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Measuring behavioural and cognitive complexity in lithic technology throughout human evolution

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ABSTRACT

Stone tool making, observed archaeologically from 3.3 million years ago, involves complex problem solving and forethought, but the relative complexity of different Palaeolithic technologies remains unknown. Decision making in replicative knapping is here used to explore the degree of behavioural and cognitive complexity involved in five different types of stone tool manufacture (bipolar, discoidal, biface, Levallois and prismatic blade) that represent the evolution of core reduction strategies from the Oldowan through to the Upper Palaeolithic. While some hypothesise that each key transition was marked by an increase in cognitive complexity, such hypotheses remain untested assumptions. Determining the level of behavioural complexity involved in each of these core reduction strategies using problem-solution distance modelling offers a means of detecting significant increases in the level of human cognitive complexity displayed over time. To directly test for differences in complexity among knapping schema, replication experiments were conducted by two highly skilled knappers. Experiments were filmed and the duration of different stages in the sequence was annotated. Hierarchical diagrams were produced showing the organisation of the different actions involved in stone tool knapping. The results show a pattern of increasingly complex behaviour through the sequence of bipolar, discoidal, prismatic blade, biface, and Levallois knapping. Neanderthals and their contemporaries, *Homo sapiens*, employed knapping technologies exhibiting comparably high levels of complexity.

1. Introduction

Recognising cognitive and behavioural complexity in the archaeological record is a key concern in palaeoanthropological research, typically with a focus on such traits as personal adornment, art, pigments, complex burials, carved bone, long distance exchange, use of adhesives, and complex projectiles (Henshilwood et al., 2009; Henshilwood and Marean, 2003; Mellars, 1991, 1989a, 1989b; Cain, 2006; Ambrose, 2010, 2001; Foley and Lahr, 1997; Klein, 1995; Marean et al., 2007; Thackeray, 1992; Wadley, 2010; Chase and Dibble, 1987; Milo, 1998; Clark, 1989; Deacon, 1989; McBrearty and Brooks, 2000; Langley et al., 2008). Such items are rare in the archaeological record however, hampering a geographically comprehensive and temporally deep perspective on cognition. The ubiquity of stone tools in the Palaeolithic record offers an alternative means of assessing cognitive complexity, but quantifying and comparing lithic behavioural complexity remains an elusive goal. This study investigates behaviour and cognition by examining the decision making involved in different types of stone tool manufacture, including bipolar, discoidal, biface, Levallois and prismatic blade core knapping (Fig. 1). These technologies broadly represent the evolution of lithic core technology from the Oldowan (c. 2.6 million years ago) to the Upper Palaeolithic (c. 50 thousand years ago).

Behavioural complexity is modelled in this paper via observations and analysis of footage of replicative knapping experiments conducted by two knappers familiar with each reduction strategy. By identifying the minutia of stages involved in these knapping sequences, and analysing these stages through the lens of concepts borrowed from neuroscience and psychology (discussed further below), the complexity of the decision making processes involved in the manufacture of different stone tools can be reconstructed. Behaviour is defined for the purposes of this paper as the actions undertaken by hominins, while cognition refers to the underlying brain functions that facilitate those actions.

To assess the behavioural complexity of different knapping tasks we use problem-solution distance modelling. Problem-solution distance modelling is based on the idea developed by Köhler (1925), that 'indirect thinking' plays a crucial role in complex tasks such as tool making. Indirect thinking involves setting aside an immediate desire or

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Fig. 1. Photographs of the replicative assemblage. Bipolar flakes showing diagnostic opposed crushing (A). Top and side views of a discoidal core (left) and a sample of discoidal flakes (right) (B). Early Acheulean style biface (left) and Late Acheulean style biface (right) (C). Preferential Levallois core (left) and associated flake (right) (D). Blade core (left) and removed blades (right) (E).

problem in favour of addressing a series of intermediate goals, the completion of which culminate in the satisfaction of the original desire (Köhler, 1925). This approach, pioneered in archaeology by Haidle and Lombard (Lombard, 2012; Lombard and Haidle, 2012; Haidle, 2009, 2010, 2012) is a means of reconstructing the number and nature of steps involved in complex technological tasks. The problem-solution distance is a measure of the conceptual distance between the perception of the original problem or need, and the final satisfaction of that need (Haidle, 2010). This method requires identifying and sequencing each step involved in overcoming a problem, meaning that the greater the number of steps, the greater the problem-solution distance. Simple knapping techniques with short operational sequences would therefore have short problem-solution distances and require less complex behaviour and cognition compared with more complex lithic technologies.

A key factor which heavily influences the magnitude of the problem-solution distance is the degree of hierarchical organisation involved in a process. Hierarchical organisation is the extent to which different component parts must take place in a particular order to achieve an overarching goal (Stout, 2011; Greenfield, 1991; Holloway, 1969). In hierarchical sequences, broad higher-order actions are divided into subordinate actions. The fulfilment of a set of subordinate tasks allows each consecutive superordinate task to be achieved until the overarching goal is accomplished. In Levallois technology for example, the faceting of a striking platform is a subordinate task