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The evolution and stability of stone tools: The effects of different mobility scenarios in tool reduction and shape features

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ABSTRACT

This work attempts to link two primary areas of focus in lithic technology studies today: shape and reduction analyses. We set out to determine whether a correlation could be found between tool shape and reduction stage in order to look for differences between different mobility scenarios and to test the strength of classical typological classifications based on the shape of the retouched segments of tools. Our study was conducted using materials from two culturally different sites, one dating to the Late Upper Paleolithic and the other to the Early Neolithic and our focus was on a single common tool class, endscrapers. Both sites are located in the same region, meaning that the hominins that inhabited them had the same opportunities for procuring locally abundant lithic raw materials. Geometric morphometrics and 3D-based reduction analyses were performed on the tools, and shape and reduction variables were cross-referenced in the search for any existing correlation between the two. Nomadic Late Upper Paleolithic groups exhibit a highly expedient tool management strategy, without shape maintenance, and considerable correlation was found between tool shape and reduction stage. Meanwhile, Early Neolithic groups left behind a curated assemblage, exhibiting shape maintenance and great reduction intensity. In this case, shape was found to be independent of reduction. Finally, we link these behaviors to different mobility strategies and raw-material transport costs, and consider the validity of exclusively typological approaches.

1. Introduction

The analysis of shape variation in prehistoric stone tools has been approached in a great variety of ways for as long as there have been archeological lithic studies. The shapes of prehistoric tools have been understood as a reflection of many different concepts, depending on the theoretical framework in which a particular lithic study was conducted. From classificatory approaches to dynamic interpretations, changes in the morphological features of tools have been linked to cognitive capabilities (Holloway, 1969; Gowlett, 2006), style (Lenoir, 1975; Tiffagom, 2003), cultural transmission (Lycett, 2008; Buchanan and Collard, 2010; Schillinger et al., 2014), mobility dynamics (Shott, 1986; Blades, 2003; Sellet, 2013), site function (Bachelleire et al., 2011), reduction (Dibble, 1984, 1987b; McPherron, 1995; Shott and Ballenger, 2007; Brumm and McLaren, 2011; Eren et al., 2013) and many other aspects of the behaviors of prehistoric peoples.

In the context of European research, typological classification has played a preeminent role in the explanation of shape differences in lithic tools. Classificatory approaches to prehistoric industries have proven very useful in distinguishing patterns of the presence/absence of certain tool types (e.g. Dufour bladelets, Solutrean points, microlithic implements), which act as chronological or cultural markers, traditionally called *fossile directeures*. Strict classification has also given order to specific shaping techniques (e.g. Quina retouch, Aurignacian retouch, Mesolithic abruptly retouched microliths versus Neolithic double-beveled microliths, etc.), which recur in specific chronologies. In addition to this broadly accepted convention, intra-tool-class shape variations have traditionally been used to establish regional dynamics, ethnicity and/or stylistic differentiation.

Nevertheless, interpreting the complete range of tool shape variation as a result of 'style' or 'cultural tradition' seems to be a simplistic way of understanding shape heterogeneity in lithic assemblages. If cultural traditions are established using the shapes of tools as a reflection of an established form, and established forms are the consequence of cultural traditions, then the concept is based on tautological or circular reasoning, restricting the interpretation of technological remains to being solely the products of culturally adapted prehistoric populations. Strict typological approaches tend to undervalue, or directly avoid, most of the constraints that condition tool production and management dynamics, i.e. raw material availability, quality and format, site function, and mobility, among others. On the other hand, a vast number of technological studies relate tool shape to some of these factors, and provide

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interesting correlations between morphology (size and shape) and, for example, mobility or raw material distribution (Andrefsky, 1994; Cowan, 1999; Blades, 2003; Eren, 2013; Jennings, 2013).

The gap between classificatory and organizational approaches becomes clear when reviewing some of the literature on the study of endscrapers, one of the most abundant Paleolithic and post-Paleolithic classes of stone tool. The most commonly used typological lists often attempt to distinguish between as many subtypes as possible within the same tool class (Sonneville-Bordes and Perrot, 1954; Fortea, 1973; G.E.E.M, 1975; Binder, 1987). Using this type of discretization, tools are classified based on technological patterns as well as on variations in shape and/or size. These shape variations focus mainly on two aspects: 1) the general shape of the object, related to the features of the shaped blank; and 2) the specific shape, related to variations in the morphology of the retouched segment.

These different methods of approaching variation in stone tool shape might be summarized as dynamic or static, depending on the importance given to continuous shape variation during the reduction process or to discretized stone tool forms. However, these must not be understood as mutually exclusive views. Shape can be independent from reduction in highly curated technologies, when shape is highly adapted to the performance of a specific task or when it is some kind of cultural manifestation of "random cultural effects" (Loviţă, 2009). In this case, function and shape exhibit convergent trajectories along the reduction process, and the latter might then be constant. On the other hand, shape may also be reduction related. In tools with an undetermined shape, it might be expected that function overcomes form, giving rise to shapes that vary to a greater or lesser extent over the course of the tool's life cycle. These two scaling directions have been called allometric versus isometric reduction trajectories (Loviţă, 2009, 2010, 2011). When isometric reductions are documented, shape is constant throughout the reduction process, and there is intentional maintenance of a specific shape. Assuming that all the configured shapes are adequate in terms of functional efficiency, then style, culture or tradition could be inferred from the maintenance of one specific morphology or another.

In lithic studies, shape analyses have traditionally been applied to shape-standardized tools such as handaxes (e.g. Saragusti et al., 2005; Lycett et al., 2006; Lubell et al., 2007; Shott and Ballenger, 2007; Loviţă and McPherron, 2011; Lerner, 2015) or projectiles (e.g. Buchanan and Collard, 2010; Loviţă, 2011; Charlin et al., 2014; Gingerich et al., 2014; Okumura and Araujo, 2014). In contrast, reduction approaches have focused (primarily but not exclusively) on unifacially retouched stone tools, primarily scrapers *sensu lato* (e.g. Dibble, 1987a; Kuhn, 1990; Shott, 1995; Shott, 1996; Hiscock and Attenbrow, 2002, 2003; Eren et al., 2005; Shott and Weedman, 2007; Eren et al., 2013; Morales et al., 2015). This work attempts to link shape and reduction analyses in order to test for relationships between the shape of a tool and its reduction stage. To that end, we selected two endscraper assemblages from two different cultural and economic scenarios, the Late Upper Paleolithic (LUP) and the Early Neolithic (EN), recovered in the same region with the same lithic resources, and with the same documented regional procurement behaviors. Assuming equal possibilities for raw material provisioning, the inference would be that the background of shape variation is related to technological organization and not to adaptive strategies to different environments. Within the same geographical area, differences between the LUP and EN assemblages must be derived from different cultures, subsistence strategies and mobility patterns. LUP groups are characterized as highly mobile foragers who exploited both coastal and inland resources, while EN groups where sedentary farmers with a developed agricultural system and surplus accumulation strategies. As has been proposed elsewhere (Binford, 1979; Kelly, 1992), different mobility strategies should result in different technological structures and organizations. So, the motivation of this work is to explore the relationship between reduction and shape in a specific tool class using as a proxy two lithic samples from different cultural groups that had the same environmental opportunities. As mentioned earlier, we assume that technological organization and tool reduction must differ in response to different mobility and economic structures. Within this context, technological organization and tool shape must vary in different directions depending on whether shape maintenance is intentional or not, and according to this, shape must appear as a reduction-related phenomenon if an imposed shape is absent or as a reduction-independent phenomenon if a stable shape is deliberately sought.

In order to explore and test this possibility, we developed a systematic approach using the tool shape analysis provided by geometric morphometrics (Bookstein, 1991) and the curation and reduction gauges provided from technological analyses.

2. Materials and methods

2.1. Site and sample selection

The geographical framework chosen for this work is the coastal and pre-coastal geological region of Tarragona in southern Catalonia (NE Iberian Peninsula), which is known for its abundance of medium to good quality flint outcrops (Soto et al., 2014) (Image S1 and Text S1), which have been greatly exploited by human populations since the Lower Paleolithic (Vallverdú et al., 2014). We selected this area based on the assumption that if the presence of raw material in the territory is high, either in primary formations or in secondary procurement areas, then a local/regional range procurement behavior and a lesser influence of remotely acquired materials would be expected, which might result in different raw material management and curation patterns. This almost exclusive local/regional raw material procurement behavior has been documented in all of the excavated archeological sites in this area, regardless of their chronology (Mangado, 2002; Fullola et al., 2007; Soto et al., 2011; Vaquero et al., 2012; Morales et al., 2013; Vallverdú et al., 2014), with the only exception being perhaps Bronze Age funerary sites containing grave goods knapped from exotic raw materials (Clop et al., 2006).

For this study, two endscraper assemblages from recent excavations were selected from the sites of the La Cativera rock shelter as a LUP sample (Morales et al., 2013) and El Cavet as an EN sample (Fontanals et al., 2008). The La Cativera rock shelter contains a nearly two-meter thick succession of Bølling-Allerød–Younger Dryas–Early Holocene occupations. El Cavet is a 7th millennia cal BP open-air Neolithic settlement in which both storage pits and occupation areas have been uncovered (see Table 1 for chronological information on the cultural horizons). The selection of the EN site was conditioned by the relatively lesser abundance of endscrapers found at EN sites compared to LUP sites. From the various old and newly excavated Neolithic sites, only El Cavet has yielded a significant endscraper sample. On the other hand, LUP sites are characterized by a typological distribution in which endscrapers and backed projectiles are the dominant tools.

2.2. Lithic assemblages

The available sample consisted of 129 endscrapers from the LUP site and 63 from the EN site. 100% of both assemblages were knapped on regional chert (Fig. 1). We analyzed the shape and reduction of all of

Table 1
AMS ^{14}C data for the La Cativera Late Upper Paleolithic and El Cavet Early Neolithic occupations.

Site	Level	Lab. Code	Sample	BP 14C Age		SD
Cativera	B	AA-23368	Charcoal	8860	±	95
Cativera	B	Beta-281623	Charcoal	8230	±	40
El Cavet	UE2014.1	Beta-222342	Charcoal	6620	±	60
El Cavet	UE2014.2	OxA-26061	Seed	6536	±	36
El Cavet	UE2012.2	OxA-25802	Seed	6440	±	40