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Distinguishing stone age drilling techniques on ostrich eggshell beads: An experimental approach

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ABSTRACT

In this article we outline a statistical method for distinguishing ostrich eggshell (OES) beads perforated with a hand turned drill bit and those created with a hafted drill. This distinction has important implications for tracking past bead-making traditions across space and time, and for tracing the first appearance and spread of hafted drilling. Previous efforts to reconstruct the way in which beads were perforated have relied on a common sense approach, usually in combination with an experimental reference. However, without blind-test results or other metrics of reliability it is unclear how accurate these methods are. We argue that the quantitative framework described here provides a much needed answer to this question and helps to further systematize the process of bead analysis. We also define a set of terms which we hope will allow for a more standardized discussion of bead production signatures and techniques.

1. Introduction

Although it is impossible to know their precise meaning to those who made and wore them, archaeological beads were likely signals of status, prestige and beauty, as they are in contemporary societies. Beads first appeared in the archaeological record as non-standardized perforated aquatic shells that are thought to have been strung and worn suspended on the body (e.g., d'Errico et al., 2009; Henshilwood, 2007). The first deliberately shaped, standardized ornaments are ostrich eggshell (OES) beads that date to the end of the Middle Stone Age (MSA) (Miller and Willoughby, 2014), and which subsequently became common during the Later Stone Age (LSA) of eastern and southern Africa. While beads hold great scholarly significance because of what they represent in terms of human cognition and sociality they are also the products of a complex technological process, which is itself worthy of study.

The manufacture process of OES beads can be organized by archaeologists in a number of ways. One of the most common systems involves determining whether the shell was perforated prior to the shaping of the bead's exterior or after, otherwise known as Pathways 1 and 2, respectively (Orton, 2008). The actual act of perforating the shell, on the other hand, has received less attention. In theory, the perforation of OES can be accomplished using a variety of techniques including pecking (repeatedly tapping the OES with an implement), gouging (pressing an implement into the OES and using a scooping motion to scrape away the surface) or punching (using a small number of directed blows with significant force to push an implement through the OES). However, personal observation by JM indicates that the vast majority of Stone Age OES beads show evidence of rotary drilling, which involves rotating a sharp implement of some kind against the shell.

This article will therefore focus on the two forms of rotary drilling that are well known from ethnographic accounts of OES bead-making and Stone Age artifacts. The first form involves manually twisting the drill bit which is held in the hand, while the second relies on a rapidly rotating a hafted drill (e.g. Wingfield, 2003; Hitchcock, 2012; Marshall, 1976; Schapera, 1965; Stow, 1905). Unlike hand-drilling, we demonstrate that hafted-drilling is highly efficient and those equipped with this technology would have been able to drill large numbers of beads very quickly. The introduction of such specialized technology may have had important social implications such as the concentration of social capital amongst select groups or the establishment of craft specialists.

Nevertheless, the precise origins of hafted-drilling are unknown. In Africa and the Near East it is assumed to have been present by the early Holocene/late Pleistocene (Gorelick and Gwinnett, 1990; Gwinnett and Gorelick, 1998; Wright et al., 2008), while in China, Yang et al. (2016) have identified hafted-drilled beads dating to the early Holocene from the Shuidonggou site (see also Wei et al., 2017). Even so, it is possible that this technique has a much greater time depth, as both rotary-drilled OES beads and hafted tools originated much earlier in the MSA.

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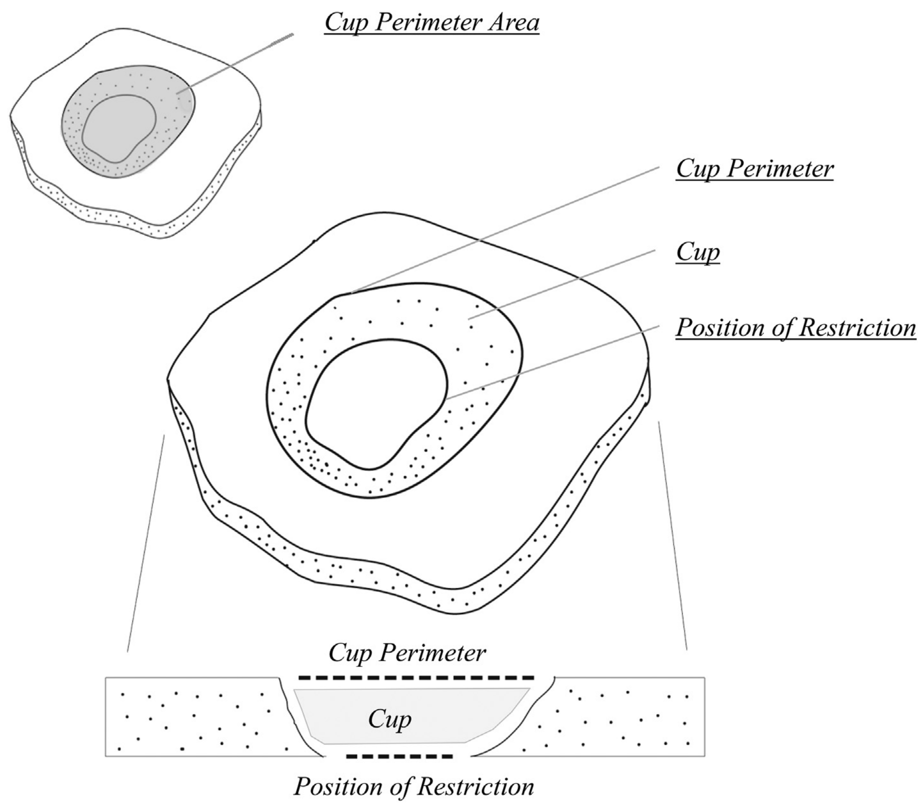

Fig. 1. Bead terminology.

It is also unclear which social, environmental and historical conditions might have stimulated the development and adoption of hafted-drilling. Resolving these questions would provide valuable insight into Stone Age technology and social life. However, many of the necessary analytical methods are either absent or lacking solid experimental validation.

Some experimental research has been devoted to the study of drilling, while only a few studies have examined the rotary drill impressions left on beads. Much of the existing literature has instead focused on the micro-wear traces left on experimental drill bits (e.g. Beyin, 2010; Coşkunsu, 2009; Kenoyer and Vidale, 1992; Unger-Hamilton et al., 1987; Yerkes, 1983). Other studies have attempted to replicate archaeological techniques by experimentally punch-piercing aquatic shells (e.g. d'Errico et al., 2005; Stiner et al., 2013; Tátá et al., 2014), and others have analyzed the efficiency of drilling with respect to variables like lithic material and shell heating (e.g. Arnold and Rachal, 2002; Nigra and Arnold, 2013). Only a handful of experiments have directly addressed the difference in aperture characteristics between beads drilled by a bit held in the hand and beads drilled with a composite tool such as a bow drill. These projects generally report that hand-turned perforations are irregular with asymmetrical/eccentric apertures (Coşkunsu, 2009; Gwinnett and Gorelick, 1991; Yang et al., 2016; Yerkes, 1983). Other characteristics which suggest hand drilling include the formation of striations that do not form complete circles (Coşkunsu, 2009), the presence of a notch within the aperture (Gwinnett and Gorelick, 1991), and the presence of “waving/fluting” inside the aperture (Yang et al., 2016).

This study builds upon previous work in a number of important ways. Firstly, most existing research relies upon a semi-systematic visual survey of the bead aperture, usually in conjunction with informal experimentation. While we do not doubt the value of such observations, these methods of bead differentiation are in some part subjective and rely largely on the skill of the analyst to be successful. Their comparability is also limited by a lack of standardized language to describe aperture characteristics. Perhaps most concerning, a blind testing program of bead drilling techniques has not been published, so it is uncertain how well these studies are actually able to predict drilling type. In any analytical field, particularly one that relies on subjective judgement, the importance of testing to validate potential methods cannot be understated (Eren et al., 2016; Evans, 2014). By making our results available this study provides a much needed experimental underpinning for existing and future research.

Secondly, we believe that dialogue between researchers could be improved by an attempt to systematize the language that is used to describe the anatomy of bead perforations. Having reviewed the literature, we therefore propose a synthesis of some terms that we hope will permit a more nuanced and mutually intelligible conversation about bead technology. We also supplement descriptions of features with detailed images to help limit uncertainty.

Thirdly, we present a statistical model capable of predicting drilling technique for OES beads on the basis of a short list of binary attributes. The method does not require expensive technology, and takes only a few minutes of assessment per bead, allowing for the analysis of a large sample. It also reveals the predictive power of these different attributes as they relate to drilling type. Perhaps most importantly, this method limits the subjectivity involved in visually distinguishing drilling types (though does not eliminate it entirely), increasing comparability and confidence.

2. Materials and methods

2.1. Terminology

Many disciplines within archaeology struggle with the challenge of effectively communicating research findings. The study of beads and bead-making is no different in this respect, and terms vary considerably between publications and sometimes lack precise definitions. Having reviewed earlier work on OES bead analysis (e.g., Jacobson, 1987a,