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The symmetry of handaxes from the Danjiangkou Reservoir Region (central China): A methodological consideration

Hao Li [a,*], Kathleen Kuman [a,b], Chaorong Li [c]

[a] School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg WITS 2050, South Africa
[b] Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg WITS 2050, South Africa
[c] Key Laboratory of Vertebrate Evolution and Human Origins & Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xizhimenwai Street, Beijing 100044, China

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ABSTRACT

In this paper, we present a three-dimensional (3D) quantitative approach to measure the degree of symmetry of handaxes from the Danjiangkou Reservoir Region (DRR), central China. Our analysis provides not only information on the bilateral symmetry, as most previous studies have done, but also on the symmetry of the profile view. The results show that the overall degree of symmetry of handaxes in plan view is much higher than for profile views in the DRR assemblages. However, the range of values for deviation from absolute symmetry for each specimen indicates that both plan and profile views possess great variability in symmetry. Comparisons of handaxes from two terraces (the Middle Pleistocene Terrace 3 and the early Late Pleistocene Terrace 2) demonstrate that the degree of symmetry did not increase over time in these two samples. Both the type of blank and the type of shaping play roles in determining the final degree of symmetry of the DRR handaxes. According to these results, we argue that there is no strictly imposed final symmetrical shape for the DRR handaxes, and the degree of symmetry is most likely related to some basic factors (e.g., bilateral and bifacial shaping and blank types). However, although a mental template for a preferred end product is absent, a conceptual standardization did indeed exist.

1. Introduction

Symmetry is a well-known characteristic of Acheulean handaxes, and various interpretations of why there is an imposed symmetrical form have been proposed by researchers. Some consider that basic factors, such as the size and shape of raw materials, the blank form, and the bilateral and/or bifacial flaking strategy, are linked to the symmetry of handaxes (Jones, 1979, 1994; Davidson and Noble, 1993; Ashton and McNabb, 1994; White, 1998; McPherron, 2000), while others think that functional adaptation, especially increased requirements for cutting and chopping in the Acheulean, would be the main reason for symmetry (Jones, 1980; Mitchell, 1996; Simao, 2002; Machin et al., 2007). In addition, some researchers argue that we should go far beyond these analyses and search for reasons in the social or cognitive context, e.g., strong social communication and learning (Mithen, 1994), sexual selection (Kohn and Mithen, 1999), aesthetic or symbolic sense (Pelegrin, 1993; Edwards, 2001; Reber, 2002; Pope et al., 2006; Hodgson, 2010, 2011), and cognitive ability (Wynn, 1995, 2000, 2002; Shipton et al., 2013; Hodgson, 2015).

No matter which explanation is preferred, they are all based on a conventional belief that symmetry of handaxes genuinely exists and can be applied not only to individual classic specimens, but also to handaxes in entire assemblages. However, we should bear in mind that this kind of belief is mainly built on subjective observations of classic or typical later Acheulean handaxes (Wynn, 1985; Mithen, 1994; Ambrose, 2001). Thus, measuring the degree of symmetry quantitatively, especially at the level of an assemblage, becomes crucial to support these beliefs. Moreover, a proper understanding of the symmetrical nature of handaxes is significant for China, as bilateral and bifacial symmetry of this type is considered to be a basic criterion in defining handaxes (see Gao, 2012 for the latest discussion).

2. Background: the study of handaxe symmetry

In order to objectively measure the symmetrical degree of handaxes, Saragusti et al. (1998) proposed a Continuous

* Corresponding author.
E-mail address: wits_ivpp@hotmail.com (H. Li).

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Symmetry Measure (CSM) approach and applied it to the study of three handaxe assemblages from Israel. The results show a generally increased trend in handaxe symmetry from the Early Pleistocene site of Ubeidiya to the Middle Pleistocene sites of Gesher Benot Ya'aqov and Ma'ayan Barukh. Nevertheless, the authors also argued that time is not the only factor affecting the degree of symmetry. Other factors, such as the nature of the raw material, are also important in determining the final shape. In addition, they noticed that even in Ubeidiya nearly symmetrical handaxes did occur, which may indicate that the ability of perceiving symmetry already existed in the earliest phase of the Acheulean (Saragusti et al., 1998). These two views, in our opinion, are instructive for our understanding of the nature of handaxe symmetry and the minds of Acheulean hominids.

To further test the change in handaxe symmetry over time, Saragusti et al. (2005) proposed an alternative quantitative method by using the 'tangent representation' in mathematics. In addition to the assemblages used earlier, they added two later Acheulean samples from the Tabun cave (bed 90 and Layer E) in Israel. Interestingly, the results show that the symmetry values of the two Tabun samples are actually close to the early Acheulean sample from Ubeidiya (Saragusti et al., 2005). This, in our understanding, indicates that the symmetry of handaxes is not strictly time-related but can have other causes influencing variability.

The two methods above were subsequently adopted by other scholars (Machin et al., 2007; Grosman et al., 2011). In addition to these, an Index of Symmetry was also proposed by Hardaker and Dunn (2005), Lycett et al. (2006) and Lycett (2008), although the calculation of this index was based on two different quantitative methods. Among them, the Flip Test proposed by Hardaker and Dunn (2005) is a simple and easily implemented method that uses photography and the calculation of pixels. Using the Flip Test method, Underhill (2007) re-examined one handaxe sample from the later Acheulean site of Cave of Hearths, which was previously subjectively studied using a 'By-Eye' measure by McNabb et al. (2004). Interestingly, Underhill's quantitative result confirmed McNabb et al.'s (2004) conclusion that symmetry was not a high priority in the production of handaxes at Cave of Hearths, although absolute symmetry did occasionally occur (Underhill, 2007). More recently, Cole (2011, 2015) systematically analyzed eight handaxe samples from British Lower to Middle Palaeolithic sites, with the ages of these sites spanning from MIS13 to MIS3. The results show that fully symmetrical handaxes in these assemblages from the later Acheulean onwards are actually at a consistently low level.

Overall, this brief overview demonstrates two main points: 1) for a better understanding of the nature of handaxe symmetry, we need to conduct more quantitative analyses; and 2) only then can the questions of a ubiquitously imposed final symmetrical shape of handaxes and an increased degree of symmetry over time be assessed. In this paper, we develop a three-dimensional (3D) quantitative approach to measure the degree of symmetry of handaxes from the Danjiangkou Reservoir Region (DRR), central China (Fig. 1). Traditional analyses have actually been two-dimensional, i.e., focusing on the lateral contours of a handaxe. However here, with the aid of 3D scanning technology, we can analyze symmetry from a three-dimensional perspective for the first time, i.e., focusing on the volume of a handaxe. In addition, our analysis provides not only information on the bilateral symmetry, as most previous studies have done, but also on the symmetry of the profile view. The meaning of a mental template in handaxe production is also discussed according to the DRR sample.

3. Materials and methods

The handaxe samples studied in this paper are from the Danjiangkou Reservoir Region (DRR) in central China (Fig. 1). Detailed technological analyses have shown both variability and commonalities of the DRR handaxes relative to western Acheulean examples, and we have argued that the Large Cutting Tools assemblage in DRR belongs to a true Acheulean techno-complex (Kuman et al., 2014; Li et al., 2014a,b). To reveal any potential temporal trend of change in symmetry, handaxes from the Middle Pleistocene terrace 3 ($N = 92$; 76 are surface-collected and 16 are in situ) and early Late Pleistocene terrace 2 ($N = 25$; surface-collected) of the Han and Dan Rivers in DRR are used; we recognize that the sample number from terrace 2 is relatively small (Liu and Feng, 2014; Li et al., 2014b; Pei et al., 2015).

Previously the ages of terraces 3 and 2 was mainly based on sedimentological observations and geomorphological context. The higher terrace 3 was considered to belong to the Middle Pleistocene, while the lower terrace 2 was known to be younger and was suggested to be of Late Pleistocene age. Recently, however, numericaldating methods were applied at some of the excavated sites on both terraces. The ESR, OSL and palaeomagnetic dating of the handaxe-bearing sites of Shuangshu and Maling 2A on terrace 3 have confirmed the ages of these two sites as Middle Pleistocene (Li et al., 2014b; Pei et al., 2015). Specifically, the age of Shuangshu is in the first half of Middle Pleistocene ($651 \pm 65 - 518 \pm 52$ ka; Li et al., 2014b), while the age of Maling 2A is in the second half of Middle Pleistocene ($386 \pm 30 - 221 \pm 20$ ka; Pei et al., 2015). The in situ handaxes excavated from the Shuangshu site are identical to the surface-collected samples on terrace 3 (Li et al., 2014b). For terrace 2, OSL and TT-OSL dating have been successful at the Dishuiyan site and obtained an age of ca 100–50 ka (Liu and Feng, 2014). More than 20 handaxes excavated from the site also confirm the provenance of the 25 surface-collected specimens used in this study.

With the use of 3D scanning technology, we attempt here to establish an alternative quantitative method to measure the symmetry of handaxes in both plan and profile views. Two types of 3D laser scanners, NextEngine and Range 7, were first used to capture 3D images of the DRR handaxes. Two steps, cleaning and merging, were carried out in this process. Cleaning aims to remove unwanted areas of a scan such as the platform used to support the tool. The purpose of merging is to build a complete 3D image from multiple scans of different portions of a tool. These images were then imported into Avizo Fire 3D Imaging Software to calculate the volume of a handaxe in its respective segments. A handaxe is segmented into two parts in both its plan and profile views based on the long axis, using the distal end as the guide for alignment. In Fig. 2, we present an example of how to orientate and segment a handaxe. The volume of each portion is then accurately calculated using the same software. The basic principle of our analysis is that the closer the volume value of each segmented portion is (in plan and profile views), the higher the degree of symmetry of the handaxe, and vice versa.

Pearson's correlation (r) was first used to estimate the overall degree of symmetry of handaxes in the two views and for the different terraces. In order to show the variable range of symmetry in a complete whole assemblage, we then converted the degree of deviation of a handaxe from complete symmetry into an absolute distance (D) value using the formula

$$D = \left| \frac{x0 - y0}{\sqrt{2}} \right|$$