**Current approaches and new directions in lithic analysis: defining, identifying and interpreting variability**

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In recent years, much attention has been given to questions such as cultural and technical transitions (e.g. the transition from the Middle (MSA) to the Late Stone Age (LSA) in Africa or from the Middle (MP) to the Upper Palaeolithic (UP) in western Eurasia), as well as how the archaeological record may help us trace dispersals and cultural connections across space and over time. Key to these questions is the issue of interpreting what causes variability within lithic assemblages, in order to distinguish cultural diffusion from convergence. Researchers are applying different approaches to the analysis of lithic assemblages in order to best highlight differences and similarities. These can be placed within theoretical and conceptual frameworks that may inform us about the contacts between human populations, either in time (vertical cultural transmission) or in space (horizontal cultural transmission).

The “Mousterian debate” is a classic example of how different approaches to lithic variability led to diverse (sometimes opposed) interpretations of the lithic record (e.g., Binford, 1973; Bordes, 1950; Bordes & Sonneville-Bordes, 1970; and see Dibble, 1987; Rolland & Dibble, 1990 for another aspect of the debate). Nowadays, lithic analyses are still, to some extent, divided into two broad groups: the qualitative *chaîne opératoire* approach, which has been built in part against the use of the Bordian typology leading to a rejection of piece-by-piece analysis and formal quantification (Soressi & Geneste, 2011), and the quantitative attribute analysis approach (e.g., Andrefsky, 2005; Clarke, 1968; Shott, 1994), which relies on a piece-by-piece study following a predetermined grid. Recently however, other approaches were added, combining the two types of analyses (e.g., Hovers, 2009; Nigst, 2012; Scerri et al., 2016; Tostevin, 2012). At the same time, new technologies such as the use of 2D and 3D digital images of artefacts (e.g., Bretzke & Conard, 2012; Chacón et al., 2016; Dogandžić, Braun, & McPherron, 2015; Grosman, 2016), have opened new perspectives in the field of lithic analysis. However, the use of these very different methods has sometimes contributed to impeding communication between researchers as well as restricting comparisons between stone tool assemblages. It has therefore become critical to increase communication between stone tool analysts.

**WORKSHOP OVERVIEW**

In order to further discuss these methodological issues, 28 lithic analysts (table 1) have participated in an international workshop entitled “Current approaches and new directions in lithic analysis: defining, identifying and interpreting variability”. The workshop was organised at the McDonald Institute for Archaeological Research, at the University of Cambridge (UK), between September 29th and October 1st, 2016, and was sponsored by a DM McDonald grant from the McDonald Institute, Cambridge and the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 655459. It was divided into four sessions: (1) intra-assemblage or intra-site lithic variability, (2) inter-assemblage lithic variability (local/regional scale, (3) inter-regional lithic variability and (4), main discussion. Within each session, short presentations on specific methods related to the topic of the session served as a basis for discussions.

Most of the debates centred around three main questions; (1) How to best characterise lithic variability at the intra-assemblage / intra-site level? (2) How to best compare assemblages at the regional and multi-regional level? (3) How to cope with the variability in methods of study of lithic assemblages in comparative analyses?

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| --- | --- | --- | --- | --- | --- |
|  | **Name** | **Session** | ***Role* / Abbrev. Title** |  | **Name** |
| **Workshop participants with presentations** | **Marta Arzarello1** | 2 | Influence of methods on the interpretations of the Italian Lower and Middle Palaeolithic | **Workshop participants without presentations** | **Valentina Borgia8** |
| **Stéphanie Bonilauri2** | 1 | Techno-functional analysis of Umm el Tlel assemblages | **Marjolein Bosch8** |
| **Knut Bretzke3** | 2 | 3D approaches for capturing, studying and visualising variability | **Emily Hallinan8** |
| **M. Gema Chacón2,4 *et al.*** | 1 | Technological behaviours from a spatio-temporal perspective: Abric Romani Middle Palaeolithic site (Spain) | **Herman Muwonge8** |
| **Mae Goder-Goldberger5** | 1 | Onset of Upper Palaeolithic: Boker Tachtit (Israel) | **Philip Nigst8** |
| **Leore Grosman6** | 2 | Lithics in 3-D: methods and applications | **Gunther Noens12** |
| **Huw Groucutt7** | 3 | Beyond NASTIES: Alternatives to named stone tool industries | **Andreas Nymark13** |
| **Erella Hovers6** | 1 | ***Discussant***– a case study for attribute analysis and refittings: A.L.894, Hadar (Ethiopia) | **Marion Prévost6** |
| **Alice Leplongeon2,8** | 3 | ***Organiser***– Testing the Back-to-Africa hypothesis using lithic artefacts | **Rachel Reckin8** |
| **Shannon McPherron9** | 2 | ***Discussant***– Building large attribute databases of Middle Palaeolithic lithics | **Ann Van Baelen8** |
| **Marie-Hélène Moncel2** | 2 | Variability in the French Acheulean and Middle Palaeolithic | **Manuel Will3,8** |
| **Giuseppina Mutri\*8** | 1 | Techno-functional interpretation of bladelet technology |  |
| **Eleanor Scerri7** | 3 | ***Discussant***– Understanding and using multivariate methods in lithic analysis |  |
| **Ceri Shipton8 & James Blinkhorn8,10** | 1 | “One trench, thirty thousand lithics” – sampling and analytical strategy |  |
| **Gilbert Tostevin11** | 3 | ***Discussant***– Refits, attributes and analytical choices in studying lithic technology |  |
| **Hermine Xhauflair2,8** | 1 | On the intentional or fortuitous shape of South East Asian denticulates |  |

**Table 1: Overview of participants of the workshop “Current approaches and new directions in lithic analysis: defining, identifying and interpreting variability”**

\*not present, but power-point presentation was given

Affiliations of participants: 1University of Ferrara (IT), 2UMR CNRS 7194, *Muséum national d’Histoire naturelle*, Paris (FR), 3University of Tübingen (DE), 4IPHES and University Rovira I Virgili of Tarragona (ES), 5Ben-Gurion University, Beer Sheva (IL), 6Hebrew University of Jerusalem (IL), 7University of Oxford (UK), 8University of Cambridge (UK), 9Max Planck Institute for Evolutionary Anthropology, Leipzig (DE), 10 Max PlanckInstitute for the Science of Human History, Jena (DE) 11University of Minnesota (USA), 12Independent researcher, 13Bircbeck University of London (UK).

**WORKSHOP DISCUSSIONS AND FUTURE DIRECTIONS FOR LITHIC ANALYSIS**

***Intra-assemblage variability***

One of the main questions related to inter-assemblage variability that was addressed during the workshop concerned the influence of time-averaging/palimpsests and site formation processes on the interpretation of assemblage variability.

Participants stressed that a good understanding of the site formation processes is crucial to discussing time-averaging and how it may influence the degree of variability within a single assemblage. Several case studies presented during the first and second sessions of the workshop (table 1) showed how an explicit sampling strategy (in the case of large assemblages) combined with an integrated approach to the lithic material may lead to high resolution data on both spatial and temporal organisation of the sites.

In the past, some inconsistencies in the results between different methodological approaches have been noted. For example, at some sites where burins were traditionally interpreted as tools, functional analyses have demonstrated that they were instead cores and that the burin spalls were the tools. Likewise, on the basis of technological attributes, a core would be classified under a certain type, while refitting analyses could demonstrate that it belonged to a different type of reduction sequence. Case studies presented during the workshop (table 1) have shown that a combined approach of the material, using technological and attribute analysis, spatial patterning analysis, refitting and use-wear / residue analyses can yield compatible and coherent information.

The case of surface sites remains one of the main challenges when considering intra-assemblage variability. However, comparisons between surface material and the material from nearby stratified sites may help to better characterise surface material.

***Inter-assemblage variability***

Questions related to inter-assemblage variability arising from the workshop were:

* Which types of assemblages and methods are relevant for a large-scale analysis?
* How can we reconcile the high resolution of intra-site variability studies with comparative studies on the regional and multiregional scales? How much can one single site tell us about the big processes?
* How can we compare surface vs stratified assemblages? How can we compare open-air vs cave sites?

Studies using medium- to large-scale comparative analyses often aim at addressing major behavioural questions, such as dispersals or cultural changes. Most participants emphasised the importance of reflecting on the kind of questions that we, as lithic analysts, can answer; what do the data allow us to ask? In addition, there is a gap between the analysis of the material and its interpretation in terms of broad cultural evolution. There is a growing need for a middle-range theory (e.g., Bar‐Yosef & Van Peer, 2009; Tostevin, 2012). In parallel, the use of predetermined terminologies, such as named stone tool industries (NASTIES, Shea, 2014) and how they guide our interpretations of the lithic variability should also to be taken into account. Some participants also accentuated the growing need for a multidisciplinary approach to issues of dispersals and large-scale cultural changes, integrating lithic analyses with palaeoenvironmental reconstructions and climate models.

Regarding the comparative lithic analyses themselves, participants seemed to reach a consensus on the necessity of quantifying how much assemblages differ from each other in order to interpret them. However, how can we deal with variables that cannot be measured, such as categorical (e.g. whether a flake is Levallois), ordinal or interval variables? For example, ordinal and interval variables are often preferred for angle measurements; blind testing of this did indeed show a high inter- or even intra-analyst variability (e.g., Dibble & Bernard, 1980). Experimental archaeology is critical to addressing some of these issues, as well as 3D-scanning. The workshop highlighted how, by allowing precise and absolute measurements of angles, curvatures and dimensions, 3D-scanning leads to a precise quantification of otherwise ordinal or interval variables. In addition, specific algorithms developed for the study of lithic analysis enable the measurement of new variables (e.g. centre of mass, area or curvature of scars, (Grosman, 2016)).

The use of these high precision tools has to be integrated within valid archaeological, behavioural questions, which can lead to new research questions, specific to these methods. Precision *per se* is not an aim, particularly regarding the main limitations of the methods: the time needed to scan all artefacts from an assemblage and the associated digital storage required.

***Lithic analyst variability***

Large-scale comparative analyses and their interpretation are perhaps where differences between “schools” of lithic analyses are the most apparent. The workshop highlighted that one of the main obstacles to large-scale comparative analyses is the lack of agreement on a list of attributes to be systematically recorded. A second “scale” of variability between lithic analysts is the difference in how they measure certain types of variables. Variables as simple as length, width or thickness measurements can be measured in a variety of ways (technological vs morphological length, maximum thickness vs thickness without the bulb, etc.) and reaching an agreement is often difficult. Participants reiterated the need to systematically provide details on how measurements were taken. This information is critical to further comparisons between assemblages.

Multivariate methods are an increasingly common way to analyse data in comparative lithic studies, as they take into account the effects of all variables in a single analysis. However, complex multivariate analyses need to be performed exactly the same ways to be comparable. Contrary to other disciplines in humanities, such as social and political sciences, there is no discipline-specific “code of conduct” for the use of complex statistical analyses in archaeology (e.g. minimum sample size, clear identification of biases). Despite their potential to discern patterns in the variability of lithic assemblages, many researchers remain sceptical of such standardized protocols for several reasons. These include: (1) the initial development of the *chaîne opératoire* approach as a rejection of formal quantification (Soressi & Geneste, 2011), (2) the fact that these types of analyses allow us to perceive patterns otherwise non-discernible, and (3) that few studies attempt to validate these results through other approaches (e.g., Scerri et al., 2016).

This workshop by no means aimed at a harmonisation of methods in lithic analysis and one of its more important outcomes was to highlight this variability of methods and that each of the methods used has potential to answer specific questions. In order to have an overview of the data, regardless of the methods used, participants highlighted the importance of always providing a descriptive summary of the data with counts and main variables.

At the end of the workshop, participants insisted on the importance of the widespread sharing of our databases (Big Data, e.g. Old Stone Age Project: <http://www.oldstoneage.com>, started by H. Dibble and S. McPherron). In the future, it will also be possible to share large databases of 3D models of entire assemblages, which could then be (re)analysed using different methods and open new perspectives for the field of lithic analysis.

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