Research Article

Marie-Elise Porqueddu*, Claudia Sciuto, Anaïs Lamesa

Reconsidering the *Chaîne Opératoire*: At the Crossroad Between People and Materials

https://doi.org/10.1515/opar-2022-0296
received December 6, 2022; accepted May 16, 2023

Abstract: This article is an introductory contribution to our Special Issue *Reconsidering the Chaîne Opératoire: Towards a Multifaceted Approach to the Archaeology of Techniques*. The *chaîne opératoire* is a central and fundamental concept for archaeological studies that has been fully appropriated and repurposed by several generations of researchers. In this paper, we would like to present some of the points discussed and illustrated by the various articles in this special issue. The aim is to highlight theoretical and practical considerations in various fields, with a diachronic focus. From the biographical approach to the study of artefacts to the challenges of interdisciplinarity through cognitive and sensory approaches, the theoretical discussion is rich and innovative, acknowledging that the *chaîne opératoire* can be used as a tool for deciphering the complex network of artefacts, environments, and societies of the past and present.

Keywords: Chaîne opératoire, diachrony, technology, interdisciplinary

1 Introduction

The *chaîne opératoire* is a key concept in archaeology and since the 1970s has been a cornerstone of technical studies, particularly for lithics analysis and especially for prehistorians. The bibliography on the subject is vast, and over the last 10 years, there have been several articles, monographs, and special issues entirely devoted to outlining the history of the concept and discussing the theoretical implications with its use (Audouze et al., 2018; Delage, 2017; Djindjian, 2013). While involving an epistemological framework, rooted in structuralist philosophy, the concept of *chaîne opératoire* can also be applied to a variety of case studies as a comprehensive method for approaching the examination of ancient technologies. This special issue gathers different contributions all aimed at showing how the *chaîne opératoire* framework can be applied beyond lithic and prehistoric studies, following a conference session organised within the European Association of Archaeologists 2020 congress. The session entitled "Reconsidering the *Chaîne Opératoire*; Recent Developments for the Study of Non-Lithic Materials" was aimed at re-discussing the *Chaîne Opératoire* as a theoretical framework in technological studies by considering its diachronic application to different artefacts and materials. The title then specifically referred to non-lithic materials to take distance from the period- and material-specific debate over the steps for lithics reduction and open the reflection to a broader public. The papers

Special Issue on Reconsidering the *Chaîne Opératoire*: Towards a Multifaceted Approach to the Archaeology of Techniques, edited by Marie-Elise Porqueddu, Claudia Sciuto & Anaïs Lamesa.

*** Corresponding author: Marie-Elise Porqueddu,** Department of Ancient and Medieval Times, Casa de Velázquez, Madrid, Spain, e-mail: porqueddu.marieelise@gmail.com
Claudia Sciuto: MAPPA Lab (Digital Methods applied to Archaeology), Department of Civilizations and Forms of Knowledge, University of Pisa, Pisa, Italy
Anaïs Lamesa: Archeological Department, Institut Français d'études Anatoliennes (USR 3131), Istanbul, Turkey

presented and the discussion that followed focused on some less investigated aspects of the theoretical implications and practical applications of the *chaîne opératoire* framework and we therefore considered gathering those contributions, in a dedicated special issue, this time open to all archaeological subjects and periods. We wish to discuss this fundamental concept applied to different case studies in archaeology to highlight some of the methodological and theoretical standpoints on which this volume is grounded as well as new reflections generated over the course of the last couple of years. From the biographical approach to the study of artefacts to the challenges of interdisciplinarity through cognitive and sensory approaches, the theoretical discussion is rich and innovative, acknowledging that the *chaîne opératoire* can be used as a tool for deciphering the complex network of artefacts, environments, and societies of the past and present.

In writing this introductory article, we are aware of the difficulty of providing an exhaustive overview of studies concerning the *chaîne opératoire*: a concept that is in itself manifold and has several applications in different contexts. There is a wide disproportion as far as scientific literature is concerned. Most studies concerning the *chaîne opératoire* deal with lithic tools or, more generally, prehistoric contexts. The choice of our arguments for this brief synopsis goes in the direction of an evaluation that is as inclusive as possible with respect to chronologies and materials, focusing on the theoretical–methodological implications with the use of the scheme, rather than a review of case studies. Furthermore, we hope to be able to use this space to free ourselves, at least in part, from the rich debate in the prehistoric field, to discuss some aspects that are perhaps less familiar to a non-specialist audience.

Our purpose is not that of retracing the history of the *chaîne opératoire* in detail nor having a critical point of view of the current literature. Instead, we aim here at presenting our perspective on different theoretical paths – that we crossed during our own research – along which this concept has been built and transformed, leading to today's debate concerning its applications. Moreover, the considerations brought forward in this discussion serve as a framework within which the articles collected in this special issue are placed. We, therefore, hope to be able to provide interesting food for thought that can be developed and expanded upon in the articles that make up this volume.

Our approach is trans-chronological and multidisciplinary. We were formed in Italy and France in the field of archaeology, archaeometry, art history, and history. Our focus is on quarries and rock-cut monuments calling interviews of craftsmen, in-context experiences, stone analysis, and source texts.

2 Accounts for Drawing a Story of the *Chaîne Opératoire*

To introduce the subject, it seemed essential to recall the early references to the *chaîne opératoire* in the archaeological literature. The concept is widely associated with French structuralist anthropology and archaeology, and especially the two authors, Marcel Mauss and André Leroi-Gourhan, whose names are linked to the conception and formalisation of the notion, even though the former never used the term directly and the latter only a few times (Djindjian, 2013; Lewis & Arntz, 2020; Martinón-Torres, 2002; Pigeot, 2011; Roux, 2019). The important contribution of Marcel Mauss lies in the fact that he was the first to formulate the link between technical activities, social influences, and the historical context, thus integrating each gesture into a precise framework (Mauss, 2004). The authorship of the definition of the *chaîne opératoire* is attributed to Leroi-Gourhan (1964, p. 164) and appears in *Techniques et Languages*, the first volume of his work *Le Geste et la Parole*: "Technique is both the skill and the tool, organized into a sequence by a genuine syntax that gives operational series both their rigidity and their flexibility."[1] This definition is quoted and widely used in most works dealing with the *chaîne opératoire*. In the book, fundamental notions are defined, such as technique, skills, and above all the idea of series, a clear sequentiality of actions which is eminently marked by using the word *chaîne*.

1 Translation from French to English by the authors.

Following the tradition started by André Leroi-Gourhan, the concept of the *chaîne opératoire* was further developed by prominent ethnologists and anthropologists whose work refined the initial definition and applied it concretely to different objects, societies, and contexts. Again, a systematic description of all the theoretical–methodological nuances and implications of the *chaîne opératoire* would go beyond the scope of this article and would require a much more extensive dissertation. We will move forward by indicating those initial takes on the concepts that we consider to be most useful for contextualising the works collected in this volume.

New formulations were developed by Robert Cresswell and Bruno Martinelli (Fancello & Mary, 2018), both insisting on the idea of *chaîne opératoire* as a series of operations and a linear process involving a goal to be reached at the end. These definitions were taken up by Hélène Balfet, whose work was aimed at demonstrating the versatile aspect and the great diversity of the *chaîne opératoire* (Balfet, 1991; Bril, 2019; Coupaye, 2015). The development of this concept was not limited to anthropologists and ethnologists but appeared very early on among prehistorians, probably due to the object of André Leroi-Gourhan's research, but also through the work of Jacques Tixier. His approach and contribution are fundamental for the development of studies on archaeological methods, mostly experimentation, that allow the empirical reconstruction of the *chaîne opératoire*, especially for artefacts dating to the prehistoric period, and particularly for lithic artefacts (Audouze et al., 2018; Djindjian, 2013; Le Brun-Ricalens, Potin, & Bordes, 2018).

Rather than going into details about the different aspects of the history of the concept of *chaîne opératoire* and the contributions of different researchers to its development, we prefer referring to the specific bibliography dedicated to the history of research and the roles of different scholars in refining the notion: the 2017 article by Christophe Delage and the 2018 response to this article by Françoise Audouze, Pierre Bodu, Claudine Karlin, Michèle Julien, Jacques Pelegrin, and Catherine Perlès as well as the 2017 article by Françoise Audouze and Claudine Karlin covering 70 years of applications. It should be noted, however, that the history of the *chaîne opératoire* is particularly sedimented within the French tradition of studies. The term has been passed on and perpetuated in French scientific literature, notably through the creation of a research group and dedicated journal: *Techniques et Culture* by Robert Cresswell (Djindjian, 2013). On the other hand, as Ludovic Coupaye (2015) points out, André Leroi-Gourhan's volume *Le Geste et la Parole* was only translated in English in 1999, and the whole of the *Evolutions et techniques* volumes have not been translated yet.

The *chaîne opératoire* framework first applied within the subject of anthropology and, particularly the study of techniques, became swiftly entwined with the concepts of material culture and technological choices (Coupaye & Douny, 2009; Martinón-Torres & Killick, 2015). Research perspectives on these subjects, both in anthropology and archaeology, have a different history in the British-North American tradition, with important methodological and theoretical differences as well as a great variety of notions (Coupaye, 2015). Multidisciplinary and empirical perspectives are privileged through the questioning of the socio-cultural uses of objects within the anthropological interpretation of consumption. This approach is reflected in the research group, Material Culture Studies at University College London as well as in the *Journal of Material Culture*, where the study of technology appears to be situated within Sciences and Technology studies (Coupaye & Douny, 2009). The concept of technical styles, formulated at the Massachusetts Institute of Technology in the United States between the 1970s and the 1980s (Martinón-Torres & Killick, 2015), is not formally opposed and different from the notion of technological choices, they even come together in the work of certain authors such as Pierre Lemonnier (1992), who contributed to the dissemination in the British-North American academia of the *chaîne opératoire* and its application in a rigorous theoretical framework (Martinón-Torres & Killick, 2015). For some authors, the spread of the *chaîne opératoire* in British-North American archaeology may be linked to the publication in 1990 of the special issue *Technology in the Humanities* in the journal *Archaeological Review from Cambridge* (Coupaye, 2015; Lewis & Arntz, 2020).

The *chaîne opératoire* is a powerful syntactic scheme and it is therefore not surprising that it is now widely adopted and used beyond Prehistory and the field of lithic studies. Nevertheless, the concept is not exempt from criticism, especially regarding its theoretical roots. One of the strongest and most pertinent criticisms of the *chaîne opératoire*, but especially of its uses, was formulated by François Djindjian (2013). He rightly points out the abuses of semiotics concerning this expression, which has finally passed into the everyday vocabulary of archaeology, losing at times its conceptual meaning. François Djindjian prefers the clearer and more

syntactically correct expression "*enchaînement d'opérations.*"[2] Beyond the way this expression is used, Djindjian (2013) makes two critical points: the poor graphic representations of it and the lack of quantification of the primary data mobilised within it.

It should be noted that theoretical reflections on the *chaîne opératoire* are mainly carried out within the frameworks in which it was born and developed, namely the anthropology of techniques and prehistoric archaeology. For this reason, in this special issue, we have chosen to open the discussion by proposing studies inside and outside these fields and to observe how researchers working on periods other than Prehistory use and develop the concept. This inclusive and diachronic approach provides an opportunity to observe how this concept has evolved and been embraced by different disciplinary domains in archaeology. This special issue reflects different approaches to the same concept which we suggest could be structured along three main axes: the biographical narrative of artefacts' trajectories; the taxonomic description of gestures and skills behind the making of an object; and an effort in understanding the relationships between craftspersons, societies, and the environment, facing the challenges of interdisciplinarity. These selected research axes highlight the networks existing between individuals and materials, whether crafting is perceived as a process in which multiple human and non-human agencies are intertwined, or as practices reflecting artisanal traditions and cultural identities.

3 The *Chaîne Opératoire*: For Whom, Why, and When?

3.1 A Biographical Approach to Artefacts

One of the aspects that seems to be recurrent in the theoretical debate is the association of the *chaîne opératoire* framework with the biographical approach to the study of objects, conceived as a biographical story of an individual (Gosden & Marshall, 1999; Joy, 2009; Kopytoff, 1986). There is no doubt that some representations of *chaîne opératoire* overlap with the life of the objects, considered as a linear evolution from its conception to discard, including possible repair and reuse. Nevertheless, there are nuanced distinctions between the two schemes that can be considered. Discrepancies have been pointed out by Maxence Bailly and Hugues Plisson (2008): the two temporalities, that of the individual and that of the object, may come close but are not necessarily superposable, leading to an idiosyncratic narrative of life and death cycles. Without seeking an overlap that may be forced, it seems better to recognise that the temporality of the object is rather different from that of humans, the life cycle is characterised by a different flow: permanence, returns, and abandonments that respond to a rhythm unthinkable for human beings. It could probably be simpler to observe that humans and non-humans exist at different rates and that a biographical narrative could help not normalise temporalities but proceed descriptively. Time becomes visible on the object through the overlapping of gestures and know-how applied to its creation and modifications: a narrative constructed through alterations, appropriations, and repairs. The technical steps aimed at regenerating and recontextualising an object become particularly interesting for establishing the connections between technicality and socio-cultural context. In these cases, we are dealing with fragmented, multiplied *chaînes opératoires* that unfold in different chronological and cultural contexts, weaving new relationships between the object and human actors (see in this special issue Martiniello, Capitanio, Sciuto, Legnaioli, & Raneri, 2023).

The biographical approach refocuses on the artefact and its interactions with individuals, while addressing a defined cultural environment as well as social and collective representations (Bensaude-Vincent, 2012; Kopytoff, 1986). The notion of the object's biography also concerns the different contexts it may have encountered and passed through, referring to different interpretative frameworks but also to, potentially, multiple physical treatments (Coupaye, Labat, & Ziegler, 2020; Kopytoff, 1986). While the biographical approach, as first

2 This term could be translated as "sequence of operations" (Coupaye, 2022, p. 39).

theorised by Igor Kopytoff (1986), underpins a particular attention to interactions among objects and with people, the same approach could encounter some limits when dealing with the multifaceted depiction of technical procedures (Lewis & Arntz, 2020). The cultural value underpinning the biography of the object might not be comprehensive of all the agencies underpinned in the technical process.

The primary use for the *chaîne opératoire* is a concrete representation of the technical process, for the anthropologists, and a model for the technical analysis of artefacts, for the archaeologist (Buob, Chevallier, & Gosselain, 2019). The concepts of life and death, applied to artefacts, may sound captivating when evoking the agency of living bodies, but risks to be guiding the interpretation towards dualistic categories of presence/absence, use/abandon, animate/inanimate. The association of *chaîne opératoire* and biographical approach should maybe point at drawing complexity, outlining transformations, links, cycles, and pathways. Although the *chaîne opératoire* does not constitute a biography of the objects, it makes it possible to outline certain technical elements of the objects' journey (Joy, 2009). The two approaches seem complementary, rather than overlapping, as an account of the links between culture and techniques, embodied in the object itself. As Coupaye et al. (2020) point out, the biography of the archaeological object is manifested through the physical traces on it referring to a past presence, action, or process. The *chaîne opératoire* is suited for the study of these material traces, making the framework particularly interesting for developments in materials science and archaeometry (Jones, 2004; Martinón-Torres & Killick, 2015).

From an archaeological point of view, the idea of mapping objects' life-histories can be seen as a broader approach to unravelling the links between technical tendencies, local know-how, and materials supply, in a way that helps also focus on different stages of an object's journey (Joy, 2009). Objects and architectures may follow several paths, changing function, cultural, and social value, undergoing several "deaths" and "reincarnations" (Joy, 2009; Tringham, 1994, 1995), all information that is fragmented and partially lost. The biographical approach overcomes the difficulties that might arise from the discontinuity of the biographical data by focusing on a macro scale, to observe technological changes over the long term (Joy, 2009). The object becomes part of a broader assemblage in which individual trajectories are intertwined. The *chaîne opératoire* is a tool for organising some key nodes of the agencies' network, from materials to craftsmen. A broader perspective can help with the study of materials that are less represented in the archaeological record or approaching a new typology (see Anguissola, 2023 in this special issue). Likewise, the *chaîne opératoire* framework can be helpful in unravelling non-functional practices, which underlie the embodiment of community beliefs. Technical practices become a bridge between spiritual symbolism and material gesture (De La Fuente & Vera, 2023 in this special issue).

3.2 The Gestures and Craftperson Behind the *Chaîne Opératoire* (or Cognitive and Sensory Approach)

By allowing the representation of the technical process, thanks to the observation of the objects and the marks they bear, the *chaîne opératoire* makes it possible to write the object's own testimony – almost an autobiography – but also to incorporate the object into the narrative of humans, whether it be the craftsperson whose hands and tools would leave these traces on the matter or other events the artefact has witnessed or taken part to (see on this Andrefsky, 2012; Bar-Yosef & Van Peer, 2009). Through the sequence of movements and gestures, the *chaîne opératoire* allows the link between the material and the human, between the individual who makes the object and the object that is made (Walls, 2016). This approach might suggest a hierarchical system in which the agency of the material is given little consideration. This kind of reading of the *chaîne opératoire* derives from a processualist imprint; however, the taxonomic scheme presents great versatility and can also be used within a symmetrical approach (see Nilham, 2023 in this special issue). The idea is that by looking at the intersection of hands and matter we are able to move the research focus on both those craftspersons, whose direct witness is absent from archaeology (Treuil, 2011), and the non-human agents too often regarded as passive actors in technical processes. This can be addressed from a number of different perspectives, with a particular focus on cognitive and sensorial aspects, through

multiscale relationships between people and matter, as well as between human populations and their cultural and social environment.

The links between cognitive sciences and archaeology are multiple, i.e. the important work of Jacques Pélegrin, Claudine Karlin and Pierre Bodu, (1988) and the book edited by René Treuil (2011), *L'archéologie cognitive*, illustrate perfectly. The cognitive approach is applied in studies on transmission, learning, and apprenticeship, particularly in prehistoric lithic studies but also in the investigations of ceramics (Bril, 2002, 2019; Eerkens & Lipo, 2007; Pigeot, 2011; Treuil, 2011; Walls, 2016). The process of learning a task and an operative sequence within the framework of the *chaîne opératoire* is a particularly developed theme. Several authors have examined the different mechanisms involved in learning, whether they are factors related to cognitive and motor development, and therefore directly relevant to the individual, or cultural factors, and thus connected to the collectivity (Castañeda, Consuegra, & Díaz-del-Río, 2019; Roux, 2019; see also the contributions of Calvo Peña, 2023 in this special issue). The emphasis on the study of skills and the relationship between individuals and groups in the development and transmission of these competencies is also reflected in works not only on apprentices but also on experts and the different levels of expertise achieved in various technical tasks (Torres & Preysler, 2020). The cognitive approach in archaeology also allows us to look at the processes of invention and the transmission of know-how, from the appearance of the first tools to the mechanisation of traditional techniques (De Beaune, 2011; Lamesa, 2022). The process ontology, as outlined by Gosden and Malafouris (2015), provides tools for analysing the agencies intertwined in minds in action, exploring the process of making as an intersection of embodied cognition and materials (Malafouris, 2021).

The influence of cultural, social, economic, and political conditions on the technical act is no longer in doubt (Martinón-Torres, 2002; Pigeot, 2011), and tracing the links between technical tendencies, labour organisation, and some specific social traits in communities is an appealing endeavour (see in this volume Lamesa, Gély & Launay, 2023). Through the *chaîne opératoire* we are able to re-establish the voice of the gesture, even when the archaeological record is extremely fragmented, tracing back connections and relationships between individuals and groups (see Anguissola, 2023 in this special issue). Nevertheless, all this calls upon a set of interwoven disciplines, to provide new information on past societies as well as their environments.

3.3 Understanding Technicites Through the Challenge of Interdisciplinarity

At the heart of archaeological and anthropological studies on technology, the *chaîne opératoire* unfolds its potential when applied in multi-inter-transdisciplinary studies. As early as at the time of Jacques Tixier's works, it became clear that technical studies could not only function through the documentation, analysis, and interpretation of the traces on archaeological objects (Audouze & Karlin, 2017; Tixier, 1988) but also needed to be integrated with information gathered through other methods. In Prehistory, experimentation was very quickly perceived as an essential scheme for understanding the gestures of the past. The empirical testing of the physical implications of production steps became a widespread practice for all archaeologists, largely contributing to a better understanding of craftspeople, materials, and tools. Similarly, an early processualist approach to ethnoarchaeology helped creating the nomenclature and a reference pattern for applying a *chaîne opératoire*-based scheme to the study of ancient crafts, with the possibility of making direct analogies between archaeological information and the results obtained from fieldwork. Although scholars have questioned the relevance of a prominently descriptive approach to the production process observed through ethnoarchaeology (Gosselain, 2016), it is precisely the understanding of the socio-cultural context of the technical gesture in its immanence that reveals the complexity of the human–material–social relationship (Lyons & David, 2019).

A quantitative analysis of the *chaîne opératoire* steps could also be pursued through a normalisation of vocabulary, and computational analyses, not without risks of falling into representations that are not statistically relevant, as pointed out by François Djindjian (2013) (Treuil, 2011). The majority of these quantitative works focus on a forensic recording of the movement itself, applying ergonomics, kinetics, or kinematics to highlight the differences between the gestures of a skilled craftsperson from those of an apprentice (Bril, 2019). Some of these studies could be seen as convening over an idea of technique, as defined by Jacques Tixier, being

the mode of physical action over the material, while the method would rather be the implementation of the transformation of the material (Bril, 2019; Inizan, Reduron-Ballinger, Roche, & Tixier, 1999).

Technical studies have then evolved considerably with the emergence of archaeological sciences (Boivin, 2005; Jones, 2004; Martinón-Torres & Killick, 2015). This combination of disciplines from geology, chemistry, physics, or engineering has provided completely new data to further refine the definition of technical tendencies. In particular, the development of provenance studies has shed light on procurement strategies and raw materials supply networks, providing data for a better definition of the early stages of the *chaîne opératoire* (Vassanelli, Petrinelli Pannocchia, & Starnini, 2023 in this volume). The application of analytical methods allows for a better understanding of material procurement and the outlining of a network between humans and their environments, providing technical details about the provenance and processing of raw materials that are relevant to our understanding of gestures.

In particular, the emergence of new theoretical trends that aim at establishing a more symmetrical relationship between humans and non-humans helped the reflection over the agencies of raw materials themselves within the *chaîne opératoire*. While in the early formulations of the *chaine opératoire* the distinction between the hand and the material was clear and the categorisation of technical tendencies was done only considering tools and movements, the impact of new-materialism and post-humanist thinking on the understanding of production processes brought a new perspective over a structuralist taxonomy (Schlanger, 1994, p. 144). The work of eminent philosophers and anthropologists such as Jane Bennett (2009) or Tim Ingold (2013) has shown how humans live with things, creating objects together with the raw materials themselves, in an exchange that can be associated with a symbiotic act. These concepts, when correlated with the archaeometric investigation over artefact's provenance, constitute the core for a transdisciplinary take on investigating the life of human communities within their territory. The *chaîne opératoire* framework could also help decipher these entangled arrays of features characterising a taskscape (Ingold, 1993). As Lyons points out (2020), the physical engagements with landscapes can be investigated through the outlining of different gestures, materials, and knowledge that are underpinned in the metamorphoses of a territory. There are several environmental implications that root the *chaîne opératoire* to the environment as well as socio-cultural context. For instance, several environmental proxies can be involved in a technical process and speak of the links between the process of making and the territory in which humans lived and provide technical details about the provenance and processing of raw materials that are relevant to our understanding of gestures (see Solnay, Kreiter, & Szilágyi, 2023 in this special issue). The scalarity of the *chaîne opératoire* system becomes the key to clarifying intangible social aspects related to the life of communities in the territories. From the analysis of single objects to the tracing of networks of environment, communities, and production, the gesture and reconstruction of technical expertise can provide interesting perspectives for the analysis of palimpsest landscapes.

The analysis of techniques is now being pursued also outside of the fields of archaeology and anthropology, as pointed out by Buob et al. (2019). Particularly, interesting developments are taking place in the fields of computer science, heritage studies, and museology (Buob et al., 2019). The latter two disciplines are directed towards the later stages of the life of the archaeological materials leading them into a whole new sphere. In these subjects, it is no longer a question of providing methods and tools for technical descriptions but rather of delivering new interpretative frameworks within which the *chaîne opératoire* can evolve and continue to be questioned. Heritage studies and museology are particularly interesting in their desire to implement, transcribe, and exhibit the technical universes using the *chaîne opératoire* (Calafat & Chevallier, 2019).

4 Conclusions

By looking at the concept of the *chaîne opératoire* beyond the environments in which it originated and developed, i.e. lithic studies and Prehistory, we can see how different attitudes have been adopted by archaeologists of different backgrounds. The ideas are multiple and complementary. We can therefore only subscribe to Marcos Martinón-Torres's conclusion (2002) that the *chaîne opératoire* is an ensemble of approaches. We are

aware that this introduction is not exhaustive with regard to the many facets of *chaîne opératoire* studies, so we have opted for a text that runs through the topics touched upon by the contributions presented in this special issue, and we defer a more in-depth review of other topics to future studies. Beyond the different theoretical standpoints behind the way researchers are now appropriating the conceptual scheme, this volume can contribute to shedding new light on the possibilities in applying the *chaîne opératoire*. The fil rouge that links all the case studies presented is surely the search for the human gestures in the interaction with the materials. In these studies, the *chaîne opératoire* remains the common point, but it only takes on its power and delivers information about past societies in combination with other tools and disciplines, the study of context being a keystone of these investigations.

Acknowledgements: This work was supported by a research grant from the Fyssen Foundation (Paris) for Marie-Elise Porqueddu, by the University of Pisa (grant: PRA_2022_17 Pratiche artigiane tra Mediterraneo ed Oriente. Studi interdisciplinary dalla Preistoria al Medioevo) for Claudia Sciuto and by a research fellowship from DIM Matériaux Ancien et Patrimoniaux/Île-de-France hosted by the team Mondes Sémitiques, CNRS, for Anaïs Lamesa.

Author contributions: All authors took an equal part in writing and working on this article.

Conflict of interest: The authors have no conflicts of interest to declare.

References

Andrefsky, W. (2012). Raising the bar: Lithic analysis and archaeological research in the Southeast. In P. J. Carr, A. P. Bradbury, & S. E. Price (Eds.), *Contemporary lithic analysis in the Southeastern: Problems, Solutions and Interpretations* (pp. 182–193). University of Alabama Press.

Anguissola, A. (2023). Seriality and Individualization: Carving the Fluted Sarcophagi from Hierapolis of Phrygia. *Open Archaeology*, *9*(1), 20220337. doi: 10.1515/opar-2022-0337.

Audouze, F., Bodu, P., Karlin, C., Julien, M., Pelegrin, J., & Perlès, C. (2018). Leroi-Gourhan and the *chaîne opératoire*: A response to Delage. *World Archaeology*, *49*(5), 718–723. doi: 10.1080/00438243.2017.1416012.

Audouze, F., & Karlin, C. (2017). 70 years of "Chaîne opératoire": What French prehistorians have done with it [La chaîne opératoire à 70 ans: qu'en ont fait les préhistoriens français]. *Journal of Lithic Studies*, *4*(2), 5–73. doi: 10.2218/jls.v4i2.2539.

Bailly, M., & Plisson, H. (2008). Introduction. In M. Bailly & H. Plisson (Eds.), *La valeur fonctionnelle des objets sépulcraux, Actes de la table ronde d'Aix-en-Provence 25–27 octobre 2006*. Aix-en-Provence: Éditions APPAM (pp. 11–15).

Balfet, H. (1991). Des chaînes opératoires, pour quoi faire? In H. Balfet (Ed.), *Observer l'action technique. Des chaînes opératoires, pour quoi faire?* (pp. 11–19). Paris: Editions du CNRS.

Bar-Yosef, O., & Van Peer, P. (2009). The chaîne opératoire approach in Middle Paleolithic archaeology. *Current Anthropology*, *50*(1), 103–131. doi: 10.1086/592234.

Bennett, J. (2009). *Vibrant matter: A political ecology of things*. Durham: Duke University Press.

Bensaude-Vincent, B. (2012). Vies d'objets. Sur quelques usages de la biographie pour comprendre les technosciences. *Critique*, *6–7*(781–782), 588–598. doi: 10.3917/criti.781.0588.

Boivin, N. (2005). Comments I: Post-textual archaeology and archaeological science. *Archaeometry*, *47*(1), 175–179. doi: 10.1111/j.1475-4754.2005.195-1.x.

Bril, B. (2002). L'apprentissage de gestes techniques: Ordre de contraintes et variations culturelles. In B. Bril & V. Roux (Eds.), *Le geste technique. Réflexions méthodologiques et anthropologiques* (pp. 113–149). Toulouse: Éditions érès.

Bril, B. (2019). Comment aborder la question du geste technique pour en comprendre l'expertise et l'apprentissage? *Techniques & Culture*, *71*, 78–91. doi: 10.4000/tc.11373.

Buob, B., Chevallier, D., & Gosselain, O. (2019). Technographies. Dans la trousse à outils de celles et ceux qui travaillent sur la technique. *Techniques & Culture*, *71*, 10–25. doi: 10.4000/tc.11926.

Calafat, M.-C., & Chevallier, D. (2019). Une technographie par l'objet: Expériences du musée national des Arts et Traditions populaires. *Techniques & Culture*, *71*, 92–105. doi: 10.4000/tc.11378.

Calvo Peña, S. (2023). Identification of Ceramic Traditions on the Prehistoric Mines of Gavà (Barcelona, Spain). *Open Archaeology*, *9*(1), 20220335. doi: 10.1515/opar-2022-0335.

Castañeda, N., Consuegra, S., & Díaz-del-Río, P. (2019). Placing the transmission of technical knowledge in the system of blade production. A case study from the Early Neolithic flint mine of Casa Montero (Madrid, Spain). *Anthropologica et Praehistorica*, *128*,

71–83. https://biblio.naturalsciences.be/associated_publications/anthropologica-prehistorica/anthropologica-et-praehistorica/ap-128.

Coupaye, L. (2015). Chaîne opératoire, transects et théories: Quelques réflexions et suggestions sur le parcours d'une méthode classique. In P. Soulier (Ed.), *André Leroi-Gourhan « l'homme, tout simplement »* (pp. 69–84). Paris: Editions de la MAE.

Coupaye, L. (2022). Making 'Technology' visible: Technical activities and the chaîne opératoire. In L. A. De Cunzo & C. Dann Roeber (Eds.), *The Cambridge handbook of material culture* (pp. 37–60). Cambridge: Cambridge University Press.

Coupaye, L., & Douny, L. (2009). Dans la trajectoire des choses comparaison des approches francophones et anglophones contemporaines en anthropologie des techniques. *Techniques & Culture*, *52–53*, 12–39. doi: 10.4000/tc.4956.

Coupaye, L., Labat, O., & Ziegler, S. (2020). Cet obscur objet d'un désir contrarié: Vers une ontologie de l'objet archéologique restauré. *Les Nouvelles de l'archéologie*, *162*, 36–40. doi: 10.4000/nda.11540.

De Beaune, S. (2011). Le processus de l'invention: Approche cognitive. In R. Treuil (Ed.), *L'archéologie cognitive* (pp. 75–90). Paris: Editions de la Maison des sciences de l'homme.

De La Fuente, D. A., & Vera S. D. (2023). Making Vessels for the Dead: Pottery-Making Practices, *Chaîne Opératoire* and the Use of Grog (Crushed Sherds) as a Technological and Cultural Choice during Late and Inca Periods in the Northwestern Argentine Region (Southern Andes). *Open Archaeology*, *9*(1), 20220338. doi: 10.1515/opar-2022-0338.

Delage, C. (2017). Once upon a time…the (hi)story of the concept of the *chaîne opératoire* in French prehistory. *World Archaeology*, *49*(2), 158–173. doi: 10.1080/00438243.2017.1300104.

Djindjian, F. (2013). Us et abus du concept de "chaîne opératoire" en archéologie. In S. Krausz, A. Colin, K. Gruel, I. Ralston, & T. Dechezleprêtre (Eds.), *L'âge du fer en Europe – Mélanges offerts à Olivier Buchsenschutz* (pp. 93–107). Bordeaux: Éditions Ausonius.

Eerkens, J. W., & Lipo, C. P. (2007). Cultural transmission theory and the archaeological record: Providing context to understanding variation and temporal changes in material culture. *Journal of Archaeological Research*, *15*(3), 239–274. doi: 10.1007/s10814-007-9013-z.

Fancello, S., & Mary, A. (2018). Le forgeron, le juge et l'ethnologue: Autour de Bruno Martinelli. *Journal des Africanistes*, *88*(2), 7–15. doi: 10.4000/africanistes.7123.

Gosden, C., & Malafouris, L. (2015). Process archaeology (P-Arch). *World Archaeology*, *47*(5), 701–717. doi: 10.1080/00438243.2015.1078741.

Gosden, C., & Marshall, Y. (1999). The cultural biography of objects. *World Archaeology*, *31*(2), 169–178. doi: 10.1080/00438243.1999.9980439.

Gosselain, O. P. (2016). To hell with ethnoarchaeology! *Archaeological Dialogues*, *23*(2), 215–228. doi: 10.1017/S1380203816000234.

Ingold, T. (1993). The temporality of the landscape. *World Archaeology*, *25*(2), 152–174. doi: 10.1080/00438243.1993.9980235.

Ingold, T. (2013). *Making: Anthropology, archaeology, art and architecture*. London; New York: Routledge.

Inizan, M. L., Reduron-Ballinger, M., Roche, H., & Tixier, J. (1999). *Technology and Terminology of Knapped Stone*. Nanterre: CREP.

Jones, A. (2004). Archaeometry and materiality: Materials-based analysis in theory and practice. *Archaeometry*, *46*(3), 327–338. doi: 10.1111/j.1475-4754.2004.00161.x.

Joy, J. (2009). Reinvigorating object biography: Reproducing the drama of object lives. *World Archaeology*, *41*(4), 540–556. doi: 10.1080/00438240903345530.

Kopytoff, I. (1986). The cultural biography of things: Commoditization as process. In A. Appadurai (Ed.), *The social life of things* (pp. 64–92). Cambridge: Cambridge University Press.

Lamesa, A. (2022). Concevoir un tombeau ou une église dans la roche: Temps, espace et communautés. *e-Phaistos Journal of the History of Technology*, *X*(2). doi: 10.4000/ephaistos.10367.

Lamesa, A., Gély, J.-P., & Launay, G. (2023). An Invention Shading Light to the Socio-History of Bonneuil Quarry Basin: The Roadheaders with Rotating Drill Bits. *Open Archaeology*, *9*(1), 20220333. doi: 10.1515/opar-2022-0333.

Le Brun-Ricalens, F., Potin, Y. & Bordes, J.-G. (2018). Jacques Tixier (1925–2018) Disparition d'un archéologue visionnaire pionnier pour une anthropologie des techniques. *Préhistoires Méditerranéennes*, *6*. doi: 10.4000/pm.1481.

Lemonnier, P. (1992). *Elements for an anthropology of technology*. Ann Arbor: University of Michigan, Museum of Anthropology, Publications Department.

Leroi-Gourhan, A. (1964). *Le Geste et la Parole. I. Technique et Langage*. Paris: Albin Michel.

Lewis, M., & Arntz, M. (2020). The *chaîne opératoire*: Past, present and future. *Archaeological Review from Cambridge*, *35*(1), 6–16. doi: 10.17863/CAM.65457.

Lyons, D., & David, N. (2019). To hell with ethnoarchaeology… and back! *Ethnoarchaeology*, *11*(2), 99–133. doi: 10.1080/19442890.2019.1642557.

Lyons, J. S. (2020). Notes on the chaîne opératoire concept for historical ecology. *Archaeological Review from Cambridge*, *35*(1), 17–26. https://www.repository.cam.ac.uk/bitstream/handle/1810/318343/ARC_35-1_Lyons.pdf?sequence=1.

Malafouris, L. (2021). Mark making and human becoming. *Journal of Archaeological Method and Theory*, *28*(1), 95–119. doi: 10.1007/s10816-020-09504-4.

Martiniello, S., Capitanio, A., Sciuto, C., Legnaioli, S., & Raneri, S. (2023). Synopsis of a Treasure. A Transdisciplinary Study of Medieval Gold Workings Biographies. *Open Archaeology*, *9*(1), 20220336. doi: 10.1515/opar-2022-0336.

Martinón-Torres, M. (2002). Chaîne opératoire: The concept and its applications within the Study of Technology. *Gallaecia*, *21*, 29–43. https://dialnet.unirioja.es/descarga/articulo/265493.pdf.

Martinón-Torres, M., & Killick, D. (2015). Archaeological theories and archaeological sciences. In A. Gardner, M. Lake, & U. Sommer (Eds.), *The Oxford handbook of archaeological theory*. Oxford: Oxford University Press.

Mauss, M. (2004). Les techniques et la technologie. *Revue du MAUSS*, *23*(1), 434–450.

Nilham, B. (2023). Materiality of Plaster Vessels: The Problem of Southwest Asian Neolithic *White Ware*. *Open Archaeology*, *9*(1), 20220332. doi: 10.1515/opar-2022-0332.

Pigeot, N. (2011). Chaînes opératoires: Contexte théorique et potentiel cognitif. In R. Treuil (Ed.), *L'archéologie cognitive* (pp. 149–171). Paris: Editions de la Maison des sciences de l'homme.

Pélegrin, J., Karlin, C., & Bodu, P. (1988). "Chaînes opératoires": Un outil pour le Préhistorien. In J. Tixier (Ed.), *Technologie préhistorique. Journée d'études technologiques en préhistoire, Meudon, 26 février 1986* (pp. 55–62). Paris: CNRS.

Roux, V. (2019). *Ceramics and society: A technological approach to archaeological assemblages*. Cham: Springer.

Schlanger, N. (1994). Mindful technology: Unleashing the chaîne opératoire for an archaeology of mind. In C. Renfrew & E. Zubrow (Eds.), *The ancient mind: Elements of cognitive archaeology* (pp. 143–151). Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511598388.015.

Solnay, E, Kreiter, A., & Szilágyi, M. (2023). The Ugly Duckling: Understanding the Making of an Early Copper Age Atypical Ceramic Vessel from the Great Hungarian Plain. *Open Archaeology*, *9*(1), 20220343. doi: 10.1515/opar-2022-0343.

Tixier, J. (1988). Technologie préhistorique. *Journée d'études technologiques en préhistoire, Meudon, 26 février 1986*. Paris: CNRS.

Torres, C., & Preysler, J. B. (2020). Experts also fail: A new methodological approach to skills analysis in lithic industries. *Journal of Paleolithic Archaeology*, *3*, 889–917. doi: 10.1007/s41982-020-00063-4.

Treuil, R. (2011). *L'archéologie cognitive*. Paris: Éditions de la Maison des Sciences de l'homme.

Tringham, R. (1994). Engendered places in prehistory. *Gender, Place & Culture*, *1*(2), 169–203. doi: 10.1080/09663699408721209.

Tringham, R. (1995). Archaeological houses, households, housework and the home. In D. Benjamin & D. Stea (Eds.), *The home: Words, interpretations, meanings, and environments* (pp. 79–107). Aldershot: Avebury Press.

Vassanelli, A., Petrinelli Pannocchia, C., & Starnini, E. (2023). The *Chaîne Opératoire* Approach for Interpreting Personal Ornament Production: Marble Beads in Copper Age Tuscany (Italy). *Open Archaeology*, *9*(1), 20220334. doi: 10.1515/opar-2022-0334.

Walls, M. (2016). Making as a didactic process: Situated cognition and the *chaîne opératoire*. *Quaternary International*, *405*, 21–30. doi: 10.1016/j.quaint.2015.03.005.