tip caused bending, as well as crushing of the socket, and eventually material failure (Knight, 2019: 262), indicating that intentional bending may be associated with other forms of damage. In lieu of any quantifiable tests, it is proposed here that the deliberate bending of a socketed spearhead is indicated by an angle of 30° or more. For thinner, tanged spearheads, 45° is taken as an indicator of intent. Where the tip is bent, a 45° angle should be present without the tip showing additional signs of use-wear (e.g. a blunted tip). Parameters are not set here for the angle of bend on other objects.

Position

The position of the bend can be a crucial indicator of intent, especially when combined with other factors. Faulkner-Jones (2016: 3–4) noted a 90° angle of bend to the tip of her replica dirk, indicating that thinner, more fragile parts of artefacts can be susceptible to more extreme bending. In addition to the spearhead tips and tangs mentioned above, the tips, hilts, and tangs of blades and tools are further vulnerable locations. Bending occurring in one or more of these locations may lessen the certainty that such plastic deformation can be considered deliberate.

DI 2: Twisting

Twisting is the lateral plastic deformation of an object along its longitudinal axis (i.e. a rotation), often observed on hafts, hilts, and blades. Twisting may indicate intentional or accidental damage. Minimal twisting could probably have been easily rectified by a competent metalworker.

Significant twisting of blades (e.g. swords, rapiers, or daggers) puts these objects out of action. In several cases, multiple twists are present that could have only occurred intentionally and probably entailed heating the object as part of the process (e.g. Colquhoun & Burgess, 1988: no. 192). In his study of halberds, Horn (2011: 53) suggests that twisted hafting plates and blades indicate wrenching in the process of removing the handle. Twisting is, thus, likely to be associated with bending and torn rivet holes. Horn later suggested that accidental twisting could be caused 'if the weapon became stuck somewhere, for example, between bones, and it was removed by force in a twisting motion' (2013: 13). It is difficult, however, to judge the likelihood of such a scenario. I am not aware of any archaeological examples, and experiments involving replicas do not describe any twisting. Other uncertainties, not use-related, concern the extent to which a blade might suffer torsion because of heat-warping (e.g. on a pyre) or through post-depositional processes, emphasizing the need to appreciate the context of the find.

While experiments are needed to quantify a set of criteria, for now, any hilt/haft and/or blade that is twisted beyond 45° along its longitudinal axis will be considered the result of intent. The position of the twist may also indicate the likelihood of intent or accident, and one might expect the presence of other DIs. Other qualifying factors would have to be present for partial twists (less than 45°) to be classed as deliberate.

DI 3: Crushing

Crushing is the plastic deformation of an object through compression and applies primarily to socketed implements or ornaments. An object is unlikely to be crushed through use; a socketed axehead, for example, cannot be crushed if it has a wooden haft providing support to the object. Crushing an object is also related to the composition of the material. For example, leaded-bronze can have a higher malleability than tin-bronze, thus it might be more prone to compression.

Post-depositional processes (e.g. ploughing, dredging) may also cause crushing. This can often be deduced from a break in the patina and/or knowledge of the context from which the find derived. Where crushing is demonstrably prehistoric, it should be considered intentional.

DI 4: Notching

Notching refers to the material displacement and plastic deformation of metal and is commonly associated with use, particularly on edged weapons (Horn & von Holstein, 2017; Gentile & van Gijn,

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2019). However, it can represent intentional damage designed to decommission. Initial observation of this indicator should be concerned with verifying the antiquity of a notch, often indicated by the consistency of the patina, and that it has not been affected by corrosion (Roberts & Ottaway, 2003: 121; Horn & von Holstein, 2017: 94ff.). The position, distribution, and depth of notches can all indicate intentionality.

Position

Notches on a blade edge might result from combat against another weapon (e.g. Bridgford, 2000; Molloy, 2011, 2017: 288–90; O'Flaherty et al., 2011). Notching in areas that might have been covered (e.g. by a hilt) is less likely to have been combat-related and instead may be the result of deliberate action—a conclusion drawn for notching on a sword from Werkhoven in the Netherlands (Fontijn et al., 2012: 207). Anderson also highlights this, stating that even when the hilt of a replica sword was struck, chipping the wood and exposing the shoulder, 'at no point was the metal component … damaged' (2012: 95); this suggests notching the metal part of a hilt requires some intent. In the case of objects that are not prone to edge damage (e.g. small pointed tools, vessels, ornaments), the very presence of notching could indicate intent.

Distribution

Regularly spaced notching along blade edges creating a 'serrated' effect has been noted on swords, halberds, and spearheads (O'Flaherty et al., 2011: 45). Regular notching is unlikely to have resulted from use and can be taken as a potential indicator of intent. Irregularly spaced notching is harder to judge; even when multiple notches are present, it is difficult to conclude that the action was deliberately inflicted without other DIs or contributing factors to support this conclusion.

Depth

Combat experiments using swords caused notches up to 4 mm deep, which are comparable with those found on archaeological artefacts (Gentile & van Gijn, 2019: 137; Knight, 2019: 258; Gentile, pers. comm.). Likewise, experiments investigating edge damage on halberds and swords suggested that notches observed on archaeological specimens were not the result of intentional damage (O'Flaherty et al., 2011). Although the dimensions of these notches are not given, O'Flaherty et al. (2011: 43) state that the notch-depth on archaeological halberds falls between 1 and 6 mm, which suggests that experimental notches did not exceed these depths. Deeper notches from combat experiments have yet to be recorded. Therefore, as a starting point, it is suggested here that any notch deeper than 7 mm could be intentional. One must be especially wary here of the impact of corrosion when measuring the true depth of a notch.

DI 5: Breakage

Breakage refers to any material separation or loss that causes an object to fracture into two or more pieces. The parameters presented below are set to help identify an intentionally broken object rather than one broken by accident, use, or post-depositional factors, though these aspects should be considered.

Composition

As with plastic deformation, composition is a vital consideration when assessing fragmentation. Again, one should consider the presence or absence of lead in the copper alloy. Fragmentation experiments have demonstrated that, when heated and struck, lead-bronze objects break more easily than tin-bronze objects and with less plastic deformation (Knight, 2017, 2019). This is because lead is immiscible in a tin-copper mixture; so, at a micro-structural level, it creates planes of weaknesses within the alloy (Scott, 2012: 242). When heated and struck, the copper alloy breaks easily—a process known as 'hot-shorting' (Knight, 2019: 252). Conversely, tin is soluble in copper, resulting in a stronger microstructure that is more prone to plastic deformation before fracturing and requires higher temperatures to achieve the same effect. Importantly, while the presence of lead lowers the tensile strength of an object when hot, it increases this same property when cold. Unheated leaded-bronze objects are more prone to plastic deformation than breakage.

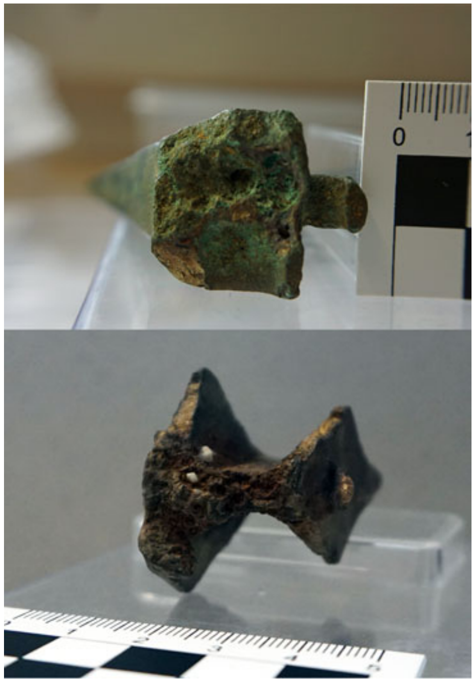

Figure 1. *Casting flaws present in the break of a palstave.* By permission of the Royal Albert Memorial Museum and Art Gallery, Exeter.

Manufacture and casting flaws

Flaws during the casting process, such as impurities in the metal or unintended inclusions (Figure 1), weaken an object. For instance, casting flaws have been highlighted in several broken flat axeheads (Moyler, 2007: 147). Consequently, any break in which macroscopic casting flaws can be observed without additional damage suggesting human agency (e.g. tool marks) cannot be automatically taken to be intentional, especially if such breaks have occurred at weak junctions in the object.

Even where tool marks are visible, working the object and other manufacturing processes may have caused fragmentation; for example, copper alloys work-harden, which can increase the brittleness and lower the tensile strength, increasing the likelihood of fracture. Here, Kuijpers' (2018) work is informative: his study of Early Bronze Age axeheads highlights the impact of the skill of a craftsperson on the resulting objects, including broken examples. He notes several axeheads likely to have 'hot-short' during working when less skilled metalworkers have struck a heated axehead (Kuijpers, 2018: 148, 181, 220–21). Such an assessment draws on compositional knowledge, as well as the general evidence of working on an object; importantly, it underlines the need to consider other aspects of the object, such as its manufacture or use, in conjunction with any damage to make a reliable interpretation.

Patterns of breakage and weak points

Here, patterns of breakage refer to the same types of object suffering similar breakages in similar places. Two possible

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explanations may account for such breakages:

(1) There was an inherent design flaw that predisposed these objects to breaking at the same point during repeated types of activity; or
(2) Objects were repeatedly broken intentionally in the same places.

Palstaves provide a possible example of the former incidence; these objects are frequently found broken at the stop ridge through the hafting plate and flanges (Figure 2). This pattern of breakage occurs at a crucial point of hafting, suggesting that during use the palstave may be prone to breaking there. Published experiments involving palstaves are limited and breakage has not been recorded (yet), so the likelihood of these objects breaking through use is currently unknown. However, the way palstaves are produced—by casting the flanges rather than hammering them—creates an inherently weak internal structure at this point that would increase the likelihood of the object breaking under stress. Therefore, although replica palstaves have not broken in use experiments, breakages should not be automatically considered to be the result of intent. Potential weak points on other objects include side-loops, rivet holes, and blade tips. Of note, the same blow that caused the replica Friarton dirk tip to bend also caused part of the wooden hilt and metal rivet hole to break (Faulkner-Jones, 2016: 3–4). At Tormarton (Gloucestershire) and Dorchester-on-Thames (Oxfordshire), broken bronze spearheads were found embedded in skeletons (Knight et al., 1972; Osgood, 2005), suggesting that earlier (and possibly later) forms of socketed spearheads may suffer material failure through use across the tip or the blade-socket junction—in this case when used as fatal weapons.

Figure 2. *Common breaking points on palstaves. Arrows indicate fracture points.* By permission of the Royal Albert Memorial Museum and Art Gallery, Exeter.

Alternatively, objects which have repeatedly broken in the same place could be the result of intentionality. For instance, the separation of a socketed axehead cutting edge from its body is unlikely to be a use-related break, yet it is repeatedly observed in the archaeological record (Figure 3). Associated damage (e.g. hammer marks) could support this interpretation, as seen on socketed axeheads. Such an assessment partly relies on the availability of experimental data alongside a suitable body of archaeological data confirming that such a pattern exists (Knight, 2017).

Multi-piece breaks

Any object broken into more than two pieces could indicate intent. Some objects may break through use, but one might expect only a single breakage. The plasticity and toughness of bronze means that, although it is possible for an object to break in half, it is less likely that a bronze artefact would fracture into several pieces

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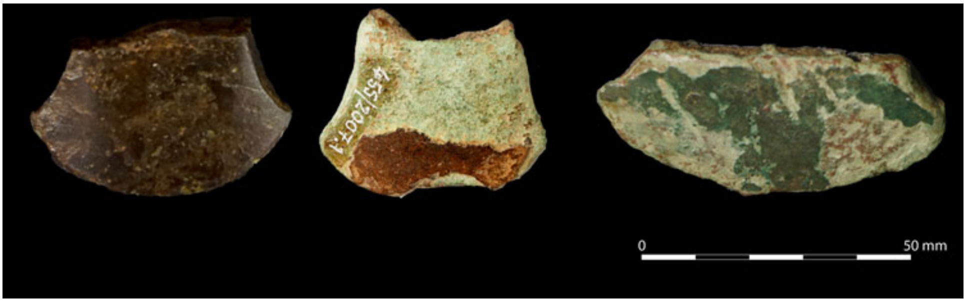

Figure 3. *Cutting edge fragments of socketed axeheads (Royal Albert Memorial Museum and Art Gallery, Exeter, acc. no. 455/2007.1, and Torquay Museum, acc. nos. A367, A368).* By permission of the Royal Albert Memorial Museum and Art Gallery, Exeter, and Torquay Museum.

through use. This has typically been considered for swords but applies to other object types.

Quilliec (2008: 70) argues that the breaking of a sword into more than two pieces cannot be accidental, especially when some swords were broken into ten pieces. Multi-piece breaks are always noted when some or all the refitting pieces are present. It is, however, often overlooked (or at least not noted) that the discovery of a mid-section of a sword blade or the body of an axehead implicitly suggests that the object was once in three or more pieces.

Some multi-piece breaks were possibly the result of post-depositional processes, which could be verified through analysis of the consistency of the corrosion. There is unfortunately no general methodology that can be applied to the study of objects broken into two or more pieces and use experiments have yet to demonstrate that this may occur through use. However, experiments deliberately breaking replica objects have produced archaeologically comparable multi-piece fragments, suggesting this is how such prehistoric fragmentation may have occurred (Knight, 2017, 2019). Knowledge of the metallurgical composition contributes to understanding the likelihood that an object may break in this fashion. It is reasonable to conclude that any object indicating a multi-piece break is the result of intentional fragmentation.

Associated marks

Marks associated with breakage are defined here as damage that can indicate the process by which an object was broken (e.g. tool marks or bending). Associated marks can confirm intentional breakage and indicate how objects were broken. Turner (1998: 36–37, 54–55), for instance, suggested that the absence of hammer marks but presence of bending associated with breaks on objects in the Grays Thurrock hoard (Essex) indicates that the pieces were probably snapped by hand. Chisel marks similarly indicate forceful blows designed to decommission an object (Figure 4).

If deliberate destruction was the work of skilled metalworkers who had a developed understanding of the material and objects (see Nebelsick, 2000; Knight, 2019: 267–69), the object may present no associated damage. Heating an object before breaking it, for instance, might only require a single strike of limited force to fracture the object, leaving no marks (Knight, 2019: 265). Alternatively, the

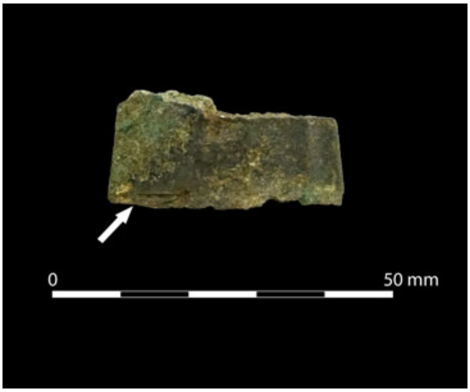

Figure 4. *A sword fragment with a chisel mark.* By permission of the Royal Institution of Cornwall.

section that was struck may be absent. Associated marks are therefore undeniably valuable when assessing intentional damage, but broken objects without marks should not be ruled out.

DI 6: Burning

Some Bronze Age metalwork has a charred appearance, even though bronze does not actually burn. Such an appearance is caused by the corrosion process and might vary across an object. The microstructure of an object might reveal whether it had been burnt prior to deposition, and examples where burning is macroscopically visible (e.g. the Late Bronze Age Duddingston Loch assemblage, Scotland) may help determine if other objects had been deliberately burnt (Bridgford, 2000: 51–52). Cremation experiments have also demonstrated that the dendritic microstructure of bronze pieces is destroyed when subjected to high temperatures (700°C) on a pyre (Marshall, 2011: 32). Further microstructural analysis is an important avenue for future investigation.

If evidence of burning can be identified, several issues become obvious. Objects may have been burnt accidentally, e.g. falling into a fire, or may have been placed on a fire, e.g. during a cremation. Alternatively, heating objects to work and anneal them is often intrinsic to the manufacturing process and affects the metallic microstructure (Kuijpers, 2018: 85–86). How might we distinguish between these processes and objects that were deliberately heated for fragmentation? This DI requires particularly careful assessment, and I would argue that isolated evidence of burning should not be interpreted as deliberate destruction. Where present, it requires additional DIs and/or contextual information to confirm intent.

DI 7: Plugged sockets

Socketed objects include axeheads, spearheads, gouges, and knifes. The decommissioning of socketed axeheads by blocking or 'plugging' the socket has been noted across Europe (Hansen, 1998; Dietrich, 2014; Dietrich & Mörtz, 2019). Sockets can be filled with fragments of other objects, sometimes of diverse materials (e.g. amber or gold), and occasionally display fracturing around the socket mouth, where the objects have been hammered in. This act requires not only putting the socketed implement out of use, but often necessitates the fragmentation of other objects to fit them inside the socket. Plugged sockets should be considered as representing intention when encountered.

Damage Ranking System

The assessment of Destruction Indicators on Bronze Age metalwork and

Table 2. *Summary of the Damage Ranking System.*

Presence of damage	Damage ranking	Description
Definitely present	0	Definitely not deliberate
	1	Probably not deliberate
	2	Probably deliberate
	3	Definitely deliberate
Uncertain	Uncertain	Uncertain damage
Definitely not present	n/a	Not applicable

quantitative criteria has been necessarily thorough to accommodate the various ways damage can occur. DIs typically occur at the end of an object's use-life, but this does not always mean that the object goes out of circulation. Accurately identifying and understanding the various DIs on objects is a crucial element for understanding the biography of an object and the interactions Bronze Age communities may have had with it. This is further informed by the depositional process, which is often another intentional action. The DIs thus offer a benchmark from which to approach damage on Bronze Age metalwork. To simplify the analysis process, a ranking system is proposed here. The Damage Ranking System (DRS) is a simple six-category index corresponding to a scale of likelihood of damage being intentional (Table 2). Some damage is object-specific, although the criteria have been presented as a set of considerations applicable to most Bronze Age copper alloy metalwork (Table 3). Significantly, the DRS is designed to rank individual forms of damage, not an object overall, because many objects display multiple unassociated forms of damage (use-related, post-depositional, deliberate, etc.). Therefore, an object may be attributed multiple rankings. Here, two case studies illustrate the practical application of the DRS proposed.

The spearhead from Sandy's Farm

Two conjoining pieces of a Middle Bronze Age socketed spearhead (Figure 5) were recovered while metal-detecting at Sandy's Farm in Devon (Knight et al., 2015: 46, no. 180). This spearhead is broken across the middle of the blade and the tip is missing (Table 4). Both side-loops are broken, and the mid-blade break has a patina consistent with the rest of the object, suggesting the break is ancient. There are no macroscopic casting flaws in the break and the break was not over a socket hollow. The conjoining break shows no apparent blow marks; but, when the pieces are refitted, there is a notch on the blade edge at the point of the break. This notch is V-shaped, 11.2 mm long and 9.2 mm deep. The corrosion of the

Figure 5. *The Sandy's Farm spearhead, Devon.* By permission of the Royal Albert Memorial Museum and Art Gallery, Exeter.

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Table 3. *Summary of criteria and considerations for applying the Damage Ranking System.*

Damage ranking	Destruction Indicator	Criteria/considerations	Object type(s)
0 Definitely not deliberate	All	Post-depositional/post-recovery processes causing damage (e.g. corrosion, ploughing, dredging, cleaning), informed by knowledge of the context/post-recovery history	All
1 Probably not deliberate	Bending	Associated with other use-wear	All
		Objects thinner than 7.5 mm	
		Up to 30° with no associated marks or breakage	Thin-bladed implements, spearheads
		Present on tools put under pressure causing material stress	Chisels, gouges, pins, possibly knives
	Twisting	Up to 45° with no associated damage	All
	Notching	Supported by research indicating use	All
		Irregular edge damage	
		Various depths (<7 mm) and/or single notches	
	Breakage	Patterns of breakage linked to use or structural weakness (e.g. side-loops, blade tips, rivet holes)	All
		Casting flaws and evidence of manufacture flaws	
2 Probably deliberate	Bending	Up to 30° with associated marks	All
	Twisting	Up to 45° with associated damage	Thin-bladed implements, tanged spearheads
	Notching	Deep notches (>7 mm)	All
		Regular, repeated notching	
		Notches in unusual positions	
	Breakage	No associated plastic deformation	All
		Associated transverse bending less than 45°	
		Patterns of breakage unlikely to be linked to use or structural weakness	
		Fragments and pieces associated with deliberately damaged material	
		Multiple broken pieces of different objects conforming to a similar size and/or weight within a single accumulation	
3 Definitely deliberate	Bending	Transverse bending over 30°	All
		Objects thicker than 7.5 mm	
	Folding		All
	Crushing	With consistent corrosion	Socketed objects
	Twisting	Present	Socketed spearheads, all axeheads, various tools (e.g. chisels)
		Over 45°	Thin-bladed implements, tanged spearheads
	Breakage	Associated plastic deformation and/or bending greater than 30°	All
		Associated tool marks	
		Multi-piece breaks (3+ pieces) except where post-depositional processes can be identified	
		Mid-section fragment indicating an object was once in 3+ pieces	
	Burning	Associated with other burnt material and/or associated DIs	All
	Plugged sockets		Socketed objects

Table 3. (*Cont.*)

Damage ranking	Destruction Indicator	Criteria/considerations	Object type(s)
Uncertain	-	Applied when objects cannot be classed within the ranking system and it would be misleading to do so. This includes: Burning evidence with no associated context or damage Damage to objects for which there are no indicators of how it may have broken (e.g. unused broken objects with no destruction indicators) Damage to objects for which there is limited understanding of how such objects were used Objects for which breakage and damage is not clear, such as those obscured by corrosion	All

notch suggests that the damage happened in antiquity and the depth of the notch suggests intent plausibly related to the breakage that might be damage-ranked 2, though there are additional considerations. The broken side-loops and missing tip are both structurally weak points, so should be damage-ranked 1. In isolation, one might come to a mixed interpretation of this object: perhaps the tip and loops broke by accident, followed by a deliberate decommissioning of the spearhead through notching and fragmentation. However, if we consider the admittedly rare examples where broken spearheads can be associated with function—namely the contemporary Middle Bronze Age spearhead from Tormarton embedded in a vertebra—we can conclude that this spearhead may have broken through use. Overall it is likely that the fragmentation across the body of the spearhead was unintentional.

A flat axehead from Abdie

In 1889, two complete Early Bronze Age flat axeheads were purchased by the (then) National Museum of Antiquities of Scotland, said to have been found in the parish of Abdie in Fife (Mitchell, 1889–90: 13). One of these axeheads is damaged (Figure 6). It is bent by some 8° in the centre of the body, and there is a fracture associated with this bend. The axehead is 10.8 mm thick at this point. Analysis of the corrosion under an optical microscope suggests that the break occurred before deposition, and earth remains in the fracture. The bend and the break are related but it is difficult to identify associated tool marks. This is due to post-recovery cleaning and small hammer marks covering the cracked face of the axehead. One tip of the cutting edge has also broken off and the cutting edge is notched and scratched. Patina preserving the original surface survives on the opposite face.

This object shows a combination of damage rankings (Table 4). Some damage, such as the scratched patina on the cracked surface, should be ranked 0, since it occurred post-recovery. Likewise, the fragmented blade tip shows fresh corrosion build-up, indicating recent material loss. The hammer marks that cover the cracked surface possibly represent prehistoric action; but it is more likely that they represent post-recovery actions, perhaps linked with cleaning, and should, thus, be damage-ranked 1 on this basis. The post-recovery damage means the cracking and bending cannot be

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Table 4. *Damage rankings for Sandy's Farm spearhead and Abdie axehead.*

Sandy's Farm spearhead		
Damage	*Ranking*	*Reason*
Broken tip and side-loops	1	Structurally weak points
Broken across the middle	1	Breakage comparable to contemporary spearheads broken through use
Notching	1	Material loss probably associated with fragmentation
Abdie axehead		
Damage	*Ranking*	*Reason*
Scratched surface	0	Damage to patina indicating cleaning
Broken blade tip	0	Fresh corrosion; weak point of axehead; cleaning of cutting edge
Hammer marks on one face	1	Covering only one surface, possibly linked to cleaning
Bending	2	8° bend; thickest part of axehead; associated with fracture; comparable with contemporary axeheads
Fracture on one face	2	Consistent corrosion; earth embedded in fracture

Figure 6. *The Abdie flat axehead, Fife.* © National Museums Scotland.

absolutely classed as deliberate damage (i.e. damage-ranked 3), but the survival of original corrosion and earth in the fracture coupled with the thickness of this piece strengthens this hypothesis. Furthermore, experimental research indicates that it is difficult to break tin-bronze flat axeheads (Moyler, 2007: 144–49), and a comparison of this axehead with other broken flat axeheads in Scotland reveals a similar pattern. Overall, the bending and breaking can be damaged-ranked 2.

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A clearer assessment and contextualization of the damage observed on this axehead allows us to approach this object from a new, informed perspective. Drawing on a range of factors, one can assess the biography of this object while clearly articulating the reasons for the assessment, something that is often missing from interpretations of such material.

Discussion

The steps illustrated in these case studies are usually quick processes of judgment, and there is inevitably flexibility within the rankings presented here. For instance, an object that has broken across a structurally weak point (Damage Ranking 1), but also displays deliberate impact marks associated with the breakage (Damage Ranking 2), might be more appropriately considered within Damage Ranking 2 than 1. A sword fragment evidencing a multi-break (Damage Ranking 3), but which has been cleaned of any patina and has a contested post-recovery history, must be considered 'Uncertain', as the post-recovery processes hinder accurate determination. There is unfortunately no overarching rule for assessing objects showing multiple forms of damage and what should take precedent. Moreover, each ranking only applies to individual forms of damage, which contributes to the overall narrative of that object, encompassing aspects of manufacture, use, post-depositional treatment, and so on. The important aspect I wish to stress is that, when making these assessments, we should follow approaches grounded in informed and ongoing research. The individual case studies show how the DRS can be applied to single finds and how this can in turn contribute to our understanding of the objects, in isolation as well as in relation to similar or associated material. By recognizing the likelihood that damage seen on metalwork is intentional, we can develop narratives that accurately portray an object's history immediately prior to deposition, without resorting to 'obvious' features. The damage on the spearhead from Sandy's Farm, for instance, is difficult to interpret without drawing on the parameters set out here. However, by recognizing that at least some of the damage may be accidental due to structural weaknesses, and drawing on parallel fragmentation of other contemporary spearheads, one can develop ideas with greater confidence about how this object became damaged in different ways and how these relate to each other. Similar analyses have been conducted on the Bronze Age sword from Werkhoven in the Netherlands (Fontijn et al., 2012) and hot-short Early Bronze Age axeheads from Central Europe (Kuijpers, 2018).

A natural progression is to apply the DRS more broadly (e.g. to a group of objects or a region), which would allow an investigation into trends of intentional or unintentional damage. While this is not presented here, a preliminary study applying the DRS to Late Bronze Age socketed axeheads from Cornwall allowed me to identify patterns in the treatment of axeheads prior to deposition; most notably twenty-three of the thirty-two axeheads studied (*c.* 72 per cent) were probably or definitely deliberately damaged (Knight, 2017: 213–18). Moreover, single finds and hoarded objects showed similarities in treatment, raising the possibility that distinguishing between the two depositional practices may not necessarily be helpful. Current shifts in theoretical perspectives are embracing both symbolic and functionalist approaches to single finds and hoards of damaged objects (Fontijn, 2019; Wiseman, 2018); the DRS offers the chance to assess the variation and diversity of damage within single groups or across wider areas to interpret trends in damage, as well as relationships between complete and incomplete objects and use-related *versus* intentional damage. This can change and strengthen how we reflect on pre-depositional processes, such as selection, accumulation, and pre-depositional treatment, and ultimately gain insights into the social role of Bronze Age metalwork.

No attempt has been made to incorporate specific parameters of quantifiable properties, such as hardness or metallurgical composition, into the DRS. This is because of the variability in these features. One can generalize that a high tin-bronze is harder than a low tin-bronze, but to set parameters around the effect this might have would require additional analysis outside the scope of this research. An appreciation of these factors is, of course, essential and should form part of the discussion wherever possible, in much the same way as context should be considered for determining the nature of the damage. However, the generality of the DRS means it has the potential to be utilized even when no scientific analysis has been undertaken or detailed context is known, such as the volume of material recovered through metal-detecting.

Overall, it should be stressed that the DRS is a working methodology, subject to alteration and refinement as new research and analyses are conducted on Bronze Age metalwork. One can envisage incorporating the use of high-powered microscopy and 3D modelling, for example, to enhance our understanding of observed damage (see Horn & Karck, 2019). The DRS offers a starting point for the classification and interpretation of damage that does not rely on assumptions about the material based from its form or presumed social role, but on knowledge of material properties, trends in the archaeological data, and integrating the increasing body of experimental archaeology involving bronze objects. From this we can build interpretations of deliberately destroyed metalwork with greater confidence.

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De la méthode dans les fragments : un système de classement gradué des atteintes au mobilier métallique de l'âge du Bronze

Les objets métalliques brisés et endommagés de l'âge du Bronze ont été étudiés maintes fois mais une méthode permettant de distinguer un dégât accidentel d'un acte intentionnel fait encore défaut. Jusqu'à présent, les études se sont généralement fondées sur des suppositions concernant les causes de ce phénomène. En se basant sur les caractéristiques matérielles des alliages de cuivre, en s'appuyant sur des recherches récentes sur l'usure des objets et en tenant compte de travaux expérimentaux sur leur fragmentation, l'auteur propose une approche méthodologique permettant d'identifier ces dégâts. Il identifie sept « indicateurs de destruction » et leurs critères de distinction permettant d'interpréter judicieusement ce matériel archéologique. Ceci le mène à proposer un système de classement gradué des atteintes au mobilier (« Damage Ranking System »), c'est-à dire une méthode d'évaluation du dommage infligé aux objets en alliage de cuivre de l'âge du Bronze basée sur la probabilité qu'un objet a été endommagé intentionnellement. Deux cas d'étude illustrent l'application de ce système. Translation by Madeleine Hummler

Mots clés: âge du Bronze, dégâts, destruction, fragmentation, mobilier métallique

Methodischer Vorgang und Teilstücke: ein Rangfolgesystem für die Bewertung von beschädigten bronzezeitlichen Metallgegenständen

Die gebrochenen und beschädigten bronzezeitlichen Metallgegenstände sind seit Langem bekannt und erforscht, aber es gibt noch keine Methodologie, die es ermöglicht, zwischen absichtliche und unabsichtliche Geschehen zu differenzieren. Frühere Untersuchungen haben sich oft auf Annahmen über die Schadensursache gestützt. Auf der Grundlage der Materialeigenschaften von Kupferlegierungen, und auf der Basis von neueren Studien über Gebrauchsspuren sowie experimentelle Untersuchungen über die Fragmentierung von Geräten aus Bronze, schlägt der Verfasser ein methodologisches Verfahren zur Bestimmung von absichtlichen Schaden vor. Sieben „Zerstörungskennzeichen" und dazugehörige Merkmale werden hier vorgelegt, um das archäologische Material fundiert zu deuten. Diese Indikatoren führen zu einem Rangfolgesystem für die Bewertung von beschädigten bronzezeitlichen kupferlegierten Gegenständen, eine Methode, welche die Wahrscheinlichkeit eines absichtlichen Schadens bewertet. Zwei Fallstudien verdeutlichen, wie solch ein System eingesetzt werden kann. Translation by Madeleine Hummler

Stichworte: Bronzezeit, Schaden, Zerstörung, Fragmentierung, Metallgegenstände