Journal of Paleolithic Archaeology
https://doi.org/10.1007/s41982-020-00060-7

Moving on from Here: Suggestions for the Future of "Mobility Thinking" in Studies of Paleolithic Technologies

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Published online: 27 August 2020

Abstract

Beginning in the early 1990s, the theme of mobility became central to many studies of Paleolithic lithic technology. Models relating group movements to the design, production, and treatment of stone artifacts have been widely employed both to explain features of Paleolithic assemblages, and as a source of information about the ecology of Pleistocene foragers. However, many of the questions that "mobility thinking" was originally adopted to answer are no longer at the center of inquiry in Paleolithic research. To remain relevant to new research agendas, new approaches to mobility and lithic technology should be developed. In keeping with the theme of this special issue, this paper discusses three areas where relatively simple changes in theory and practice could help to integrate "mobility thinking" into emerging research questions of broad, cross-disciplinary relevance: these include territories and ranging patterns, social networks, and intra-group variation in mobility.

Keywords Mobility · Hunter-gatherers · Territoriality · Social networks · Cooperation

Mobility is central to the lives of hunter-gatherers. Hunter-gatherers solve many social and economic problems simply by deciding where, when, and with whom to move. These movements can occur at many scales. People might facilitate sharing simply by shifting their hearth a few meters closer to that of a close friend or relative. At the other extreme, people could respond to local resource shortages or social tensions by picking up and moving into an entirely different region. But what most anthropologists and archeologists have in mind when they discuss hunter-gatherer mobility are intermediate scales of movement—daily, weekly, or seasonal displacements within a regular foraging territory.

This article belongs to the Topical Collection: *Old Stones, New Eyes? Charting future directions in lithic analysis*
Guest Editors: Marie Soressi and Shumon Hussain

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Beginning in the early 1980s, archeologists studying ancient foragers began to incorporate ideas about mobility into their thinking. A large part of the inspiration came from a series of highly influential papers synthesizing evidence about mobility among recent hunter-gatherers (Binford 1976, 1980, 1982; Kelly 1983, 1992). This work showed how the movements of forager groups varied somewhat predictably according to the structure of habitats and the availability of resources in time and space. The next phase of publications proposed models for how the movement of foragers as individuals and groups could influence the designs and life histories of artifacts and the ways assemblages formed (Binford 1976, 1979; Kelly 1988; Kelly and Todd 1988; Kuhn 1992, 1994; Nelson 1991; Shott 1986). This work reflected the widespread recognition that the characteristics of artifacts deposited at a site do not just tell us about what went on at that site: they also carry signals of events and processes unfolding in other parts of the landscape. When considered in the light of mobility, features of artifacts and assemblages could provide information about landscape use, foraging, group sizes, and other elements of behavior in the remote past.

Three or four decades on, "mobility thinking" in a general sense has become a fundamental part of research on Paleolithic hominins (e.g., Féblot-Augustins 1997a, b; Kuhn 1995; Turq et al. 2013) as well as more recent hunter-gatherers. Terms such as logistical and residential mobility, curated and expedient artifacts, "procurement zones," and technological provisioning have entered the everyday lexicons of many Paleolithic archeologists. It is now even possible to make systematic comparisons between different times and places or different hominins, such as in the seminal work of Féblot-Augustins (Féblot-Augustins 1997a, 1999, 2009; see also Layton et al. 2012). Meanwhile, ideas about how and why foragers move have been re-evaluated and expanded (Churchill et al. 2016; Grove 2009; Grove et al. 2012; Morgan 2009; Whallon 2006).

The incorporation of mobility thinking into lithic studies has provided many novel and important insights into the behavior of Paleolithic humans. At the same time, this success carries significant risk. Entering the third decade of the twenty-first century, ideas about mobility and its influence on lithic technologies are widely, routinely, and sometimes uncritically applied to a range of archeological questions. The focus on forager mobility in the 1980s and 1990s was part of a broader effort by a diverse group of researchers to move archeological explanation away from ethnic differences as the primary source of variation in material culture, and towards consideration of ecological, economic, and environmental influences. That battle is largely over. Today, some researchers are asking how we can go beyond "mere" adaptive or ecological explanations. Unwarranted assumptions about the simplicity or profundity of different kinds of causal explanations aside, it is inevitable that Paleolithic archeology, and human evolutionary studies more generally, have moved on to face new problems, to seek answers to different kinds of questions. To remain relevant, mobility thinking needs to show how it can contribute to resolving some of the emerging questions in Paleolithic studies.

Fortunately, movement at different scales remains central to many key issues in human evolution (Churchill et al. 2016; Hamilton et al. 2016; Kuhn et al. 2016), and indeed evolution more generally (Nathan 2008; Nathan et al. 2008). In this paper, I discuss three areas where mobility thinking can continue to advance Paleolithic archeology and, in the process, contribute to answering larger scientific questions. I

emphasize areas where archeologists can play a role in broader inquiries that cross disciplinary or sub-disciplinary boundaries. The greatest potential for scientific and intellectual growth can be found in questions which interest researchers from different fields. None of these directions is exactly new—some researchers are already working on similar problems and have been for some time. But they could be developed further. And none demands major technical advances. What they do require is that we rethink certain ideas and approaches. The three areas suggested for expanded inquiry are as follows: (1) territories and ranging patterns; (2) (re)construction of social networks; and (3) intra-group variation in landscape use.

This paper focuses on questions that arise from evolutionary and ecological perspectives on the Paleolithic past. Researchers approach the study of Paleolithic artifacts from many different perspectives. Ancient artifacts can be understood as evidence for environmental adaptation, as expressions of cognitive abilities or tendencies, as tokens of social relations, or as traces of individual expression, agency, or resistance. I adopt an evolutionary perspective because it is well suited to the coarse temporal grain of the record of Pleistocene archeology, and because it fits best with the phenomenon of mobility, the topic about which I was asked to write for this special issue. Not coincidentally, this way of thinking is also amenable to my own knowledge and background.

Territories and Ranging Patterns

Biological anthropologists see movement as a key influence on human evolution. Changes in locomotor efficiency are well documented in the fossil record. The origins of bipedalism, the origin of the genus *Homo*, the appearance and success of *Homo habilis/Homo ergaster*, and the dispersal abilities of various hominins have all been linked to changes in locomotor efficiencies and indirectly to patterns of movement (Aiello and Key 2002; Antón and Swisher 2004; Bramble and Lieberman 2004; Jungers 2009; Kuhn et al. 2016; McHenry 1994; Pontzer 2012; Pontzer et al. 2009; Steudel-Numbers and Tilkens 2004; Wang et al. 2004). Movement is important because it provides the essential link between anatomy and ecology. Terrestrial animals need to move in order to find food and water. Diet and trophic levels directly influence foraging rages and the sizes of territories among humans and other terrestrial animals (Churchill et al. 2016; Gittleman and Harvey 1982; Hamilton et al. 2016; Hamilton et al. 2007a, b; McNab 1963; Tucker et al. 2014), so changes in what hominins ate and how they got their food should be reflected in habitual movement patterns. Holding group size and environmental richness constant, foragers who focus on mobile large game typically utilize relatively large foraging ranges, whereas foragers with broader, more diversified diets often use smaller territories and practice more restricted movement at a landscape scale (Binford 2001; Hamilton et al. 2007a; Kelly 2013). For similar reasons, the sizes of foraging groups also influence how individuals move across landscapes. The relevance of territory sizes and scales movement is not restricted to early time ranges: it is easy to imagine how these phenomena are implicated in hominin dispersals into new environments (Kelly 2003; Kelly and Todd 1988; Morgan 2009) and interactions with populations already there.

The importance of scales and patterns of movement in human evolution raises the question of whether archeologists can reconstruct foraging ranges and/or territories. In

fact, not only can we do it, we are the only scholars in a position to do it, and we have made considerable advances already. Systematically combining two common analytical approaches to Paleolithic assemblages—mapping lithic raw material acquisition and studying patterns of raw material provisioning—should produce comparable data related to foraging territories in different times and places.

The term "territory" needs to be clarified here. We can recognize different kinds of human territories (Binford 1982; Dyson-Hudson and Smith 1978; Zedeno 2014), according to the interval of time and the activity or currency under consideration. The kind of territory I am concerned with here, and which concerns many other scientists interested in human diets and movements, is roughly equivalent to "foraging territory." It refers to the parts of the landscape an organism or a group of organisms regularly visits in the course of searching for food. It is crucial in this context to differentiate between territory and territoriality. The latter term carries an implication of some form of boundary defense—an organism exhibits territoriality when it makes an effort to control access to a particular patch of ground or set of affordances (Burt 1943; Cashdan 1983; Hill et al. 1983; Peterson 1975). Hominins and other animals can utilize territories—indeed they must do so—without being actively territorial (Codding et al. 2019; Dyson-Hudson and Smith 1978; Hill et al. 1983; Peterson 1975).

The first step in establishing the sizes and shapes of territories is to determine what parts of the landscape hominins visited. In deep time, such information comes mainly from displacement of lithic raw materials. Stable isotopes of Sr and other elements can provide some clues as well (Alexander Bentley 2006; Budd et al. 2004; Rubenstein and Hobson 2004), but the spatial and temporal resolution are limited: stable isotopes are ideal for detecting changes in territory over an individual's lifetime but less useful for understanding seasonal or daily movements. Moreover, research on raw material procurement is by now a routine part of many Paleolithic projects. Where the local raw material environment permits, source attribution may provide a very detailed picture of where hominins procured different sorts of stone and how far they were prepared to move stones.

As Lucy Wilson and others (Aubry et al. 2012; Browne and Wilson 2013; Heasley 2015; Moreau et al. 2015; Wilson 2007b) have established, just knowing where stones came from is not sufficient. The first generation of lithic raw material studies treated environments as featureless plains: distance-to-source was used as a direct measure of the time and effort people expended in procuring good stone for making tools (Wilson 2007b). But of course, most landscapes are not featureless plains. Topographic features such as slopes and physical barriers may constrain or channel movement. Fortunately, tools such as geographic information systems (GIS) and digital elevation models (DEM) make it possible to produce models of modern and ancient landscapes that capture key aspects of the ways people might have experienced them in the past. These digital tools allow researchers to propose much more realistic maps of potential utilized landscapes, including least-cost-pathways between sites and sources of stone, and to map potential ranges of travel from particular localities based on time rather than straight-line distance (Browne and Wilson 2011, 2013; Delpiano et al. 2018; Wilson 2007a).

In fact, a number of researchers have addressed varying scales of mobility and territory sizes in both the Eurasian and Paleolithic (Bernard-Guelle 2005; Féblot-Augustins 1997a, 2009; Layton et al. 2012) and the American Paleoindian periods (Carr 2017; Ellis 2011; Smith 2010; Stothers 1996). For the most part, these ambitious

studies focus on a limited array of data, such as maximum transport distances, and/or a limited array of artifacts, particularly projectile points. There are good practical reasons for doing this: such information is widely available, enabling broad comparative studies. Still, maximum transport distances and projectile points tell us only part of the story (Bamforth 2009). The fact that a sourced raw material is present in a site tells us only that people went somewhere, or knew someone who went there, not how regularly and why they went (Kelly 2011; Newlander 2018). To get a better idea about the regularity of visits to particular places and the effective distance of raw material movements, which are better indicators of foraging ranges, we need to look more closely at what was moved, and at the spatial scales of strategies for managing raw materials.

The raw material zones identified by Geneste in the 1980s (1985, 1988, 1992) represent a fundamental contribution to this endeavor. Working with admittedly simple models of landscape, Geneste identified three concentric "zones" in the exploitation of lithic raw materials by Middle Paleolithic hominins in southwest France. Materials obtained within a few kilometers of a site typically dominated Middle Paleolithic assemblages in Generste's study area, and these types of stone were characteristically represented by the full range of products and byproducts of manufacture. These indicators show that nearby stones had been collected quite regularly, and that they had been brought to the site in an unprocessed state. Raw materials from more distant sources, more than 20 km away, were normally much scarcer and were typically present only as heavily modified "finished" tools or other presumed end products such as Levallois blanks. Raw materials from the intermediate area were typically present in intermediate frequencies, and were represented by both end products and byproducts, particularly cores that had been prepared before being carried to the site.

Theoretical and ethnographic models of field processing (C. Beck et al. 2002; R. Beck 2008; Lupo 2006; Metcalfe and Barlow 1992) show that decisions about whether to remove low-utility parts of a resource will depend on the cost of transport, which is strongly influenced by the distance between point of procurement and point of consumption, as well as the relative values of time spent in the field vs. in camp. Thresholds of reduction and processing such as those identified by Geneste indicate where costs increased as a consequence of habitual movement. Marked increases in field processing, exemplified by differences in the treatment of materials from each of Geneste's zones, should be indicative of cost thresholds. Raw materials that are both abundant and show signs of being reduced on site were probably collected and transported at very low cost. Assuming that a good deal of (though not all) raw material procurement was "embedded" in other activities (Binford 1979), these rocks are likely to have come from areas regularly visited by hominins, sometimes in the context of seeking other resources. Types of stone that show intermediate (or variable) levels of processing probably came from localities that were occasionally visited, but that lay far enough away from the site in question to force decisions about field processing. Rocks from the third zone, rare and rarified, are less clearly indicative of territories: they may be better indicators of individual ranges or even social networks (see below).

Geneste's original study proposed radii for each of the three zones. But his work represents just one place and time. The sizes and shapes of raw material zones, the points of inflection in patterns of procurement and processing, should vary from place to place. They will be influenced by habitual mobility and ranging patterns as well as the nature of the raw material environment. This is the key to understanding changes in

foraging ranges and territory sizes. The sizes of zones from which raw material was commonly procured and transported in an unmodified state should be indicative of, though not isomorphic with, the sizes of foraging territories. If people regularly carried materials to a site in bulk from sources 50 km away, it is safe to assume that they were often close to those sources. If on the other hand raw materials from more than 10 km away are very rare in an assemblage, it is likely that the people who produced those artifacts seldom ventured out farther than that during normal foraging activities. The sizes and shapes of the intermediate zones are more likely to be shaped by a combination of topography and the distributions of other resources, which would concentrate hominin activities in specific parts of the territory.

These principles are already embodied in the common habit of labeling lithic raw materials local or non-local (or exotic). In practice, if a particular raw material is abundant and represented by a full range of débitage products, meaning that it was transported in a raw state and worked in situ, we often consider it "local" (Andrefsky 1994). If on the other hand a particular material is scarce, and is represented mainly as the end products of reduction—shaped tools and/or selected blanks—we are likely to consider it non-local or "exotic." It is also obvious that the distance thresholds used to distinguish local and exotic materials vary by orders of magnitude. In Geneste's studies of Middle Paleolithic, any material coming from more than 15–20 km of a given locality would fit Andrefsky's definition of "exotic." By contrast, in late Upper Paleolithic of Eastern Europe or the early Paleoindian period in North America, raw materials collected from within 50 km, or even 100 km, of a site may appear "local" based on their abundance and treatment (e.g., Amick 2010; Féblot-Augustins 1997a). Such contrasts in the scaling of distinctions between local and exotic, the distances over which people shifted strategies of raw material transport and processing, provide first-order approximations of patterns of habitual movement and sizes of foraging territories in different times and places.

In fact, several research teams have already begun to address more subtle dimensions of mobility patterns and range sizes using a range of lithic evidence, especially at Middle Paleolithic sites (Chacón et al. 2007; Ekshtain et al. 2016; Fernández-Laso et al. 2011). Still, it will not be possible to study territory sizes by looking for shifts in the treatment of raw materials in every location. The efficacy of this approach is strongly dependent on the local raw material environment. The ideal situation is one in which multiple sources of stone, easily differentiated and roughly equivalent quality, are situated at a range of distances from the site in question: this describes Geneste's research area for example. In geological contexts with fewer or less easily distinguished sources, the patterns will be less clear. And the whole program becomes more difficult as time depth increases and landscapes and raw material sources become less accessible. Nonetheless, results from the limited number of comparative studies done to date suggest that research on raw material exploitation, guided by careful attention to differential processing and transport, can provide important and unique insights into movement patterns and territory sizes of Paleolithic hominins.

Social Networks

Natural and social scientists have become increasingly aware of the importance of networks of relationships in structuring ecological and evolutionary dynamics (Borgatti

et al. 2009; Economo et al. 2008; Fontaine et al. 2011; Gray et al. 2010; Torney et al. 2011). Stimulated by the insightful work of Gamble and colleagues (Foley and Gamble 2009; Gamble 1996, 1998; Gamble et al. 2014), this realization has extended to researchers studying the Paleolithic (Barton et al. 2007; Kobayashi et al. 2016; Kuhn 2012; Marwick 2003; Stiner 2014; Stiner and Kuhn 2006; Uthmeier 2016; Whallon 2006). Social networks are vital to the lives of hunter-gatherers. They can be sources of material, mates, and perhaps most importantly, of information (Fitzhugh et al. 2011; Hamilton et al. 2007b; Whallon 2006; Wiessner 1977, 1986; Winterhalder 1996). Social networks are also the insurance policies of hunter-gatherers. The web of inter-personal ties structures an individual's ability to call on others for assistance, or to obtain access to resources or territories to which he or she is not normally entitled (Wiessner 1977, 1982, 1986). The larger and more extensive an individual's network is, the better he or she is protected from local environmental fluctuation and other unpredictable challenges. Some researchers have argued that *Homo sapiens* maintained large social networks as they dispersed across Eurasia, and that this provided an advantage over more parochial hominin groups (Burke 2012; Gamble 1998; Pearce and Moutsiou 2014).

Thinking about social networks is as important to studies of cultural transmission and evolution as it is to studies of ecology. Social networks are the medium across which ideas flow—they make inter-group cultural transmission possible. Relationships between people spread across the landscape determines whether how far and how fast ideas can move. The sizes of "cultural populations" are effectively determined by the sizes of social networks, meaning that networks may also affect rates and patterns of cultural evolution (Baldini 2015; Barrett et al. 2012; Derex et al. 2018; Henrich 2004; Shennan 2008; but see Vaesen et al. 2016)

Among foragers, social networks are typically created and maintained by the circulation of objects, through what we conventionally call exchange. But this is not trade in the sense of value exchanged for value. The goods which circulate in Hxaro (Wiessner 1977, 1982) and similar exchange or gifting systems are mainly tokens of relationships. They are not intrinsically valuable. Their value comes from the relationships they represent (Mauss 1954). Because the flow of objects and materials creates and maintains the structure of many social networks, archeologists believe that they can use the movement of objects in the past to trace the scale and topology of a network. So, for example, increasing scale in the movement of obsidian and other raw materials is sometimes cited as evidence for expanding social networks in the later MSA or Upper Paleolithic (Ambrose 2012; Blegen 2017; Brooks et al. 2018; Marwick 2003; McBrearty and Brooks 2000; Pearce and Moutsiou 2014; Stiner and Kuhn 2006). And this may be true. But it raises a familiar challenge, namely distinguishing exchange of objects from direct procurement and other processes that help things move around forager landscapes (Kelly 2011; Newlander 2018). How do we know that an object moved from source to resting place because people handed it off one to another, as opposed to moving in the pockets or packs of individuals going about their normal lives? Because value is not intrinsic, and because we are dealing with mobile people, well-known generalizations about the material signatures of different kinds of exchange (e.g., Renfrew 1975) may not be useful.

One way forward in this area is to focus on what was moved, in what form and how it was transformed along the way. Below are some simple propositions which could be evaluated using controlled archeological data or ethnographic information.

1. Direct procurement of stone for the purposes of provisioning places with raw material is expected to focus on tool-making potential, rather than finished artifacts (Kuhn 1992, 1995). Consequently, it is more likely to result in bulk movement of unprocessed or processed raw material. Distance effects should be clearly expressed as fall-offs in quantity, and increases in field processing (C. Beck et al. 2002; R. Beck 2008; Metcalfe and Barlow 1992) in correlation with distance from source. As discussed in the previous section, if the source is comparatively close to the point of consumption, we can predict evidence for movement of minimally processed materials, with a wide variety of products and byproducts represented at the point of consumption. For sources at intermediate distances, we expect field processing (removal of low-utility parts) and a focus on moving high-utility objects such as cores.
2. Displacement of objects occurring as a consequence of individual mobility—things transported as parts of mobile toolkits or personal gear—should be identifiable through the life histories of artifacts. Such artifacts are carried and used over long periods of time, and this should be reflected in high levels of reduction, reworking and repurposing of artifacts. Moreover, all other things being equal, the amount of reworking or resharpening should be at least weakly correlated with the distance between the locus of procurement and the point of discard. Objects that form part of transported, individual gear normally do not travel in a straight line from source to the location of discard. However, in the absence of other indicators, distance to source is the best proxy for time in use.
3. Exchange relations and personal networks should be represented by movement of different kinds of materials and different kinds of life histories. Based on ethnographic cases, we can predict that exchange relationships will be created and maintained through circulation of specific kinds of "finished" goods, such as points or blades. There may be fall-offs in quantity with distance. However, under some conditions, people may preferentially seek out strategic social connections with more distant individuals (Kelly 2013: 145) so distance-decay relationships may be irregular or even negative. On the other hand, goods that moved across exchange networks should not have been used extensively before they got to the intended recipient. Consequently, there should be no evidence for extended life histories prior to an artifact arriving in a site. An exception might be objects that are exchanged specifically because they are relics or curiosities.

Once again, the success of studying Paleolithic network formation will depend in part on the geological environments of study areas. Localities with multiple sources of raw material of similar quality will be the most amenable to this kind of research (e.g., Frahm et al. 2019; Tomasso and Porraz 2016). Temporal resolution is also a potentially confounding factor in attempting to reconstruct ancient networks from displacements of objects. While we are safe in assuming that stone artifacts did not move themselves long distances, we can be less sure of the temporal scale of the actions that resulted in the displacement. If transport by geological forces can be ruled out, the fact that an

object moved from "point a" to "point b" means that either someone carried it or that it was passed from one individual to another. An "exchange" might have been a single event, involving two people who in fact had a personal relationship. However, unusual or interesting objects could be passed from hand to hand many times, perhaps spanning generations. The single piece of obsidian from central Anatolia recovered from an Upper Paleolithic deposit at Yabrud shelter II in Syria (Frahm and Hauck 2017) or fragments of Chinese bronze artifacts in pre-contact sites in Alaska (Cooper et al. 2016) are not necessarily evidence for direct contacts between trading partners over thousands of kilometers. As curiosities, these objects might have changed hands many times, over many years, before they arrived in the sites where they were discovered.

Intra-Group Variation

Pro-sociality and cooperation are fundamental properties of living human societies. People cooperate more frequently, and in more contexts, than just about any other vertebrate (Burkart et al. 2014; Chudek and Henrich 2011; House et al. 2013; Tomasello et al. 2012; Tomasello and Vaish 2013). The level of cooperation among humans is comparable with that of social insects, and may even represent an "evolutionary transition in individuality," a fundamental shift in the unit of selection (Andersson and Törnberg 2019). Consequently, the evolutionary roots of—and routes to—hominins' extraordinary pro-sociality is a topic of great interest in paleoanthropology and beyond.

The challenge of investigating cooperation in the deep past is recognizing the evidence. What tells us that hominins were acting in a coordinated manner rather than as individual agents? Clues may come from observations that people were able to complete tasks, such as successfully driving and corralling herds of large animals or erecting huge stone monoliths, that would have been beyond the capacities of individuals working in isolation. Another source of information, more directly relevant to the study of stone tools, involves activity differentiation. Cooperation among recent foragers always involved a degree of specialization, whether by age, gender, or acquired skill. The familiar division of labor by gender among hunter-gatherers is but one example. Children, older people, and individuals with special skills or knowledge may also make unique contributions according to their capacities and expertise. The cooperation of temporary specialists is unique to humans (among primates) and may have been important to the success of some hominin taxa (e.g., Kuhn and Stiner 2006). Questions of how much labor differentiation might have existed at different times in the past would bear directly on levels and patterns of cooperation.

Returning to the theme of mobility, field studies have shown that individuals within the same group who forage for different resource, who experience different constraints on movement, or who engage in different ranges of activities, have different mobility regimes (Cashdan and Gaulin 2016; Hawkes 1995; Hernando et al. 2011; MacDonald and Hewlett 1999; Pontzer et al. 2015; Roughgarden et al. 2006; Surovell 2000; Vashro and Cashdan 2015; Vashro et al. 2016; Wauguespack 2005). Skeletal evidence sometimes, though not always, supports generalizations about differences in movement patterns between males and females (Stock and Pfeiffer 2001; Villotte et al. 2010; Watson and Stoll 2013). Consequently, if we want to study the emergence of

cooperation and activity specialization in hominins, it would be useful to look more closely at how different individuals, or at least kinds of individual, moved across the landscape and modified stone tools.

Almost everything archeologists have written about the topic of mobility approaches it as a property of groups. The notion of residential vs logistical mobility or foragers vs collectors refers to decisions made by hypothetical groups. Of course, we all know that groups are composed of individuals, each of whom has slightly different motivations and limitations. Fortunately, we have at our disposal a reasonable amount of information from ethnographic studies concerning the ways different kinds of individual use landscapes. And we have a proven set of ideas about how lithic technological strategies and artifact life histories are influenced by movement patterns, many cited at the beginning of this paper. Putting the two together, we can easily come up with predictions about how lithic products of individuals specializing in different sorts of foraging or manufacture activities will differ. Early attempts to infer gender identity from different classes of stone tool were one initial step in this direction (Gero 1989, 1991; Sassaman 1992), and more sophisticated approaches have been explored more recently (Elston and Zeanah 2002; Zeanah 2004).

The first requirement of searching for signs of activity differentiation and cooperation is to re-assess mobility-related variation within assemblages, especially temporally fine-grained ones. Few good-sized assemblages of stone artifacts are genuinely homogeneous. Most contain evidence for more than one method of blank production, along with implements with varying life histories. For example, no matter how sophisticated other forms of production may be, assemblages almost always contain evidence for simple flake production. As Vaquero and Romagnoli argue, we need to take such non-optimal, seemingly unsophisticated technological strategies seriously (Vaquero and Romagnoli 2018). Approaches to lithic technology that focus on the cognitive implications of technological complexity, or that highlight uniquely derived behaviors as indicators of common descent, may play down apparently unsophisticated, simple modes of blank production. But for the purposes of understanding differences in strategies among cooperating individuals, such phenomena are essential. Likewise, we tend to focus on extensively modified, sometimes reworked, implements when discussing artifact design or life histories. Yet, such heavily worked implements are often found alongside of simple, minimally modified or unmodified tools. These simple core technologies and minimally used tools are not necessarily the products of incompetent or lazy people. They may well be products of individuals who used the landscape in particular ways, and who in turn experienced a distinct set of constraints on making and using stone tools.

Unpacking assemblage variability and isolating evidence for differing strategies of artifact manufacture and use that could be linked to varied economic roles is no easy undertaking. There are at least two important methodological challenges. One of these is to determine whether especially simple/crude/opportunistic artifacts and production events are products of novices, or whether they were made by individuals filling specific sorts of needs. Evidence of differential raw material procurement combined with use wear should provide important clues about technological strategies tied to different roles and specializations. Artifacts made by novices, especially learners, are unlikely to be used as extensively as the products of more experienced knappers. Close statistical associations between certain “simple” artifacts and particular functions may

also point to production which was quick and easy because of explicit decisions, as opposed to production which was simple because the makers could not manage anything else. Where available, spatial evidence and refitting (e.g., Audouze and Enloe 1997; Chacón et al. 2007; Clark 2015, 2016; Koetje 1994; Vaquero 1999) should provide circumstantial evidence about when and where different sorts of manufacture processes were carried out, and whether "simple" processes were products of specific strategies or limited competence (e.g., Takakura 2013).

The other major challenge stems from the temporal grain of the archeological record. It is a profound (but all too common) mistake to assume all parts of an assemblage were contemporaneous (Dibble et al. 2016; Holdaway et al. 2016). Obviously, the first criterion to consider is the amount of time it took for an assemblage to accumulate. All components of an assemblage which truly represents a "single occupation" can be considered roughly contemporaneous, but very few Paleolithic sites provide this kind of resolution (Audouze and Enloe 1997; Enloe 2006; Moncel and Rivals 2011; Pettitt 1997). Here again, refitting and spatial evidence may help to isolate events which were either contemporaneous or sequential within limited time frames. Even in deposits with coarse chronological resolution, repeated associations are more likely to reflect close temporal proximity of manufacture and use than singular observations (Kuhn and Clark 2015). If two very different production strategies consistently occur together in assemblages at multiple localities or across long stratigraphic sequences, the most parsimonious conclusion is that they were repeatedly executed by the same groups of people: the alternative, that completely unrelated behaviors always occurred repeatedly in the same places, seems less reasonable.

Conclusion

Ideas about hunter-gatherer mobility and its effects on lithic technology have been highly influential for studies of hunter-gatherer lithic assemblages from the Paleolithic as well as later periods. Many Paleolithic archeologists are comfortable with "mobility thinking," and are prepared to use it both as an end itself and as a foundation for thinking about other kinds of dynamics in the past. However, it is not enough to replicate the successes of the past. As the fields of paleoanthropology and human evolution research evolve, they turn to new kinds of research questions. As discussed in the opening section, the phenomenon of mobility remains central to humans' ecological and evolutionary history (Kuhn et al. 2016). The particular ways people move around the landscape have had profound impact on skeletal evolution. They are also fundamental to humans' success as cooperative beings and as colonizers of diverse environments. Consequently, important new areas of inquiry about human behavior and its evolution still intersect with dimensions of individual and group mobility. And, importantly, lithic studies are still uniquely well-positioned to provide information about past human movements, across broad ranges of time and space.

This paper outlines three areas where lithic evidence related to human movement could continue to play a central role in answering important contemporary questions about human ecology and social evolution. Territories and ranging patterns, social networks, and variation in individual activities are topics of growing interest in paleoanthropology and beyond, and archeologists are uniquely prepared to advance

the study of these phenomena. In my view, the continuing relevance of lithic studies and mobility thinking to research in human evolution is not dependent on major technical breakthroughs. Much of the evidence we need to study, these phenomena are already available or could be made available with relatively minor changes in practice. All that is needed to redirect the focus of lithic studies are some conceptual and methodological adjustments. Such goals are well within reach.

Acknowledgments I thank Shumon Hussain and Marie Soressi for inviting me to participate in the 2018 UISPP symposium "Old Stones, New Eyes?" and to contribute to the special into which it evolved. After 30+ years in the field, it is particularly gratifying to be identified as someone who might still manage to imagine a novel way of looking at things. I also salute their patience with my revisions to the manuscript, which took much more time to complete than they ought to have. Three anonymous reviewers also provide extensive comments that helped sharpen and improve the paper.

Compliance with Ethical Standards

Conflict of Interest The author declares that there is no conflict of interest.

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