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# Steps towards operationalizing an evolutionary archaeological definition of culture

Felix Riede

## Abstract

*This paper will examine the definition of archaeological cultures/techno-complexes from an evolutionary perspective, in which culture is defined as a system of social information transmission. A formal methodology will be presented through which the concept of a culture can be operationalized, at least within this approach. It has already been argued that in order to study material culture evolution in a manner similar to how palaeontologists study biological change over time we need explicitly constructed 'archaeological taxonomic units' (ATUs). In palaeontology, the definition of such taxonomic units – most commonly species – is highly controversial, so no readily adoptable methodology exists. Here it is argued that 'culture', however defined, is a phenomenon that emerges through the actions of individuals. In order to identify 'cultures', we must therefore construct them from the bottom up, beginning with individual actions. Chaîne opératoire research, combined with the formal and quantitative identification of variability in individual material culture behaviour allows those traits critical in the social transmission of cultural information to be identified. Once such traits are identified, quantitative, so-called phylogenetic methods can be used to track material culture change over time. Phylogenetic methods produce nested hierarchies of increasingly exclusive groupings, reflecting descent with modification within lineages of social information transmission. Once such nested hierarchies are constructed, it is possible to define an archaeological culture at any given point in this hierarchy, depending on the scale of analysis. A brief example from the Late Glacial in Southern Scandinavia is presented and it is shown that this approach can be used to operationalize an evolutionary definition of 'culture' and that it improves upon traditional, typologically defined techno-complexes. In closing, the benefits and limits of such an evolutionary and quantitative definition of 'culture' are discussed.*

## **Introduction**

There is considerable debate amongst anthropologists and archaeologists about the ontological status of human ‘culture’. A plethora of definitions have been offered (Kroeber and Kluckhohn, 1978, Kuper, 1999), the vast bulk of which are anchored in ethnographic accounts or foreground cognitive dimensions of human experience. Hence they are of limited utility to archaeologists who, by and large, have to contend with a patchy and discontinuous record that consists exclusively of more or less durable material culture. Although of limited utility to archaeologists, many definitions of culture nonetheless recognise that the social transmission of information is at its core (for a recent review of the North American literature, see Lyman, 2008). Pitt Rivers (1875, 298), for instance, noted that “hereditary transmission” of cultural traits underpins our ability to recognise series of cultural transformations. These observations were later formalised in the typological method (Montelius, 1903) and subsequent seriation approaches (O'Brien and Lyman, 1999, Riede, 2006b).

In this paper I will argue that an alignment of ‘culture’ with processes of information transmission allows the development of a specifically archaeological definition of culture under the umbrella of Darwinian Theory. Such an approach rests on the rejection of typological concepts of culture, which remain widespread in archaeology. Instead, it is argued, culture may be understood as a materialist, population-level phenomenon that is generated through the actions of individuals and that takes archaeological shape through the consistent socially learnt repetition of such actions across generations. In historical perspective this approach lends itself to tree-like exploratory models – cultural phylogenetics – and this may aid in not only classifying a given set of archaeological remains into culture-like groupings, but also in answering long-standing questions about processes of change in material culture, action and behaviour. I will present a brief case study from the Southern Scandinavian Late Glacial of how such a specifically evolutionary archaeological method of defining cultures can be operationalized.

## Information transmission and material culture evolution

The transmission of information is at the core of Darwinian models of evolution (Jablonka and Lamb, 2006). First formalised with respect to genetic information transmission, there is now a widespread recognition that salient information transmission covers a much greater number of domains, such as the epigenetic, the social and behavioural, as well as the ecological (Jablonka and Lamb, 2005, Nielsen, 2007, Odling-Smee, 2007, Odling-Smee et al., 2003, Wells et al., 2006). Noted already by Lewontin (1970) a long time ago, Jablonka and Lamb (2006, 237) reiterate that Darwinian evolution can emerge in any information transmitting system because...

*...the transmission of information between generations, whether through reproduction or through communication, requires that a receiver interprets (or processes) an informational input from a sender who was previously a receiver. When the processing by the receiver leads to the reconstruction of the same or a slightly modified organization-state as that in the sender, and when variations in the sender's state lead to similar variations in the receiver, we can talk about the hereditary transmission of information. This typically occurs through reproduction, but it can also occur through communication if communication leads to a trait of one individual being reconstructed in another. Clearly, if the hereditary transmission of information is seen in this way, there is no need to assume that all hereditary variations and all evolution depend on DNA changes.*

The archaeologists Eerkens and Lipo (2007, 246) underline that “it is more productive to conceive of a general case in which genetics, culture, language, and the like are simply versions of generic inheritance systems, structured means in which information is passed between sources and destinations. These systems differ greatly in their implementation, dynamics, and degree of fidelity...but this is irrelevant to their information-theoretic structure”. In sum, when the transmission of information between generations – by whatever means – displays the properties of trait *variation* between units, *heritability* and *differential representation* of these traits from one

generation to another, some form of Darwinian evolution is the result. Note that in such formulations of Darwinian evolution crude selection and survival only play minor roles. The agents creating the material culture variation act purposefully and intentionally. They are knowledgeable, yet they are not omniscient (Mesoudi, 2008) and the picture of cultural evolution invoked here is demonstrably not the kind of evolution caricatured by post-processual theorists (e.g. Shanks and Tilley, 1993).

That Darwinian Theory holds some promise for understanding long-term material culture change was recognised early on by pioneering scholars such as the Swedish antiquarian Oscar Montelius. Although it took some time for Darwin's ideas to become widely disseminated in Scandinavia (Kjærgaard and Gregersen, 2006), references to his works become more common in archaeological texts shortly after translated works first become available. In the early 1870s the Swedish scholar Hans Hildebrandt (1873, 17) stated that "if any science at present needs its Darwin, it is comparative archaeology". Recognising the evident similarities in the palaeontological and archaeological records, and the challenges faced by workers in both fields, he went on to draw explicit analogies between archaeology and palaeontology (e.g. Hildebrandt, 1880). Oscar Montelius further elaborated this point by making the case for the similarities between cultures in an archaeological and species in a palaeontological sense (Montelius, 1884, Montelius, 1899). Beyond this basic insight he (Montelius, 1903, 20) argued that

*it is in actual fact rather amazing that Man in his labours has been and is subject to the very same laws of evolution. Is human freedom indeed so limited as to deny him the creation of any desired form? Are we forced to go, step by step, from one form to the next, be they ever so similar? Prior to studying these circumstances in depth, one can be tempted to answer such question with «no». However, since one has investigated human labours rather more closely, one finds that clearly, the answer has to be «yes». This evolution can be slow or fast, but at all times Man, in his creation of new forms, needs to conform to the very same principles that hold sway over the rest of nature.*

Montelius clearly recognised that the evolution of culture was historically constrained, that the creation of new forms was contingent on their predecessors, and

that the transmission of information is vital in shaping material culture expressions. His student Nils Åberg (1929, 508) reiterated that “typology is the application of Darwinism to the products of human labour”. However, the notion that cultures are analogous (as natural or analytical units) to species as they were thought to be the late 19<sup>th</sup> and early 20<sup>th</sup> centuries is fundamentally flawed, precisely because both entities were defined typologically. The species concept in biology is still controversial (e.g. Ereshefsky, 1992, Mayr, 1957, Rieppel, 2007), but the essentialism of typology has long been abandoned for ‘population thinking’ (Ghiselin, 1974, Hull, 1965, Mayr, 1959). This epistemological revolution came about at a time when archaeologists had roundly rejected the application of Darwinism to human works (e.g. Brew, 1943) and had instead turned towards ecologically and sociologically inspired approaches (Riede, 2006b, Trigger, 2006). Despite the fact that Mayr (1959) brought this issue to the attention of anthropologists at the time, even those archaeologists seeking inspiration from the biological sciences directly (e.g. Clarke 1968, Gandert 1950) appear to have been unaware of these developments. As a consequence, many archaeologists employ types for building diachronic sequences and for making arguments about change over time, something for which such entities are profoundly ill-suited (Lyman and O'Brien, 2003, Lyman and O'Brien, 2004, O'Brien and Lyman, 2000). From the adoption of population thinking flows a focus on *variation* and the need to use quantitative techniques (Mayr, 1976, 27-8):

*The assumptions of population thinking are diametrically opposed to those of the typologist. The populationist stresses the uniqueness of everything in the organic world. What is true for the human species, that no two individuals are alike, is equally true for all other species of animals and plants...All organisms and organic phenomena are composed of unique features and can be described collectively only in statistical terms. Individuals, or any kind of organic entities, form populations of which we can determine the arithmetic mean and the statistics of variation. Averages are merely statistical abstractions; only the individuals of which the populations are composed have any reality. The ultimate conclusions of the population thinker and the typologist are precisely the opposite. For the typologist, the type (eidos) is real and the variation an illusion, while for the populationist*

*the type (average) is an abstraction and only the variation is real. No two ways of looking at nature could be more different.*

Eerkens and Lipo (2005, 2007) and Eerkens and Bettinger (2008) have similarly argued that variation in material culture should be the focus of archaeological enquiry, at least in so far as it is concerned with the social information of transmission.

Population thinking alone, however, cannot lead to a readily operationalized definition of culture in an archaeological sense. Whilst helpful to ethnographers working with contemporary populations (Bloch, 2005, Sperber, 1996), and indeed some anthropologists pursuing an evolutionary approach (Mace and Holden, 2005), these definitions of culture are predicated on having comprehensive linguistic information. Cultures, in this view, are socio-linguistic entities and mutual intelligibility is understood as a proxy measure of interaction akin to Mayr's (1957; also Mayr, 2000) interbreeding criterion (Fig. 1). For archaeologists lacking linguistic information, however, such a formulation is problematic. Palaeobiologists who cannot observe interbreeding directly face similar difficulties and have argued that a phylogenetic species concept may be more suitable for examining long-term changes in the historical relatedness and changes in adaptation in the organic world (e.g. Mishler and Theriot, 1999, Nixon and Wheeler, 1990, Wheeler and Platnick, 1999). These species, however, are not ontologically equivalent to living species, just as an archaeological culture or techno-complex cannot be compared to cultural groups observed ethnographically. In order to avoid confusion, therefore, the culture = species notion should be rejected. Where does this leave us?

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Fig. 1  
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It is important to remember that species in palaeontology are merely one kind of taxonomic unit (Lee 2003). Phylogenetic species then, are one of the operational taxonomic units of palaeobiology, and it has been suggested (Foley, 1987), most recently by Gamble et al. (2005), that similar units should be used for in archaeological enquiry. The use of archaeological taxonomic units (ATUs)

incorporates the key epistemological insights of the rejection of essentialism and avoids the terminological confusion surrounding the term ‘culture’; they are the “cultural counterpart to the operational taxonomic unit (OTU) of biology and evolutionary science” (Gamble et al., 2005, 195). In contrast to most definitions of ‘culture’, the ATU concept offers archaeologists a pragmatic avenue for constructing appropriate units for cultural phylogenetics. O’Hara (1997, 323) has further suggested that “tree thinking” complements the population perspective by providing an explicit historic dimension (O’Hara, 1997, 324-5; my emphasis):

*Tree thinking is simply the phylogenetic counterpart to population thinking, and like population thinking it has brought a more completely evolutionary perspective to systematics...Tree thinking, in contrast to group thinking, considers species in a phylogenetic context, not as independent replicates but as parts of a single phylogenetic tree. If we seek to understand common causes acting in evolution then the replicates we need to examine are not species, but the evolutionary events that are of interest in a particular study, and this can only be done by plotting those events on a tree...Although tree thinking...is an aspect of systematic biology, the idea of tree thinking isn’t necessarily tied to living things – all it requires is descent and inheritance.*

A great number of recent studies have advanced the use of tree-building approaches in anthropology and archaeology (see chapters and references in: Lipo et al., 2006, Mace et al., 2005, O’Brien, 2008, O’Brien et al., 2003). Here, I investigate one of these approaches using a case study from the Southern Scandinavian Late Glacial. In particular, the resulting phylogenetic diagrams will be explored as tools for defining archaeological cultures.

### **Defining archaeological taxonomic units**

Although Gamble and colleagues have reopened the discussion on taxonomic units in archaeological analyses, they fail to provide an adequate methodology for actually constructing such units. Taxonomies remain inert classification exercises



unless they are placed into an explicitly evolutionary framework (see Riede, in press; Fig. 2). The subjects of evolutionary archaeological analysis are the “learning lineages” (Harmon et al., 2006, 209) of craft production, manifest in their consistent and repeated material expressions.

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Fig. 2

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By virtue of their biological endowment, humans are strongly predisposed towards both learning (Fragaszy and Perry, 2003, Laland, 2004, Reader and Laland, 2003, Shennan and Steele, 1999, Tomasello et al., 1993) as well as teaching (Tehrani and Riede, 2008, Thornton and Raihani, 2008). Contexts of scaffolded learning and indeed of active teaching can, at least on occasion, be identified in the archaeological record (see Bamforth and Finlay, 2008). Although other methods for identifying the appropriate units of cultural transmission (Pocklington, 2006, Pocklington and Best, 1997) have been put forward, Apel (2008), Apel and Darmark (2007), Riede (2006a, Riede, 2008b) and Tehrani and Riede (2008) have suggested that detailed technological analyses, following the *chaîne opératoire* approach, can be used to identify those elements of material culture that are consistently passed on from generation to generation, at a level suitable for archaeological enquiry. Similarities in material culture are generated through the historical relatedness of their makers and their placement within communities of learners/teachers that persist over archaeological time. On the level of the population of learners, such traits – as proxies for the knowledge, skill and know-how – can be tracked in space and time. Specifically for the Late Glacial, it can be demonstrated at several locales that teaching played an important role in the transmission of craft skills (Bodu et al., 1990, Pigeot, 1990) taking place at flint-knapping ‘schools’ and workshops (Fischer, 1988, Fischer, 1989b, Fischer, 1990). Such traits are decidedly not memes (Dawkins, 1976) or cultural viruses (Brodie, 1996, Cullen, 1996); these cannot be identified archaeologically (Lake, 1998) if indeed they can be identified or exist at all (Aunger, 2006, Bloch, 2000, Boyd and Richerson, 2000, Sperber, 2000). Either way, a replicator akin to genes is not a necessary condition for cultural evolution to follow Darwinian principles (Henrich and Boyd, 2002, Henrich et al., 2008) and a focus on

knowledge and its material expression in durable craft items offers an empirically more solid, and at least for archaeologists much more useful, starting point. Placing knowledge and know-how firmly in the centre of an evolutionary approach to culture further highlights the conceptual ground that this approach shares with other archaeological paradigms, especially agentive ones (Riede, 2005, VanPool, 2008, VanPool and VanPool, 2003). Although traditionally seen as theoretically conflicting, Apel (2008, 95) has recently noted that, encouragingly, “this division of interest has diminished as researchers use the operational chain approach in studies of evolutionary aspects of artefact continuity and change”. As pointed out repeatedly by Shennan (1989, 2004a, 2004b) these approaches are in fact complimentary, with the evolutionary framework providing a diachronic perspective on individual action.

Such actions are executed by individuals (Dobres, 2000). In order to construct archaeological taxonomic units grounded in empirical values, we must therefore begin with individual artefacts. This approach largely parallels those by O’Brien and colleagues (Darwent and O’Brien, 2006, O’Brien et al., 2001, O’Brien et al., 2002) and Buchanan and Collard (2007, 2008a, 2008b), except that it foregrounds the relation of the technological action to the attributes used in the analysis. Here, we focus on lithic projectile points from the Southern Scandinavian Late Glacial. Projectile points in general are often sensitive culture-historical markers (Beck, 1998) and the Southern Scandinavian set is no exception (Fig. 3): “There are several grand changes in lithic projectile points that provide horizon markers for all of northwestern Europe” (Price, 1991, 198). On the basis of these changes, the culture-historical sequence consists of the Hamburgian culture (‘Classic’ and Havelte facies), and the Federmesser groups (FMG), followed by the Bromme and Ahrensburgian cultures (see Eriksen, 2002, Terberger, 2006). Yet, as Fischer (1993, 52) points out “knowledge of the geographical and chronological range of the four groups is as yet very limited. As a result, any attempt to assess their inter-relationship must remain preliminary”. While some workers (e.g. Madsen, 1996) have suggested that repeated episodes of colonisation or *landnam* may have shaped this picture, others see the process as one of gradual, continuous and autochthonous adaptation of local human groups to slowly ameliorating climatic conditions (e.g. Fischer, 1989a, Fischer, 1991). However, recent advances in environmental science have led to a major refinement of traditional time-averaged climatic models based largely on relatively low-resolution pollen analyses (Björck et al., 1998, Blockley et al., 2006, Burroughs, 2005, Eriksen, 2002). In

particular, recent revisions of the dating for some of these techno-complexes (Grimm and Weber, 2008) and the growing recognition that the Laacher See volcanic eruption, dated to c. 13,000 BP (Baales et al., 2002, Blockley et al., 2008), had a major impact on the culture-historical development in the area (Riede, 2007a, Riede, 2008a) make a reassessment of the Southern Scandinavian Late Glacial both pressing and timely (see Gramsch, 2004). Despite over 150 years of archaeological research in Southern Scandinavia (Jensen, 1982, Klindt-Jensen, 1975), we remain “stymied...by our lack of basic taxonomic knowledge of the parts that make up the things we identify as societies” (Pocklington, 2006, 30). It is this lack of taxonomic clarity then, rather than a particularly patchy database which makes unravelling the processes that have shaped the Late Glacial archaeological record in this region so difficult.

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Fig. 3

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Fig. 4

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For this study, a database of 607 projectile points was collated. Each specimen was examined for a suite of 23 qualitative/technological and quantitative/metric traits (Fig. 4 and Appendix 1). Using exploratory data analysis (e.g. Tukey, 1977), an appropriate coding schemes for each character was devised. Interestingly, this approach has recently been shown to not only facilitate a reasonably faithful (yet strictly quantitative) discrimination of artefact classes, but that these classes match meaningful definitions of populations using these very same artefacts (Abramov et al., 2006; see also Begossi et al. [2008] for a discussion of how biological folk taxonomies correspond to those derived using biological scientific principles). In an initial analysis, NETWORK software ([www.fluxus-engineering.com](http://www.fluxus-engineering.com)) was used to construct a phylogenetic network, based on the entire database. Phylogenetic networks are powerful new tools in phylogenetic analysis, specifically designed for dealing with large amounts of data, and for investigating the reticulating or horizontal transfer of genetic information (Bandelt et al., 1999, Morrison, 2005). Recent studies

in cultural and linguistic phylogenetics have applied these (Forster and Toth, 2003, Nakhleh et al., 2003, Nakhleh et al., 2005, Riede, 2008b) and similar (Bryant et al., 2005, Lipo, 2006) methods to counteract the long-standing criticism that reticulation and blending in cultural evolution obscure the historic/phylogenetic signal in cultural data beyond retrieval (Brew, 1943, Kroeber, 1917, Moore, 1994, Terrell, 1988). The results presented in Figure 5 show that although the network is no doubt complex, it does show a significant tree-like structure. Moreover, the phylogenetic analysis successfully recovers the broad typological categorisations previously offered, but provides an explicit hypothesis of how these are related. The most salient feature of the network graph is the different structures found within the four techno-complexes: The more clustered patterns in the Bromme culture, for instance, imply fewer strictures on flint knapping, its teaching and execution than, for instance, in the Hamburgian. This notion is supported by broader technological analyses that view Bromme technology as relatively “straightforward” (Madsen, 1992, 128), “wasteful” (Fischer 1991, 116) and “simplified” (Barton, 1992, 192), while the Hamburgian flint technology as highly elaborate, “a more complex technology, perfectly fitted to having scarcer and perhaps more distant and varied lithic resources” (Madsen, 1992, 128). This complexity is somewhat paradoxical in light of the ready abundance of high-quality flint in Southern Scandinavia (Madsen, 1993), but can be explained in terms of historical inertia – a reflection of the Magdalenian ancestry of Hamburgian groups (see Burdukiewicz and Schmider, 2000, Schmider, 1982). Alternatively, the linear arrangement of Hamburgian clusters may indicate successive bottlenecks in small populations under fairly tight regulation of craft production.

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Fig. 5  
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Incorporating the entire range of technological variability in the dataset used here is conceptually attractive, but it distracts from the overall goal of defining archaeological taxonomic units or cultures. Although individual idiosyncrasies are clearly critical for generating cultural evolutionary processes by providing variation on which these same processes can act, it is repeated behavioural patterns and consistent trans-generational teaching and learning that are of interest here (see also

O'Brien et al., 2002). The NETWORK software provides a useful statistical output which allows a stepwise exclusion of characters from the analysis in order to refine the phylogenetic signal (see Riede [2007b] for further details). The exclusion of highly variable characters and the focus of stable ‘constellations of knowledge’ (Keller and Keller, 1996) reduces the dataset to a matrix of 16 archaeological taxonomic units, each defined by twelve characters (Table 1).

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Table 1  
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For the analysis of such smaller datasets a number of techniques are available (Felsenstein, 2004, Hall, 2004). Many archaeologists have used tree-building methods to investigate both variability in stone artefacts in general (Cziesla, 1998, Kind, 1992) as well as specifically European Late Glacial cultural differentiation (e.g. Burdukiewicz, 1986, Burdukiewicz and Schmider, 2000), but invariably these were so-called phenetic approaches, which are inadequate for distinguishing historical relatedness (Brooks and McLennan, 1994). Both parsimony-based as well as maximum likelihood (ML) approaches can be used to generate evolutionary trees, and both methods can be used in the context of defining archaeological cultures phylogenetically. Here we chose Bayesian phylogenetics because it provides a statistically robust way of constructing phylogenies for use in comparative analyses (Mace and Holden, 2005, Mace and Pagel, 1994). Bayesian statistics have already been introduced to archaeology in the area of radiocarbon calibration (e.g. Buck, 2001) and functional artefact classification (Dellaportas, 1998). They offer a means of incorporating uncertainty and prior information about the data into its analysis. Bayesian phylogenetics is ideally suited for tackling what has become known as ‘Galton’s Problem’ (Naroll, 1961), first raised by Francis Galton in response to a cross-cultural analysis of marriage patterns by Edward B. Tylor. Galton objected that “some of the occurrences might result from transmission from a common source, so that a single character might be counted several times from its mere duplicates”, in other words that historically related units of analysis are not statistically independent because they may be derived from a common ancestor (see Tylor, 1889, 272). All comparative analyses, be they of cultural or biological data, are plagued by this

methodological challenge and although a number of solutions have been suggested (e.g. Denton, 2007, Hull, 1998), the use of phylogenies as hypotheses of historical relatedness amongst the units under consideration allows valid statistical procedures to be developed (Harvey and Pagel, 1991, Mace and Pagel, 1994, Pagel, 1992). Contemporary comparative methods offer an arsenal of analytical techniques that take account of Galton's dilemma. They are "one of biology's most enduring sets of techniques for investigating evolution and adaptation" (Pagel and Meade, 2005, 235), can be used to examine a variety to cultural processes, and have seen increasing use by phylogenetically-minded anthropologists (Mace and Holden, 2005, Mace and Pagel, 1997, Mace and Pagel, 1994, Mace and Sellen, 1997).

The results of this analysis are presented in Figure 6. Not surprisingly, some of the traditional typologically defined groupings are evident. However, it is noteworthy that statistical support for the Hamburgian clades is low and that FMG and Hamburgian (esp. Havelte Group) taxa are often grouped together. In light of recent dating evidence (Grimm and Weber, 2008), this can perhaps be interpreted as an indication of significant interactions between these northern and southern groups respectively. The Bromme clade is both robust and highly diverse. This clade was the result of the isolation of northern groups following the eruption of the Laacher See volcano and the subsequent demographically-mediated loss of bow-and-arrow technology as well as more complex stone working skills (Riede, 2007a, Riede, 2008a). Indeed, this culture can be defined as a monophyletic clade (an ancestor and all its descendants). Interestingly, the tanged point groups (the Bromme [clade A] and Ahrensburgian [clade B] taxa in clade C) are a sub-group of the Arch-backed Point complex (ABP: the Late Magdalenian and Federmesser tradition; clade D). Phylogenetically, they are not therefore equivalent units and cannot be separated at the level of a 'culture'. Hierarchical schemes for subdividing Late Glacial cultures are not, of course, new (Kozłowski, 1999, Schwabedissen, 1954), but framing such a hierarchy explicitly and on the basis of individual artefact morphologies provides a useful starting point for exploring the processes that created these hierarchical patterns in the first place. For instance, elsewhere I use this phylogeny to explore whether the introduction of domestic dogs played a role in enabling and structuring the Late Glacial re-colonisation process (Riede, in prep.). Long presumed to have been important in this process (Eriksen, 1996, 2000), this key 'innovation' can be seen as part of the human constructed niche (Bleed, 2006) and in investigating this

niche construction process it is critically important that, following Galton, we control for the historical relatedness of the units under study (Odling-Smee et al., 2003).

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Fig. 6

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While there are no straightforward means of deciding which level of branching defines an archaeological ‘culture’, workers can now decide which clades or components of the tree may collectively be referred to as a ‘cultural’ group. In any case, we now have an explicit hypothesis of historical relatedness of craft lineages manifest empirically in the archaeological record. Even simple trees are not straightforward in their interpretation (Sandvik, 2008) and, certainly, the picture of Late Glacial technological diversity suggested here is somewhat more complicated than previously proffered schemes, but it arguably constitutes a significant improvement over previous uni-lineal, typological schemes in that it facilitates further analysis. The great strength of evolutionary analyses is that they often reveal counter-intuitive insights and that it draws our attention towards new avenues of investigation.

## **Conclusion**

In 1847, William Whewell (1847, 637) noted that “Comparative Archaeology”, along with a geology and historical linguistics is a historical science that is conducted differently to fields such as physics and chemistry. Historical events, he added, are contingent, necessitating the parallel investigation of patterns *and* processes of change and causality (see also Bintliff [1999] and O'Brien and Lyman [2000] for more recent discussions). A little later, Darwin proposed a mechanism that produces these sequences of contingent changes in the biological world, and shortly after the publication of his *Origin* some 150 years ago references to this mechanism – descent with modification – become more common in some archaeological writings. Montelius, for instance, picked up on the similarities between palaeontology and archaeology suggesting that there is much methodological and epistemological overlap. However, the early part of the 20<sup>th</sup> century saw an “eclipse of Darwinism”

(Huxley, 1943, 22; also Bowler, 1983) and an intellectual fragmentation of the sciences. The revolutionary rejection of essentialism and typological thinking in biology, whose implications on unit-building are profound and still debated today, passed by the archaeological establishment (see discussions by Sackett [1991] for a discussion of this with regards to French Palaeolithic research, and O'Brien and Lyman [1999] and O'Brien and Lyman [2000] for a more general treatment from an American perspective).

It is argued here that the bottom-up construction of units for diachronic cultural studies rooted in individual technical action provides an empirically-grounded rationale for the application of phylogenetic methods to archaeological data. Although numerous scholars, especially in Eastern Europe (e.g. Kozłowski and Kozłowski, 1979) have used explicit taxonomic approaches to archaeological classification and even tree-building and network methods for data analysis (e.g. Burdukiewicz, 1986, Schild, 1984), these were methodologically flawed. Contemporary phylogenetic principles were not readily adopted in Eastern Europe and Russia (Todes, 1989) and this may be reflected in the use of phenetic rather than phylogenetic methods in archaeology. It is argued here that detailed technological analyses allow us to construct units of analysis that index 'culture' as a system of social information transmission (Boyd and Richerson, 1985). Placing these units in nested hierarchies of increasingly exclusive shared characters facilitates both the definition of 'cultures' – strictly perhaps as monophyletic clades – as well as the comparative analysis of casual processes acting upon these units in the first place. Ultimately, which clades or clusters of clades we designate as a 'culture' is an arbitrary decision. Archaeological data provides access primarily to the actions of past people as manifest in durable material culture. If we build our definitions of 'cultures' from this database, any such definition will not be equivalent to those used by ethnographers. Artefact types are the common "idiom of description" (Sackett, 1999, 115) in archaeology, and talking of archaeological 'cultures' is certainly a useful linguistic convention. As such the notion cannot readily be abandoned, but much like the typological approach as a whole, it holds only limited analytical utility (see Bisson [2000] for an archaeological argument, and Levit and Meister [2006] for a biological one). In contrast, a phylogenetic definition of archaeological cultures based on an explicit use of ATUs that reflect past human actions, renders such groupings analytically tractable.



We must not forget, however, that phylogenies are always merely *hypotheses* of relatedness based on current knowledge and characters that are specific to a given dataset. Although a phylogenetic definition of ‘culture’ may not be epistemologically unassailable (Lee, 2003, Lee and Skinner, 2008), Pagel (1994, 30) has stressed that “pragmatism is a virtue in science, and...strict adherence to epistemological criteria, although laudable in principle, can often hinder rather than promote the understanding of empirical phenomena”. Here, I endorse such a pragmatic stance and have presented first steps towards an operational definition of culture under the umbrella of evolutionary archaeological theory. A cultural phylogenetic framework demands explicit units, but it makes these units comparable and it opens the door to further, empirical analyses that rely on the construction of precisely such units.

The tracing of individual craft lineages for a single class of tools is the first step in a more comprehensive analysis of material culture (Riede, 2008b, VanPool et al., 2008). Methods for collating and comparing phylogenies that are historically associated are available (Page, 2003, Page and Charleston, 1998) and hold the promise of building more synthetic pictures of cultural evolution that draw on a wide range of craft production domains (e.g. lithics, ceramics, artistic production; Riede, in press-b). The conceptual overlap between the data employed, and the analytical challenges faced by evolutionary biologists and archaeologists may warrant the application of such co-phylogenetic approaches. Unfortunately, there is still considerable misunderstanding about the remit, goals and limits of an evolutionary archaeology (see Kristiansen [2004], Shennan [2004a] and Henrich et al. [2008] for discussions), but with regards to the definition of archaeological cultures evolutionary archaeologists “understand the problem of units and scale, accepting that a cultural phylogeny represents in only the broadest of terms the path that most of the members of a culture followed...The key word is *broadly*; no phylogeneticist would view a cultural phylogeny using ‘cultures’ as taxonomic units as anything but a broad picture of ancestry” (O'Brien et al., 2008, 54). The mere definition of cultures, however, is not the ultimate goal of anthropology or archaeology. What we are interested in is addressing and explaining the processes that have shaped our past, that shape our present. It is quite clear that traditional, implicit, typological definitions of culture are analytically moribund: “culture is everything to anthropology, and it could be argued that in the process it has also become nothing” (Foley and Lahr, 2003, 109). The approach outlined here suggests a rather narrower, somewhat reductionist, and

knowledge-centred definition of culture. It promotes a return to a more decidedly comparative archaeology in the sense of Whewell and Hildebrand and in so doing it offers new ways to examine the processes that are at the heart of archaeological inquiry.

**Appendix 1.** List of all traits measured and calculated. For similar attempts at describing Late Glacial armature shape see Fischer (1985), Burdukiewicz and Schmider (2000), Ikinger (1998), Szymczak (1987), Madsen (1992), Madsen (1996), Hahn (1993), and Beckhoff (1967).

- I. Maximum length
- II. Maximum width
- III. Maximum thickness
- IV. Body/tang ratio
- V. Percussion bulb presence & morphology
- VI. Tang orientation vis-à-vis bulb of percussion
- VII. Tang retouch direction, right
- VIII. Tang retouch direction, left
- IX. Tang retouch length, right
- X. Tang retouch length, left
- XI. Hafting notch (presence/absence)
- XII. Tang symmetry
- XIII. Tang alignment vis-à-vis midline
- XIV. Shoulder angle, right
- XV. Shoulder angle, left
- XVI. Tip angle
- XVII. Tip retouch intensity, right
- XVIII. Tip retouch intensity, left
- XIX. Tip retouch direction, right
- XX. Tip retouch direction, left
- XXI. Tip retouch length, right
- XXII. Tip retouch length, left
- XXIII. Tip alignment

**Table 1.** Characters and character states used in the Bayesian tree-building exercise.

CHARACTER	<i>Character State</i>	CHARACTER	<i>Character State</i>
I. Maximum Length	0. $\leq 45\text{mm}$ 1. 45mm - 68mm 2. $> 68\text{mm}$	VII. Tang Retouch	0. Opposing 1. None 2. Same side
II. Maximum Width	0. $< 19\text{mm}$ 1. $\geq 19\text{mm}$	VIII. Tang Symmetry	0. $> 2.5$ 1. 1.5 - 2.5 2. 1.0 - 1.4
III. Maximum Thickness	0. $< 5\text{mm}$ 1. $\geq 5\text{mm}$	IX. Tip Retouch	0. None 1. Unilateral 2. Bilateral
IV. Size <sup>a</sup>	0. $< 39$ 1. 39 - 58 2. 59 - 166 3. $> 166$	X. Combined Tang/Body Ratio <sup>c</sup>	0. $< 23$ 1. 23 - 42 2. $> 42$
V. Tang/Body Ratio <sup>b</sup>	0. Unilateral retouch 1. No tang 2. $< 2.0$ 3. $\geq 2.0$	XI. Retouch Extent Ratio <sup>d</sup>	0. 4 - 18 1. 19 - 40 2. $> 40$
VI. Percussion Bulb Morphology	0. Faint bulb 1. Pronounced bulb 2. Distinct Bulb with scarring	XII. Tang Retouch Symmetry	0. $\leq 1.4$ 1. No tang 2. $> 1.4$

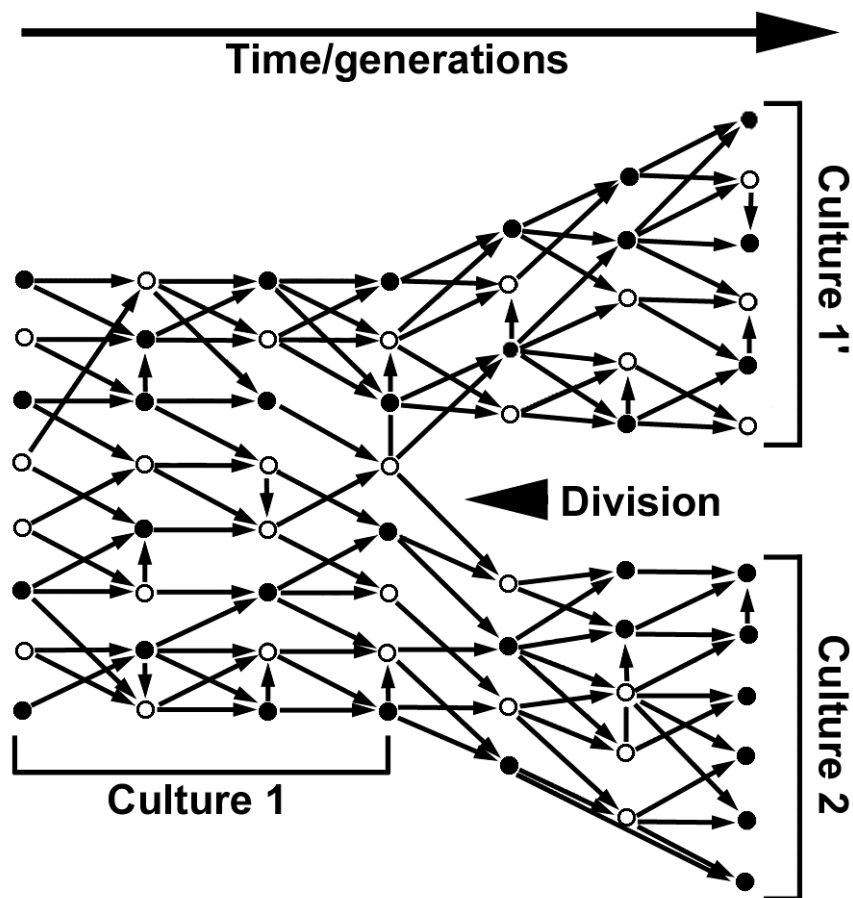
<sup>a</sup> *Size = Length x Width x Thickness.*

<sup>b</sup> *Tang/Body Ratio is the ratio between maximum length and the lowest common tang measurement of a specimen (i.e., however far retouch extends on both sides of the specimen).*

<sup>c</sup> *For this ratio maximum length is divided by the tang/body ratio of the specimen.*

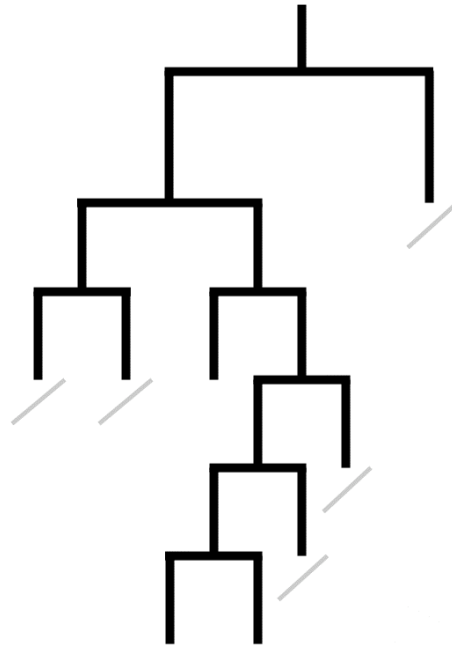
<sup>d</sup> *This is calculated by adding together the total retouch extent of a given specimen and dividing this by length multiplied with width*

## Figures and figure captions

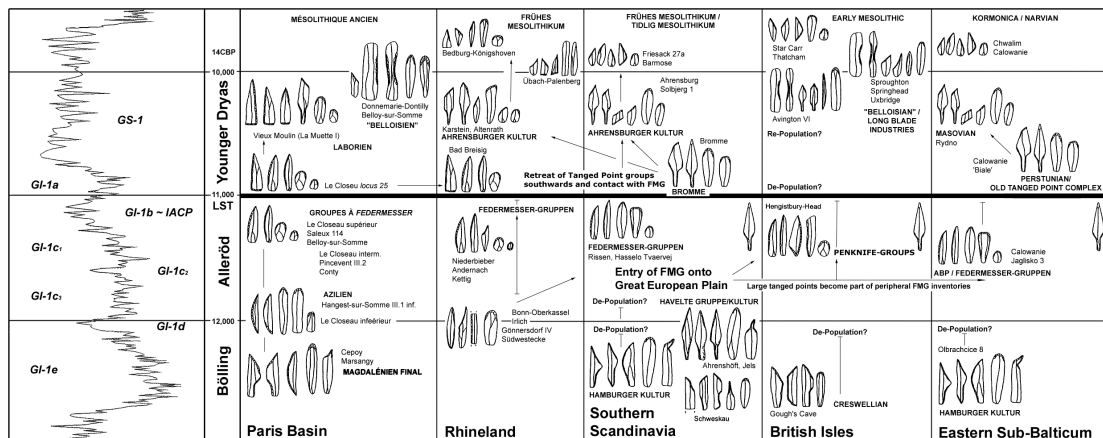


**Figure 1.** An archaeological culture (Culture 1) as a heterogeneous population of teachers/learners (○ and ●) and their intellectual and/or artefactual sub-lineages. The various modes of cultural transmission (vertical, oblique, horizontal; see MacDonald, 1998) produce complex patterns of expression. Over time/generations, when the horizontal transmission between two segments of the ancestral population diminishes, empirically recognisable new cultures arise (Cultures 1' and 2). Which particular mode of transmission dominates at a given time is an empirical question (Bellwood, 1996). Note that what is not shown here is that in each generation some individuals are likely to leave no cultural descendant, terminating a particular sub-lineage. This figure is redrawn from Hennig (1966).

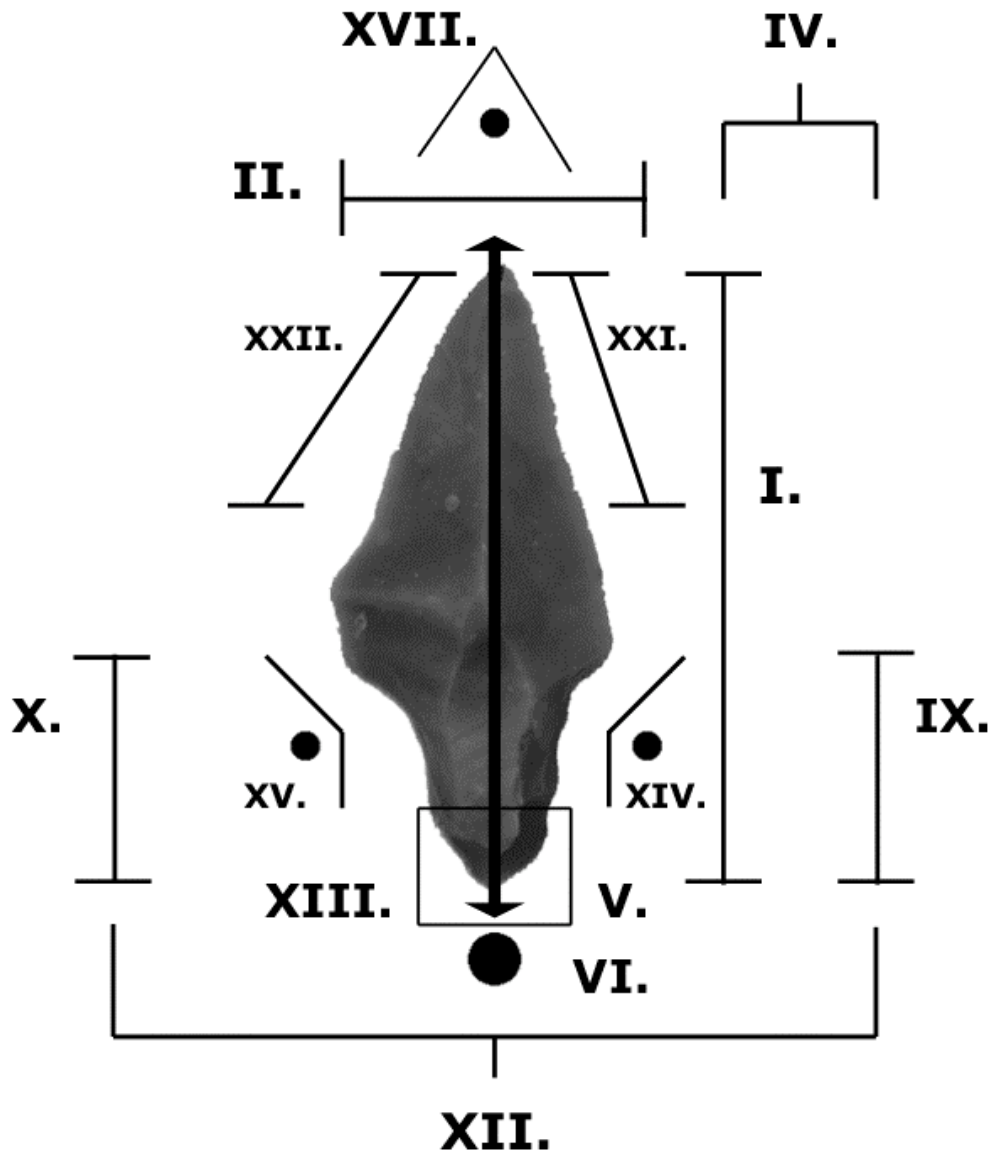
	Equivalent	Examples from Gamble et al. (2005) > <i>this study</i>
ATU1	Period	Palaeolithic, Mesolithic, > <i>Late Upper Palaeolithic</i>
	Sub-period	Early Mesolithic, > <i>Terminal Palaeolithic</i>
ATU2	Techno-complex / Culture	Aurgignacian, > <i>Arch-Backed Piece Complex</i>
	Culture / Industry	Upper Magdalenian, > <i>Hamburgian, Bromme</i>
	Industry / assemblage	Magdalenian IV, > <i>Havelte phase</i>
ATU3	Artefacts / type fossils	Navettes, Mouilah points, > <i>Zinken, Bromme points, Wehlen scraper</i>
	Attribute	Scalar retouch, truncation, > <i>tang-thickness / orientation, tip retouch</i>



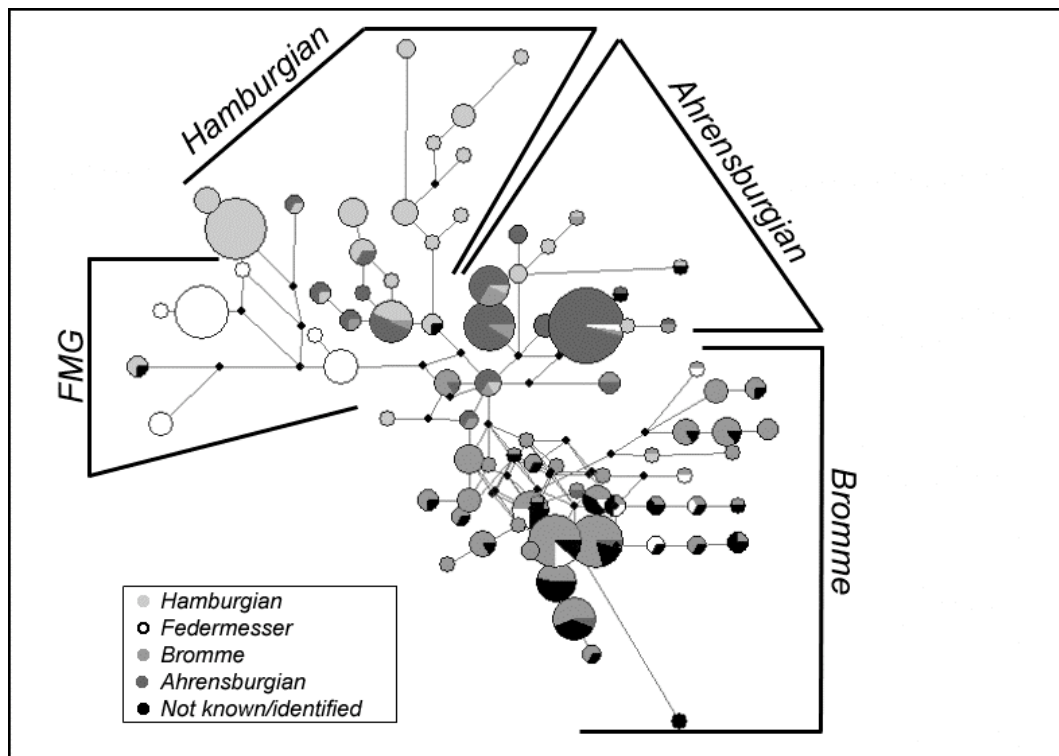
**Figure 2.** Left, the division of archaeological taxonomic units for the North European Late Glacial suggested by Gamble and colleagues. Right, a schematic representation of how these units may map onto a phylogenetic branching diagram. Such diagrams must be generated, and read, from bottom to top beginning with the smallest units distinguishable by a shared history of social information transmission.



**Figure 3.** A culture historical scheme for some regions in Northern Europe, juxtaposed to the high-resolution  $\delta O^{18}$  temperature proxy record of the GISP2 ice-core. The scheme is originally based on Baales (2002), but modified in light of recent work (see text and Riede, 2007b).

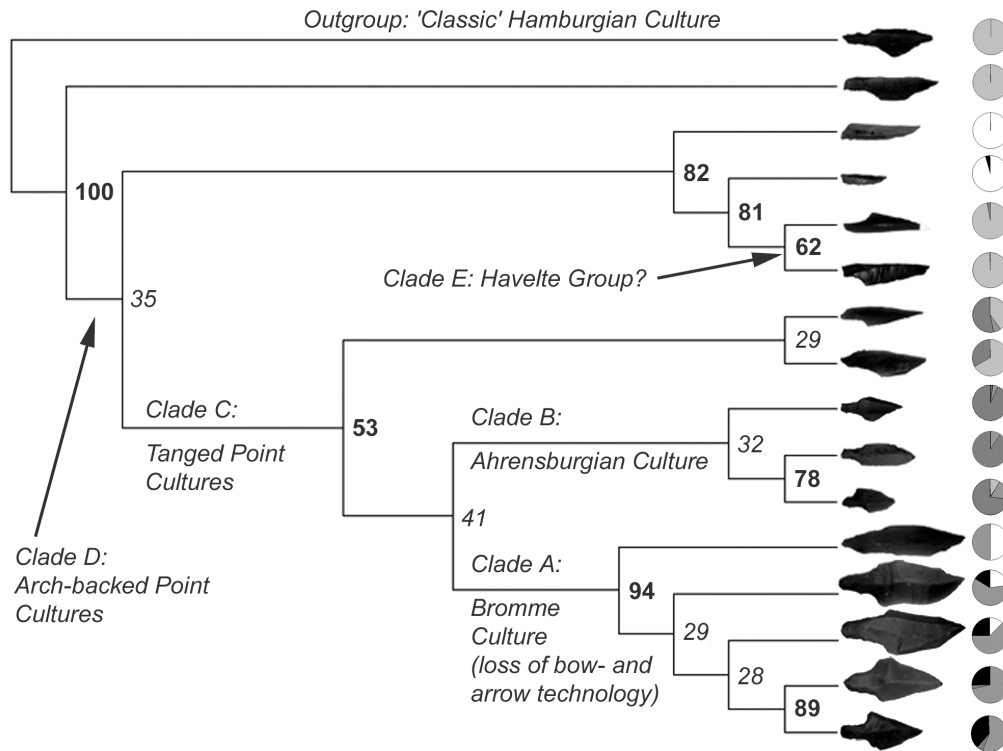


**Figure 4.** An example of the lithic armatures measured for his study. This particular specimen is the classic ‘Bromme’ or large tanged point from Nørre Lyngby, northern Denmark, one of the first Palaeolithic artefacts identified in Scandinavia (Jessen and Nordmann, 1915). Photo by the author with permission of the National Museum of Denmark, Copenhagen. All attributes measured and those used in the final phylogeny-building exercise are listed in Appendix 1.



**Figure 5.** A phylogenetic network of Late Glacial projectile points from Southern Scandinavia. Node size is proportional to the number of actual artefacts that fall into it and each node is shade-coded by its typological composition. The typological assessment of the excavator or curator is followed in this. Note the contrast between, for instance, the Bromme cluster with many smaller but highly connected nodes and the Hamburgian cluster showing a more linear arrangement with, on average, larger nodes. Guidelines for the interpretation of phylogenetic network graphs are given by Bandelt et al. (1995) and Bandelt et al. (1999).





**Figure 6.** The consensus tree based on a sample of 100 Bayesian trees produced using the Markov Chain Monte Carlo (MCMC) methods implemented in *BayesPhylogenies* (Pagel and Meade, 2004). The model of evolution used is a simple multistate model (KSTATES), where the rates of gain and loss of the traits are presumed to be equal. 10,000,000 iterations were run and the tree universe sampled at every 40,000<sup>th</sup> iteration to ensure statistical independence of each sample. The tree shown here is the consensus tree of the last 100 trees in the resulting sample. The numbers along the branches are the posterior branch support. Note that support for some clades is rather low. This tree is rooted with the taxon that contains dates from the site with the oldest radiocarbon date in the region (Ahrenshöft: see Clausen, 1998), belonging to the ('Classic' Hamburgian culture). This correspondence may indicate the degree to which horizontal transmission has shaped these taxa and their position. Only coherent clades with high branch support, for instance clade A (Bromme Culture) should be used to define archaeological 'cultures'. As in Figure 5 the pie charts behind each taxon show the typological composition of each taxon. The mixed composition of some taxa may be due to misclassification of specimens, in particular those derived from older excavations. The difficulty of distinguishing morphologically and technologically between some Hamburgian and Ahrensburgian artefacts, for instance, has created some confusion about the relatedness of these groups. Before radiocarbon

dates became available, the Ahrensburgian was commonly seen as a direct descendant of the Hamburgian (e.g. Bordes, 1968), in part because both groups practiced specialised reindeer hunting economies, but despite the fact that there are salient differences in their technology, settlement pattern and demography (Riede, 2007c, Riede, in press-a). Note also the occurrence of large tanged points assigned to FMG on contextual grounds. These make up parts of the ancestral Bromme taxa and indicate that the origin of this clade or culture must be sought in the Federmesser groups of the middle Allerød (Riede, 2007a, Riede, 2008a).

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