

Weapons of Maths Instruction: A Thousand Years of Technological Stasis in Arrowheads from the South Scandinavian Middle Mesolithic

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This paper presents some results from my doctoral research into the evolution of bow-arrow technology using archaeological data from the south Scandinavian Mesolithic (Edinborough 2004). A quantitative approach is used to describe the morphological variation found in samples taken from over 3600 armatures from nine Danish and Swedish lithic assemblages. A linked series of statistical techniques determines the two most significant metric variables across the nine arrowhead assemblages in terms of the cultural transmission of arrowhead technology. The resultant scatterplot uses confidence ellipses to reveal highly distinctive patterns of morphological variation that are related to population-specific technological traditions. A population-level hypothesis of a socially constrained transmission mechanism is presented that may explain the unusually long period of technological stasis demonstrated by six of the nine arrowhead phase-assemblages.

Keywords

Arrowheads, evolution, lithics, Mesolithic, population, Scandinavia, technology

Introduction

The bow-arrow weapon system is demonstrably a highly significant technological achievement (Bergman 1993), and one that can be directly related to changes in both diet breadth and violence within and between certain prehistoric populations (Maschner 1998). Indeed, it appears very likely that the success and/or failure of specific individuals and groups may well have depended on adopting, innovating, avoiding or switching weapon technologies and associated tactical strategies in many ethnographically recorded groups (Bettinger and Eerkens 1999; Edinborough 1999; Maschner and Reedy Maschner and Reedy Maschner 1998; Shennan 2001). When tracked through time and space, variation within components of the bow-arrow weapon system (such as the lithic arrowhead) may reflect scale, mode and tempo of technological evolution (Bettinger and Eerkens 1999; Hughes 1998). Although environmental caveats are not specifically addressed below (but are elsewhere, see Edinborough 2004), this paper presents a useful method to describe and explain specific morphological changes to arrowhead technology at a population level of analysis. Sadly, the scale of analysis and explanation adopted here has fallen out of favour with many British archaeologists over recent years. One of the key aims of this paper is to demonstrate that this perspective has much to offer archaeology, and that it does no harm whatsoever to switch analytical scales on occasion (see Bettinger and Eerkens 1999; Shennan 2001).

In order to track evolutionarily significant technological changes, my initial case study identified mean values of certain important technological traits determined as significant through published experimental studies. These traits may or may not be affected

by optimising technological strategies related to specific prey-capture strategies employed by past populations using and depositing this technology. However, overall point size and wound infliction capability can be considered functionally important to the success of an individual and/or group over time, i.e. in certain environments these technical factors are potentially subject to selective pressure (see Hughes 1998). A linked suite of statistical techniques was employed to identify key metric attributes of the various assemblages so that explicit technological relationships could be demonstrated graphically. The aim was to distinguish technological traditions within and between the armature assemblages.

Method and Data

The lithic projectile points used in this study originate from two main types of blade technology. The first is that of indirect percussion, using a punch blade tool associated with a complex microburin technique to shape the individual projectiles, resulting in blades and subsequently microliths of a highly consistent maximum thickness. This technique is strongly associated with technology attributed to the Kongemose culture (cf. Fig.1 and Table 1). The second blade technology is less complex and is termed a hard hammer direct percussion technique, one that is used to detach blades from a core, resulting in generally thicker blades with characteristically less standardised microliths. This is a technology strongly associated with Late Mesolithic Ertebølle culture (Table 1; cf. Karsten and Knarrström 2003). It was anticipated that these differentiated reduction techniques would leave clearly different statistical signatures indicative of distinct technological traditions. More specifically, it was hoped that the cultural transmission mechanisms themselves, i.e. the ‘social learning’ mechanisms, could be identified in terms of Boyd and Richerson’s (1985) seminal work.

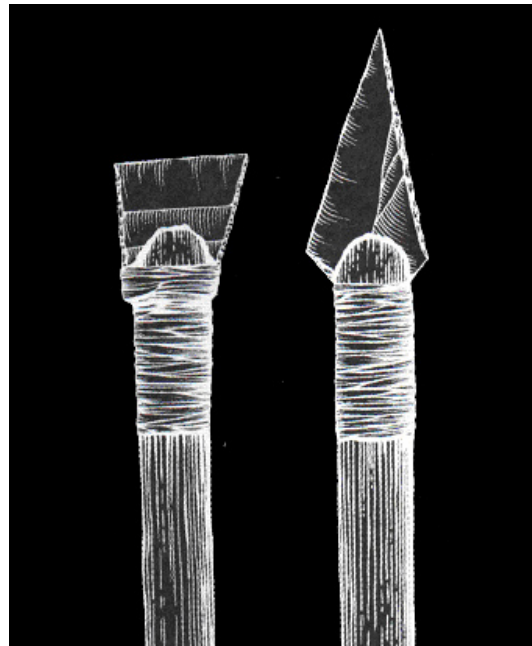


Figure 1. Hypothesised arrow-hafting method for ‘Kongemose’ phase arrowheads following Karsten and Knarrström (2003)

| | |
|--------------------------|------------------|
| Ertebølle Culture | Starts c.5500 BC |
| Kongemose Culture | Starts c.6400 BC |
| Maglemose Culture | Starts c.8900 BC |

Table 1. Approximate chronology for the case-study. Note that each culture-history phase has traditionally been subdivided further e.g., the Blak phase (starts c.6500 BC) is the first sub-phase of the Kongemose culture. Adapted from Vang Petersen (1999).

Extensive metric data were recorded from over 3600 Scandinavian microliths previously classified as arrowheads – all attributed to the Kongemose and Ertebølle cultures by the excavators. The data came from nine stratigraphically sealed phases from seven sites (Fig. 2). Each microlith was weighed, measured for maximum thickness and digitally scanned. A total of seven metric variables were recorded for each point, except in the case of one site, Blak II, where the metric variables were only available from scanned images. The bulk of the sites were attributed by the excavators to the Kongemose: Blak II was seen as a pre-Kongemose phase; one phase of the Tågerup excavations was related to the Ertebølle; and Tågerup SU6 was seen as an intermediate phase between the Kongemose and the full blown Ertebølle (Karsten and Knarrström 2003; Sørensen 1996; Vang Petersen 1979).

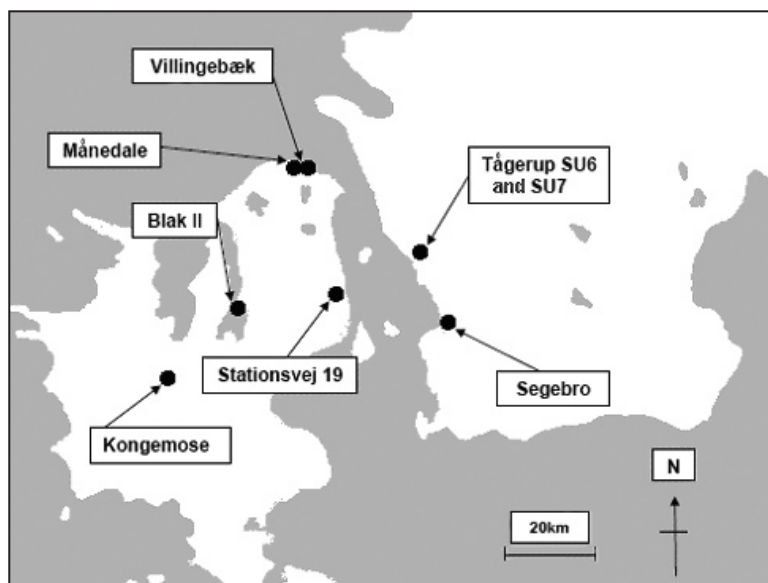


Figure 2. Schematic map of study area, showing the seven sites.

The point variables recorded for the statistical analysis presented below are detailed in Fig. 3 and consist of edge, base, long diagonal, short diagonal and internal angle measurements. With the previously obtained weight and thickness measurements, this gave a maximum total of seven continuous variables for each microlith. It is important to note that edge and base dimensions are arbitrarily named. It should also be noted that these measurements are not identical to those used by Vang Petersen for his original frequency seriation (Vang Petersen 1979, 1984). The internal edge angle used here is the angle that is made by measuring a straight line from the centre of the shortest external dimension on the point (named the base) down through the centre of the point in a lateral line to the centre of the opposite edge (named the edge), and by measuring the internal angle measured at the intersection of the line made by the edge with the lateral line – minus 90°. This differs from Vang Petersen's original method in that his base dimension is not always the shortest external dimension, as is the case here. This is im-

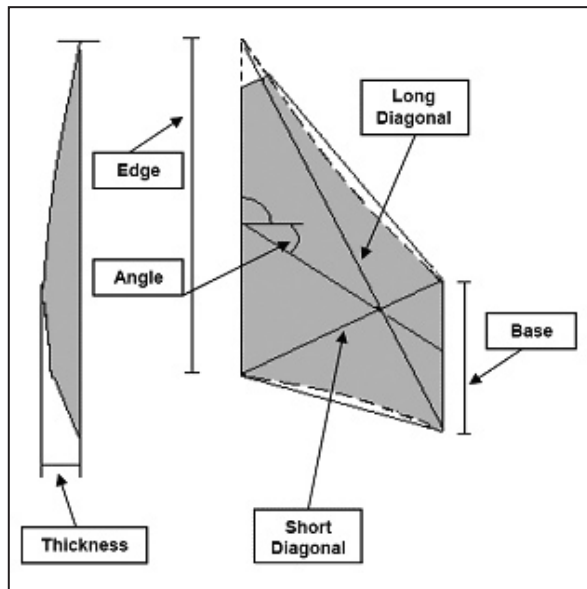


Figure 3. Schematic of point dimensions used for the study. The weight variable was also recorded.

portant because the location and position of the hafting element/base and ‘cutting edge’ could be counterintuitive, as functional analysis of the Tågerup assemblage arrowheads suggests that contemporaneous Blak II assemblage points may also be transversely mounted rather than obliquely mounted (cf. Knarrström and Karsten 2003).

A major problem was how to deal meaningfully with such a large amount of potential data from 3600 points sourced from nine Mesolithic sites, especially as assemblage sizes ranged from 34 points in the case of Blak II, to over 1400 in the case of Tågerup. The solution was to take a random sample of 30 virtually complete points from each assemblage, giving a representative total of 270 points from the nine sites. Point tips from this sample were often slightly chipped or broken, presumably due to taphonomic processes as well as impact damage. However, as overall shape was largely intact, perimeter dimensions were easily reconstructed from digital scans using *Adobe Photoshop*. Where the points were clearly damaged beyond simple reconstruction – and these were few in number across all assemblages – they were not used in the analysis sample. A large number of linked statistical techniques were employed to identify morphological variation (Edinburgh 2004); results from some of the key techniques are presented below.

Statistical Analysis

The first step was to run a series of descriptive statistics to identify technologically significant trends in the nine data assemblages. This determined how much variation there was in the distribution of each single point variable for each of the nine assemblages, and how much variation existed when assemblages were combined. Another aim was to determine whether or not individual point variables were normally distributed, as this could be of essential importance for choosing more complex multivariate procedures

(Shennan 1997: 92). Frequency distributions in the form of histograms of each variable for all the sites combined (270 points) were run on the data to determine whether any particular variable had a bimodal distribution indicative of a separate technological tradition. Of the seven variables from the combined nine-site sample, the most peculiar distribution was that of the angle.

The shape of the angle variable histogram (Fig. 4) demonstrated a largely bimodal distribution. This did not fit my initial expectations concerning the traditionally accepted lithic point shapes. The angle variable is particularly important, as the point types were determined by Vang Petersen (1984) largely by the 'obliqueness' of the internal angle, from which he subsequently classed rhombic (for Blak), oblique (for Kongemose) and transverse (for Ertebølle) arrowheads. Following Vang Petersen, one would therefore expect the angle distribution to show three rather than two peaks. It could be argued that there are three overlapping distributions shown in Fig.4, with peaks at about 5°, 30° and 40°.

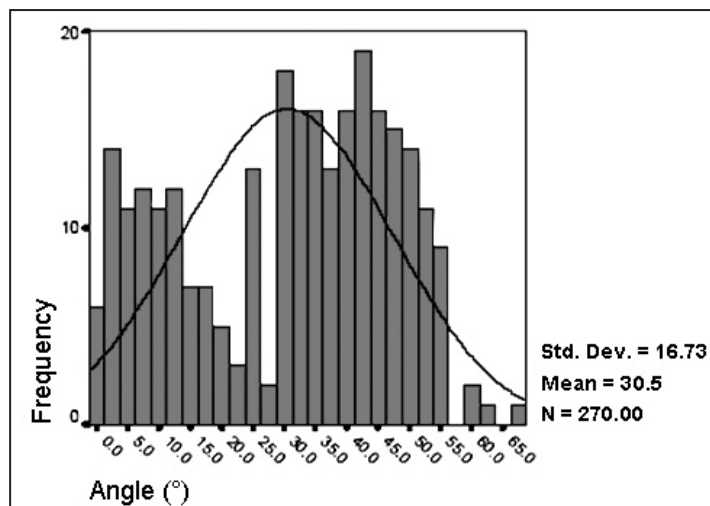


Figure 4. Histogram of angle variable for all armature samples in the nine case-study phases, showing a bimodal distribution.

To investigate these distributions further, each site assemblage was removed from the total in turn, and the total distribution frequency for the remaining angle variables was recalculated. When the Blak II, SU7 and Tågerup Ertebølle points were removed from the total assemblage, the result was a clear unimodal distribution. No other site, when deducted from the total point assemblage, altered the total angle's bimodal distribution. The Blak II, SU7 and Tågerup Ertebølle sites exhibited a unimodal dispersal for the angle variable. It seemed reasonably likely that the angle variable indicated whether or not an arrow is transversely hafted, so these three phases may share a common technological tradition of transverse arrowhead hafting. This assumption was strongly supported by lithic use-wear analysis carried out by Bo Knarrström (2001) on the arrowheads from the Tågerup assemblage that spanned all the chronological periods in

question. Knarrström concluded that where micro- and macroscopic evidence existed in the Tågerup arrowheads (point impact damage, haft impact damage and wood polish from the arrow-shaft), only the Kongemose phase arrowheads were obliquely hafted, whilst the Blak, Intermediate SU6 and Ertebølle phase arrowheads were all transversely hafted. As the Blak phase is much earlier than the Tågerup Ertebølle phase (Karsten and Knarrström 2003; Knarrström 2001), it was concluded that the less complex Ertebølle arrowhead was probably a later technological reinvention, closely related to a population bottleneck prior to the Ertebølle that resulted in loss of certain complex manufacturing traditions (Edinborough 2004). At any rate, there was clearly no simple linear technological progression from Early Kongemose to Early Ertebølle arrowhead manufacturing traditions.

To explore these ideas in the data, a series of 179 bivariate scattergrams was generated for the entire data set based on all possible pairings of all variables (Edinborough 2004). Interestingly, the results failed to show any consistent bivariate relationships across the phases, although certain relationships between size and shape were clearly more characteristic of some assemblages than others. All outliers were noted, although when checked against the original data no samples justified removal from the overall sample. Bivariate scatter plots were then constructed to establish mean values of the variables against each other. Multivariate statistics (principal component analysis and discriminant analysis) were then used to quantify the amount of variation in each variable. In other words, the mean amount of inter-assemblage trait variation was established. The time-averaged traits produced clear evidence of technological relationships between assemblages. The results were distinct, as mean values separated and grouped clearly (space restricts publication here; for results of full statistical analysis see Edinborough 2004: Ch. 5).

By way of summary, the Tågerup Ertebølle data was in every case separated out from a main cluster, often joined by Tågerup Intermediate and Blak II away from the central group of the remaining six phase-assemblages (Fig. 5). The six remaining phases, comprising Kongemose, Månedale, Tågerup-Kongemose, Stationsvej, Segebro and Villingebæk, remained homogeneous, with surprisingly little morphological variation. This supports a view of very similar technological traditions 'locked in' over a remarkable period of time, with at least a thousand years of technological stasis according to the results of Bayesian chronological phase-models (Edinborough 2004: Ch. 4). This remarkably long period of stasis within a highly complex technology could be explainable in terms of a socially constrained lithic tradition.

Figure 5 shows the confidence ellipsoids of the means of the variables at a 90% confidence level without the scatterplot data-points, leaving just the orientation and relative size of the ellipses visible. It is proposed that this is an excellent way of indicating inter- and intra-phase variation in the lithic technology, especially if there is clear stability over time in the lithic projectile morphology. There are distinctive differences between Blak II, SU7 and Tag Ertebølle, which are clearly separated out from the main cluster of six phases. In further contrast, they are orientated in the same direction compared to the results from the other six assemblages, which form a very tight cluster. This indicates

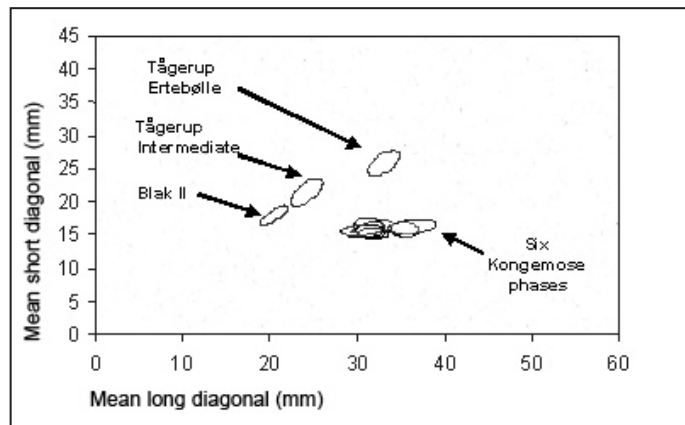


Figure 5. Confidence ellipsoids (confidence interval = 90%) for means of all nine arrowhead-assembly phases. Blak II, SU7, and Tågerup Ertebølle are clearly separated from the main Kongemose group of six phases which cluster together very tightly.

at least two distinct lineages of technological traditions. This is interesting, as different mean distributions may be seen at different times and places, and may indicate different traditions moving towards or away from an optimum technology given a constant selective environment. It is reasonable to suggest that, following Friis-Hansen's (1990) arguments, there is only one engineering optimum for each arrowhead shape, and that the Kongemose 'slashing' oblique shape is more functionally efficient for hunting large ungulates than the simpler, narrower transverse arrowhead. On the other hand, the transverse arrowhead may be a more optimal solution when hunting a wider range of prey types, as it costs less in terms of manufacturing and teaching time (Edinborough 2004). Another consideration is that of the population size relating to a given group of social learners, a possibility explored in part by Henrich (2004). Although lacking in empirical evidence, Henrich proposed that a population bottleneck in Tasmania resulted in the loss of certain complex fishing technologies, but with an increase in complexity in simpler fishing technologies. These possibilities were explored using multivariate statistics in my doctoral thesis and will be the subject of forthcoming publications. In conclusion, the time-stepped ellipse orientation (see Fig. 5) represents a useful technique for representing different traditions of lithic point technology for different assemblages, although these have to be qualified on a case-by-case basis, and be presented as testable hypotheses.

Summary and Discussion

This paper has quantified variation between the nine time-stepped arrowhead assemblages of Scandinavian Middle Mesolithic sites. Despite a large, randomised sample of points from all assemblages, the few outliers from the variables analysed by descriptive statistics suggest that the uniform nature of projectile points used in this analysis were correctly classified as arrowheads and were highly unlikely to come from other arte-

fact classes. The quantitative analysis of the point variables from the chronologically central group of the six Kongemose phases proved remarkably homogeneous (Fig. 5), indicating a common sphere of technological and social interaction. This constrained point-making tradition lasted for over a thousand years whilst exhibiting remarkably little variation, and is to my mind suggestive of an extraordinarily exacting social structure (Edinburgh 2004). The bimodal frequency distribution of the angle variable indicates that the Blak II, SU7 and Tågerup Ertebølle phases had a very different arrow-head fabrication tradition to the six-phase main Kongemose group. As Blak II blade technology was similar to the main Kongemose group of six phases, the Blak II phase is likely to be a technological precursor as suggested by Sørensen (1996). However, without assuming hafting orientation for the Blak II arrowheads, the morphological characteristics of this assemblage are clearly much closer to SU7 and Tågerup Ertebølle, suggesting an independent transverse innovation horizon for early Blak II phase points in support of Knarrström's (2001) conclusions from his use-wear analyses. It is worth reiterating that given a constant selective environment, using Friis-Hansen's (1990) Cutting Index as a guide, the slashing points found in the main Kongemose group of points are thought to be inherently more effective in hunting large ungulates than the Ertebølle transverse shapes. The implications of this performance difference for the different case-study population histories have been examined in my thesis.

In conclusion, this paper has sought to describe and explain some specific technological pathways by avoiding the fuzzy, teleological or at best 'black-box' methods adopted by many currently fashionable qualitative arguments. In contrast, a quantitative approach has been used to demonstrate the nature of specific technological relationships. The distinctive centrality of the 'Kongemose' phase-assemblage of arrowheads (Fig. 5) is highly indicative of a very stable complex cultural tradition, whose stability I would propose is probably due to a process of socially constrained indirect bias (cf. Bettinger and Eerkens 1999; Boyd and Richerson 1985). More importantly, at a general theoretical level, the loss of complex Kongemose traditions demonstrates that techno-cultural complexes are in no way inevitably 'improving', and that any classical ladder-like notion of cultural evolution, i.e. 'progress', is not just subjective, but wrong (Edinburgh 2004).

Accounting for technological evolution is clearly complex. It is acknowledged that key issues such as the relationship between absolutely-dated occupation phases and typology, prey-species and point morphology, climate and human/prey population levels are not addressed here. Perhaps the biggest archaeological challenge that remains is to explicitly explain multiple tool traditions in terms of their respective environmental and human population histories. My future research will focus upon exploring and comparing these fundamental issues at a variety of temporal, spatial and technological scales.

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