Rethinking Chaîne Opératoire: Agency and Cognition in Bronze Age Aegean Pottery Production

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ABSTRACT

The aim of this project is to rethink and re-envision the *chaîne opératoire* approach by considering theories of agency and cognition. I investigate three hypotheses: (1) *chaîne opératoire* is frequently engaged with only partially, (2) *chaîne opératoire* can be enhanced by considering theories of agency (ways of doing) and cognition (ways of thinking), and (3) that by incorporating theories of agency and cognition and further re-envisioning the framework we may arrive at a novel approach for the methodological analysis of production processes. This thesis is divided into three parts.

In Part One, Leroi-Gourhan's *chaîne opératoire* approach is reviewed and the main components are defined. Developments of the *chaîne opératoire* approach and, in particular, adaptations of the *chaîne opératoire* approach for archaeology are explored. Archaeological case studies of Bronze Age Aegean pottery are compiled for analysis due to the popularity of the *chaîne opératoire* approach within this subject as well as pottery's unique affordances. Upon analysis, I develop a taxonomy of three Use Types of the *chaîne opératoire* approach. Each Use Type draws on distinct elements of the *chaîne opératoire* approach. I argue that outdated theories of agency and cognition are at the center of the discrepancies between the significant scope of the framework and its practical use(s).

In Part Two, theories of agency and cognition are analyzed. I propose that the significant scope of the framework can be supported by theories of emergent, enactive, relational, co-constructive agency. Thereafter, I develop an avenue for the inclusion of these theories of agency within a *chaîne opératoire* approach. I then propose that the significant scope of the *chaîne opératoire* approach can similarly be supported by theories of embodied, enacted, and extended cognition due in part to how closely linked these theories are to process trends and *milieus*. Following analysis, I propose a singular framework which links these cognitive theories with process trends and *milieus*.

Part Three is the culmination of this work wherein I produce a novel *chaîne opératoire* approach which accounts for contemporary theories of agency and cognition demonstrated via application to a case study at Zakros. Throughout this project I also develop the visualization of the *chaîne opératoire* approach. What has historically been imagined as a linear framework, is re-envisioned commensurate with the theoretical amendments proposed. The final proposed

framework and visualization effectively link the finite aspects of making with the larger phenomenon of the process of making.

INTRODUCTION

Archaeologists seek answers to questions about our common human history within the material record. By examining extant objects, architecture, residue, and traces of life, we seek to understand these things and their environments which shaped, and were shaped by, the human experience. Yet it is impossible to completely recreate the past because of the complex phenomenon of human *being*. *Being* human means actively performing life on a daily basis in an ever-changing context over multi-scalar interactions with the surrounding environment (both physical and abstract). Archaeology is therefore a "systematic attempt to characterize these performances in their original spatial and social contexts, as well as how they develop over time" (Hilditch 2020, 64). The first step in this systematic characterization is to physically unearth material evidence – to excavate. I myself spent time in Crete excavating at Sisi, the site of a Minoan Palace. It was a summer spent toiling with my small pickaxe (or skalistíri; in Greek σκαλιστήρι), trowel, and brush under the hot sun uncovering history piece by piece, one thin layer of earth at a time. Much of the material uncovered at excavation sites is ceramic. "Ceramic" comes from the Ancient Greek keramikós (or κεραμικός) meaning "of or for pottery". The terms "ceramic" and "pottery" are used fluidly throughout this text.

Ceramic wares have the unique ability to withstand floods, fires, earthquakes, and most importantly - time. However, one of the complications of archaeology is that much of the material record is only partial. Many of these pieces of human history we recover are pottery fragments, also called pottery sherds. These pottery sherds are excavated, documented, sorted, washed, and meticulously pieced back together. In some cases, the sherds come together in the forms of spouted pouring vessels, enormous storage vessels, practical drinking cups, intricate figurines, useful tools, and more. One of the many questions archaeologists are left wondering is "how was this made?". People often balk at the notion that civilizations existing nearly five millennia ago could have developed the knowledge and tools to create intricate figurines, colorful glazes, enormous vessels, waterproof jugs, and so on. The popular television show 'Ancient Aliens' is a testament to just how far modern people will stretch their imagination to attribute palaces, pyramids, and feats of engineering to anything else *but* our common ancestors.

So, the answer to the question "how was this made?" is incredibly important. In order to answer this question, archaeologists require a methodological framework to study material culture and production processes of the past. In order to investigate this complex material record archaeologists have developed methodologies which are informed by various theories (social, technological, ecological, economical, and more). My research is an inquiry into *how we study* production processes. By refining our methods for studying production processes, we may in turn improve our ability to understand prehistoric knowledge, ways of life, beliefs, ecology, trade, and furthermore correctly attribute accomplishments to the peoples responsible for them.

A framework for the study of making

In order to study how things are made, we require a methodological framework. *Chaîne opératoire* has been developed over many decades as a methodological framework for the study of production processes. To understand the scholarly lineage from which the popular framework *chaîne opératoire* emerges, we begin with Émile Durkheim who, in the late 19th and early 20th centuries, insisted that sociology as a scholarly subject must emphasize the social phenomena and emergence of social properties (or social facts) in contrast to his contemporaries who drew on subjects such as biology, psychology, and economics as a way to inform sociological understanding (for translations of key texts see Durkheim 2004). It is unsurprising then that his student and nephew Marcel Mauss also emphasized the emergent process or "unfolding" of techniques as well as their social significance further suggesting that techniques contain cultural identifiers which could be found in an individual or group's *habitus* (from the Latin meaning a habit or custom and the acquired ability or faculty) (Mauss 1934). According to Mauss, the *habitus* can be observed through even the most mundane bodily activities such as digging with a spade, running, swimming, even the position of the hands at mealtime (Mauss 1934). Mauss furthermore postulated that we may find evidence of these social phenomena (*habitus*) not only in an object but also in the process of making an object. So, through the influence of Durkheimian sociology, we see a shift in interest from the finished object to the process of production. In order to analyze these *habitus*, Mauss showed particular interest in tracing a "chain" of operations, bodily movement, and techniques used to transform a material from various unfinished stages to its final form. Through the acceptance of Mauss' work, it is broadly agreed that social phenomena can be observed within production processes.

Following in this school of theory emerges the prehistorian and archaeologist André Leroi-Gourhan, a student of Mauss, who proposed the *chaîne opératoire* approach for studying production processes. Expanding on Mauss' "chain" of operations, bodily movement, and techniques, Leroi-Gourhan proposes *chaîne opératoire* which he used to describe "both gestures and tools, organized in a chain by a veritable syntax that simultaneously grants to the operational series their fixity and flexibility" (Leroi-Gourhan 1964a, 114). The term "syntax" is purposefully chosen to emphasize the ways in which bodily technique and production processes unfold organically and relationally, much like the development and unfolding of a language. Both techniques and languages are common to a wider group while being perpetuated or performed by the individual. *Chaîne opératoire* was soon widely utilized in the study of lithic production which we explore in Chapter Two. While this introduction briefly and broadly contextualizes this work within the research landscape, Chapter One offers a thorough review of the origins and development of the *chaîne opératoire* approach.

Visualizing the *chaîne opératoire* approach

While *chaîne opératoire* is recognized broadly as a methodological framework it is also specifically utilized as a visual representation of production processes. This stems from ethnographers' practices of transcribing ethnographic field notes into graphic form as illustrated by Figures 1 through 8. Leroi-Gourhan's works are filled with illustrations of objects, functional components of tools, production processes, and more which underline his interest in a variety of concepts with particular emphasis on the process of making. Balfet urges researchers to be "clear about what we expect of" graphic representations of *chaîne opératoire* studies due to the visual simplification of data (Balfet 1991, 18). We will see that due to the flexibility of the *chaîne opératoire* approach, as well as its use in various fields, there is no single visual template which can be employed across all studies. Leroi-Gourhan's student Lemonnier develops a system for classifying technologies wherein one may take an organic (based on material), functional (based on functions of components), or relational (how components are related to each other) approach to create graphic representations (Lemonnier 1992, 37). Furthermore, he elaborates that this can be visually represented by maps, graphs, or tree diagrams. The significant differences between Leroi-Gourhan and Lemonnier's approaches are outlined in Chapter One. For now, we consider their approaches to visual representation of production processes. The examples given here are but a few selections indicative of particular trends in visual representations and which have material applications. In later chapters

we will see theoretical proposals which further develop the visualization of the *chaîne opératoire* approach.

These visual representations are especially useful in the fields of ethnography and anthropology as analytical tools or templates for mapping processes observed through fieldwork with living peoples (Gosselain 2018). In Figure 1 Leroi-Gourhan outlines the stages of bodily actions to produce a bifacial lithic tool. This illustration promotes a visual understanding of field notes describing a sequence of bodily actions and various types of physical impact required to reduce and shape a stone into a sharp-edged tool. Taking a relational approach in Figure 2 Leroi-Gourhan outlines connections between elementary actions and tools using a graph. In Figure 3 we see Lemonnier outline an operational sequence, taking after Cresswell's approach. In Figure 4 Lemonnier outlines an operational sequence with a tree diagram. Valentine Roux, another key figure in the development of *chaîne opératoire*, tends toward photography, illustration (Figure 5), and tree diagrams. In Figure 6 we see Choleva opt for a basic outline containing tree diagrams to visually represent two wheel-coiling methods of pottery making. Figure 7 and Figure 8 show Gosselain's use of a combined graphic and photographic approach to represent phases and subphases of pottery production (Gosselain 2018). Of course, there are numerous other visual representations illustrated by the aforementioned scholars and others. Each of these serve a unique purpose specific to the study itself and help to represent the material production process. These visual representations are reflections of the flexible, and at times unwieldy, *chaîne opératoire* approach and depend greatly on the aim and content of each study. The wide variety of visual representations can cause epistemological confusion with regard to the *chaîne opératoire* approach. In the following chapters, we revisit the visualization of the *chaîne opératoire* approach. In keeping with the long history of developing visualizations for a *chaîne opératoire* approach, I aim to further the development of visual representation of this approach within the field of archaeology.

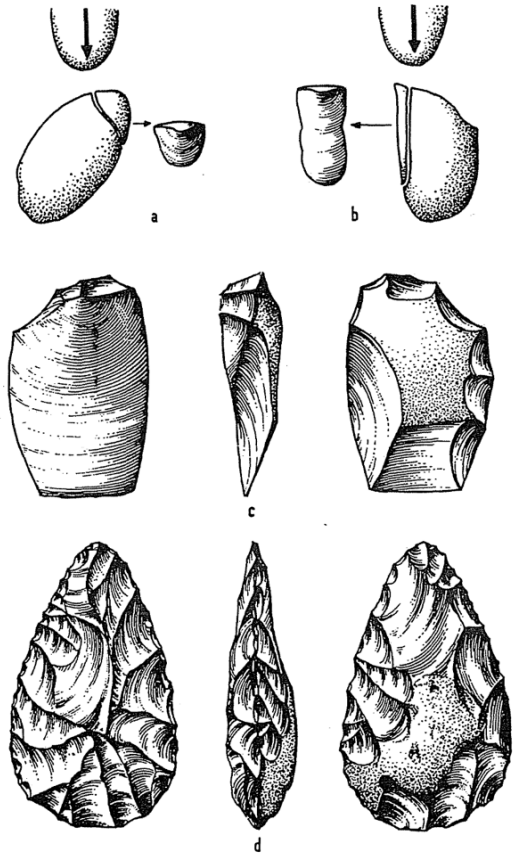


Figure 1. Illustration of a sequence of actions including impact resulting in a sharp-edged tool (Leroi-Gourhan 1964a)

		Dental percussion	Manual percussion	Percussion with the nails
	Aggression / Acquisition / Feeding	Crushing Sectioning	Hammering	Scraping Digging
Grasping: labio-dental	Relationship	———	Tearing ———	
Digito-palmar	Brachiation, seizing Affective contact Kneading Cupping Snuggling, protection	Crusher Knife Awl Spike	Chopper, hammer, club Spatula	Notcher Digging-stick, pick, hoe
Interdigital	Peeling Grooming Molding	Graver Punch Needle		Scraper
Projection		Spear	Stone, projectile Bola	

Figure 2. Connections between elementary actions and tools (Leroi-Gourhan 1964a)

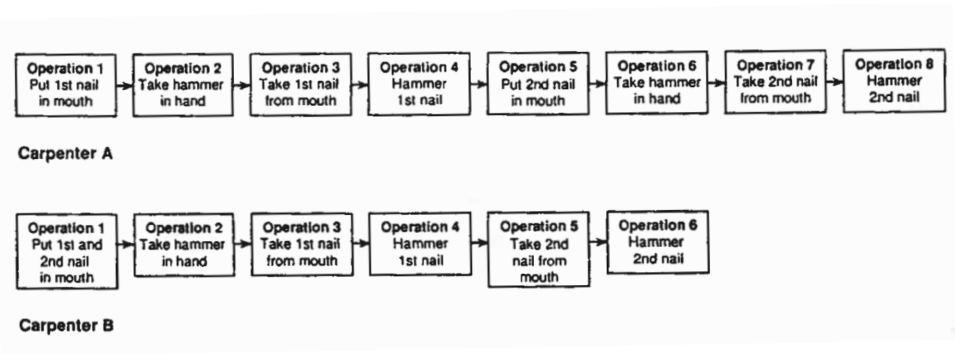


Figure 3. Two operational sequences highlight similarities and differences between Carpenter A and Carpenter B's processes (Lemonnier 1992)

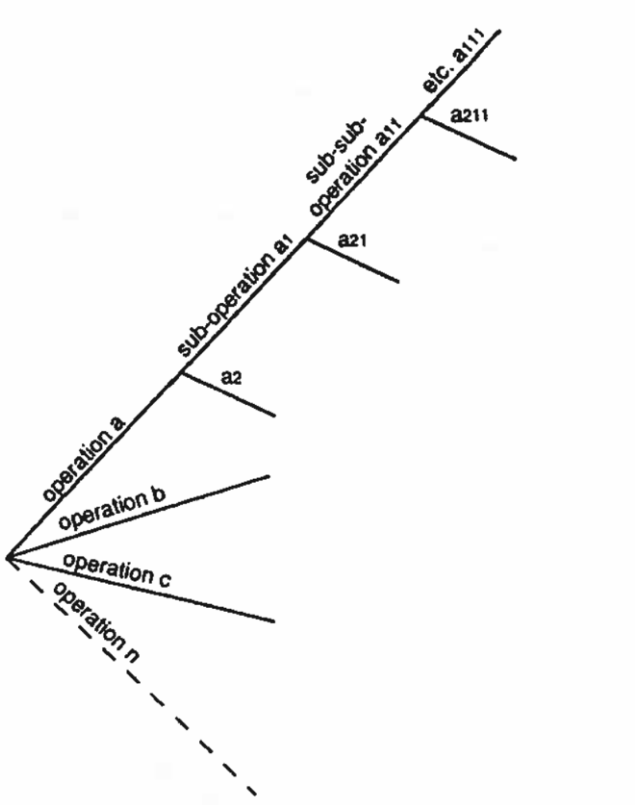


Figure 4. One example of Lemonnier's tree diagrams where branches represent operations and sub-operations involved in an operational sequence (Lemonnier 1992)

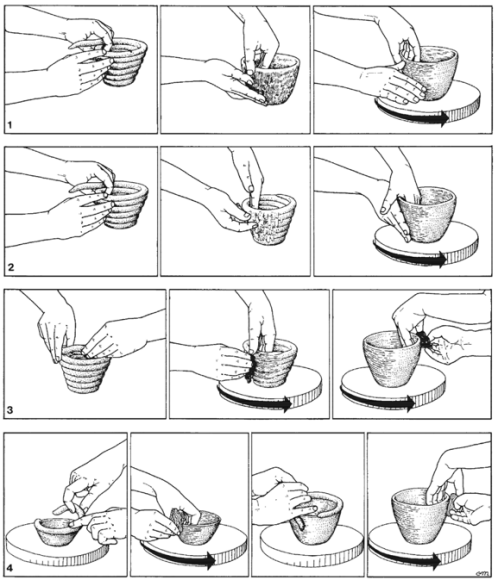


Figure 5. Manufacture of ceramic pots according to the four wheel-fashioning methods (Roux and Courty 1998)

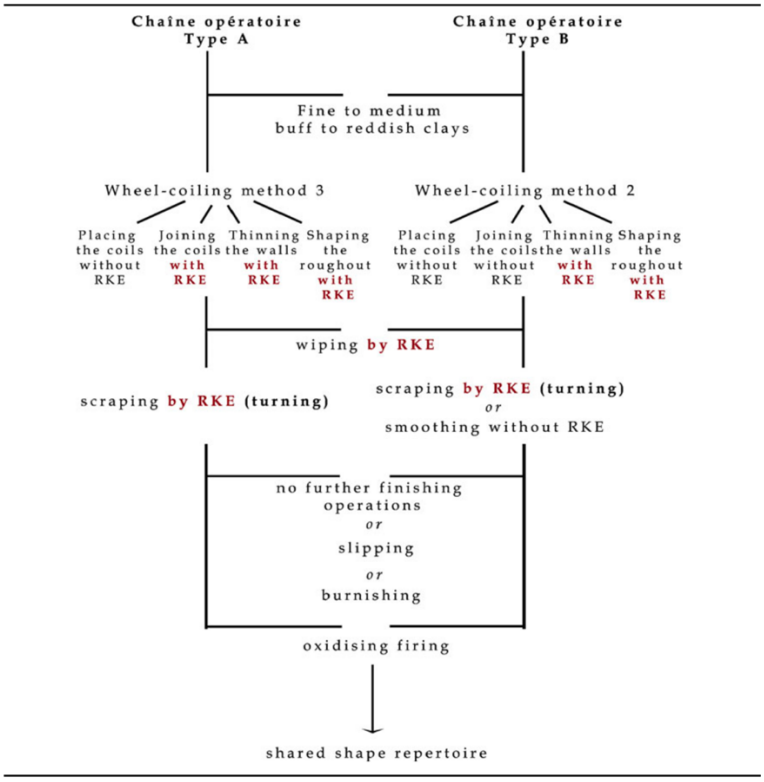


Figure 6. Diagram outlining two variants of wheel-coiling methods (Choleva 2020)

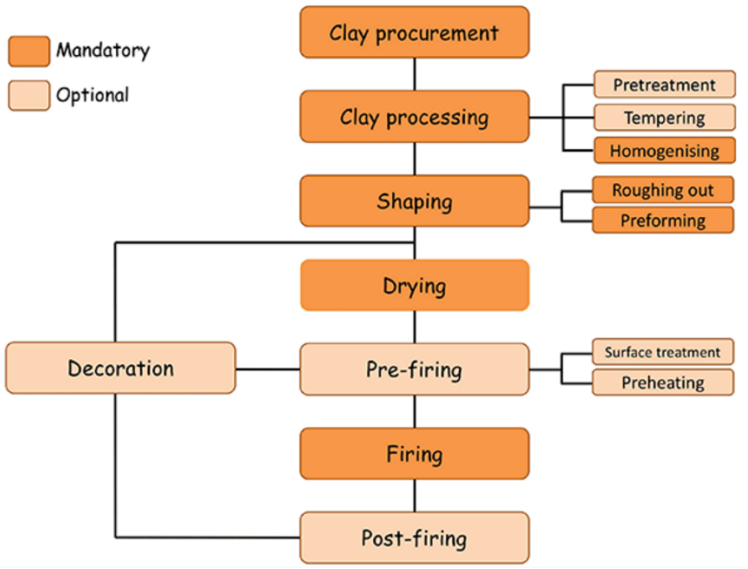


Figure 7. A graph representing phases of pottery production observed through ethnographic research (Gosselain 2018)

Figure 8. Photography is used to visualize a production phase from the previous figure (clay processing) which is further delineated by its sequence (grog fabrication) and operations (grinding and winnowing) (Gosselain 2018)

Throughout the development of the *chaîne opératoire* approach there are a variety of visual representations which differ based on the research question, material focus, and the researcher's personal preference. While each of these approaches to visual representation serve specific purposes, there are three problems to consider. First, each visual representation serves a unique epistemological purpose, but no single approach serves all purposes. Second, these visual representations (illustrations, graphs, tree diagrams) indicate one-directional approaches which

focus teleologically on the final outcome. In many cases they appear to visually represent recipes or blueprints for making things. Third, these visual representations emphasize the physical material and cannot or do not accommodate non-functional or non-material elements of production processes such as agency, cognition, tradition, environment, or cosmological beliefs. It is my aim throughout this work to develop a visual representation of the *chaîne opératoire* approach which can encompass all possible contributors to a process of production, which illustrates the complexity of process while also offering scalability, and which reflects the non-linear, multi-directional, relational nature of production processes. The ways in which we visualize methods is incredibly important. They guide our thinking. The unique visual representation of *chaîne opératoire* which I develop is not only useful as an analytical tool for mapping or plotting processes, but it *enlivens* archaeological data, and furthermore visually represents complex theoretical concepts which inform the way we think about making and about being human.

Research aims

The *chaîne opératoire* approach was developed as a method to better understand the phenomenon of making by drawing on a range of scientific, philosophical, and theoretical fields of inquiry. Throughout the framework's development, researchers have drawn on specific facets of the *chaîne opératoire* approach, disregarding the elements which do not suit a particular study, or which remain theoretically or practically underdeveloped. Furthermore, while the *chaîne opératoire* approach was initially developed by ethnographers and anthropologists, it has been adopted by archaeologists and adapted to suit the needs of the field. This adoption and adaptation serves as proof of its immeasurable flexibility and efficacy. In its adaptation for archaeological purposes, the overall *chaîne opératoire* approach has developed into three distinct approaches (later defined as Use Types in Chapter Three) which draw on specific elements of the framework. Each of these *chaîne opératoire* approaches relies upon and results in prescriptive models of production processes including anthropocentric ways of doing (agency), and computational ways of thinking (cognition). I suspect that if it were possible to incorporate new theories of agency and cognition with the *chaîne opératoire* approach we may produce a framework for studying the phenomenon of making while avoiding such prescriptive models. Therefore, I propose a theoretical reappraisal of the *chaîne opératoire* approach in order to rethink *chaîne opératoire* by subjecting it to new relational questions and theoretical frameworks related to the fields of agency and cognition. While this work is

contextualized within the landscapes of each theoretical field of agency (Chapter Five) and cognition (Chapter Seven), it must be acknowledged that this project as a whole would not be possible without the groundwork laid by Carl Knappett. Knappett's work is referenced throughout, but conceptually his (2005) book *Thinking Through Material Culture: an interdisciplinary perspective* has greatly influenced this project as a whole. Knappett's work is aimed broadly at analyzing the intersection of material culture, agency, and network theory. Others have taken similar approaches to material culture and themes of agency, or cognition, which are detailed in Chapters Six through Ten. The approach I develop uniquely tackles both agency and cognition and furthermore brings these concepts together with the *chaîne opératoire* approach. By rethinking the *chaîne opératoire* approach, I aim to produce a renewed *chaîne opératoire* approach which simultaneously accounts for the finite aspects of production processes (mechanical elements) with the larger phenomenon of *ways of doing* and *ways of thinking* (phenomenological elements).

Making the thesis: structure and method

Addressing many large topics, this work is presented in three parts including detailed literature reviews alongside each theoretical chapter. Part One comprises "The Background" and is made up of Chapters One through Four which set the stage. First, we must understand the *chaîne opératoire* approach, its scope and capacity, as well as the key elements of the framework. Chapter One illustrates the history of thought from Émile Durkheim to Marcell Mauss to Leroi-Gourhan – a school of thought which led to and influenced the *chaîne opératoire* approach. Not only does this background serve to situate this project, but it is also imperative as many of Leroi-Gourhan's works have recently been translated to English. Leroi-Gourhan's work is viewed by many as timeless (partially due to the fact that it is indeed quite open-ended) and covers a variety of fields such as ethnography, anthropology, material culture studies, and technology. Leroi-Gourhan's work has had a lasting impact not only on the aforementioned fields but also influenced fields of inquiry such as aesthetics, linguistics, and philosophy (Schlanger 2025, 5). Contemporary scholars of the *chaîne opératoire* approach continue to refer to Leroi-Gourhan's works, to translate them, continue to develop the concepts, and find potential for continued research within the original texts (e.g., Audouze 2002; Audouze and Karlin 2017; Schlanger 1994b; 2005; 2025). Nathan Schlanger states:

> "...we would be quite mistaken to typecast Leroi-Gourhan's work as being of 'merely historical interest.' Besides missing the wider purposes of both intellectual history and science studies, such a dismissive appraisal would also lead us to belittle the demonstrable impacts and current potentials of his technological contributions. In fact, ... several original aspects of Leroi-Gourhan's technological propositions have hardly aged at all and have actually increased their potential for generating new research questions and perspectives today [emphasis added] — be it regarding the material efficiency of technical actions, the ethnographic and sociological appraisal of the *chaîne opératoire*, or indeed the development of cognitive archaeology" (Schlanger 2025, 4).

Chapter Two provides an overview of the ongoing development of the *chaîne opératoire* approach. The various ways in which the *chaîne opératoire* approach has been adapted to archaeological research by key figures are highlighted. Additionally, common materials (lithics and ceramics) which arise in *chaîne opératoire* studies are highlighted, as well as reasoning as to why pottery is well-suited to further develop the *chaîne opératoire* and its visual representation. Lastly, current applications of the *chaîne opératoire* approach as well as my own proposal for a phenomenological approach for archaeology are contextualized within the ongoing development of the field. Chapter Three provides documentation and analysis of twenty three *chaîne opératoire* case studies within the Bronze Age Aegean period. These twenty three case studies are the result of a literature search targeting all Bronze Age Aegean studies which name *chaîne opératoire* as their methodology and whose material application is pottery. By examining the studies' methodologies and practical applications we uncover which element(s) of the *chaîne opératoire* approach are engaged. This results in three groups of case studies each of which engages with some or no element(s) of the *chaîne opératoire* approach. I classify these as Use Type(s) One, Two, and Three. The taxonomy and analysis of these *chaîne opératoire* Use Types serve two purposes: (1) the Use Types contextualize the current use(s) of the *chaîne opératoire* approach within its development; (2) we may also understand how each Use Type is situated within contemporary archaeological theory. By situating the *chaîne opératoire* Use Types within contemporary archaeological theory, the opportunity to drive the development of *chaîne opératoire* forward by incorporating theories of agency and cognition is highlighted.

Part Two of this project makes up "The Theory". To begin, in Chapter Four the strengths and weaknesses of the Use Types are discussed and contextualized in the development of the *chaîne opératoire* approach and also contextualized within contemporary archaeological theory. In doing so, a disconnect is highlighted between the capacity for a phenomenological *chaîne opératoire* approach and its practical use as seen in the Use Types. I attribute this disconnect to the lack of engagement with theories of agency and cognition within the *chaîne opératoire* Use Types – theories which exist within Leroi-Gourhan's proposal for the framework. While each Use Type serves a practical purpose, each has its limitations including prescriptive typology, anthropocentric ways of doing, and computational ways of thinking. These limitations provide the basis for further investigation into theories of agency and cognition.

Chapter Five provides a thorough review of theories of agency including the indexical approach, primary and secondary agents, person-like agency, Actor Network Theory, objects' lives, and entanglement. It is through exploring these topics that I find correlations with Leroi-Gourhan's works, as well as novel avenues for incorporating such theories into a practical *chaîne opératoire* approach while taking a unique phenomenological approach. Chapter Six commences with discussion of where agency does exist in the *chaîne opératoire* approach through Leroi-Gourhan's theoretical developments, and the ways in which it is engaged with in the *chaîne opératoire* Use Types. I highlight how we can bridge the gap between the phenomenological potential of the *chaîne opératoire* approach and its practical use by engaging with theories of agency. I draw on various elements of theories of agency formulating an approach informed by network theory, typology, objects' lives, contextual reading of objects, entanglement, and relationality to rethink the *chaîne opératoire* approach with regard to agency.

Following a similar approach, in Chapter Seven I review and analyze theories of cognition including the topics of cognitivism, embodied cognition, embedded cognition, extended cognition, and enactive cognition. I review again the ways in which the *chaîne opératoire* approach already accounts for these theories of cognition, and the ways in which the Use Types do (or do not) engage with these theories. While in many ways the *chaîne opératoire* approach has the ability to account for contemporary cognitive theories, there is no practical outline for the application of a *chaîne opératoire* approach which accounts for contemporary cognitive theories while also taking a phenomenological approach. In Chapter Eight, drawing on theories of embodied, extended, and enacted cognition, I formulate a *chaîne opératoire* approach which accommodates these theories, takes a phenomenological approach, and yet still remains practically useful for archaeologists. At

this point in the project, we have two distinct frameworks – one which incorporates theories of agency with *chaîne opératoire* and one which incorporates theories of cognition with *chaîne opératoire*. It is then our task to bring these two frameworks together to provide a *chaîne opératoire* approach which simultaneously accounts for the finite aspects of production processes (mechanical elements) with the larger phenomenon of *ways of doing* and *ways of thinking* (phenomenological elements).

Part Three, "The Resolution", is the culmination of this project. Part Three is the space in which we rethink the *chaîne opératoire* approach with respect to relational theories of both agency and cognition, and to join together the two proposed frameworks (incorporating agency and incorporating cognition) into one. This, as the latest development of the *chaîne opératoire* approach, propels it forward into contemporary approaches to archaeology including Process Archaeology and cognitive archaeology. In this section the phenomenological capacity of the *chaîne opératoire* approach is reviewed to once again ground this research. In doing so, we arrive at a *chaîne opératoire* approach which includes emergent, enactive, relational, co-constructive agency and embodied, enacted, extended cognition.

Having reconsidered the key elements of *chaîne opératoire* and redefined them to account for new theories of agency and cognition, the proposed framework is tested in a case study. I have selected for this exercise an early excavation report from the Bronze Age Aegean site Zakros (sometimes also called Zakro or Kato Zakro). Zakros is a harbor site, located on the easternmost coastline of Crete, most likely participating in the vast trade routes of the Aegean, Near East, and mainland Greece. This particular excavation report from Zakros is conducive to this exercise for a number of reasons. The Zakros report uniquely (1) outlines pottery found at distinct locations (pits and houses) rather than an emphasis on morphology or functionality; (2) the report references similar finds from near and far (Palaikastro, Phaistos, Psychro, and Knossos); (3) the report references finds of non-ceramic materials (e.g., metals); and (4) there is existing ethnographic and anthropological research regarding modern potters of Crete from which we may draw information. Reasons for selecting the Zakros excavation, rather than one of the previously analyzed case studies, are expanded upon in Chapter Nine.

In this case study of Zakros, I outline examples showing how pottery from this site might be studied using the *chaîne opératoire* approaches which *do not* account for agency and cognition (Use Types One and Two). Next, I approach the same excavation of pottery following my proposal for rethinking *chaîne opératoire* to understand how the proposed framework can be applied. Using

visualizations the proposed *chaîne opératoire* approach is contextualized within the broader development of the approach and furthermore represents the theoretical advancements in archaeology. Elements of the proposed *chaîne opératoire* approach are defined: typology/classification, modes of action, process trends, and *milieus*. By creating and overlaying visual representations of these elements, I hope to at once illustrate how incredibly complex this approach is while also allowing the approach to become accessible and scalable. In the end, we are left with a *chaîne opératoire* approach which includes emergent, enactive, relational, co-constructive agency and embodied, enacted, extended cognition. This proposed *chaîne opératoire* approach is able to simultaneously account for the finite aspects of production processes (mechanical elements) with the larger phenomenon of *ways of doing* and *ways of thinking* (phenomenological elements).

Following the three main parts of this research, in Chapter Ten we explore how the concepts presented throughout this work contribute to the overall development of archaeological method and theory. In particular, I highlight two contributions: (1) the impact this work has on the *chaîne opératoire* approach and how this proposed iteration fits within its life story and ongoing development, and (2) the significance of revisualizing the *chaîne opératoire* approach. Furthermore, by rethinking *chaîne opératoire* I highlight the potential that this newly proposed framework has for re-evaluating many existing studies of production processes and the potential to uncover novel data. Finally, I dedicate space to discuss the directions in which this research may proceed in the future.

~ Part One: The Background ~

CHAPTER ONE

ORIGINS AND DEVELOPMENT OF THE *CHAÎNE OPÉRATOIRE* APPROACH

Introduction

As archaeologists we study human history through material culture in an effort to uncover and understand lives which came long before us. Archaeologists question how artefacts were made and used, by whom, and how. And while the focus of archaeological excavations and studies has not changed, the ways in which we think about archaeology and the ways in which we execute archaeological studies has evolved over many decades. This chapter outlines in detail the *chaîne opératoire* approach: its origins, development, and applications. It is prudent to understand the development of the foundational concepts of *chaîne opératoire* in order to highlight how these very same concepts have been adopted and adapted within the field of archaeology.

What is the contemporary relevance of these original works developing the *chaîne opératoire* approach? Apart from establishing the background of philosophical and scientific thought, these works retain their relevance. Many scholars today continue to translate, analyze, critique, and appreciate the works of Leroi-Gourhan precisely because they remain relevant and impactful. Additionally, because Leroi-Gourhan's works draw inspiration from various fields of study, his work consistently invites renewed interest and application to modern research within fields such as psychology, linguistics, and even computer sciences. To discuss *chaîne opératoire* approaches without highlighting the salient features as developed by Leroi-Gourhan would do a great disservice to the reader. In the words of one of the foremost *chaîne opératoire* experts, "Besides missing the wider purposes of both intellectual history and science studies, such a dismissive appraisal would also lead us to belittle the demonstrable impacts and current potentials of his technological contributions…[in fact] several original aspects of Leroi-Gourhan's technological propositions have hardly aged at all and have actually increased their potential for generating new research questions and perspectives today" (Schlanger 2025, 4).

Inspired by Émile Durkheim's interest in social phenomena and emergence of social properties (or social facts), and Marcel Mauss' "unfolding" of techniques, their social significance,

and the individual or group's *habitus*, Leroi-Gourhan set out to encapsulate these concepts within a methodological framework (Mauss 1934; Durkheim 2004). The *chaîne opératoire* approach is rooted in the aforementioned French school of thought as a method of evidencing the concepts of social phenomena, collective knowledge, technology (application of conceptual knowledge to achieve practical goals), and techniques (socially informed methods of applying said conceptual knowledge), as well as the processes through which these phenomena unfold.

Deliberately taking a wide approach, "production processes" within archaeology function as the focus of this project rather than niche fields of interest such as technology or technique for a number of reasons. While related to technology (application of conceptual knowledge to achieve practical goals), and techniques (socially informed methods of applying said conceptual knowledge), the term production process encompasses the technology necessary for producing, the technology being produced, and the techniques embodied in the process. Both technology and technique can be investigated as elements of production processes. Furthermore, the term technology encompasses not only the application of conceptual knowledge to achieve practical goals but it also describes technological objects (e.g., a cellphone). The term technology further has a modern connotation, and has both moral and ethical implications related to industrialism, capitalism, colonialism, and politics (Coupaye 2022c, 437). Throughout this work we encounter studies which focus deliberately on technology or technique – these terms will be used when referencing specific works but should be understood as components of the larger production process. Taking this broad approach to production processes enables us to consider *chaîne opératoire* as inclusive of many social phenomena and materials.

It is also important to note that the *chaîne opératoire* approach has its roots in the fields of ethnography and anthropology. While the origins of the concept are outlined for context, this project focuses on the use of the *chaîne opératoire* approach within the field of archaeology. Its use in archaeological studies relies on the main concepts developed by ethnographers and anthropologists, however, the main concepts have been adapted for archaeological purposes. In order to maintain a focus on archaeology, the history of the *chaîne opératoire* approach is intentionally succinct. There are many brilliant publications which provide full historiographies of the *chaîne opératoire* approach and its ethnographic and anthropological applications, and they will be noted wherever appropriate. As a final note on semantics and the guiding interests of this project, let us consider the phrase "*chaîne opératoire* approach" which has already appeared in the introduction of this project. This phrase is used specifically to encompass the numerous ways in

which the foundational concepts of *chaîne opératoire* are employed. In some cases, *chaîne opératoire* is referred to as a systematic methodology (practical way of gathering data), or a framework (conceptual approach), or both (Schlanger 2005, 19). Additionally, *chaîne opératoire* functions as a visual template for illustrating or visualizing technological processes. It will be made clear in this text wherever the *chaîne opératoire* approach is used explicitly as a methodology, framework, or visual template. However, with the aim of analyzing a multitude of applications across various fields, I refer to the "*chaîne opératoire* approach" in most cases of its application.

The central concept of the *chaîne opératoire* approach stems from the postulations of Marcel Mauss, Leroi-Gourhan's professor and mentor, who believed that technical gestures are conscious and emerge from individual and collective practical reason (Schlanger 1994b, 144). For Mauss, "even the most corporeal and biological aspects of humanity… arbitrary in their action [can be] appropriated into the social domain and rendered efficient there" as socially and historically dependent technical gestures (Schlanger 1994b, 144). Furthermore, technical gestures involve choices (e.g., techniques, materials, and physical actions) which are not solely based on function and therefore constitute components of a person or group's social and cultural context (*habitus*). In the case of archaeology, this information can lend itself to an intimate view of the ancient gesture-maker (a person or group) and their sociocultural context. While ethnographic and anthropological studies often have access to the peoples of interest, archaeologists do not have the ability to visit, speak to, observe, and become involved with the subjects of their research. The concept that technical gestures may lend insight to ancient peoples and their sociocultural context is therefore invaluable. Employing this logic in the field of archaeology, the goal is to discover unique elements of the producer's gesture and tool-use (ways of doing), as well as logic (ways of thinking), and their greater sociocultural context. This can include elements such as the complex social, ecological, and cosmological elements involved in ancient technological activity (Lemonnier 1992, 1; Schlanger 2005, 19).

Following in the footsteps of Mauss, Leroi-Gourhan took an interest in technique, technology, and more broadly production processes. His work can be seen as an effort to reconcile Mauss' abstract theories with the need for a methodological framework, culminating in the conceptualization of a *chaîne opératoire* approach. Leroi-Gourhan popularized the term *chaîne opératoire* which he used to describe "both gestures and tools, organized in a chain by a veritable syntax that simultaneously grants to the operational series their fixity and flexibility" (Leroi-Gourhan 1964a, 114). This definition is simultaneously specific and ambiguous. As we will see throughout this

project, Leroi-Gourhan's writing is full of incredibly specific terminology drawn from a range of scientific fields which is then used to compose descriptions and imagery of concepts. His work in some cases lacks clear definitions, outlined models, or replicable methods. With this "fixity and flexibility", we see the application of Leroi-Gourhan's concepts used in a wide variety of methods across various fields of study. The very diversity of methods and fields in which we find Leroi-Gourhan's concepts employed proves the versatility and effectiveness of the *chaîne opératoire* approach. Researchers have considered the utility of standardizing and schematizing the *chaîne opératoire* approach, arguing instead for the preservation of its very flexibility and therefore diversity of applications (Balfet 1991). In agreement with the preservation of flexibility, this project is not an attempt to "standardize" the *chaîne opératoire* approach in archaeological studies. I do, however, find a pattern of distinct methods of application in archaeological studies (see Chapter Three "Use Types"). This taxonomy of methodological applications offers an avenue for recognizing the merits and efficacy of these distinct *chaîne opératoire* approaches. Outlining these methods of application furthermore highlights avenues for incorporating contemporary theories of agency and cognition within the *chaîne opératoire* approach.

In addition to the aforementioned obstacle of defining the *chaîne opératoire* approach, Leroi-Gourhan's work was originally written and published in French. The earliest translation is published 1993, decades after his first major work was first published in 1943. In 2025, another major translation was published – this work includes selected texts from Leroi-Gourhan's oeuvre for translation to English (Schlanger 2025). Despite the efforts of translators, not all of Leroi-Gourhan's work has been translated into English. Additionally, the concepts that Leroi-Gourhan proposes stem from the long and diverse French school of thought – much of which also remains to be translated to English. Aside from this language barrier, one of the reasons for the lack of clarity within Leroi-Gourhan's works is due to the fact that he borrows terminology from many disciplines to formulate his novel approach. As Audouze states, "Leroi-Gourhan borrowed from philosophy, social anthropology, prehistory, paleontology, and biology, without adopting the full theoretical framework and practice of any of them" (Audouze 2002, 278–79). The *chaîne opératoire* approach is influenced by so many fields of inquiry alongside a range of theory and philosophy, that the methodological framework is, to put in in Leroi-Gourhan's own terms, both "fixed and flexible". The fixity and flexibility, specificity and ambiguity, mechanical and phenomenological aspects of the *chaîne opératoire* approach results in an unwieldy framework which is used frequently and flexibly through various interpretations. In this chapter I aim to make sense of this *chaîne opératoire* approach made

up of various scientific fields of inquiry and methods, and a range of theory and philosophy, all of which is defined mostly through figurative description and visual representations by Leroi-Gourhan.

Early development of the *chaîne opératoire* approach: technical gestures, modes of action, and motive gestures

As has been briefly outlined in the introduction, *chaîne opératoire* was initially proposed to describe both gestures and tools in an operational schema which encompasses both fixed and flexible elements. But how? Major themes explored by Leroi-Gourhan in the early stages of the development of *chaîne opératoire* include gestures, modes of action, technical facts, technical tendencies, and *milieus*, which are defined and discussed in this chapter. Leroi-Gourhan cannot be described simply as a prehistorian or ethnologist without the caveat that his research involved deconstructing barriers between various disciplines including, but not limited to, biology, ergonomics (e.g., contemporary work by Maget), psychology, sociology, and linguistics (Audouze 2002, 281). His vision for the *chaîne opératoire* approach stems from a multidisciplinary approach drawing heavily on the aforementioned fields, intuiting a strong correlation and continuity between the biological and social realms. In his own words, the "social body" is "a prolongation of the anatomical body" (Leroi-Gourhan 1964a, 20). However, as Schlanger notes, in Leroi-Gourhan's effort to correlate the fields of biology and prehistory, a rather "deterministic and teleological view of human evolution" occurred (Schlanger 1994b, 145). This will be addressed later in discussions and critiques of *chaîne opératoire* and cognitivism but is worth mentioning in relation to the development of the framework.

Still, Leroi-Gourhan's intent was to uncover the interrelationality of things, not to analyze things themselves in isolation from one another. As Levi-Strauss wrote shortly after Leroi-Gourhan's death, Leroi-Gourhan worked to "reduce the chaotic diversity of the empirical data to invariant relations and to use a method of transformations" (Levi-Strauss 1988, 203-204). Part of Leroi-Gourhan's multidisciplinary approach was in pursuit of a new lens with which to view his subject. He does so in part by following the Durkheimian and Maussian school of thought; Leroi-Gourhan's work shifts the focus away from the final artefact to the production of the artefact. By focusing on the production of an artefact, Leroi-Gourhan is able to use these results as a comparative ethnographic tool. As we will see, Leroi-Gourhan and other ethnologists and anthropologists use the *chaîne opératoire* approach to compare objects and processes across broad geographic regions and across various groups of peoples.

Leroi-Gourhan turned his attention to material culture and techniques as integral elements of human nature that can be traced from the earliest hominids to the present day. Mauss introduced the notion that technical gestures are socially and historically context dependent. However, according to Lemonnier, Mauss did not create a feasible framework for said analysis of technical gestures in relation to one another (Lemonnier 1992, 1). Leroi-Gourhan's work on the subject begins where Mauss left off, with his first major work published in two volumes, *Evolution et techniques – L'homme et la matière,* and *Evolution et techniques – Milieu et techniques* which consist of a thorough investigation and classification of techniques as well as theory of technique (Lemonnier 1992; Leroi-Gourhan 1943; 1945). These two volumes are an attempt to create a formalized approach for the observation, classification, and analysis of technical gestures. The term "technical gestures" describes any action involving any object or tool wherein the importance of action, matter, and tool are equal, and each are treated as separate entities. Based on Leroi-Gourhan's work, Lemonnier further develops and defines the term "technical gestures" as actions on matter involving an object or tool (Lemonnier 1992, 1). A technical gesture is also described as "a basic unit of technical action…the smallest unit of action on a material" (Balfet 1991, 17). While recognizing that technical gestures are socially influenced, Lemonnier separates the social influence from the basic description of the action so that technical gestures can be observed as units of analysis and later studied in conjunction with their social and historical context (Lemonnier 1992).

In an effort to produce a novel approach, in these two volumes and his later work *Gesture and Speech,* Leroi-Gourhan centers "modes of action" as the subject of analysis rather than classification of technical gestures, tools, and objects. Allied with his effort to study not the thing itself but the interrelation of things Leroi-Gourhan defines modes of action as the "intermeshing of tools and the motive gesture" and posits that "the real significance of tools is in the gesture, which makes them technically effective" (Leroi-Gourhan 1964a, 237, 242; Schlanger 1994b, 145). In this sense, "gesture and tool form a single whole" thus negating the possibility for analysis of techniques, tools, and or objects in isolation (Leroi-Gourhan 1964a, 242). While seemingly similar, technical gestures and modes of action do have important distinctions and emphases. After initial work on technical gestures (after Mauss' phrasing), Leroi-Gourhan's work explores this notion further which leads to his emphasis on modes of action, meaning a "motive gesture", wherein the tool and the action become conflated (Audouze 2002, 283). In modes of action the matter upon which the gesture is focused is deemphasized in the equation. Furthermore, the term "action" is elaborated upon in

definition by the phrase “motive gesture”. This allows for a more fluid description wherein the action is now a *gesture in action with and through tools*.

Unity and diversity of techniques: technical tendencies and technical facts

Leroi-Gourhan emphasized the need for an all-encompassing approach which would be applicable not only to gestures or actions but also complex techniques. Leroi-Gourhan compiled some 40,000 entries (material objects) which would be used in his classification of techniques. The purpose of *Evolution et techniques – L’homme et la matière* was to create a system for the categorization of material objects according to a rationalized methodological system (Ehrich 1952, 145; Audouze 2002, 283). *Evolution et techniques – L’homme et la matière* essentially substantiates an encyclopedia of modes of action. Two principles delineated the classification system. First, materials are classified according to their physical properties and the potential modes of action taken to transform them (physical forces and bodily actions) (Audouze 2002, 283). Second, modes of action are classified according to their “finality” – these are further classified by their elementary means and forces such as percussion, prehension (types of grasping), heating, and/or use of water (Audouze 2002, 283). Through the reduction and classification of elementary forces Leroi-Gourhan was able to then able to observe techniques in production processes through visible patterns (recurring choices of gesture, tool, and material) within their socio-historical context.

These classifications enabled Leroi-Gourhan to further divide technique into two phenomena which he named technical facts (or *les faits*) and technical tendencies (or *la tendance technique*) (Leroi-Gourhan 1945). These concepts serve as devices for comparing the evolution and acquisition of techniques and the material evidence thereof across groups of peoples. Technical tendencies describe the ways in which “the laws of geometry or rational mechanics” drive peoples to develop techniques for producing similar objects (Leroi-Gourhan 1945, 338). Technical tendencies describe the apparent similarities of objects and tools which we may find across civilizations that have had no contact. For example, due to the laws of physics combined with human needs we find most roofs are peaked rather than flat and that sharp swords have handles with which to hold them. The technical tendency “has an inevitable, foreseeable, rectilinear character … [which] drives the handheld flint [tool] to acquire a handle” (Schlanger 2025, 102). Leroi-Gourhan posited that technical tendencies develop and “evolve” in a manner similar to the process of natural selection and therefore he utilized models of biology and selectionist evolution to examine them

(Leroi-Gourhan 1964a). While technical tendencies describe observable similarities across groups (peaked roofs), technical facts describe the variations of forms which materialize based on a group's sociocultural and natural environment (e.g., a thatched, round, peaked roof versus a wooden, rectangular, peaked roof) (Schlanger 2025; Leroi-Gourhan 1943). Technical facts describe variations and furthermore degrees of variation (i.e., degrees of fact or degré du fait) within the overall tendency (Leroi-Gourhan 1943). For example, we may find one or more technical tendencies within the structural organization of harpoons across all groups which hunt large marine life. We then find technical facts (and degrees of fact) which distinguish one group's harpoon from another (e.g., length of harpoon, handle material, shape of blade, etc.).

By incorporating these technical tendencies and technical facts into the *chaîne opératoire* approach, ethnographers and anthropologists can understand elements of technical choices, enskilment and transmission highlighted by technical actions and techniques. Furthermore, they may deduce certain implications of a group's sociocultural context also known as the group's *milieus* (discussion forthcoming). The project of this thesis is to underline and incorporate these technical tendencies and technical facts into the *chaîne opératoire* approach for archaeologists alongside concepts of agency and cognition in order to rethink the *chaîne opératoire* approach. In doing so I aim to produce a renewed *chaîne opératoire* approach which simultaneously accounts for the finite aspects of production processes (mechanical elements) with the larger phenomenon of *ways of doing* and *ways of thinking* (phenomenological elements).

Some note that the influence of selectionist evolutionary biology is outdated and therefore this element of the *chaîne opératoire* approach ought to be disregarded (e.g., Schlanger 1994a), while others promote a related approach drawing instead on modern theories of evolution (Riede 2006). Each of these arguments are worth considering and merit further exploration although it remains outside the scope of this work. Leroi-Gourhan's interest in selectionist evolutionary theories is merely one aspect within the field of biology which he draws on and furthermore does not necessarily impact the *chaîne opératoire* approach as a whole; this topic is more closely related to Leroi-Gourhan's exploration of cognition which is outlined in Chapter Eight. A summary is offered by Audouze, "Leroi-Gourhan's work was a vast philosophical construct, the purpose of which was to relate biological, anthropological, sociological and aesthetical factors in a teleonomical [goal directed] view of evolution" (Audouze et al. 2017, 720). The aspect of selectionist evolutionary theory which does indeed impact the *chaîne opératoire* approach in archaeology is addressed by theories of agency (Chapters Six and Seven) and of cognition (Chapters Eight and Nine).

Milieus

With modes of action, technical tendencies, and technical facts established, Leroi-Gourhan then proposed in volume two of *Evolution et techniques – Milieu et techniques,* that transmission, diffusion, and innovation should be analyzed from the greater perspective of a social group in its entirety. This was Leroi-Gourhan's foray into explaining how human intelligence interacted with the tangible ecology (environment, resources, population, etc.) and intangible ecology (cosmological beliefs, cultural values, etc.). He posited that transmission, diffusion, and innovation could be analyzed through his three key concepts *milieu extérieur, milieu intérieur,* and *milieu technique* (Schiffer 1994, 203). The exterior *milieu* (*milieu extérieur)* is an all-encompassing term which includes the natural environment, material culture, and ideas of other groups of people. The exterior *milieu* is continually addressed and expanded upon by scholars in research regarding material cultural ecology – for instance Ingold challenges the academic tradition of separating studies of material culture from those of ecological anthropology, a topic which will be discussed in following sections regarding current explorations of *chaîne opératoire* (Ingold 2012).

The second key concept, interior *milieu* (*milieu intérieur*) then describes the "intellectual capital of a given group"(Audouze 2002, 285). This interior *milieu* contains traditions and perpetuated modes of thought and action. It also contains the group's *milieu* technique (*milieu technique*) – the third key concept. This *milieu* technique emerges as feedback from the ongoing relationship between the interior and exterior *milieus*. The *milieu* technique is perpetually evolving, and while new information, skills, and technical gestures can be added to a group's *milieu* technique it is posited that this is an accumulative process, and acquisitions are seldom erased. Furthermore, the *milieu* technique responds to pressure from the exterior *milieu* in the form of responses or borrowing. For example, technical actions can be responses to external pressure (e.g., resource scarcity), while internal modifications and improvisation can occur through borrowing from the exterior *milieu* (borrowing from other groups' practices for example).

Finally, an accumulation of responses and borrowing can lead to mutation of the *milieu* technique and therefore a mutation of the interior *milieu*. The *milieu* technique is considered to be inherently continually developing. This includes covariations such as the covariant presence of the wheel in a group (e.g., the pottery wheel, wheeled carts, and spindle whorls) (Andersson Strand 2012). If the *milieu* technique is indeed continual, it implies that all elements are compatible with

each other. This is later disputed in studies of sociocultural plasticity (how open a sociocultural group is to changes, adoption, or adaptation of new ideas and technology) where elements can be incompatible and therefore affect a group's likelihood to adopt or adapt to new technical information (Lemonnier 1993). Studies of this kind have been carried out regarding the potential introduction of pottery-making methods to Middle Minoan Crete (Knappett 2004; Jeffra 2013; Roux 2020). These studies typically outline that despite the introduction of new techniques or technologies some groups show resistance to adoption or adaptation.

While Leroi-Gourhan did not fully develop a *chaîne opératoire* approach nor link these concepts together, the key concepts which he proposed have been adapted to suit anthropological and archaeological methods. Through my reading of the archaeological literature included in this project I have interpreted varying usage of modes of action, technical tendencies, technical facts, and *milieu* (or similar concepts) as the tenets of the *chaîne opératoire* approach: a method for analysis with which we may understand the interrelated nature of production processes and the ways in which they may have occurred as well as relevant sociocultural factors as defined in exterior *milieu*, interior *milieu*, and *milieu* technique (the *milieus*).

The *chaîne opératoire* approach encompasses four concepts:

- Analysis of modes of action
- Technical facts
- Technical tendencies
- *Milieus*

The classification of modes of action aids in uncovering technical tendencies and technical facts, all of which can highlight elements of a person or group's *milieus*. In Chapter Three we will see that many studies which employ a *chaîne opératoire* approach often identify some but not all of these four concepts in their methodology depending on the focus of the research.

Gesture and Speech: mobility, liberation, and exteriorization

In *Gesture and Speech* (1993) Leroi-Gourhan elaborates on the technical classification system defined in his two volumes of *Evolution et technique* and proposes that the natural environment conditions not only technical choices and tendencies, but also transmission, diffusion, and

innovation. In his own words, “A study of technics limited to classifying different types of tools and analyzing different stages of manufacturing processes would bear the same relation to ethnology as systematic zoology does to animal biology” (Leroi-Gourhan 1964a, 237). He goes on to state that while *Evolution et technique* forms the basis of his theory, the “real significance of tools is in the gesture, which makes them technically effective” (Leroi-Gourhan 1964a, 237). As such his next major work is focused on gesture via links to a selectionist evolutionary model with special attention given to relations between technique, enskilment, operational memory, and society (Audouze 2002, 288). Leroi-Gourhan argued that human intelligence as it pertains to technology (transmission, diffusion, and innovation) developed alongside the interaction and entanglement of the body and its physical environment. Leroi-Gourhan further defines the tool as a “testimony of the exteriorization of an efficient gesture” and that it is “the materialization of the interaction of matter with the means to transform it” (Leroi-Gourhan 1971, 319; 1973, 333 as cited in Audouze 2002, 287-8). Exteriorizing physical and cognitive efforts via tools is a concept which is later developed as extended cognition (see Chapter Seven). This specific interest in exteriorization lead Leroi-Gourhan to explore the cognitive elements of the *chaîne opératoire*.

Three key concepts within *Gesture and Speech* relevant to the discussion of mental stages within *chaîne opératoire* are*:* mobility, liberation, and exteriorization. These concepts stem from Leroi-Gourhan’s studies regarding mental stages which inform gesture-tool relationships. Mobility, liberation, and exteriorization are defined respectively: the hand acting through direct motor function, the hand separated from motor function, and mechanical automation (or self-exteriorization) (Audouze 2002, 288). Relying on a model of evolution, Leroi-Gourhan draws parallels between human technicity (aptitude and level of technical knowledge and skill) and the evolution of hominids. Mobility refers to the literal mobilization of hominids - not basic mobility (for many animals are mobile) - but the advent of bipedalism. Leroi-Gourhan takes this evolutionary stage, bipedalism, straight from paleontological studies as the first of three stages toward technicity. Bipedalism signifies a drastic change in the hominid evolution and is one of the most distinguishing characteristics of human beings (Leroi-Gourhan 1964a, 26; Audouze 2002, 289). With bipedalism came the freeing of the “anterior field” (the hand, mouth, and brain); mobility is the result of this freedom. Now the hand can act directly through motor function to engage with its environment (e.g., digging with the hand) (Audouze 2002, 290). The second term, liberation, refers to the freedom of the hand to act separated from the motor function, as in the ability to act with tools (e.g., digging with a shovel). As Leroi-Gourhan states, the freedom of the hand offers liberation which “almost

necessarily implies a technical activity different from the apes… and commands the use of artificial organs, that is, of implements" (Leroi-Gourhan 1964a, 90).

Exteriorization then refers to mechanical automation or self-exteriorization. In all of Leroi-Gourhan's work, he identified three stereotypical tendencies of humans in relation to technicity: a constant drive to increase efficiency, diversity, and specialization. With an interest in exploiting these three factors, human technicity eventually leads to mechanical automation according to Leroi-Gourhan. Audouze summarizes this tendency and its ultimate trajectory: "Unlike other mammals, humans are generalists. Every time a specialization occurs, it is exteriorized outside the human body" (Audouze 2002, 289). Exteriorization is revisited later in *Gesture and Speech* by Leroi-Gourhan when describing the human ability to exteriorize information via memory and language. These three concepts (mobility, liberation, and exteriorization) allow for further analysis of technical acts within the *chaîne opératoire* approach, and emphasize the interrelated nature of gesture, tool, and the mind.

Defining the *chaîne opératoire* approach

The *chaîne opératoire* approach is much more than an avenue for reproducing production sequences and techniques. While Leroi-Gourhan is known for popularizing the term *chaîne opératoire*, there is no "formal" development of *chaîne opératoire* as a standardized methodological framework. Instead, the concepts of modes of action, technical tendencies, technical facts, and *milieus* are what later became associated with, and known as, the *chaîne opératoire* approach. While yes, this approach aids in understanding the physical properties of materials and technical acts, the foundational concepts of the *chaîne opératoire* approach also account for entangled ways of learning, enskilment, ecology, and cosmological beliefs, as well as the social frameworks (age, gender constructs, division of labor, etc.) which inform, and are informed by, everyday practices. As developed over time, the *chaîne opératoire* approach is composed of four elements (modes of action, technical tendencies, technical facts, and *milieus*) which analyzed together can form a picture of the dynamic entanglement of materials, gesture, innovation, borrowing, and skill-sharing which are therefore understood as situated occurrences influenced by their socio-historical and ecological context. Together, these four concepts allow researchers to observe techniques as natural phenomena and to better understand the apparent unity of techniques found worldwide as well as the diversity found within unique social systems. The *chaîne opératoire* approach is

significant due to its ability to observe the entanglement between these elements. We will see in upcoming discussions that in many cases, especially in the *chaîne opératoire* approach adapted for archaeology, researchers utilize one or more of these concepts in their *chaîne opératoire* approach, but do not always engage all four concepts.

Lemonnier's anthropological approach: operational sequences and technological choices

Around the time of the publication of *Gesture and Speech,* Lemonnier takes on the task of relating the concepts of *chaîne opératoire* to a feasible methodological framework. In doing so, Lemonnier illustrated the vast potential of the *chaîne opératoire* approach as a practical approach. Lemonnier, a primary interpreter of the French scholars Mauss and Leroi-Gourhan, plays a defining role in the development of the *chaîne opératoire* approach. It is for this reason, in addition to his own significant contribution to the field, that his work deserves our attention in this overview of the development of the *chaîne opératoire* approach.

For Lemonnier, "operational sequences", or descriptions of the transformation of matter *over time,* constitute the data for his *chaîne opératoire* approach (Lemonnier 1992, 4). The factor which differentiates Lemonnier's operational sequences from Leroi-Gourhan's modes of action is that operational sequences imply a focus on temporal and spatial elements and is scalable from the individual to the group as a whole. In his *chaîne opératoire* approach, Lemonnier asks anthropologists to compare and contrast operational sequences between and within groups while paying attention to variations over time. In his seminal work Lemonnier outlines a theoretical framework wherein techniques are newly defined as socialized action on matter which involve implements, procedures, and knowledge (Lemonnier 1992). He argues that differing techniques and operational sequences are the result of "technological choices", a term he adopts from French Structuralist Lévi-Strauss (Lévi-Strauss 1963). Such technological choices may be "strategic tasks" which are explained by a technological or physical constraint that cannot be avoided or varied without undermining the entire project. If not a strategic task, it may be deemed a "technical variant" which are flexible choices available to the producer and can appear arbitrary but are always socially and culturally relevant. In the case of technical variants, the researcher must investigate all other factors including the social context of said variations (a notion similar to *milieus*). Here we see that Lemonnier faces the same dilemma that Leroi-Gourhan received criticism for: how can we link empirical data (modes of action/strategic tasks) with abstract factors (*milieus*/technical variants)?

In his *chaîne opératoire* approach, Lemonnier underlines the importance of techniques as a system: each technique is the locus of multiple interactions. In agreement with Leroi-Gourhan, Lemonnier reiterates that without action and knowledge of its effects, the tool is nothing. However it is imperative to note that action is constantly being adjusted as is the tool, and also that techniques are often self-referential as they share the same resources, knowledge, sites and actors (Lemonnier 1986, 154). This approach lends itself then to study not only the relation between material and actor but of the coexistence and reciprocal transformation of a technical system and of the socioeconomic organization of the society as a whole. He borrows a theoretical framework from Lévi-Strauss to accommodate this type of phenomenon wherein a local technical system can be conceived of as "a group of significant choices" which are compatible or incompatible with other choices (Lemonnier 1986, 172).

Through his study of the Anga people Lemonnier demonstrates that while there is evidence for arbitrary choices among techniques, it would be impossible to form a theory of material culture wherein a set of arbitrary choices or a pattern of techniques substantiates an ensemble of signifying traits, and that in addition this theory would not provide "ready to use recipes" permitting anthropologists to attribute symbolic functions to a particular technical repertoire (Lemonnier 1986, 173). In other words, Lemonnier is careful of the propensity of the researcher to equate perceived patterns with symbolic meaning, and notes that not all technical choices have the same signification; while some may be indicative of identity, some may instead be responses to economic necessity (Leroi-Gourhan's would perceive these responses indicative of the *exterior milieu)*. However, to Lemonnier, the most crucial information to be gained from technical studies, in his words, are in the "the relationships between the elements of these systems" which are more important than the elements themselves (Lemonnier 1986, 174).

Lemonnier's operational sequence approach is widely acknowledged as a significant contribution to the *chaîne opératoire* approach. There are two distinct yet general understandings of the operational sequence approach: (1) that Lemonnier's operational sequence approach to *chaîne opératoire* as a theoretical concept about technology emphasizes the role of tools within action, or tools animated by gesture as Leroi-Gourhan initially postulated; and (2) that Lemonnier's *chaîne opératoire* approach is an adaptable methodological framework wherein tools and techniques may be classified and supported by complementary methodologies (Bar-Yosef and Peer 2009). Much like Leroi-Gourhan, Lemonnier's approach offers a certain flexibility which invites further development.

In the forthcoming chapter we explore these developments and adaptations within the field of archaeology.

CHAPTER TWO

ADAPTATIONS OF THE *CHAÎNE OPÉRATOIRE* APPROACH FOR ARCHAEOLOGY

Archaeological adaptation of the *chaîne opératoire* approach

The popularity and adaptability of the *chaîne opératoire* approach instigated the incorporation of new perspectives especially within the field of archaeology. Fields of interest developed contemporaneously, many of which have been integrated into the development of *chaîne opératoire* approaches including technological choices (Lemonnier 1993; Dobres 2010), apprenticeship and skill sharing (Roux and Courty 1998; Berg 2011; Roux 2016), and cosmological perspectives, social phenomena, cognition, and agency (Gosselain 1999; 2000b; 2008; Coupaye 2009; Walls and Malafouris 2016; Walls 2016; 2019; Lorenzon and Ahola 2024). These themes pose important questions regarding the relationship between people and production processes and ultimately broaden the scope of the *chaîne opératoire* approach in the field of archaeology. In this chapter we explore major contributions to the *chaîne opératoire* approach in the field of archaeology as they relate to the aforementioned themes.

The *chaîne opératoire* approach, as initially developed, excels as a universal comparative frame for technical processes in order to find communalities and differences. There is an emphasis on production of objects and processes as well as their relationship to human needs, local limitations, enskilment, operational memory, and transmission. Furthermore, in its early development and especially within the field of ethnography, the *chaîne opératoire* approach is used to document and compare processes and practices (creating objects, hunting, farming, etc.). Again, as an example, the harpoon is a general need for hunting large marine life, however due to local limitations (e.g., materials available, depth of water, method of hunting, etc.) we see the local characteristics of the harpoon vary (e.g., material, length of harpoon, shape of blade). Modes of action, the smallest units of production which produce local characteristics, can be observed and recorded through ethnographic fieldwork.

Archaeologists, however, do not have the same ability as ethnographers or anthropologists to engage in fieldwork with living peoples of interest. As such the *chaîne opératoire* approach has been adapted by archaeologists to focus closely on uncovering the modes of action within production processes. Modes of action, "intermeshing of tools and the motive gesture" illuminate elements of production processes. But modes of action can also illuminate production *practices* and the sociocultural context in which these production practices are fostered. As we will see, modes of action are determined using methods such as macroscopic and microscopic examination of objects, as well as supplementary methods such as ethnoarchaeology and experimental archaeology. After gathering evidence of modes of action, the data is compiled from the site over time, or across regions to extrapolate information about the production of an object and the sociocultural group which produced it. Compiled datasets of modes of action over periods of time or geographically across sites or regions are hereafter referred to as "process trends". Through the determination modes of action and extrapolation of process trends, archaeologists attempt to interpret the data to better understand the producer and their broader sociocultural context. The *chaîne opératoire* approach for archaeologists has the capacity to encompass all *chaîne opératoire* concepts, however, there is an important shift in focus toward modes of action and "process trends" (trends of modes of action over time and across geographic regions).

As mentioned, the *chaîne opératoire* approach is used widely across academic fields and specializations with regard to a variety of materials. To include and summarize all of it would leave little room to discuss the theoretical questions at the heart of this project. Furthermore, there are many highly regarded works providing historiographies of the topic and its application across various fields and materials which will be referred to throughout. This chapter is intended as a broad overview of trends in the *chaîne opératoire* approach for archaeology with attention given to ethnoarchaeological and experimental supplemental methodologies. While the *chaîne opératoire* approach is applied to a variety of materials, special attention is paid to the popular fields of lithic and ceramic analysis. In Chapter Three we examine specific applications of the *chaîne opératoire* approach in archaeological studies of Aegean Bronze Age pottery which are outlined in detail.

Experimental archaeological approaches

As an avenue to analyze modes of action, experimental archaeological methods are introduced to the *chaîne opératoire* approach. Experimental archaeology is best defined as "the fabrication of

materials, behaviors, or both, in order to observe one or more processes involved in production, use, discard, deterioration, or recover of material culture" (Skibo 1992, 29); in other words experimental archaeology tests archaeological hypotheses by reproducing artefacts in a manner that simulates past scenarios. In some cases experimental archaeology is used in conjunction with ethnoarchaeology by involving indigenous peoples or people with generationally-shared knowledge in experiments testing elements of pottery production for instance (see Roux and Corbetta 1989).

Experimental methods used to supplement the *chaîne opératoire* approach are particularly prevalent in the French archaeological field of lithic replication and refitting (flint-knapping). This is due in part to the high proportion of lithic remains at French archaeological sites, but also the limited translation of French texts (including but not limited to works by Haudricourt, Karlin, Maget, Pelegrin, Tixier, and others). In the case of lithics, experimental flint-knapping has produced a significant body of French archaeological work and constitutes a sub-field of archaeology in and of itself (e.g., Boëda 1982; 1988; 2013; Boëda et al. 1990; Bordes 1953; 1954; Pelegrin 1990; Pelegrin et al. 1993; Pigeot 1987; 1990). It is important to highlight some principal elements of this field which influence the development of the *chaîne opératoire* approach for archaeology.

First, lithics are unique in that they are brittle and fragments break away in "conchoidal fractures" (Pelegrin et al. 1993, 2). Additionally, both the striking tool and the object in production play a role in the production process – the material density, surface morphology, as well as speed, angle, and force of the physical action are all important factors. Second, the flint-knapping process is reductive (flakes are removed from the surface and cannot be replaced) and non-continuous (the process cannot be reversed) (for illustrations see Boëda 1982; 1988; 2013; Boëda et al. 1990). Third, no two flint nodules are identical, precision requires hundreds of hours of practice, and "complete control" of the knapping process is not possible due to the multitude of factors (Pelegrin et al. 1993, 2). The reductive and non-continuous nature of flint-knapping lends itself to linear process-oriented reconstruction. Therefore process-oriented methodological frameworks such as the *chaîne opératoire* approach are popular in this field. Because it is impossible to reverse any stage of the process, flint-knapping can be visualized and analyzed as successive modes of action, enabling archaeologists to roughly replicate modes of action and uncover the mechanics of the production process.

Utilizing experimental methods to supplement the *chaîne opératoire* approach demonstrates the great variability of production processes. Special attention must be paid to these analyses as the researcher may approach the process with preconceived notions, specific

objectives, or modern biases. Nonetheless, experimental archaeology provides useful insights to modes of action (intermeshing of tools and the motive gesture). By identifying production processes, archaeologists are able to uncover material limitations, environmental constraints, and highlight basic physical and cognitive aspects of the process to provide an image of the techno-economic environment as well as some aspects of the cultural context. Specifically, concepts related to Leroi-Gourhan's operational memory are further developed through experimental flint-knapping. These concepts describe an explicit understanding and mental representation of materials and forms (knowledge) as well as the intuitive evaluation required to act according to conceptual and tactile information to make operational decisions (know-how). Pelegrin describes a flint-knapping process according to these neuro-psychological concepts:

> "The stone tool maker is guided by a series of mental images of shapes which already exist in his mind (concepts, templates). These range from the selection of the rough block and its positioning, through pre-forming and shaping, all the way to finishing through a series of adjustments to platforms and flaking surfaces. At each of these stages, the real situation is compared with the underlying mental image of the ideal next stage. Various modes of action which could be used in the next step of the process are visualized in order to correct and/or progress the work. The competent knapper then decides which mode of action is both desirable and feasible" (Pelegrin et al. 1993, 3).

These neuro-psychological concepts of knowledge and know-how emphasize internal mental representations and corresponding actions made *onto* or *toward* materials, concepts we return to in future chapters. Overall, it is widely accepted that a *chaîne opératoire* approach to lithic studies have advanced our understanding of past societies, particularly those of the Paleolithic periods, by revealing glimpses of neuro-psychology and enskilment (Wynn 1985; Pigeot 1990; Pelegrin 1990; Pelegrin et al. 1993; Schlanger 1994a; Karlin and Julien 1994; Bleed 2002; Tostevin 2011).

As with lithic remains, pottery survives in large quantities within the archaeological record due to its widespread use and durability. Studies of pottery production are also amenable to process-oriented methodological frameworks and unsurprisingly became a popular subject of the *chaîne opératoire* approach, particularly with the incorporation of supplemental experimental

methods. According to Jeffra, experimental methods in the context of a *chaîne opératoire* approach "frequently focus on specific segments of the manufacturing process and are drawn from assemblage-specific or site-specific questions" (Jeffra 2015, 143). Experimental methods for ceramic analysis begin with macroscopic (e.g., Roux and Courty 1998; Roux 2016) or microscopic (e.g., Berg 2009; 2011) observation in order to identify surface features, and subsequent testing of hypotheses using various pottery forming methods and tools. Additionally, 3-D printing and modeling is used in some cases (Hilditch et al. 2021). In this way, the experimental methods are similar to lithic studies.

In contrast to lithic production processes, which are the result of reduction sequences, pottery production is characterized by additive sequences. In pottery production organic clay material is procured, wedged, temper is added, and forms are created by joining pieces of clay together. The resulting forms are therefore a result of an accumulation of material (as well as minor reductive elements such as incising and trimming). The flexibility of the *chaîne opératoire* approach is highlighted by its application to both reductive (e.g., lithic) and additive (e.g., ceramic) production processes. Due to the differing properties of additive processes, such studies encounter one key issue. Roux outlines this issue regarding the analysis of additive processes of pottery production:

> "The identification of the [pottery] manufacturing process is a difficult exercise in the sense that each gesture produces features which can obliterate the previous features and that surface features are not polysemic: not only the same surface features can be obtained by different techniques, but also the same technique can produce different surface features. This explains why ceramic *chaîne opératoire* analysis has taken a longer time to develop…" (Roux 2016, 7).

This difficulty is further complicated by the fact that because the same surface features can be created using a wide variety of techniques, we see a large degree of technique variation between and *within* groups. Basic pottery forming techniques include slab-building, molding, pinching, percussion, coiling, wheel-coiling, and wheel-throwing (Jeffra 2019). There is also a wide variety of tools used in pottery production. For instance, there is archaeological evidence of pottery wheels (hand rotation, kick wheel, fly wheel), incising tools (finger, string, chisels, knives, etc.), beating tools (hand, bat, paddle, etc.), and many more. Each of these can be used in numerous combinations to produce a wide variety of surface features and forms. Equally, each of these tools can be used to

create *the same* surface features and forms. For example, a potter may use coiling, pinching, and smoothing tools to form a round vessel with an open lip; however, the same potter can use wheel-fashioning or slab-building (among other techniques) to create the same surface features and form. As a result of this high variability in production choices, archaeologists have adapted the *chaîne opératoire* approach for ceramics to examine not only modes of action and operational memory in sequences (as with lithics) but also to examine the technological landscape and dynamic social processes related transmission, innovation, and enskilment within and throughout groups of potters (Gosselain 1999; 2000b; 2008; Van der Leeuw 2009; Knappett and Van der Leeuw 2014a; Roux 2020).

Transmission, innovation, and enskilment within pottery production processes and tools can be observed through the use of experimental methods to recreate basic formation methods and comparing the surface features with those at local and regional archaeological sites. For example, in one study Jeffra has produced a typeset of clay vessels using four basic wheel-forming methods (combinations of modes of action) observed in the archaeological record (Figure 9).

	Forming the coils	Joining the coils	Thinning the coils	Shaping the roughout
Method 1				RKE
Method 2			RKE	RKE
Method 3		RKE	RKE	RKE
Method 4	RKE	RKE	RKE	RKE

Figure 9. Four wheel-forming methods demonstrating the degrees of RKE (rotative kinetic energy) incorporation at different stages of the process (after Roux and Courty 1998, 750, table 1)

After producing a typeset, the features are compared with those of archaeological finds throughout Bronze Age Crete (Middle Minoan IB – Late Minoan IA). What we find is the widespread use of wheel-forming methods 3/4 across all sites (from small-localized sites to large palatial production sites), which indicates a not only transmission of knowledge, skill, and tools, but also a *preference* for wheel-forming methods 3/4 especially in the case of small and medium sized vessels (Jeffra 2013). In the case of medium-large and large vessels there is a wide variety of formation methods used across all sites, indicating no strong preference for wheel-use (Jeffra 2013). Jeffra states that by "successfully defining the specific [modes of action] … and expanding the analytical scale to search for longer-term patterns of stability and change; a better picture of technical practise through time can emerge" (Jeffra 2015, 148). This typeset experiment is just one example of many which use

experimental methods to supplement the *chaîne opératoire* approach to analyze modes of action on a small scale and extrapolate to analyze evidence of process trends across a broader geographic and temporal landscape (Van Der Leeuw and Torrence 1989; Van Der Leeuw 1993; Jerolyn Morrison and D. Evely 2008; Roux and Jeffra 2015; Murphy 2020; 2024).

Experimental methods used to supplement the *chaîne opératoire* approach have produced significant findings within the field of archaeology, especially with regard to identifying modes of action, process trends, and the behavior of materials under certain circumstances. These studies follow a linear analysis of how an object was made. Experimental methods furthermore highlight the existence of variability and choice in production processes. While experimental methods reveal the existence of both variability and choice within production as a process, this information cannot reliably define those sociocultural aspects of production as a practice (Rye 1981). Researchers must consider the overall context including the environmental and technological constraints, the social and political organization, and the ideology or belief systems of the peoples making these choices in order to explain why particular technological choices were made and what material and social effects they had (Sillar and Tite 2000, 4).

Ethnoarchaeological approaches

Recognizing that the *chaîne opératoire* approach benefits from ethnographic methods, there is an ongoing effort by archaeologists to develop ethnoarchaeological methods to be used alongside the *chaîne opératoire* approach. Due to the characteristic variation and choice in production among additive processes, there is an abundance of related ethnoarchaeological research. As such, this discussion centers ethnoarchaeological studies of additive processes in order to emphasize major themes of these methods and the ways in which they support the *chaîne opératoire* approach. Ultimately, we see ethnoarchaeological methods supplement the *chaîne opératoire* approach not only in underlining the nuance and variability of modes of action but also highlighting process trends and lastly revealing aspects of the groups' *milieus*. This is not designed as an all-encompassing review, rather the aim is to highlight themes which contribute to the development of the *chaîne opératoire* approach in archaeology and provide a background to the theoretical questions at the center of this project.

Van der Leeuw states, "In the absence of archaeological data, we must look to ethnography to understand the implications" of contextual changes within a group which may impact the

production process of an artefact (Van der Leeuw 2009, 96). Through ethnoarchaeological approaches such as observation of materials and techniques, insight can be gained from "traditional" potters (or other makers) who continue to work in the region (Rye 1981). Rye defines the "traditional" potter as one who uses materials, tools, techniques, and firing methods which are not of recent introduction (Rye 1981, 14). The ethnoarchaeologist may confirm the "antiquity" of a practice through the potter's testimony, literary sources, and comparison to archaeological data (Rye 1981). Broadly speaking, direct influences (material, natural environment, technological knowledge) and indirect influences (economic and socio-political systems) can be explored through ethnoarchaeological methods (Sillar and Tite 2000). The development of an ethnoarchaeological *chaîne opératoire* approach is spearheaded by key figures who focus on themes of transmission and transformation (e.g., Gosselain 1999; 2000b; 2008), cultural context (e.g., Hodder 1982; Hodder and Hutson 1986; Hodder 1992), skill-sharing (e.g., Roux and Corbetta 1989; Roux and Courty 1998; Roux 2016; 2019b; 2019b; 2020), and variability, choice, and mechanisms of change (e.g., Van Der Leeuw and Torrence 1989; Van Der Leeuw 1993; Van der Leeuw 2009). Ethnoarchaeological methods adapted for the *chaîne opératoire* approach provide context for the development of the aforementioned themes by highlighting not only modes of action and process trends, but also sociocultural *milieus*.

While experimental methods certainly illuminate elements of production processes, especially modes of action and process trends, the results may require additional context especially in the case of additive processes such as pottery. Archaeologists therefore often supplement experimental research with ethnographic fieldwork as part of the *chaîne opératoire* approach. For instance, Gosselain compares experimental data regarding Cameroonian pottery firing temperatures with ethnographic data. The results show that while experimental methods of firing pottery result in ceramic objects similar to Cameroonian pottery, the experimental methods do not highlight the diversity of firing approaches and therefore the sociocultural context (*milieus*) which can be observed through ethnoarchaeological methods (Gosselain 1992). As Rye points out, "descriptions of surviving traditional potters contribute to our knowledge of ceramic technology in ways that no reconstruction of archaeological evidence can achieve" (Rye 1981, 14). In other words, ethnoarchaeological methods reveal choices and "reflect a traditional skill which might be expected to be much closer to prehistoric reality than any experimental approximation" (Gosselain 1992, 244).

Similarly, Roux and Corbetta explore concepts of craft specialization and apprenticeship by combining experimental and ethnoarchaeological methods in collaboration with potters in Uttam

Nagar (West Delhi) (Roux and Corbetta 1989). In order to supplement archaeological finds at the site of Amri dating to the 4th and 3rd millennia of the Indus civilization, researchers collaborated with local potters in Uttam Nagar to understand the transmission and development of wheel-throwing practices. Various experimental and ethnoarchaeological methods were combined to measure motor skills, dexterity, and length of apprenticeship (Roux and Corbetta 1989). This data outlines two important aspects of pottery production: (1) the complexity of wheel-throwing techniques and (2) the duration of apprenticeship for wheel-throwing. Note that "duration" here is marked by the researchers' Euro-centric views of time and may not reflect modern or prehistoric peoples' concepts of time. We see again that while experimental methods alone replicate similar modes of action and produced objects, ethnoarchaeological methods reveal sociocultural context of pottery production.

In the particular case of additive processes such as pottery, we see that because the same form can be achieved through numerous modes of action dictated by choices, changes can be made at any stage of the process without compromising the production of an object (Gosselain 2000b). In this way, pottery production processes are uniquely flexible and pottery materially allows for borrowing and innovation all while producing the same (or similar) outcomes. Where archaeological data may expose the existence of borrowing and innovation (visible changes to modes of action within a groups' process trends), it is ethnoarchaeological methods in conjunction with the *chaîne opératoire* approach which can highlight how a group borrows or adopts certain tools and techniques into their own *milieus*. This, by Leroi-Gourhan's definition, would constitute an alteration of the *milieu* technique caused by the interaction of the internal and external *milieus*. Researchers therefore examine borrowing and innovation, transmission and skill-sharing through ethnoarchaeological methods supplementing a *chaîne opératoire* approach (e.g., Van Der Leeuw and Torrence 1989; Van der Leeuw 2009; Knappett and Van der Leeuw 2014a).

These same ethnoarchaeological methods can be used in conjunction with the *chaîne opératoire* approach to also highlight non-diffusion (or persistence) of techniques within one or more groups even when faced with novel tools and techniques (Roux et al. 2017). Studies show that in many cases potters learn through intergenerational apprenticeship, or from local teachers; therefore socially constructed notions of identity and heritage are enmeshed in the potters' practices (Gosselain 2008; Walls 2016). Ethnoarchaeological methods in conjunction with a *chaîne opératoire* approach reveal that "becoming [skilled] is a life process, closely entangled with personhood and increasing importance and connection within the community" (Walls 2019, 273). Therefore, in some cases, groups are less likely to adopt tools and techniques from other groups.

While archaeological evidence may highlight the persistence of certain production processes, ethnoarchaeological methods support a deeper understanding of this persistence.

Supplementing the *chaîne opératoire* approach with ethnoarchaeological methods may also highlight spiritual and metaphorical elements of production, use, and discard of objects. Through archaeological excavation, funerary practices are observed such as the use of pottery vessels for human burial (such as pithoi or larnakes in Bronze Age Crete, or large clay vessels Inland Niger Delta, Mali, and Cameroon, among others) (Gosselain 1999; Vavouranakis 2014). However, it is through ethnoarchaeological methods that researchers further contextualize these funerary practices. Elements of the *milieus* such as spiritual and metaphorical associations with pottery are highlighted. For example, relationships between pottery and life stages such as birth, puberty, marriage, procreation, and death are illuminated through ethnoarchaeological methods such as observation and interview (Gosselain 1999). Across the Atlantic, archaeological data underlines the cultural significance of Mayan caches (buried bundles of objects); they are usually found buried underneath architectural structures indicating a distinct and repeated pattern of behavior (Vadala and Duffy 2021). It is through a combined *chaîne opératoire* and ethnoarchaeological approach that researchers gain insight into the temporal aspect (these are multi-day events), the expressive aspect (prayer, song, procession), the associated beliefs (that cache deposits animate the architecture and prevent the building's lifeforce from wandering), as well as the material deposition of a Mayan cache dedication (Vadala and Duffy 2021, 1028). However, archaeologists must be careful not to associate *every* element of production with spiritual and metaphorical beliefs - which brings us to an important discussion of ethnoarchaeological methods.

A note on ethnoarchaeology

Before moving forward, the critiques surrounding ethnoarchaeology must be noted. Gosselain's views are presented in particular. In his article titled "To Hell with Ethnoarchaeology", Gosselain provides an excellent review of the origins of ethnography and ethnoarchaeology (Gosselain 2016). Gosselain's case begins with the origins of ethnoarchaeology which are rooted in what are ultimately racist Western views of non-Western peoples. These views describe non-Westerners as exotic, primitive, more closely related to prehistoric peoples, and who are furthermore perceived as "living fossils" (Gosselain 2016, 219). The idea that there are peoples who remain today "untouched" by Western technologies, and who therefore must be more closely connected to our prehistoric

ancestors is a concept perpetuated by Western colonial agendas and unfortunately persists. Consequently, the methodology of such studies are sometimes imbued with these concepts. This is one of many reasons to continually examine and develop methodological frameworks especially as they relate to ethnography, anthropology, and archaeology. In order to test hypotheses regarding prehistoric tools and techniques, ethnoarchaeologists often turn to supposedly "premodern" peoples. I refer to a quote, which Gosselain also highlights, drawn from a satirical book called *Bluff your way in archaeology* by the author Paul Bahn. While this work is satirical, there is no humor without truth. Bahn describes ethnoarchaeology:

> "...picking on some unsuspecting group of people (hunter-gatherers, simple villagers, sheep farmers, etc.) – preferably in the third world or Alaska. You then go and live among them for a while, taking note of how and when they make and use things, and how and when they break and discard them...After figuring out what you think is going on with the use and discard of objects (you should never stay around long enough to master the language) you return to your desk and use these brief studies to make sweeping generalisations about what people in the past and in totally different environments must have done (Bahn 1989, 52–53)."

I urge the reader to consider Gosselain's thoughts on the ethnoarchaeologists' emphasis of tradition and ritual in non-Western societies. Western researchers can, and have, fallen into the habit of projecting ideological differences onto non-Western societies. In many cases Western societies are consistently associated with rational and scientific thought while non-Western societies are more often associated with traditions and rituals (Gosselain 2016, 222). Non-Western technology and production are then seen as socio-symbolic rather than economic; "While Western artisans are endlessly seeking profit and competing with each other, their non-Western counterparts would thus spend their time praying and socializing" (Gosselain 2016, 222). It is through this correlation of non-Western peoples with "non-rational" ideologies that researchers may come to believe that the answers to questions regarding prehistoric artefacts exist in modern non-Western societies. In doing so a belief is perpetuated that such artefacts or technologies are so intrinsically tied to social or symbolic systems that they remain unchanged and undeveloped for millennia. This type of thinking "denies the historical dimension of technical practices and, by extension, the dynamics of change experienced by *all* societies" (Gosselain 2016, 223). Research suggests that

changes in technology are not inherently linear (e.g., a progression from digging with the hand, to digging with a stick, to digging with a spade, to ploughing), and that necessity is not the "mother of invention" (e.g., Pfaffenberger 1992). For example, studies in the Bronze Age Aegean pottery show that despite the widespread existence and knowledge of the pottery wheel in the Middle Minoan period, combination techniques (hand-building combined with rotation) were generally favored by the Late Minoan period (Jeffra 2013).

In a rebuttal to Gosselain's critique of ethnoarchaeology, Roux argues in support of ethnoarchaeology in her article "Not to throw the baby out with the bathwater", stating that ethnoarchaeological studies are not intrinsically prejudiced but instead use narrow research questions to capture the social complexity in modern non-Western peoples (Roux 2017). And while many of her points are valid, and no not *all* ethnoarchaeology is problematic, I agree with Gosselain that we must be careful in ethnographic approaches to archaeology, especially of technology. Further to this, it is important to consider the sources of criticism and support. Questions also arise about how we acknowledge the issues of power and authority in ethnographic studies (Brück 2005). For instance, if a study of South American female potters is carried out by white, non-Spanish-speaking, men, should this not be noted? Furthermore, who gets to decide what data is important enough to include in the study, and are those same things relevant or important to the subjects of the study? On the subject of ethnoarchaeology, Gosselain decides ultimately to "get rid of it!" and promotes looking beyond similarities in the material record and ethnographic contexts.

Keeping in mind our criticism of ethnography, we see studies which take an ethnoarchaeological *chaîne opératoire* approach which do not to make direct comparisons between the archaeological record and modern non-Westerners; instead these studies draw on a *chaîne opératoire* approach to trace links between situated practices and concepts of cognition, agency, cosmological beliefs, community perception, memory, and other social phenomena (Gosselain 1999; 2000b; 2008; Coupaye 2009; Walls and Malafouris 2016; Walls 2016; 2019; Lorenzon and Ahola 2024). There have also been attempts to revalidate ethnoarchaeological methods, and it seems the approach will continue to be improved and developed (e.g., Knappett and Van der Leeuw 2014a; Roux et al. 2017; Roux 2019a). More and more, we see a shift within the field of archaeology toward interdisciplinary methods and approaches which reflect increasingly popular theoretical models (Nørgaard 2024). Gosselain suggests efforts be made to broaden the scope of analysis, taking every element of the context into consideration, rather than relying on ethnoarchaeology to provide clues. As will be seen throughout this project, Gosselain's perspective and the recent efforts

to invoke an interdisciplinary approach has informed my own reconsideration of the *chaîne opératoire* approach.

Further contributions: contextualizing this project

In response to these key developments and critiques of the *chaîne opératoire* approach, there is an increased interest in the relationship between the *chaîne opératoire* approach and concepts such as classification and typology (Lemonnier 1986; Sellet 1993; Riede 2006; Bar-Yosef and Peer 2009), transmission and apprenticeship (Roux and Corbetta 1989; Jeffra 2015; Knappett and Van der Leeuw 2014b; Van Ruden 2015), material ecology (Ingold 2012; Lyons 2020)**,** cognition (e.g., Schlanger 1994a; Lombard and Haidle 2012; Fairlie and Barham 2016; Walls and Malafouris 2016; Walls 2016; 2019; Malafouris 2020; Ulanowska 2020), agency (e.g., Dobres 1999; Dobres and Hoffman 2000; Dobres and Robb 2000; Malafouris 2008; Knappett and Malafouris 2008; Coupaye 2009; Van Oyen 2015; Coupaye 2020; 2022b) and temporality as it pertains to archaeological paradigms and the study of technology (Malafouris and Gosden 2015; Lucas 2021). For example, Walls (2016) explores the topics of cognition, agency, and dissemination of knowledge influenced by theories of entanglement; he states that *chaines* (production sequences) are made up of a situated field of relationships through which knowledge is built between generations of peoples (Walls 2016). Walls urges researchers to view production sequences as developed between generations, through embodied actions, and the entanglement of brains, bodies, and materials. Furthermore, Walls poses the argument that dissemination of knowledge be viewed as a developmental ecology constantly rebuilding itself through environmentally situated co-construction. I briefly mention these topics here to illustrate the continued interest in the *chaîne opératoire* approach, which is the landscape in which this work is situated. These themes are revisited and elaborated upon in the forthcoming chapters regarding theories of agency and cognition and my proposal for incorporating them with the *chaîne opératoire* approach.

On materials

Upon translation of Leroi-Gourhan's *Gesture and Speech*, along with other French texts, the *chaîne opératoire* approach has become increasingly widespread with applications to additional materials (e.g., pottery, textiles, metallurgy). Furthermore, there is a continued interest in broadening the scope of *chaîne opératoire* studies. For instance a special issue publication as recent as 2023 calls

for non-lithic *chaîne opératoire* studies to "take distance from the period-specific and material-specific debate over the steps for lithics reduction and open the reflection to a broader public" (Porqueddu et al. 2023, 1).

In addition to the differences between lithic (reductive) and ceramic (additive) processes, studies of pottery production present another distinctive characteristic through which to reconsider the *chaîne opératoire* approach. Pottery production is uniquely characterized by spatiotemporal entanglement of mind, body, and material in *flow*. This entanglement and flow which is particularly characteristic of pottery production is highlighted by Malafouris in his work developing Material Engagement Theory which centers a relational phenomenological approach to mind, body, and material through themes of agency, cognition, and signification (Malafouris 2013).

As we recall in Chapter One, the *chaîne opératoire* approach also features themes of agency and cognition through Leroi-Gourhan's emphasis on the entanglement of gesture, tool, and mind. I draw on Material Engagement Theory throughout this work to further develop and incorporate these themes within the *chaîne opératoire* approach. Because of the relationship between pottery production and the spatiotemporal entanglement of mind, body, and material in *flow* as well as Leroi-Gourhan's emphasis of these themes, I propose to rethink the *chaîne opératoire* approach drawing on examples of pottery production analysis. While there is a clear focus on pottery production within this project, the *chaîne opératoire* approach ought not to be confined to any specific material or process. We will find in the chapters to come that regardless of the material focus of any *chaîne opératoire* approach, production processes are inherently connected to various materials, practices, environments, institutions, identities, and beliefs.

Concluding remarks

Compiling and analyzing the history and development of *chaîne opératoire* constitutes a lifelong project in and of itself (Audouze 2002; Martinón-Torres 2002; Audouze et al. 2017; Delage 2017a; 2017b; Lewis and Arntz 2020; Collins 2021). As such, the aim of this project is not to develop a historiography of the topic but instead to highlight key themes in the development of the *chaîne opératoire* approach. This broad overview provides the context necessary to subject the *chaîne opératoire* approach to contemporary theories of agency and cognition in the forthcoming chapters. The *chaîne opératoire* approach is an invaluable approach for any study in relation to people, processes, practices, objects, and tools. In many cases, the use of the *chaîne opératoire* approach

remains somewhat limited to observation and analysis of the most diminutive, mechanical, components of the human-technological relationship. And while there may be foundational limitations in the scope and application of the *chaîne opératoire* approach, these limitations can also provide insight into some dimensions of artefacts by highlighting where in fact these limitations or gaps in the *chaîne opératoire* approach exist (Coupaye, 2009). In other words, having taken a *chaîne opératoire* approach and exhausted all data, what are we missing? Highlighting these limitations, exploring potential solutions, and reconsidering the *chaîne opératoire* is the ultimate aim of my work.

> "It goes without saying that a theoretical methodology/paradigm such as the *chaîne opératoire* will have its flaws and anachronisms. Yet the renewed maintenance of the *chaîne opératoire* within archaeological studies in recent years demonstrates its ongoing importance to the study of material culture and past societies" (Lewis and Arntz 2020, 14).

The *chaîne opératoire* approach continues to be subjected to ongoing debate and maintenance. Coupaye states that *chaîne opératoire* is "a methodological tool that presents some analytical advantages, provided some theoretical precautions are taken" (Coupaye 2009, 441). Martinón-Torres elegantly states that while we must not make sweeping conclusions, when "dealing with *chaîne opératoire* we may walk cautious steps [to better understand] the space between material and culture which cannot be filled effortlessly" (Martinón-Torres 2002, 39). On the other hand, Bar-Yosef asks for a total reconsideration of the *chaîne opératoire* approach, proposing that we may be trying to "squeeze blood from stone [tools]" (Bar-Yosef and Peer 2009, 117). Of course, there are some weaknesses in the *chaîne opératoire* approach, as with any approach which is used to understand a complex phenomenon. Regardless, I believe that the *chaîne opératoire* approach offers the capacity to observe and analyze social phenomena so long as we recognize the *chaîne opératoire* approach for what it is: an artefact in and of itself.

In Part One of this project, the *chaîne opératoire* approach is considered as an artefact; we observe its context, production, use, discard, repair, and re-use as with any other artefact. I agree with claims that this artefact, the *chaîne opératoire* approach, presents some limitations. However, it is my view that many researchers have engaged with only some, not all, of the central elements of the *chaîne opératoire* approach. Therefore, I propose that many of the limitations are in a way self-

imposed. Through reconsidering the production, context, and use of the *chaîne opératoire* approach we may renew it once again. By grappling with theoretical questions such as agency and cognition as they relate to production processes, we may rethink and re-envision the *chaîne opératoire* approach and ultimately arrive at a novel framework for analysis of the multidimensional, entangled, emergent, relationship between people and things.

CHAPTER THREE

CHAÎNE OPÉRATOIRE IN BRONZE AGE AEGEAN POTTERY

Introduction

Having discussed *chaîne opératoire* in a broad sense, we turn to case studies in Bronze Age Aegean pottery to further analyze how the *chaîne opératoire* approach is applied in archeological research. This allows for a thorough investigation of the practical use of the framework, how these use cases engage with the *chaîne opératoire* approach, and aids in contextualizing them within the ongoing development of the *chaîne opératoire* approach. Why Bronze Age Aegean pottery? Not only has there been an increased interest in taking *chaîne opératoire* approaches beyond lithics to other materials (Porqueddu et al. 2023), pottery also offers a unique perspective from which to observe production processes. Pottery is characterized by its additive process and the spatiotemporal entanglement of mind, body, and material in *flow* which is so uniquely exemplified in pottery production. As many potters will anecdotally confess, clay does not always do what they want it to do; potters must work in unison with and through clay in a creative process which takes place in the moment(s) of making (Malafouris and Koukouti 2020; 2022; Malafouris 2023; Malafouris et al. 2023).

Second, *chaîne opératoire* approaches are frequently employed in Bronze Age Aegean pottery analyses. There is a wide variety of use cases from which to consider the ways in which the *chaîne opératoire* approach is applied. In order to understand the relevance of *chaîne opératoire* approaches in the Bronze Age Aegean, we must contextualize the case studies at hand through developing a picture of the geographic region and time period. Having highlighted the region during the period and sociocultural patterns and changes, we see how our case studies utilize *chaîne opératoire* approaches. The Bronze Age (3100 B.C. to 1200 B.C.) is eponymously named for the historic period characterized by the use of bronze (Hilditch 2020, 76). The dates of the Bronze Age by fall within the range of 3000 B.C. to 1125 B.C. at which point there is a fall of Aegean civilizations such as the Minoans and Myceneans (Betancourt 2007, 3). “The Aegean” refers to the geographic area encompassed by the Aegean Sea which includes the Northeastern Aegean Islands, East Aegean Islands (Euboea), Northern Sporades, Cyclades, Saronic Islands, Southern Sporades, and Crete (Figure 10). The Bronze Age Aegean is a time period and geographic region which shows documented

evidence of distinct sociocultural patterns and developments, especially within pottery production. For example, there is an increased use of the pottery wheel for wheel-fashioning methods during the Bronze Age Aegean (Jeffra 2013). Drawing upon the case studies throughout the forthcoming theoretical discussions Chapters Five through Nine should offer a sense of grounding where one is liable to lose their footing.

Figure 10. Map of the Aegean (Betancourt, 2007)

Why here? why now?

In order examine how the *chaîne opératoire* approach is utilized in case studies, it is prudent to survey studies from a period where there is abundant material, where there is a connection to sociocultural patterns and developments, and where the *chaîne opératoire* approach has been widely used. Evidence of human activity is present in the Aegean as early as the Paleolithic times (before c.a. 10,000 B.C.) (Preziosi and Hitchcock 1999). However, the Bronze Age Aegean in particular has captured the attention of scholars for many decades and continues to substantiate abundant archaeological research. Situated between the Greek mainland, Anatolia (present day Turkey), the Near East, and north Africa, the Aegean region boasted trade routes integral to crossing and circumnavigating the Mediterranean Sea (Betancourt 2007). As a result of this trade network

touching upon a variety of cultural localities, the archaeological record throughout this period highlights a unique diversity in architectural style, modes of visual expression such as wall paintings and vibrant ceramic glazes, writing systems, political structures, and economic systems (Preziosi and Hitchcock 1999).

The Bronze Age Aegean saw a significant rise in production of pottery connected with sociocultural elements such as established production processes (hand-building methods) and developing production processes (wheel-fashioned or wheel-thrown methods) (Jeffra 2013). The increased use of wheel-fashioned and wheel-thrown methods during Early Bronze Age II and Early Bronze Age III across the Aegean is just one of the many significant manifestations of technological developments in this geographic and temporal landscape (Choleva 2012). This shift in technological practice is both fostered by and affects the sociocultural *milieus* of those groups who come into contact with wheel-fashioning and wheel-throwing production processes. Due to the interwoven nature of technology and sociocultural elements involved in this shift, the use of *chaîne opératoire* approaches in Bronze Age Aegean pottery analysis is significant.

Defining the parameters: methodology

A comprehensive literature search was caried out through the University of Oxford's Bodleian Library database, Google Scholar, and JSTOR to gather the data analyzed in this chapter. Searches specifically targeted the following terms: "Archaeology"; "Bronze Age"; "Aegean"; "pottery" OR "ceramics"; "*chaîne opératoire*". Forward and backward reference searches were then performed on results of interest to retrieve additional relevant studies. Studies were then filtered and kept where the following criteria were met: (1) the study is archaeological; (2) archaeological data is dated to the Bronze Age; (3) archaeological data is of the Aegean; (4) archaeological data is pottery; (5) *chaîne opératoire* is stated as the methodological approach (or is used together with supplemental methods); and (6) the study aims to "investigate or recreate the *chaîne opératoire*". Cases of pottery production have been included regardless of their production method (handmade or wheel-fashioned). Furthermore, studies which are primarily Aegean but also include assemblages within the wider Greek and Near Eastern regions are included (e.g., Choleva 2012; 2018). Such cases facilitate discussion of process trends by taking broad geographic perspectives. Parameters for exclusion as case studies are: (1) *chaîne opératoire* is discussed only in theory but not engaged as a methodology (e.g., Knappett 2004; 2011b; Kiriatzi and Knappett 2016); (2) the study is a meta-

analysis; (3) the study is a historiography of the *chaîne opératoire* approach. Note that while works which discuss the *chaîne opératoire* only in theory are not included as case studies, they are discussed throughout this project. Results of the literature search and criteria-fitting produced twenty three case studies which identity the *chaîne opératoire* approach as the approach to analysis of Bronze Age Aegean pottery (Figure 3).

Each of the twenty three studies were analyzed using the following qualitative question: which aspects of the *chaîne opératoire* approach does the author(s) engage with (modes of action, technical tendencies, technical facts, process trends, *milieus*)? In answering this question, the twenty three case studies fell into three categories which are designated as *chaîne opératoire* "Use Types".

- Use Type One: scholars use a *chaîne opératoire* approach to analyze modes of action (distinct physical actions)
- Use Type Two: scholars use a *chaîne opératoire* approach to analyze modes of action *and* process trends (distinct physical actions as well as visible patterns including recurring choices of gesture, tool, and material within their sociohistorical context)
- Use Type Three: scholars use the term *chaîne opératoire*, but do not engage with the framework.

Each of these three Use Types identify and engage with one or more strengths of the *chaîne opératoire* approach. By engaging with only part(s) of the *chaîne opératoire* approach, the methods and results of these studies vary greatly. Some case studies are represented by more than one Use Type (e.g., Choleva's 2018 study which I classify as Use Type One *and* Use Type Two). In such cases, the studies will be discussed more than once. This is meant to outline not only the many ways that the *chaîne opératoire* approach is employed but also how it is often employed in multiple ways within one study. The differentiation of Use Types serves to contextualize the studies within the broader development of the *chaîne opératoire* approach. Use Type One tends toward an empirical data-driven approach to archaeology and broadly resembles reconstruction efforts (following in the tradition of lithic refitting) based on the *chaîne opératoire* approach's ability to uncover modes of action. Use Type Two tends toward an interpretative approach to archaeology including contemporary social theory; however, it relies on the Use Type One's approach to empirical data (modes of action). Use Type Three does not significantly engage with the central elements of the *chaîne opératoire* approach. Situating these Use Types supports our understanding of how *chaîne*

opératoire is engaged in archaeological pursuits and where perhaps it can be further developed by incorporating additional recent theoretical advancements.

Publication	*Chaîne opératoire* elements engaged	Use Type
Burke, Zavadil, and Kordatzaki, 2021	Modes of action	Use Type One
Georgel-Debedde, 2022	Modes of action	Use Type One
Menelaou, S., et. al 2024	Modes of action	Use Type One
Choleva, 2018	Modes of action	Use Type One/Two
Choleva, 2012	Modes of action; Process trends	Use Type Two
Choleva, 2020	Modes of action; Process trends	Use Type Two
Choleva, Jung, and Kardamaki, 2020	Modes of action; Process trends	Use Type Two
Mentesana et al., 2016	Modes of action; Process trends	Use Type Two
Menelaou and Kouka, 2021	Modes of action; Process trends	Use Type Two/Three
Alexandrou and O'Neill, 2013	Not applicable	Use Type Three
Berg, 2007	Not applicable	Use Type Three
Berg, 2011	Not applicable	Use Type Three
Doudalis, 2018	Not applicable	Use Type Three
Hilditch, 2020	Not applicable	Use Type Three
Jeffra, 2013	Not applicable	Use Type Three
Jeffra, 2015	Not applicable	Use Type Three
Roux and Jeffra, 2015	Not applicable	Use Type Three

Jenkins, 2022	Not applicable	Use Type Three
Menelaou, 2020	Not applicable	Use Type Three
Mentesana, 2014	Not applicable	Use Type Three
Mentesana, 2019	Not applicable	Use Type Three
Morris, O'Neill, and Peatfield, 2019	Not applicable	Use Type Three
Murphy, 2020	Not applicable	Use Type Three

Figure 11. Case studies in the table above are classified by the elements of *chaîne opératoire* approach with which they engage. Classifications lead to the assignment of Use Types.

Applications of *chaîne opératoire* in Bronze Age Aegean pottery studies

As has been outlined in Chapter One, the *chaîne opératoire* approach consists of classification, modes of action, technical tendencies, technical facts, process trends, and *milieus*. However, a methodological structure was not developed by Leroi-Gourhan to deploy the *chaîne opératoire* approach in a manner which would be widely replicable. Leroi-Gourhan developed the concepts of the *chaîne opératoire* approach, and established the theoretical underpinnings, but there is no simple program for implementation. For this reason, distinct *chaîne opératoire* approaches have been developed to suit various purposes. In the case of Bronze Age Aegean pottery analysis there is a pattern of three distinct archaeological *chaîne opératoire* Use Types:

- Use Type One: use of the *chaîne opératoire* approach to analyze modes of action
- Use Type Two: use of the *chaîne opératoire* approach to analyze modes of action *and* process trends
- Use Type Three: use of the term *chaîne opératoire*, lacking significant engagement with the methodology.

Use Type One: *chaîne opératoire* of modes of action

The first Use Type examines only modes of action (technical actions or gestures which are fixed spatially and temporally). This approach focuses on identifying, defining, and understanding the

physical steps taken to produce a clay form. In other words, what are the actions, materials, and tools involved in this process? The results of this type of *chaîne opératoire* approach may demonstrate elements of production such as: procuring clay, wedging clay by kneading or stomping, rolling clay to form coils, shaping the coils by stacking, joining the coils by pinching or adding slip, then smoothing the surface, and so on (Roux and Courty 1998). These modes of action are useful in understanding the mechanical elements of production processes. The Use Type One approach emphasizes an empirical treatment of production processes using macroscopic or microscopic observation methods to classify formation methods and material characteristics in combination with heuristic methods including refitting work and, in some cases, experimental replication.

Use Type One approaches relate closely to Roux's *chaîne opératoire* approaches to pottery production. First, Roux provides us with a general guide to describing pottery production processes and their operational sequences (Figure 12). This involves identifying physical actions in the roughing out and pre-forming stages. Roux also separates forming methods with Rotative Kinetic Energy (RKE) and those without RKE – in other words methods which do or do not use a pottery wheel. This general guide supports the description of physical actions in the production process of pottery. Roux further states that this is only one of two "*chaîne opératoires"* present in an instance of production. The second *chaîne opératoire* for Roux, is the ways in which these physical actions are implemented which underlines variation related to sociocultural factors (Roux 2019a). In order to uncover these variations, Roux proposes to classify entire assemblages through a *chaîne opératoire* approach.

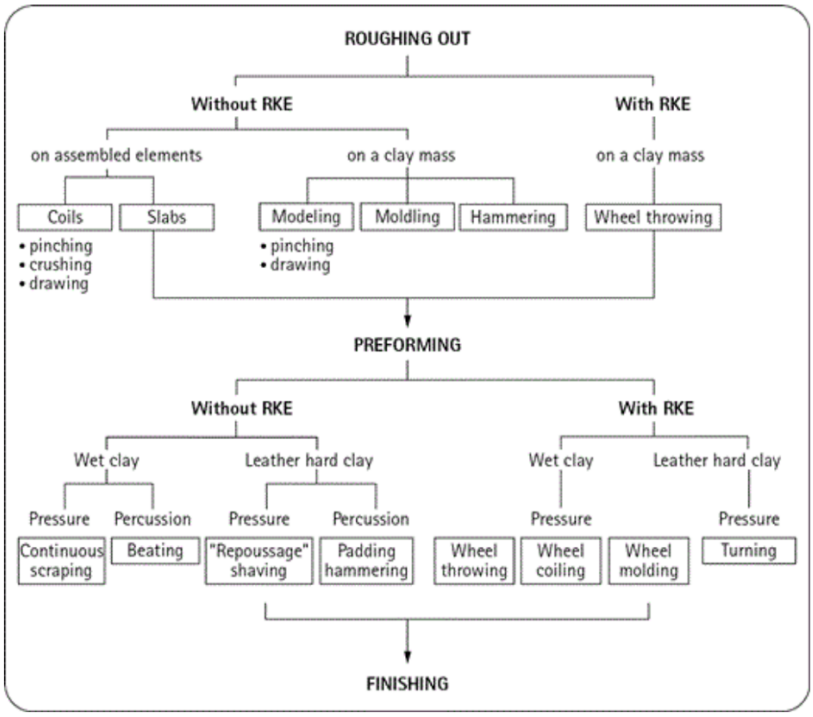


Figure 12. Two families of pottery production processes are outlined. Those without Rotative Kinetic Energy (RKE) are presented on the left, and those with RKE are presented on the right. We see the main physical actions required at the roughing out stage and the preforming stages (Roux 2016).

Roux develops an approach to classify assemblages according to the *chaîne opératoire* concept which follows three steps: (1) sort the material by technical groups (the manufacture process as expressed by microfabric alignment or surface features present on the vessel; (2) sort technical groups by technopetrographic groups (with reference to the petrofacies present at the archaeological site) in order to further characterize the technological transformation from raw material to its present stage; (3) sort by morphology and style within each technographic group (Roux 2016, 9) (Figure 13). According to Roux, the outlined "… successive and embedded sortings are meant to characterize the different *chaîne opératoires* present in the assemblage (the technopetrographic groups) and link them to the intention of the potter (the finished products)" (Roux 2016, 9). Through analyzing the Use Type One case studies, we find similarities to Roux's approaches to the first *chaîne opératoire* of main actions in particular (Figure 12); that is the classification of technical groups by forming methods, petrographic characteristics, macroscopic analysis of morphology and style.

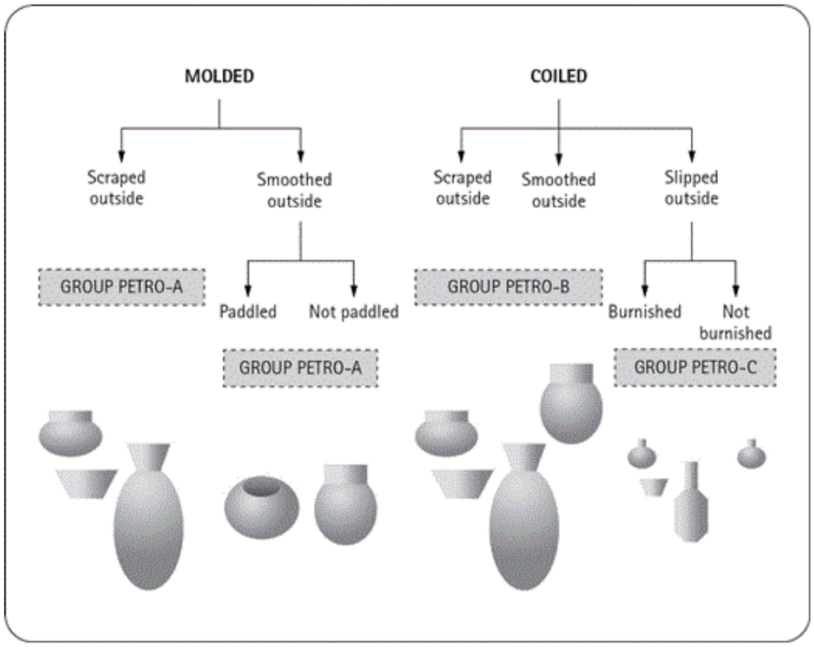


Figure 13. Example of Roux's technostylistic tree. The tree on the left illustrates molded vessels made of the same petro-group (A) which have varying preforming techniques (scraped or smoothed outside) dependent on functional variability. The tree on the right illustrates coiled vessels of the same petro-group (B) which have primary and secondary preforming techniques co-varying with clay sources and relate to functional categories (Roux 2016).

Use Type One: the method

This type of *chaîne opératoire* approach usually begins with classifying items through a typological system referring to features such as size, shape, glaze, formation method, firing method, clay fabric, and more (Roux 2016; 2019a). Items are sorted further into groups by additional features as needed. Methods such as x-radiography to identify clay fabrics and experimental archaeology to identify formation techniques can be employed to classify the pottery for analysis (Berg 2009; Caloi and Bernardini 2024). In all cases where the *chaîne opératoire* approach is used to understand modes of action alone, *chaîne opératoire* is viewed as a method to "recreate" the stages of a production process. Four studies exemplify this type of *chaîne opératoire* approach in Bronze Age Aegean pottery (Choleva 2018; Burke et al. 2021; Georgel-Debedde 2022; Menelaou et al. 2024). This approach often results in a linear reconstructivist recipe for a production process which can be reproduced through experimental archaeological methods. We will see later how this recipe-type

result produces useful data and how it can also limit our understanding of the broader phenomenon of the process of making.

Observing modes of action

How are modes of action observed using Use Type One *chaîne opératoire* approach? One common method is macroscopic analysis (Georgel-Debedde 2022; Menelaou et al. 2024). For example, the visible marks and traces left behind on objects can serve as evidence of fingers, tools, and certain methods such as coils as seen in Figure 14 (Georgel-Debedde 2022). Through the additional use of microscopic analysis, the orientation of clay particles can be observed to distinguish certain methods such as pinching, coiling, slab, and rotation (wheel-fashioning or wheel-throwing) as seen in Figure 15 (Berg 2009; 2011; Thér 2015). Or through experimental archaeology vessels are replicated using various methods and later compared to the archaeological record as seen in Figure 16 (Jeffra 2013).

Figure 14. Detail of the inner wall of a bathtub larnax from Mochlos showing rhythmic corrugations and over-thickness representative of coil-building (Georgel-Debedde 2022)

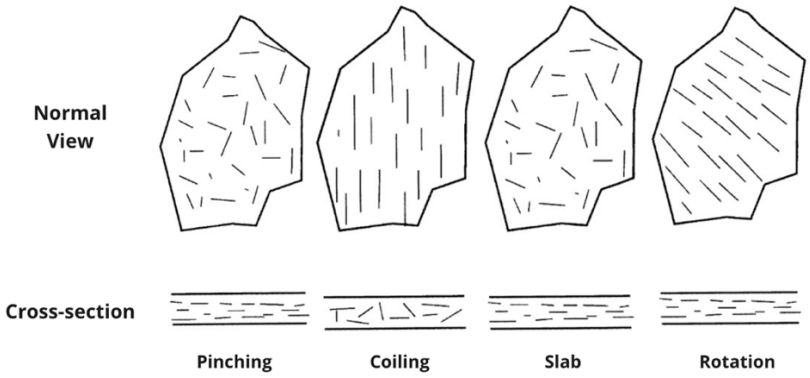


Figure 15. Characteristic features of clay particles under the stress of certain formation methods (Berg 2009)

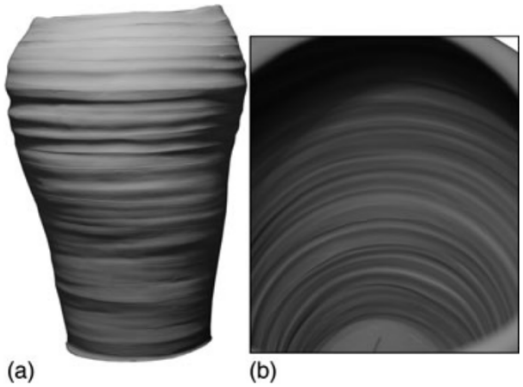


Figure 16. Experimental vessel showing (a) exterior and (b) interior walls demonstrating characteristic traits of wheel-fashioning methods whereby it was produced (Jeffra 2013)

Examples of modes of action

In Burke's study of pottery traditions at Pheneos, which are compared with other sites across the Peloponnese and Aegean region, we can clearly identify the Use Type One *chaîne opératoire* approach (Burke et al. 2021). The methodology explicitly states that a *chaîne opératoire* approach is used to examine and to characterize key aspects of the ceramic assemblage, typology, materials, and technology (Burke et al. 2021, 4). In keeping with the outline of this Use Type One approach, the study begins with typological sorting of wares by size, shape, decoration (glazed/unglazed; slip present; scoring present), and type of clay fabric (course/fine; tempered/untampered; level of vitrification). Macroscopic, petrographic, x-radiography, and experimental archaeology are employed in this study to classify ceramic wares into groups and subgroups. Experimental vessels are created to gain insight into the manufacturing process and to aid in identifying pottery forming techniques through identifying macroscopic similarities (Burke et al. 2021, 7). Based on clay fabric type, indication of firing and surface modification, and formation methods (in this case coil, slab, paddle-beating) the study concludes that the majority of pottery consumed at Pheneos was produced by local potters, using a limited range of raw material, who understood the properties of clay well enough to produce vessels of varying size and shape, with a range of decorative elements. The range of vitrification led the researchers to conclude that the local potters did not have regularly controlled methods for firing (both in terms of atmosphere and firing temperatures). Conclusions about formation methods are also outlined. Based on the variety of hand-building techniques, and

lack of wheel-fashioning methods, the results suggest to the authors that while there is a general standardization in shaping, there may have been more than one potter working simultaneously (Burke et al. 2021, 16). Use Type One studies accomplish the goal of examining and characterizing key aspects of the ceramic assemblage: morphology, typology, formation methods, and finishing techniques. The production process is reconstructed by the key physical actions are reconstructed in a linear order by identifying modes of action involved in the production process.

We see that the Use Type One approach indeed identifies modes of action to a degree of accuracy and provides evidence of production processes at site level. However, modes of action are identified through data trends based on distinct typological categories – samples must be gathered in large numbers to uncover similarities which can be defined as community-wide modes of action. What happens to the outliers, the data which doesn't conform to the trend? For instance, in the study of pottery at Pheneos, an outlier is discovered. An irregularity which is named the "core" technique is uncovered in the examination of the stems of large vessels (Burke et al. 2021, 15). In this technique a smooth slab of clay is wrapped around a rough lump of clay, a technique only found on the stems of large goblets (Figure 17).

Figure 17. The "core" technique for building the high stem of a large Fine Grey Burnished MH III goblet (Burke, Zavadil, and Kordatzaki 2021)

While this irregularity is noted, it is considered a "local peculiarity", and the study moves on to consider the data fitting within the overall pattern observed. When a *chaîne opératoire* approach only considers modes of action, irregularities such as this "core" technique are labeled as outliers

or anomalies. In fact, focusing on this irregularity might reveal insights about the groups' ways of thinking, problem-solving, sociocultural views, and even ecology. Is the evidence of the "core" technique dated only to a specific period, or does it develop over a prolonged period? Was this method a response to failed attempts at building a large goblet stem? Is a heavy or filled stem meaningful to this particular group? Was this technique used at a time of abundance of material and later abandoned due to material scarcity? Was this method abandoned due to firing difficulties? These gaps in findings exist because the analysis of modes of action in isolation can be reductive. No technical system exists in isolation from its sociocultural, historical, and ecological context as is agreed upon by scholars of Western philosophy beginning as early as the 1930's in (Mauss 1934; Leroi-Gourhan 1943; 1945; 1964a; Lemonnier 1992). We will see that in order to answer questions such as the ones I have proposed, modes of action must be complemented by analysis of process trends which are discussed in the following Use Type Two. However, if a study aims specifically to uncover a general picture of physical gestures on a small scale (one vessel, one assemblage, or at site level), Use Type One accomplishes this goal.

Let us consider another recent study which uses a *chaîne opératoire* approach to consider modes of action alone. This study utilizes a Use Type One *chaîne opératoire* approach focused on modes of action to understand the gestures necessary in building a Minoan larnax, a type of clay sarcophagus common to Crete during the Early to Late Bronze Age used to inhume the dead (Figure 14) (Georgel-Debedde 2022). The goal is ultimately to examine the manufacturing process and "reconstruct their [Minoan potters] *chaîne opératoire* specifically related to the fashioning stage, that is the sequence of 'operations which transform the clay paste into a hollow form…'" (Georgel-Debedde 2022, 70). This description of the study is one of many which uses a *chaîne opératoire* approach to reconstruct a *chaîne opératoire*. In this case (and others) the term *chaîne opératoire* indicates both a guiding methodological framework *and* the results of the study. This study aims to use a *chaîne opératoire* approach to identify modes of action taken to turn raw, unformed, clay into a sarcophagus. The results, which constitute a recipe for making, are then also called a *chaîne opératoire*, implying that *"chaîne opératoire"* is both a method and a result. It is worth mentioning this because while there is nothing wrong with utilizing the term in this way, it can sometimes add confusion to the analysis of the *chaîne opératoire* approach.

This larnax study is carried out using a Use Type One *chaîne opératoire* approach which first sorts larnakes into categories by physical attributes such as marks, patterns of fractures, and variations in wall thickness. Microscopic analysis is carried out to determine surface finishing

techniques. Further, experimental archaeology is conducted to mimic forming techniques (slab and coiling). Finally, ethnographic data is collected by interviewing local potters at Margarités who continue to use Bronze Age Aegean pottery production methods. The results of this study propose several different "*chaîne opératoires*" for each stage of production, and several possible techniques for building a larnax. Unique methods are attributed to chest and bathtub larnakes which the authors surmise may be due to two specific groups, one building chest larnakes and the other building bathtub larnakes. While there are trends observed within the production of each larnax-type, there are also variations which cannot be explained by the Use Type One *chaîne opératoire* approach which considers only modes of action. For instance, while most chest larnakes are constructed using a coiling method, some are built using a slab method (Georgel-Debedde 2022, 81). Other variations include the presence of feet, the formation methods of the feet, and also in the formation of the upper rim of the larnax (Georgel-Debedde 2022, 81). The study explains that the differences may be associated with the existence of several workshops with unique forming techniques, noting that the results cannot provide enough information to speculate on the nature of these workshops, the locations, nor the number of them (Georgel-Debedde 2022, 82). Here the author recognizes the limitation of a Use Type One *chaîne opératoire* approach.

A third case study plans to "reconstruct and compare the *chaîne opératoires* linked to the potter's wheel within local production" and to further explore how this "new technology" impacted local pottery production during the Early Bronze Age Aegean (Choleva 2018, 19). This study will also be revisited in the forthcoming section as it focusses on both modes of action and process trends. However, the explicit attempt to "recreate the *chaîne opératoire*s" qualifies this as a Use Type One case study. The methodology as it is described begins with visual inspection of the local ceramic assemblages which indicate the use of the pottery wheel. Next, it uses "the *chaîne opératoire* approach [to reconstruct] the different stages involved in the manufacturing process on the basis of observation and analysis of the macro-features that are diagnostic of the different operations" (Choleva 2018, 50). This methodological approach which is aimed at reconstructing processes can aid in understanding certain physical elements of a production process. The reconstructivist Use Type One *chaîne opératoire* approach highlights isolated actions which make up a recipe for production. It is important to note that reconstructing the steps of a production sequence can in fact be quite useful. However, the *chaîne opératoire* approach also has the capacity to uncover the social aspects of technology. Discussion of this study will be continued in the following section where additional elements of the *chaîne opératoire* approach are considered by Choleva.

On the whole, examining modes of action via a Use Type One *chaîne opératoire* approach is useful for understanding specific instances of elementary forces (such as percussion), and tool-use (Leroi-Gourhan 1964a). This type of *chaîne opératoire* approach is effective in observing the "length" of a process (successive actions in time which constitute a process or part of a process) (Martinón-Torres 2002, 33). Use Type One studies which focus on modes of action usually culminate in a recipe for making, which lends insight to a linear replication of production processes. At the same time this approach isolates the recipe from the culture who produced it, from its context – in other words its *milieus*. Modes of action alone cannot explain creative thinking, cosmological views, cultural values, or unique responses to the intangible social ecology. Furthermore, a recipe for making cannot always be followed to the letter due to the varied affordances of materials. This is particularly true of the affordances of clay. This is evidenced, for example, by the "core" technique which cannot fit within the overall trend of modes of action, and also by the variations of methods within each larnax type. The Use Type One *chaîne opératoire* approach to observe modes of action isolated from their contexts leads researchers toward a linear reconstructionist *chaîne opératoire* research program (Riede 2006). And while this Use Type One *chaîne opératoire* approach is not unproductive, it does not account for how small-scale intra-site variations and irregularities are affected by, and affect change upon, large-scale patterns across geographic and temporal landscapes. Studies which take the Use Type One *chaîne opératoire* approach geared toward reconstruction or replication on a small-scale (site level) produce results which aid in site level understandings of modes of action. So, if there is a "length" to be examined by Use Type One, can there also be a "width" which describes an additional dimension of processes (Martinón-Torres 2002)? We explore this additional dimension in the forthcoming Use Type Two *chaîne opératoire* approach.

Let us recall the early development of the *chaîne opératoire* approach based on Mauss' philosophy that technical acts are social and context dependent. Early developers and interpreters of the *chaîne opératoire* approach emphasize the classification of modes of action on matter rather than the classification of objects' physical features. In a rather harsh review, Riede states that these results are so simple they "can be assessed by specialist and lay-person alike…[which has] steered researchers away from scientific theory and towards either, ultimately, relatively trivial assertions about intra-site structure or supposedly agentive or social interpretations" which lack sufficient theoretical grounding (Riede 2006, 51). Although Reide's review is quite harsh in my opinion, the value in this critique is that Use Type One *chaîne opératoire* approaches often lack context and theoretical grounding to draw conclusions about sociocultural elements of a group. Referring to a

Use Type One *chaîne opératoire* approach Sillar offers a similar critique, "this [type of] analysis will not be sufficient [to draw sociocultural conclusions] if it is confined to a linear analysis of how a particular object was made" (Sillar and Tite 2000, 4). Nonetheless, I would argue that Use Type One *chaîne opératoire* approaches are valuable as a method to understand modes of action, the physical properties of a process, in isolation from their sociocultural contexts. In fact, perhaps isolating modes of action from their broader sociocultural context offers some benefit to the particular aim of a study. So long as a Use Type One approach is not leveraged to draw broad sociocultural conclusions, there is no harm. Rather than critique the Use Type One approach, Martinón-Torres urges researchers to consider "the major significance of the [*chaîne opératoire*] strategy" which according to him contains both the "length" and "width" of the object of study (Martinón-Torres 2002, 33).

Both Riede and Sillar emphasize that without a broader context, we must use caution when drawing conclusions about the sociocultural aspects of a group based solely upon a recipe of modes of action. Martinón-Torres on the other hand aims to inspire researchers to consider the scope of the *chaîne opératoire* approach and its potential to uncover more than one dimension of a process. It is my aim to explore this scope and potential of the *chaîne opératoire* approach and inspire others to continue to do the same. Leroi-Gourhan and other developers and interpreters of the *chaîne opératoire* approach recognized the limitations of what I identify as a Use Type One approach, which is why modes of action are only one part of the elements of the *chaîne opératoire* approach. Leroi-Gourhan explicitly stated that technical facts and technical tendencies (or modes of action and process trends in archaeology) are two halves of the same phenomenon (Leroi-Gourhan 1943). While modes of action describe fixed physical actions or properties, process trends describe socially informed choices visible over time and space. Process trends are observed through the lens of a groups' *milieus* (i.e., socio-historical context *across and through space and time*). So, we must consider modes of action *in conjunction with* process trends and *milieus* if the aim is to draw conclusions about the sociocultural elements of a group. We see how this is attempted in the forthcoming Use Type Two analysis.

Visualizing Use Type One

Two visual representations occur in the Use Type One case studies presented here. First, Burke, et. al. include a table illustrating characteristic forms alongside their associated wares, primary forming

techniques, and secondary forming techniques. This table (Figure 18) reads similarly to Roux's technostylistic tree diagram (Figure 13) albeit in table format. The technostylistic tree was developed by Roux to be used in conjunction with the production process flowchart which illustrates discrete physical actions in production processes (Figure 12). In conjunction with the production process flowchart, the technostylistic tree can highlight social elements of technostylistic choices. Without a production process flowchart, the table (Figure 18) only illustrates the relationships between forms, wares, and methods but cannot be linked clearly to discrete physical actions where these relationships and therefore choices occur. A narrative description later highlights potential physical actions in the production sequence. Whereas Roux's technostylistic tree diagram begins with forming methods, then petrographic identification, and finally morphology and style, Burke's organization of the same key elements are relayed in the opposite order. While this table does support the reader's understanding of the relationships between these elements, it does not expand on the sequence or choices of physical actions necessary for the formation process.

Vessel form	Associated Ware		Forming method	
	Burnished or polished	D-o-L matt-painted	Primary technique	Secondary technique
Open shapes (e.g. goblets, kantharoi)	+	+	Coil-building	Paddle-beating(occasionally)
Small closed pots	–	+	Pinching	Paddle-beating(very rarely)
Large closed pots (jugs/jars)	+*	+	Slab-building/coil-building combined with paddle-anvil	–

Figure 18. Vessel forms and their associated wares are classified alongside forming methods which have been identified macroscopically or microscopically (Burke et al. 2021).

Second, Choleva also develops a diagram (Figure 19). This diagram presents similarities to Lemonnier's diagrams of operational sequences (Figure 20), perhaps referencing the tradition of transcribing ethnographic field notes (adapted for archaeology), and also shows similarities to Roux's approach to a flowchart of physical actions (Figure 12). The figure illustrates action sequences (roughing out, preforming, and finishing), and their relationship to morphological and petrographic characteristics. In Menelaou and Kouka's study we do not find a visualization of production processes via the *chaîne opératoire* approach (Menelaou and Kouka 2021). Instead, the authors provide images of clay fabrics and tables cataloguing assemblages. This study uses only narrative descriptions of technological actions and techniques. Similarly, Georgel-Debedde provides only narrative descriptions of the forming phases alongside images of the completed larnakes, forgoing a visualization of the production processes via the *chaîne opératoire* approach

with regard to the study (Georgel-Debedde 2022). The numerous visualizations of the Use Type One approach demonstrates again the flexibility and ambiguity of the *chaîne opératoire* approach.

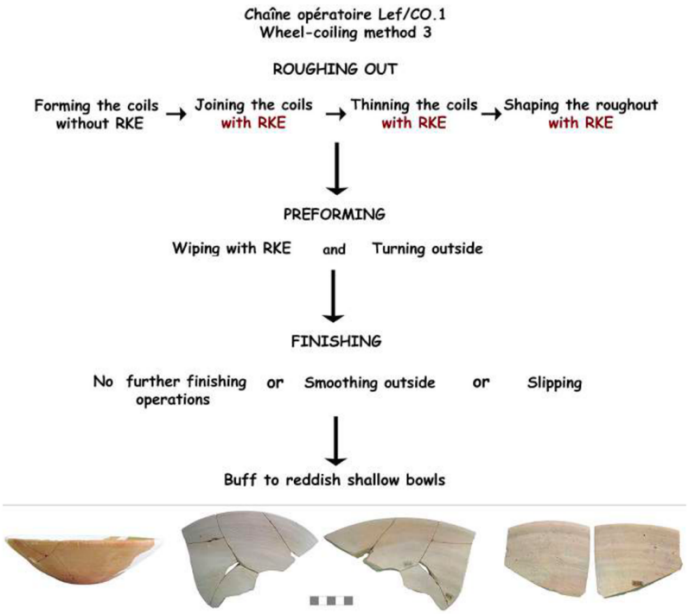


Figure 19. Visual representation of the *chaîne opératoire* approach in use by Choleva. The diagram illustrates three phases of main actions (roughing out, preforming, and finishing) which produce buff to reddish shallow bowls from raw clay material (Choleva 2018).

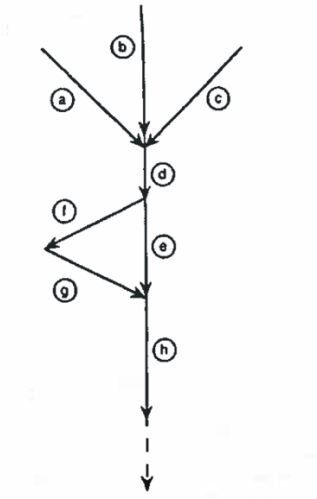


Figure 20. Lemonnier's sample diagram of an operational sequence wherein operations A, B, and C must be completed before operation D, and so on. In this case operation E can be bypassed via the F-G pathway leading to operation H (Lemonnier 1992).

Use Type Two: *chaîne opératoire* of modes of action and process trends

If, as I have argued, the *chaîne opératoire* approach has the capacity for the analysis of modes of action and process trends in conjunction, let us consider some use cases where this approach is employed. First a reminder of the definition of process trends. Process trends refer to socially informed choices which can be observed through space and time and, while they often appear to be arbitrary, they contain the key to understanding a group's *milieus*. Process trends transcend the fixed nature of modes of action; they do not strictly dictate the completion of a process. For example, on the island of Kythera, potters may have emulated the Cretan style of pottery, a finding which is referred to broadly as "Minoanizing" (Broodbank and Kiriatzi 2007). Emulating the formation methods of a foreign and distinct group (Minoans) does not impede *nor* improve Kytheran potters' ability to produce pottery, it is a socially informed *choice*. As another example, there is evidence that even after the widespread use of the pottery wheel in Bronze Age Crete, some groups preferred a combination of hand-building and wheel-fashioning methods especially in certain circumstances (e.g., large vessels), regardless of the conceptual and practical knowledge of wheel-throwing methods (Jeffra 2013; Roux and Jeffra 2015).

The analysis of process trends requires scholars to look for data trends but also for outliers (e.g., Minoanizing styles or hand-building) not only on the site level, but in some cases across a wider geographic and temporal landscape. Commonalities can signify macro-scale regional knowledge and practices, while outliers can signify micro-scale endogenous and cumulative cultural change (Knappett and Van der Leeuw 2014a). These outliers can signify distinct shifts in the status quo – socially informed choices made by an individual or a group. These macroscopic and microscopic data are each equally valuable. Together, these data help to define a group's *internal milieus, external milieus, and technical milieus*. Of the case studies analyzed for their *chaîne opératoire* approaches, only six take a Use Type Two *chaîne opératoire* approach which incorporates both modes of action and process trends (Choleva 2012; 2018; 2020; Choleva et al. 2020; Mentesana et al. 2016; Menelaou and Kouka 2021).

The Use Type Two *chaîne opératoire* approach offers an intuitive and comparative approach overall, albeit relying on a Use Type One approach to modes of action. As such, these studies generally follow the Use Type One method (including Lemonnier's treatment of operational sequences) with the addition of broader anthropological and ethnographic approaches to *chaîne*

opératoire much like Lemonnier's further development of the *chaîne opératoire* approach. Lemonnier emphasizes the usefulness of this approach to observe diversity and commonalities among individuals and groups at the inter-site or intra-site level. Lemonnier further develops the analysis of variations *over time* (process trends) in his *chaîne opératoire* approach. We see this strategy utilized in the Use Type Two *chaîne opératoire* approaches herein. Lemonnier also highlights the notion that technological choices may be social (*milieu interior* or specifically *milieu technique*) or environmental (*milieu extérieur)*.

While Lemonnier offers various templates for visualizing operational sequences (modes of action) (Figure 3, Figure 4, and Figure 20), visually representing process trends presents significant challenges. Comparison of operational sequences for commonalities and differences is the most common method Lemonnier utilizes, especially in his seminal work *Elements for an Anthropology of Technology* (Lemonnier 1992). For example, a side-by-side comparison of two carpenters' methods highlights distinct choices such as beginning the task with two nails in the mouth instead of one at a time (Figure 3). In another example (Figure 21), Lemonnier drafts a table comparing the various physical actions of each French region's salt brining processes highlighting similarities and differences across the regions. These comparisons aid in drawing some conclusions intuitively regarding each group's choices (process trends). In the case of anthropology, the researcher may supplement this information by surveying peoples of these regions to gather further information about these technical choices – an option that archaeologists do not have access to unless carrying out supplemental studies such as ethnoarchaeology amongst closely related modern peoples. Nevertheless, archaeologists may certainly benefit from the comparison of groups' modes of action to highlight overarching trends of process trends as is clear from the Use Type Two *chaîne opératoire* approaches herein.

REGION	stir without fine-salt	gather the salt	break -up fine salt and stir	break-up fine salt without stirring	stir thoroughly every day		stir thoroughly every other day	
					twice	once	collection day	non-collection day
Camac	X						X	
Mesquer	X	X				X		
Guérande	X	X				X		
Noirmoutier	X	?	X	X	(X)	X		
Bourgneuf			X				X	
Bouin		X	X			X		(X)
Beauvoir			X				X	
St Gilles	X		X			X		
Olonne		X	X			X		(X)
Talmont	X		X	X		X		
Ré	X	X	X	X	X			
Seudre	X	X	X		X			
Oléron	X		X		X			

Figure 21. Lemonnier illustrates similarities and differences within the practices of stirring salt brine among thirteen salt marshes on the coast of France (Lemonnier 1992)

Use Type Two: the method

What steps are taken in this approach? First, modes of action are analyzed as with the Use Type One *chaîne opératoire* approach previously described. Second, in order to study process trends, the scope of analysis of modes of action is expanded to include a broader geographic or temporal landscape as developed by Lemonnier. Additional ethnographic (Choleva 2012), and anthropological (Choleva 2018) methods can also be employed. As we know, modes of action are spatially and temporally fixed actions which are required in order to physically produce the desired form, and which commonly occur across various cultures. For example, in order to form a coiled vessel, one must roll pieces of clay in order to achieve the coil shapes. The mode of action is a snapshot of one mechanical element within a larger phenomenological process. Process trends on the other hand, are not fixed spatially or temporally. They can only be observed as trends which appear and change *across* and *through* space and time.

Changes in production processes, such as the incorporation of novel tools and techniques, can only occur where there is technical and social elasticity (Knappett 2004, 257). Technical and social elasticity indicates the propensity for change in a given group with regard to a technological process. In groups with high elasticity, there is visible archaeological evidence of variability in one or all components of a technical process while other groups with low elasticity are considered rigid and

do not demonstrate variability (Pfaffenberger 1992; Gosselain 2000b; Knappett 2004). Understanding the elasticity of social groups can further underline process trends; when confronted with novel technologies and techniques, how does a group react? Do they adopt novel tools quickly? Or do they perhaps *adapt* such tools to suit their existing processes? Or do they reject novel tools, demonstrating a preference for their own established approach? These responses offer glimpses into group's *milieus* and further illuminate the long-term process trends of groups.

In Choleva's study of pottery production at Lerna, she considers modes of action via typological analysis of vessel size, formation methods, and finishing techniques presenting similarities to Roux's approach (Choleva 2012). She then employs ethnoarchaeological and anthropological approaches across a broad geographic area, following Lemonnier's approach, including Western Anatolia to explore changes in technological practices within the two regions. Choleva uncovers evidence of pottery formation methods (modes of action) which may indicate dissemination of pottery formation method knowledge and trade of objects (Choleva 2012). Similarly, Mentesana works to reconstruct the formation methods of ceramic wares at Phaistos, later comparing the formation methods with consumption practices (Mentesana et al. 2016). In another example, Menelaou and Kouka (2021) observe and describe the modes of action of cookware production based on analysis of clay fabrics and local resources on the island of Samos. This data regarding local (geographic and temporal) modes of action is compared to modes of action found across the wider region including Western Anatolia in the study which spans nearly 3,000 years from the Chalcolithic period (4700 B.C.) to the Bronze Age (1700 B.C.). Including a broad range of data including patterns and changes of local modes of action but also a broader geographic and temporal landscape of modes of action can lend insight into the cultural practices and social choices; the scale and inclusion of anthropological and ethnographic theory within these Use Type Two studies often facilitates a shift from modes of action to process trends.

Observing process trends

So how exactly can an archaeologist observe process trends? As I have noted, this can be achieved by viewing modes of action across a wider region or time period. Perhaps, we observe one site over a long period of time (e.g., Mentesana et al. 2016). Alternatively, we might observe multiple sites across time (e.g., Choleva 2012; 2018; 2020; Choleva et al. 2020; Menelaou and Kouka 2021). First, these studies must uncover the modes of action to understand how processes are carried out within

an assemblage, during a specific period, and usually at a specific site. Second, they broaden the scope of the study either geographically, temporally, or both. The aim is to trace modes of action across a wider geographic and temporal landscape. This is the data which can be analyzed for process trends. As mentioned, a variety of secondary methods are often employed to accomplish such a task: anthropology, ethnoarchaeology, experimental archaeology, x-radiography, and chemical analysis, all with the common goal of gathering modes of action as a source of data to analyze from a broader perspective.

Choleva takes an approach categorizing assemblages based on macroscopic analysis of technical traits, stylistic traits, and morphological traits - an approach resembling Roux's methodology (Choleva 2012; 2018; 2020; Choleva et al. 2020). On the other hand, Mentesana employs microscopic analysis of petrographic traits and clay fabric provenance as well as morphograpic traits to compare with findings of post-production consumption (Mentesana et al. 2016). In Choleva's studies she compares her findings at Lerna, Pefkakia, and Lefkandi with Western Anatolian pottery practices and findings at Ayios Vasileios (Laconia) with pottery practices across the wider Argolid region (Choleva 2012; 2018; 2020; Choleva et al. 2020). Similarly, Menelaou (2021) analyzes the clay fabric in cookware at sites on Samos from the mid 5th to the early 2nd millennia B.C. (Chalcolithic through Bronze Age) and also compares this data to cookware fabrics found in Western Anatolia. These studies embrace the notion that process trends transcend the limitations (space and time) of modes of action. Process trends can be seen as long-term patterns (choices) of modes of action which are therefore understood as socially and historically context dependent. Furthermore, they are elements that do not necessarily impede or improve production. And finally, these process trends can only be observed across broad geographic and or temporal landscapes.

Examples of process trends

Let us review some examples of process trends and how they have been observed in the archaeological record. Mentesana's (2016) study outlines that while there are a variety of ceramic wares fashioned through a range of production methods (disjointed), the wares were likely used together as a set (unified) in consumption practices. Choleva's study analyzes the use of combination methods (hand-building in conjunction with wheel-fashioning) despite the existence of wheel-throwing methods which highlights visible process trends (Choleva 2012). This data indicates that the potters at Lerna preferred local, established, methods and indicates resistance to novel

methods. In other words, these potters demonstrate low socio-technical elasticity. In the study of cookware from Samos and the Western Anatolian region spanning nearly three millennia, a distinct production process was discovered which persisted despite the use of substantially disparate raw materials in said process. This persistence in production practices leads to the conclusion that formation techniques may have been shared between generations through learning networks which surpass ecological factors and therefore indicate sociocultural values and continuity in technique despite changes in clay resources (Menelaou and Kouka 2021). This type of information has the potential to expose certain value systems, cosmological beliefs, economic factors, skill-sharing, and consumer preferences.

Choleva asserts that taking ethnoarchaeological and anthropological approaches can shed light on socioeconomic, ideological, cultural, and cognitive aspects of production processes (Choleva 2012, 375). It is important to note that while Choleva's research is focused on the Aegean, she broadens the scope of this study to include Western Anatolian pottery traditions, as we also see in the example of cookware studies by Menelaou. This geographic "zoom out" is a common factor in observing process trends; through this approach we observe parallels between Bronze Age Aegean pottery and Western Anatolian pottery which allows for discussion of transmission and dissemination of technological information and traditions or practices. This also grounds discussions of socio-technical elasticity: the openness of a group to adopt new technology or techniques introduced by an outside group (Gosselain 2000a; Knappett 2004, 257). Similarly, sites on Crete and Cyprus are compared with the Northern and Southern Levant by Roux and Jeffra in an effort to understand the spread of the pottery wheel across the larger Aegean and Near Eastern region (Roux and Jeffra 2015). Again, we see that process trends can be observed within a larger context as with these two studies which compare an Aegean site with a Near Eastern site.

Through her analysis of Aegean and Anatolian pottery traditions, Choleva determines the pottery wheel is part of an Anatolian pottery tradition which is introduced to the Aegean region during the late Early Bronze Age II (Choleva 2018; 2020). Findings which show the Anatolian pottery tradition present in new assemblages at Lefkandi, however, the pottery wheel-use appears to be unique to Anatolian-style pottery (Choleva 2018, 66). On the other hand, findings from her study show that at Pefkakia the Western Anatolian wheel-made pottery practices were rejected, however they did adopt the morpho-stylistic features of Western Anatolian vessels (Choleva 2018, 66). Taking an even broader approach in 2020, Choleva includes assemblages from various sites on the Anatolian peninsula, the Aegean islands, and mainland Greece (Choleva 2020). In her findings she concludes

that Anatolian wheel-made pottery traditions were introduced to Greece and the Aegean in a "synchronous technological phenomenon" via regional and interregional interactions throughout the late Early Bronze Age (Choleva 2020, 66). However, these findings are not indicative of the pottery wheel as an Anatolian "invention" brought to the Aegean – there is evidence of pottery wheels and bats in the Aegean predating this period. Nonetheless, this data does provide insight into Aegean groups' socio-technical elasticity when presented with an exterior groups' particular method.

Note that a debate surrounding hand-built and wheel-fashioned pottery production is ongoing. Some purport that the pottery wheel was a foreign innovation introduced to Crete and thereafter to the greater Aegean region from the Near East (Pendlebury 1939; Childe 1956; Knappett 1999; Choleva 2012; 2020, 65), while others support the theory that the pottery wheel was an internal development contemporaneous to other groups' use of the pottery wheel which may certainly have gained popularity through contact with other regions, or for other reasons (Xanthoudídes 1927; Warren 1969; Day et al. 1997; Berg 2011; 2012; Haas-Lebegyev 2014). While this discussion is important it is not the focus of this chapter. However, the debate highlights the importance of appropriate methodologies in this field of study.

Overall, the Use Type Two case studies present a consistent *chaîne opératoire* approach and as a result the findings consistently offer the ability to analyze process trends in pottery formation processes. Each of these studies is specific to Bronze Age Aegean pottery, however, we may find further indications of process trends if additional elements of the region's sociocultural and technical *milieu* were incorporated. For example, Coupaye integrates many elements such as cosmological beliefs (spirits in the soil) and social behavior (building a fire, lunch breaks, respect for the spirits) in his *chaîne opératoire* approach to Papua New Guinean yam farming (Coupaye 2009). If practices and crafts related to pottery are considered, such as textile traditions perhaps, results of Aegean pottery research may vary significantly. In a 2014 study, it was found that "before the appearance of the potter's wheel, pieces of mats, textiles or vine leaves" were used to turn large coil-made vessels *during* their production, leaving imprints of textiles on the base of such vessels (Haas-Lebegyev 2014, 106). There is widespread evidence of the use of textiles and fibers in this manner from the Neolithic to the Late Bronze Age (Haas-Lebegyev 2014; Karnava et al. 2019). By including additional sociocultural and technical choices within the *chaîne opératoire* approach to observe the production process and *all* of its entangled sociocultural elements (*milieus*), we may uncover additional insights to the Aegean pottery tradition. We will see how additional practices and crafts can be incorporated into a *chaîne opératoire* approach in Chapters Six through Ten.

Visualizing process trends

Visualizing data trends over broad geographic and temporal landscapes through the *chaîne opératoire* approach presents challenges. Whereas modes of action can be presented through straightforward visual sequences (Figure 3, Figure 5, Figure 7, Figure 8), sketches (Figure 1), flow charts (Figure 6, Figure 12, Figure 13, Figure 19), and tree diagrams (Figure 4 and Figure 20), process trends are not as easily visualized through the same visual tools. Modes of action can be visualized more easily in two dimensions because of their isolation in space and time; however, the defining trait of process trends is their phenomenological characteristic and the ability to observe them only through the passage of time or comparatively amongst geographic locations. Martinón-Torres offers a visualization which includes both the "length" and "width" of a *chaîne opératoire* approach (Figure 22). We see in his visualization what a complex task it is to visualize processes. In the case of Use Type Two, it is unclear in Martinón-Torres' diagram how to incorporate the elements of "length" and "width" *across* and *through* space and time to accommodate process trends for archaeologists. We return to the issue of visualization and explore further developments in Chapters Six through Ten.

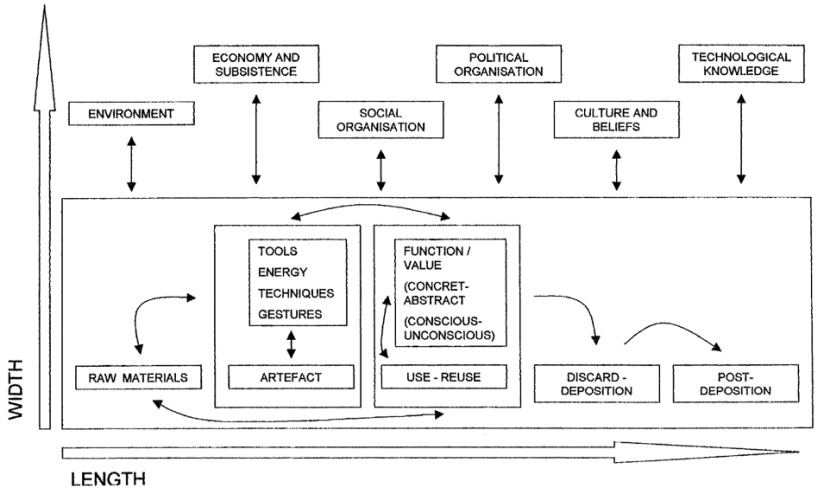


Figure 22. Diagram representing the "length" and "width" of a *chaîne opératoire* approach (Martinón-Torres 2002)

Because of this visual complexity, some forego a visual representation of process trends altogether (Mentesana et al. 2016; Menelaou and Kouka 2021). Others rely on visualizations similar to Lemonnier's table comparing regional preferences for stirring salt brine (Figure 21). Choleva

illustrates the distribution of four wheel-fashioning methods which indicate the levels of RKE usage (Method One is the least use of RKE and Method Four is the most use of RKE) (Figure 23). In this figure, the distribution of wheel-fashioning methods is compared *over time* at the site, indicating the variations in process trends. In her 2018 study, Choleva aims again to illustrate the frequency of RKE usage over time at Pefkakia, in this instance opting for a line graph indicating rising and falling percentages over four phases (progression in time) (Figure 24). Both serve the same epistemological purpose of demonstrating variability in process trends over time, at an individual geographic location. Shifting from a temporal comparison to a geographic comparison, Choleva mirrors Lemonnier's regional comparison table in her own study of hand-built versus wheel-fashioned pottery in the Aegean and Near East (Figure 25) (Choleva 2020).

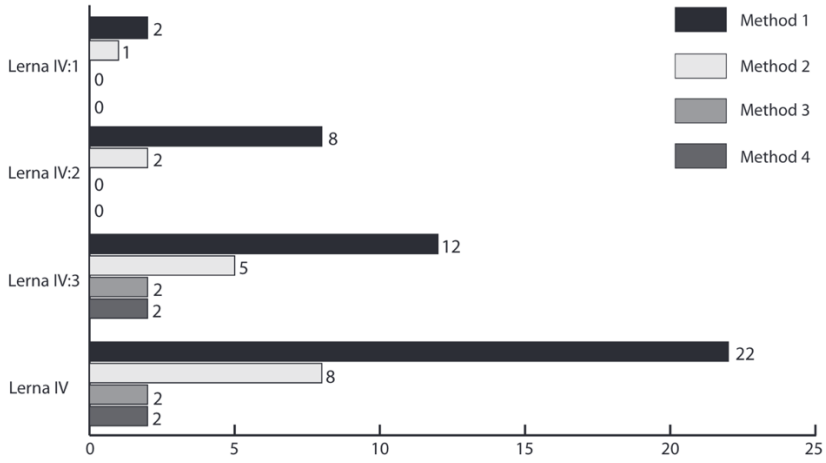


Figure 23. Choleva compares the frequency of wheel-fashioning methods at Lerna IV over three phases in time (Lerna IV:1 – LernaIV:3) in the late Early Bronze Age III. This comparison aims to outline process trends at the site over time as well as the totals of all three phases (lower most bar chart) (Choleva 2012).

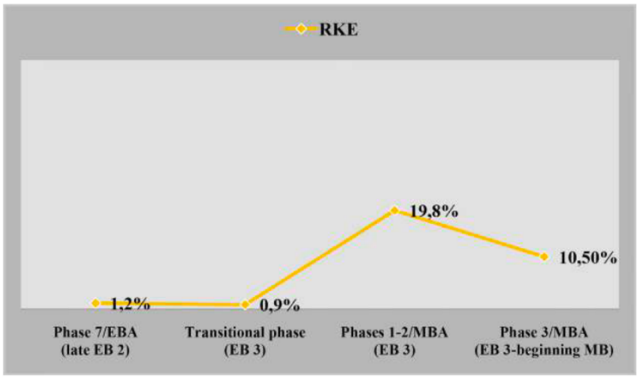


Figure 24. Choleva compares the percentage of wheel-fashioned forms (presence of RKE) over four distinct phases at Pefkakia (Choleva 2018).

Sites	Percentages	Identified wheel-made pots/sherds in studied excavation areas	Examined hand-made variants in studied excavation areas
		Northern Aegean	
Troy IIb–early III	10–20%	822	?
		Eastern Aegean	
Emporio I	4%	61	8
Heraion II–III	Low	22	7
Liman Tepe V	Low		
Bakla Tepe	Low		
		Central Greece	
Palamari II–III early	10%	19	157
Lefkandi I	16.8%	53	59
Ayia Irini III	0.1%	6	39
Pefkakia EB7	1.2%	10	54
Mitrou	Low	1 or 2	42
Thorikos Mine 3	0.3%	2	12
Manika	Low		
Thebes Group B	Low		

Figure 25. Quantity and percentages of wheel-made pottery at excavated and published sites across the Aegean and Central Greece in the late EBIII (Choleva 2020).

While these charts, graphs, and tables can visually represent the comparative data necessary to discuss process trends, these figures are difficult to incorporate within the same visual framework as those representing modes of action (e.g., flow charts, tree diagrams) because of their characteristic differences. In the Use Type Two *chaîne opératoire* approach which analyzes both modes of action and process trends, the *chaîne opératoire* approach is employed to analyze process trends purely as conglomerate data compiled from large datasets of modes of action. While this does illustrate frequencies of production methods (similar sequences of modes of action), it does not visually represent the sociocultural nuances at play. These nuances must then be demonstrated through written description. Is it possible to include process trends and their sociocultural nuances

within one consolidated visualization of the *chaîne opératoire* approach? Solutions to this question are explored in Chapters Six through Ten.

Use Type Three: *chaîne opératoire* as a "buzzword"

The Use Type Three approach is the most common with fifteen studies represented in this category. In this Use Type, there a few themes: (1) First, the term *chaîne opératoire* is referred to as a methodology, but the central concepts are not engaged; (2) the term *chaîne opératoire* is used only to refer to a sequence of actions, or a recipe for making; or similarly uses the term with the aim to "reconstruct" a *chaîne opératoire*; and finally (3) in some cases experimental archaeology as a methodology claims to draw on aspects of a *chaîne opératoire* approach. Through a review of *chaîne opératoire* case studies it is clear that the term *chaîne opératoire* is popular, it is used frequently and carries significance. This review also highlights that the term *chaîne opératoire* has become interpreted and applied in various ways. This Use Type Three illustrates the variety of interpretations of the *chaîne opératoire* approach, its popularity, as well as its ambiguity.

***Chaîne opératoire* as a popular term**

In a number of these archaeological studies, *chaîne opératoire* is explicitly referred to as the methodology but the elements of the framework (classification, modes of action, process trends, and *milieus*) are not engaged. For instance, studies discuss the term *chaîne opératoire* and the entangled nature of production, skill, dissemination, and culture but do not outline how the author will engage with elements of the *chaîne opératoire* approach (Berg 2007; Murphy 2020). In many of these cases, scholars productively discuss the theory behind *chaîne opératoire*, the development by Leroi-Gourhan, and the entanglement of sociocultural and technical spheres with the process of making (Morris et al. 2019; Hilditch 2020, 70). Despite the fruitful discussion of the *chaîne opératoire* approach, we see in these cases that a sequence of events is named "a *chaîne opératoire*" which is then successfully analyzed using other methods. This underlines the power and popularity of the term "*chaîne opératoire*"*;* it holds weight and credulity as an archaeological approach and is simultaneously ambiguous. This also underlines the need to revisit and reconsider the *chaîne opératoire* approach for archaeologists. The *chaîne opératoire* approach offers a rich and multi-faceted approach to archaeology – it is a unique tool which can be employed to enliven aspects of the distant past and is undoubtedly very popular for these reasons.

Chaîne opératoire as a recipe for making

As mentioned previously there are many instances wherein the term *chaîne opératoire* is used only to refer to a sequence of actions, a recipe for making, a blueprint for production. While modes of action can indeed outline sequences of operations within a production process, this recipe or blueprint-type approach can limit the phenomenological aspects of the *chaîne opératoire* approach in some cases. The *chaîne opératoire* approach indeed has the capacity to outline operational sequences. However, when reduced to this aspect the outcome is a recipe or blueprint. However, the *chaîne opératoire* approach also has the capacity for capturing the phenomenological aspects of production processes as they unfold through space and time as well as the sociocultural nuances associated with production processes.

The use of the *chaîne opératoire* to refer to recipes or blueprints for making exemplifies how the term has become widely used as a catchall phrase referring to recipes for production processes. For instance, Menelaou's 2021 paper which is cleverly titled "Cooking up pottery recipes", mentions the use of *chaîne opératoire* to recreate a recipe for making which may be tied to the prehistoric pottery production techniques at Samos (Menelaou and Kouka 2021). A similar *chaîne opératoire* approach is used to understand recipes for making pottery supplemented by x-radiography and chemical analysis as well as geological prospection and experimental reconstruction (Menelaou 2020). Berg's paper titled "*Exploring the chaîne opératoire through X-radiography*" provides an outline for the use of x-radiography in order to "understand the *chaîne opératoire* of ceramics" (Berg 2011, 1). We find the term *chaîne opératoire* is not referencing the archaeological approach but is instead used to represent a recipe or blueprint for making. Berg's case study illustrates the potential for x-radiography as an important supporting method to a *chaîne opératoire* approach and the results show that actually, x-radiography can be hugely beneficial by verifying modes of action such as clay particle alignment and clay provenance (Berg 2011).

Further examples of utilizing *chaîne opératoire* as a method for reconstructing a production process are abundant. Many refer to "the ceramic *chaîne opératoire*", "a *chaîne opératoire*", "each stage of the *chaîne opératoire*", and "the performance of a *chaîne opératoire*" frequently. In some cases, researchers use experimental archaeology to produce modern typesets of ceramic vessels, then compare those with archaeological assemblages at various Aegean sites intending to "clarify the *chaîne opératoire*" of objects (Jeffra 2013). These are compelling studies and produce well-

regarded results. Again, the term *chaîne opératoire* describes a prescribed linear set of actions, a recipe for making. Similar cases include studies are aimed at "reconstructing the *chaîne opératoire* of pottery" or investigating "one aspect of the ceramic *chaîne opératoire*" (Mentesana 2014; Mentesana et al. 2019; Roux and Jeffra 2015). The widespread use of the term *chaîne opératoire* to refer to a recipe for making I believe is driven by the flexibility and ambiguity of the *chaîne opératoire* approach. However, in these cases the foundational elements of the *chaîne opératoire* approach could be engaged to produce a deeper understanding of the phenomenon of production processes.

Experimental archaeology supplemented by *chaîne opératoire*

In a few cases, we see the explicit use of experimental archaeology influenced by the *chaîne opératoire* approach. Jeffra's 2014 study titled "Experimental approaches to archaeological ceramics: unifying disparate methodologies with the *chaîne opératoire*" is one such example. Jeffra offers two steps to tailor experimental archaeology to a *chaîne opératoire* approach in order to create a "*chaîne opératoire*-influenced experimental archaeology" (Jeffra 2015, 144). First, one must address the production process they aim to study (number of steps taken in the process, and degree of difficulty to carry these out, and furthermore degree of difficulty in disseminating them) (Jeffra 2015, 143). Second, one should "integrate *chaîne opératoire*" by defining the relationship between the proposed production process and the broader context of assemblages, periods, or sites (Jeffra 2015, 144). This approach is well-constructed, demonstrates a clear understanding of the foundations of the *chaîne opératoire* approach, and engages with elements of the *chaîne opératoire* approach while considering ways in which it might supplement experimental archaeological methods.

While this study is not related to Bronze Age Aegean pottery, I highlight it here as a unique approach which integrates some elements of the *chaîne opératoire* approach with an experimental methodology. Some researchers cite Jeffra's approach with the aim to supplement experimental archaeology with a *chaîne opératoire* approach but in some cases lack engagement with the foundational concepts of the *chaîne opératoire* approach (Alexandrou and O'Neill 2013; Jenkins 2022). Jeffra explicitly states that the *chaîne opératoire* approach can supplement experimental archaeology by elucidating the social phenomena related to production processes, that a *chaîne opératoire* approach is a powerful tool to bridge the gap between technical and social approaches, and furthermore that she hopes "future researchers will be able to craft more robust experimental

methodologies which can be readily directed toward anthropologically relevant conclusions" (Jeffra 2015, 141).

Concluding remarks

Through this review of Bronze Age Aegean pottery production studies, three *chaîne opératoire* Use Types are highlighted. In the Use Type One case studies the *chaîne opératoire* approach is used to identify and analyze **modes of action in isolation from their sociocultural context**. This is based on typological classifications of assemblages by features such as size, shape, glaze, formation method, firing method, clay fabric using a *chaîne opératoire* approach in combination with macroscopic and microscopic methods to determine features such as clay fabric, clay particle orientation, physical markings on the surface of vessels, and overall formation methods. In these cases, we see elements of the *chaîne opératoire* approach used to "recreate" the stages of a production process resulting in a linear recipe for making. This Use Type engages with the *chaîne opératoire* approach successfully insofar as it addresses modes of action.

In the Use Type Two case studies we see the *chaîne opératoire* approach used to identify and analyze **both modes of action and process trends**. This is carried out by first identifying and analyzing modes of action as described by the Use Type One approach. Next, process trends are observed across a broader geographic and temporal landscape sometimes incorporating ethnographic and anthropological methods. This approach engages with both modes of action and process trends. This approach grapples with the broader potential of the *chaîne opératoire* approach which is to link technologies with their sociocultural context.

In the Use Type Three case studies we see the term *chaîne opératoire* used in three ways: (1) referring to *chaîne opératoire* without engaging with the foundational elements of the approach; (2) the term *chaîne opératoire* is used only to refer to a sequence of actions, or a recipe for making; or similarly uses the term with the aim to "reconstruct a *chaîne opératoire*"; and (3) using experimental archaeology supported or influenced by *chaîne opératoire* yet in some cases there is little engagement of the elements of the *chaîne opératoire* approach. In many of these cases the impact of the *chaîne opératoire* approach is not outlined in the results. We see this in the majority of the twenty three Bronze Age Aegean pottery case studies presented here. The volume of Use Type Three case studies signals the popularity of the *chaîne opératoire* approach in Bronze Age Aegean pottery studies as well as its ambiguity.

In cases which employ the Use Type One and Use Type Two approaches to *chaîne opératoire*, some issues arise. Both use a system of typology to classify assemblages according to physical features in order to "recreate" a production process or a recipe for making through the analysis of modes of action. The Use Type One cases begin and end with this typology and analysis. However, the *chaîne opératoire* approach has the capacity to uncover more than a recipe for making. It also has the capacity to link the mechanical elements with the phenomenological aspects of a group's production processes. The Use Type Two cases employ the same approach to modes of action and later build upon it by incorporating related archaeological data from a broader context across multiple sites or regions and over an extended time period to identify process trends. This approach is useful and produces compelling results regarding formation methods for pottery making. However, by assuming production follows a seamless linear recipe for making according to the results of a typological system, the issues of agency and cognition arise.

The recipe for making assumes that agency is a human property where there is no feedback or interplay between the maker and the material. Many potters will anecdotally share that while they may have a conceptual outcome in mind, the process consists of working *with* and *through* the clay in the moment(s) of making (Malafouris and Koukouti 2020; 2022; Malafouris et al. 2023; Malafouris 2023). We must also note that the Use Type One and Use Type Two *chaîne opératoire* approaches reconstruct a recipe which assumes a computational view of cognition. This computational view proposes that human beings gather data as input, manipulate the input through symbolic representations within the brain, and later output that manipulated data in the form of actions and language. But is the mind computational? Is the mind confined by the skull? Current theoreticians of cognition would argue this is not true. The mind is now understood to function through a phenomenological process of thinking *through* and *with* things. Furthermore, the mind is affected by being in a body and by our interactions with world around us.

Can we pinpoint these underlying assumptions of agency and cognition within the fundamental elements of the *chaîne opératoire* approach? If so, is it possible to rethink the *chaîne opératoire* approach in light of contemporary paradigms and theories of agency and cognition to further develop the framework? Resolving the aforementioned critiques of the three Use Type approaches and rethinking the *chaîne opératoire* approach newly situates it within contemporary archaeological theories of agency and cognition and furthermore provides the basis for its future expansion.

CHAPTER FOUR

THEORETICAL IMPLICATIONS AND LIMITATIONS IN THE PRACTICAL USE OF *CHAÎNE OPÉRATOIRE*

Introduction

Given the case studies outlined in Chapter Three, there are a number of ideas and questions to discuss which determine the trajectory of this project as a whole. First, what exactly is the scope and capacity of the *chaîne opératoire* approach to link the mechanical elements of production with the phenomenological aspects of making, and how do the Use Types support this capacity? Reviewing the elements of the *chaîne opératoire* approach offers a fresh perspective from which to view our Use Types. Second, given the significant scope of the *chaîne opératoire* approach, and our Use Types, is it possible to strengthen the practical applications of the *chaîne opératoire* approach? The Use Types outlined by our case studies bring to the forefront some limitations in the practical applications of the *chaîne opératoire* approach. I suspect these limitations are due to a disconnect between the practical use (Use Types) of the *chaîne opératoire* approach to uncover the mechanics of the making process, and the broader scope of the *chaîne opératoire* approach to connect these mechanical elements with the greater phenomenological meaning behind the making. Third, are there novel ways of rethinking the *chaîne opératoire* approach which can bring together the practical Use Types and the broader scope of the *chaîne opératoire* approach? Finally, a discussion of this disconnect results in novel possibilities for rethinking the *chaîne opératoire* approach which situate the framework within contemporary archaeological theories of agency and cognition.

Considering the scope of *chaîne opératoire*

Let us return briefly to the beginning, to the vision, the impetus, for designing the *chaîne opératoire* approach. The theory which later results in the *chaîne opératoire* approach stems from the postulations of Marcel Mauss, Leroi-Gourhan's professor and mentor, who believed that technical gestures are conscious and emerge from individual and collective practical reason. Furthermore, "even the most corporeal and biological aspects of humanity... arbitrary in their action [can be]

appropriated into the social domain and rendered efficient there" (Schlanger 1994b, 144). Mauss also acknowledged that technical gestures involve choices (of techniques, materials, and physical actions for example) which reveal their social and cultural contexts or *habitus* (following Durkheim's social facts). Technical gestures can in effect offer an intimate view of the ancient producer's logic, technique, ecology, and greater cultural phenomena such as the complex social, ecological, and cognitive elements involved in technological activity (Lemonnier 1992, 1; Schlanger 2005, 19).

Leroi-Gourhan used the term *chaîne opératoire* to describe "both gestures and tools, organized in a chain by a veritable syntax that simultaneously grants to the operational series their fixity and flexibility" (Leroi-Gourhan 1964a, 114). Physical actions and gestures are analyzed through traces of physical manipulation which can be seen on, and in, material remains via macroscopic and microscopic analysis. Additionally, actions and gestures can be analyzed through by-products of production (waste and discard) which can be observed within the archaeological record (Schlanger 2005, 19). As discussed in Chapter Two, the concepts of the *chaîne opératoire* approach have been adapted for archaeology due to the limitations of this particular field of research.

The *chaîne opératoire* approach, as adapted for archaeology, consist of three main concepts:

- Analysis of modes of action (intermeshing of tools and the motive gesture) through classification
- Process trends (socially informed choices visible over time)
- *Milieus*

Importantly, Leroi-Gourhan's intent was to uncover the *interrelationality of things*, not to analyze things themselves in isolation from one another. In order to do so, Leroi-Gourhan conceptualized a multidisciplinary approach with which to view his subject. For archaeologists, this includes the combination of an empirical processual approach including classification and modes of action with what we now call a post-processual, or even process archaeology, approach including process trends and *milieus*. Despite the fact that Leroi-Gourhan did not fully define and articulate the *chaîne opératoire* approach in his works, these major elements (modes of action and process trends) and two lenses with which to view them (classification and *milieus*) are sufficiently outlined and worth reconsidering. Leroi-Gourhan's work shifts the focus from the final artefact to the *process and context* of the artefact's making and being. To what extent do the Use Types engage with these

elements and their capacity to link the mechanical elements with the phenomenological aspects of production processes?

Use Type strengths: supporting the aim of *chaîne opératoire*

Through studies which take the *chaîne opératoire* approach to observe modes of action (technical actions or gestures which are fixed spatially and temporally), there is no mistaking the potential for the *chaîne opératoire* approach to outline measurable elements of a production process to a high degree of accuracy. Therefore, studies which isolate modes of action (Use Type One) do broadly support one of the major aims of the *chaîne opératoire* approach - to uncover gestures, tools, and technical choices involved in a production process. In Use Type One studies, as we recall, assemblages are typologically sorted by their macroscopic and microscopic features resulting in patterns which can be further broken down into possible "steps" taken within the production process.

For example, in Georgel-Debedde's study of Minoan larnakes, we uncover the probable actions, operations, and tools involved in the production process of larnakes (Georgel-Debedde 2022). These actions, operations, and tools include coil and/or slab building combined with pinching, pulling, and beating the surface to achieve the desired outcome. Additional pieces added to the larnakes such as legs and handles are made using additional hand-building methods uncovered through secondary and tertiary typological characterizations after the initial analysis of the body of each larnax. This Use Type One *chaîne opératoire* approach, which largely focusses on modes of action, results in a recipe for making. This recipe can be reproduced through experimental archaeology (reconstructions) and offer invaluable information. Such a recipe provides a description of the basic physical labor, skill, and mechanical knowledge associated with a production process.

The value of this Use Type One recipe-oriented approach is further highlighted by Jeffra's success in creating an experimental set of wheel-fashioned vessels based on the key elements of a production process as outlined by such recipes (Jeffra 2013). Experimental reconstructions can provide archaeologists with materials to study which are less precious – they can be broken apart or re-fired for example. Through trial and error, experimental archaeology can aid in understanding which tools and techniques create vessels similar to the prehistoric subjects of studies. While utilizing a Use Type One approach to modes of action provides valuable information, the resulting recipe illustrates only a fraction of the *chaîne opératoire* approach's capacity for insight into

production processes. While valuable, the results are limited to recipes for production, and this type of approach cannot accommodate the sociocultural aspects of production processes.

Use Type Two studies which incorporate process trends are predicated on a compilation and discussion of modes of action. These Use Type Two studies broadly support the significant scope of the *chaîne opératoire* approach which is to link gestures, tools, and techniques with their social and historical context to gain insight beyond the functionality of an object. In Choleva's study of pottery at Lerna, we see that the modes of action outlined (coil-building, wheel-fashioning, and wheel-throwing) can be linked to trade networks across the Aegean and including Western Anatolia (Choleva 2012). Starting with modes of action within a specific assemblage and later broadening the scope of the study to include modes of action across a wider region enables the shift from modes of action to process trends.

Through the Use Type Two *chaîne opératoire* approach which marries modes of action with process trends, a broader image of the social and historical context of a production process is outlined. For example, in the aforementioned study of pottery at Lerna, we learn that there may have been trade routes between Western Anatolia and the Aegean. Consequently, further studies may involve discussion of additional social and historical contextual elements related to these proposed trade routes. As such, this Use Type Two *chaîne opératoire* approach attempts to link gestures, tools, and techniques with their socio-historical context. This proves to be a valuable expansion of the recipe-results offered by Use Type One by elaborating on the broader socio-historical context of the production process such as ecology, trade, and dissemination of knowledge gained through viewing modes of action across a wider geographic and temporal landscape. However, I question whether this approach fully addresses the phenomenon of making and the meaning behind it. For example, without considering additional contextual elements, how can we know about a group's values or cosmological beliefs? While viewed through different scales, both Use Type One and Use Type Two focus mainly on modes of action which are discovered through typological classification. Use Type Three highlights the ambiguity and flexibility of the term *chaîne opératoire* and demonstrates a variety of interpretations of the approach; however as Use Type Three does not engage with the elements of the *chaîne opératoire* approach it will not be analyzed in the forthcoming chapters.

Use Type limitations: limited engagement with the *chaîne opératoire* approach

While the scope of the *chaîne opératoire* approach is broadly supported by the Use Types One and Two, there are some ways in which the Use Types are limited by their approaches. Leroi-Gourhan strived toward a framework which would be unbound by the Processual Archaeological and Structural Anthropological paradigms (Collins 2021). While the *chaîne opératoire* approach was not fully realized during his lifetime, the objective and capacity for the framework is outlined his many works: the *chaîne opératoire* approach serves to analyze both gestures and tools by way of their fixed and flexible characteristics with the aim of uncovering the interrelationality of gestures and things, thereby understanding the greater phenomenon of making and doing. The *chaîne opératoire* approach can also be understood within the context of its intellectual pedigree originated by Durkheim and developed by Mauss who proposes that technical gestures are conscious and emerge from individual and collective practical reason, and furthermore, technical gestures are socially and historically context dependent. Do the current practical Use Types, outlined in Chapter Three, fully realize the significant scope of the *chaîne opératoire* approach? Are there limitations to the ways in which the *chaîne opératoire* approach is engaged with that hinder the realization of its broader capacity? I suspect that while Use Types One and Two engage with some elements of the *chaîne opératoire* approach, there are theoretical hindrances that thwart even the best attempts at marrying modes of action and process trends with the phenomenon of production processes. In order to understand these limitations highlighted by the Use Types let us consider the ways we might rethink the *chaîne opératoire* approach. What are the theoretical implications of the Use Types One and Two which limit their *chaîne opératoire* approaches?

Prescriptive typology

Both Use Types One and Two operate on a foundation of typological categorization of physical traits of materials. Leroi-Gourhan proposed to classify objects based on physical traits in order to underline modes of action (the intermeshing of tools and the motive gesture). However, studies using the *chaîne opératoire* approach often focus on physical properties of materials without exploring modes of action and the resulting implications. For example, materials are typologically classified according to vessel size, shape, decoration, clay fabric, and firing methods in Use Type One case studies (Burke et al. 2021; Georgel-Debedde 2022; Choleva 2018). Similarly, in Use Type Two case studies, materials are typologically organized according to vessel size, formation methods,

and finishing techniques among other traits (Choleva 2012; 2018; 2020; Choleva et al. 2020). What we do not see are classifications of modes of action (intermeshing of tools and motive gestures). All case studies which fall under Use Type One or Use Type Two are predicated upon a system of typological classification of materials' physical traits alone. This typological system plucks materials from their context (material, social, historical) and rearranges them according to a system based on shared traits – regardless of their context upon excavation. If an assemblage of various ceramic vessels were uncovered together, and potentially used or discarded together, why should they be displaced into arbitrary sets based on differing physical traits? The theoretical background of the *chaîne opératoire* approach suggests that modes of action cannot be separated from each other nor separated from their social and historical context. If separated, the interrelationality of things is difficult to recover. Lemonnier states that when analyzed in isolation, technical gestures (or modes of action) can only surmount to a description of their informational dimension such as physical constraints, description of decoration, or morphological categorization (Lemonnier 1992). The issue of de-contextualizing materials via typological systems is not new; there is ongoing work to promote a contextual reading of materials in order to do away with such a prescriptive method (Hodder and Hutson 1986; Hodder 2011; 2016; Knappett 2022). Further discussion of these approaches to typology follow in Chapters Seven, Nine, and Ten.

So how did *chaîne opératoire* become so reliant upon typology? While Leroi-Gourhan did indeed promote a typological system based on modes of action as an initial step in the *chaîne opératoire* approach, it is clear that the typologies were meant to be considered in relation to each other and other systems. For example, modes of action are described as inextricably linked to the environment (physical, social, historical) in which they are produced (Leroi-Gourhan 1943, 27). Furthermore, while a study may begin with classification of modes of action, the description of objects or tools could include more than the dominant features (e.g., vessel size or clay fabric) and the modes of action (e.g., coil-building or wheel-fashioning). Including particular details such as the symbolic meaning of the object or tool wherever possible can add to the contextual description of the item (e.g., a vessel with an elongated spout may be used for ceremonial pouring of valuable liquid, or maybe the vessel has been buried with other valuable materials such as jewelry or weapons) (Leroi-Gourhan 1943). This symbolic meaning is of course part of the ontological context of the object and cannot be derived from a typology of physical features as in case studies which take the Use Type One *chaîne opératoire* approach to modes of action. While undoubtedly valuable in certain instances, the typological approach to uncovering modes of action as demonstrated by

the Use Type One and Use Type Two case studies cannot account for information beyond a description of their informational dimension. In short, Use Type One and Two may overly isolate objects and actions. As Lemonnier warned, this approach can only offer descriptions of an object or tool's physical constraints, description of decoration, or morphological categorization (Lemonnier 1992).

Anthropocentric ways of doing

Predicated on a typological system to uncover modes of action, taking the Use Type One or Use Type Two approaches, we inevitably arrive at "recipes" for production processes. The study of Minoan larnakes is one example wherein the study concludes with multiple variations of recipes for building Minoan larnakes whether they are coil or slab-built and which finishing techniques may be used to achieve the final appearance (Georgel-Debedde 2022). These objects or tools are classified according to a typological system of physical features and laid out in neat order. And while this information is useful in many ways, the modes of action are isolated from their contexts. This decontextualized recipe-oriented approach is one limitation to the Use Type One and Two *chaîne opératoire* approaches.

I propose that this limitation is due to an anthropocentric approach to ways of doing. These recipes for production processes outline a simple action-and-outcome sequence. An action is done *onto* or *toward* a material, which affects a physical change in the material. In the case of the Larnakes (Use Type One), Georgel-Debedde observes and classifies larnakes according to physical features such as the corrugations and varied thickness of the inner wall of a larnax, and upon this typological system prescribes an action-and-outcome sequence. Although the author has not created their own visual depiction, I have analyzed their description to create the action-and-outcome sequence seen in Figure 26.

Figure 26. Action-and-outcome sequence in a Use Type One approach depicting actions done onto or toward the material resulting in coil-built Larnax (after Georgel-Debedde Use Type One case study)

Similarly, in the case of Choleva's study at Lerna (Use Type Two) we see a typology of physical features, followed by further typology of morphological traits, giving way to an action-and-outcome sequence described by formation method, formation operation, and final outcome. In this case I have again created the following visual representation of the action-and-outcome sequence described in the study (Figure 27).

Figure 27. Action-and-outcome sequence in a Use Type Two approach depicting action done onto or toward material resulting in wheel-fashioned vessel removed with string tool (after Choleva Use Type Two case study)

While yes, this action-and-outcome sequence does describe some aspects of physical action impacting the appearance and form of a material, there is certainly more to it. Modes of action and process trends are inextricably related to their environment (physical, social, and historical). So, these recipes of modes of action have reduced actions to their most superficial traits which underline notable mechanical elements of a process (presence of coils or presence of string cutting technique). This action-and-outcome sequence not only isolates objects and actions from their context, but this also assumes that human beings are solely responsible for both action and outcome. What if we consider occurrences which are "neither altogether a cause nor altogether a consequence, neither completely a means nor completely an end" (Latour 1999, 153)? Can we consider occurrences which do not have definitive beginnings and endings, which have more than one active actor (human) and one passive recipient (object)? What happens when we consider that objects also have the capacity to affect change onto or toward other things or people?

By assuming production follows a seamless action-and-outcome recipe for making according to the results of a typological system, the issues of agency (the ability to have an impact) and cognition (boundaries of the mind and ways of thinking) arise. This recipe for making assumes that agency is a human property where there is no feedback or interplay between the maker and the

material. Many potters will anecdotally share that while they may have a conceptual idea of the final product, the process consists of working *with* and *through* the clay in the moment(s) of making (Malafouris and Koukouti 2020; 2022; Malafouris et al. 2023; Malafouris 2023). In other words, clay does not always bend precisely to the potter's will. Often a potter must act and adjust in the moment entangled *with* and *through* the clay in order to produce a result. The current archaeological applications of the *chaîne opératoire* approach, Use Types One and Two, require an anthropocentric way of doing which cannot accommodate the notion that objects may have the ability to impact other things or people (agency). Agency is the topic of Chapters Six and Seven and will be discussed in great detail and are developed to suit a *chaîne opératoire* approach.

At this junction we move from the topic of anthropocentric ways of doing, to discuss ways of thinking. In discussing ways of doing, we understand that the maker and the making may be affected by elements other than simple human action-and-outcome sequences. We arrived at the notion of agency which is perhaps more than a human trait, and which will be further discussed in Chapters Six and Seven. Another element which is unaccounted for is the ways of thinking implied by the Use Types of the *chaîne opératoire* approach. So, what are the ways of thinking which are implied within the *chaîne opératoire* Use Types?

Computational ways of thinking

In order to perform an anthropocentric way of doing, we must also have a supporting way of thinking. In other words, if people make things based on a recipe, people must mentally conceive of a recipe in the first place. This further implies that people think in this recipe-like manner. The mind must behave like a computer: the mind receives information, manipulates it internally, produces an outline or plan, and produces output of that information in the form of actions. In a sense, the maker creates an internal blueprint (way of thinking) which is a guideline for the physical recipe for making (way of doing).

In the *chaîne opératoire* Use Types, outlined in Chapter Three, we see this way of thinking implied quite clearly. As mentioned, if modes of action are accomplished by people doing action *onto* or *toward* materials, then the ways of thinking must support this. Continuing with the example of building a Minoan larnax, we see the recipe for doing is outlined clearly as follows: coils or slabs are formed using hand-shaping methods, then joined, and later the surface is beaten to achieve the final appearance (Georgel-Debedde 2022). If this recipe encompasses all of the physical actions

required for making the object, then it follows that the mind must work in a way which supports this. So, according to the aforementioned recipe, the mind must conceive of a blueprint which includes each element in the recipe as well as the final product. This blueprint may begin with an internal representation of the desired outcome, as well as the steps taken to achieve this outcome. Another way to envision this internal process is through computation: A (form coils) + B (join coils) + C (beat surface) = D (finished larnax). If human beings follow recipe-like doing, and blueprint-like thinking, the final outcome ought to be predictable and regular. We know through observational research, interviewing potters, and experimental studies that the results of pottery making are not always predictable and regular. But how can we account for this? If our ways of doing extend beyond anthropocentric action *onto* or *toward* materials as I have proposed, we then must ask if there is more to the mind than internal representations, blueprints, and computations.

To be sure, this blueprint thinking makes sense in the simplest terms. However, there are elements which affect our ways of thinking (and therefore ways of doing) which are not included in the aforementioned computation. This computation is taken out of the context of the thinker's world. If the *chaîne opératoire* approach has the capacity to better understand the phenomenological process of making of an object, then it follows that the thinker, their ways of thinking and doing, and their worldly context are all equally important. According to Material Engagement Theory (MET), the mind is not limited by the skull (Malafouris 2008; 2013; 2013; 2019; 2020; Malafouris and Renfrew 2010). Our ways of thinking extend beyond internal representations, blueprints, and recipes. Malafouris states that "we do not just think about things…we primarily think with and through things" (Malafouris 2023, 2). Malafouris further states, "…the starting point for studying the processes we label as 'cognitive' or 'mental' cannot be localised inside the head of the individual but needs to incorporate all relevant aspects of the material environment" (Malafouris 2023, 2). If our ways of doing are anthropocentric (confined to recipes), then our ways of thinking must also be anthropocentric (internal blueprints confined to the skull). Whereas, if our ways of doing extend beyond anthropocentric recipes, then our ways of thinking must also extend beyond anthropocentric blueprints. How can this "extended" way of thinking be incorporated into the *chaîne opératoire* approach? This is the basis of Chapters Eight and Nine wherein theories of cognition are introduced, analyzed, and consequently incorporated into the *chaîne opératoire* approach.

Ways of (re)thinking about *chaîne opératoire*

These anthropocentric ways of doing (recipes) and ways of thinking (blueprints) underpin the *chaîne opératoire* Use Types outlined in Chapter Three. Each case study is predicated on modes of action and in some cases thereafter expanded and analyzed for process trends. Both Use Type One and Use Type Two *chaîne opératoire* approaches are constructed upon these anthropocentric ways of doing (recipes) and ways of thinking (blueprints). There are subsequent limitations to the *chaîne opératoire* approach. As I have discussed, these ways of doing (recipes) and ways of thinking (blueprints) do not fully encompass the phenomenological process of making because they do not sufficiently represent ways of human *being*. This approach as seen in the Use Types One and Two isolates the making from the maker and their context. Furthermore, the Use Type One and Two approaches can produce results which cannot be explained by recipes for making and blueprints for thinking. For example, the "core" technique (the case of large goblet necks filled with clay) is noted but cannot be accounted for through this lens and as such the technique is cast aside as an anomaly (Figure 17) (Burke et al. 2021, 15). But is this really an anomaly, or is it characteristic of the ways of human *being* which cannot be described through recipes and blueprints? This is just one example of the limitations of the scope of inquiry set by the *chaîne opératoire* Use Types. There may be a way to learn more about these anomalies through rethinking the *chaîne opératoire* approach and its theoretical pillars.

I argue that there is a disconnect between the practical applications of the *chaîne opératoire* approach and the much broader scope of the framework itself. The *chaîne opératoire* approach offers the capacity to better understand the phenomenological process of making. However, the Use Types limit the scope of inquiry to the interpretation of recipes for making, and blueprints for thinking. There are those who have attempted to resolve similar disconnections through the proposals of new archaeological methodologies such as Material Engagement Theory (MET) (Malafouris 2008; 2013; 2013; 2019; 2020; Malafouris and Renfrew 2010) and Process-Archaeology (P-Arch) (Malafouris and Gosden 2015) in which phenomenological and relational approaches are taken to archaeological studies. These methodologies are invaluable, and the *chaîne opératoire* approach can surely benefit from incorporating phenomenological theories of ways of being, doing, and thinking in order to offer a new practical approach to the *chaîne opératoire* approach. Inspired by methodologies such as Material Engagement Theory and Process-Archaeology, I propose to rethink the *chaîne opératoire* approach. In the following chapters I define and explore the concepts of emergent, enactive, relational, and co-constructive agency in addition to embodied, extended, and enactive cognition. I

then propose to incorporate these theoretical concepts with the *chaîne opératoire* approach. This rethinking of the *chaîne opératoire* approach resolves the profound chasm between the practical use of the framework which seeks to uncover the discreet units of the process of making (the mechanics of making), with the much broader and significant scope of the *chaîne opératoire* approach which can also describe the relational, relativistic, in-flow, nature of human *being* and the phenomenon of making.

CHAPTER FIVE

AGENCY IN ARCHAEOLOGY

Introduction

As early as the 1970's, archaeologists' focus turned from the artefact as a passive marker of economic and social activity to the artefact in relation to its use in practice and its meaning (Hicks 2010). The reconciliation of the structural (artefact as a passive marker) and semiotic (artefact in relation to practice and meaning) approaches culminated in "material culture studies" which includes objects, artefacts, things, as well as structures. With this came an interest in the notion of agency (the ability to affect change) stemming from Marxism and Practice Theory which proposes that material culture is "active" and can act toward humans (Dobres and Robb 2000; Hicks 2010; Jones and Boivin 2010; Dobres 2014). Through this approach, material culture is understood to be more than a passive symbol or a signifier of social activity. While material culture is made of and made by social relations, it is also actively shapes who we are and how we engage with the world around us. This research has resulted in the development of concepts such as "materiality" and "material agency" which reflect an interest in the physical nature of things, their affordances, and their ability to have an impact (Jones and Boivin 2010).

With its expertise in studies of human history via material culture, archaeology holds unique potential for rethinking what an object is and does, and how objects shape, confine, change, direct, and reflect humanity. If archaeologists were to neglect objects' impact on people, we might overlook an important aspect of what it is to be human. Studies of agency, particularly material agency, can shed light on the role that objects play in human life and reshape our understanding of the effect objects have on humans, and humans on objects. The application of material agency in archaeology can lead to a more vibrant, complete, understanding of how objects have shaped humanity's past, present, and future. Material agency is a "fundamental concept that allows us to focus upon the way in which people and things are mutually related" (Jones and Boivin 2010, 351). That being said, the debate surrounding material agency is long, historied, and challenging. What I present here is a brief survey of the research landscape highlighting important themes presented by key figures in the literature regarding material agency. I further highlight major themes in the development of theories

of material agency including: the indexical approach, primary and secondary agents, person-like agency, network theory, objects' lives, entanglement, and relationality. Considering each theme's nuances and strengths, a case for material agency emerges. This in turn supports the following discussion in Chapter Six regarding how we might incorporate theories of agency with the *chaîne opératoire* approach.

Scholars have time and again renamed the subjects of material agency including: "material culture" (Miller 1991), "indexes" (Gell 1998), "objects" (Gosden 2005; Latour 2005; Knappett 2011b), "things" (Miller 1997; Olsen 2010; Bennett 2010; Hodder 2011), "non-humans" (Sørensen 2018), "agents" (Latour 1999), and "actants/actors" (Latour 1996). This is in part an effort to mitigate confusion or bias related to the particular vocabulary surrounding the idea that non-humans may have agency. It seems that no matter the terminology, there are some who will always become entrenched in the semantics of material agency theories (see for example the years-long debate which became increasingly centered on semantics and the meaning of the term agency, rather than remaining centered on theory (Lindstrom 2015; Ribeiro 2016; Lindstrom 2017; Sørensen 2018; Ribeiro 2019). I'll begin this chapter with a quote by Sørenson (2018) to provide a platform from which to start: "…the point for me is not the word 'agency' itself, but what it has been used to describe…What I hold to be a beneficial framework for understanding agency *for archaeology* is to pay attention to the complicity of objects, materials, artefacts, non-humans, or whatever we call them, in the shaping of societies" (Sørensen 2018, 97–98). Many of the forthcoming texts are entrenched in semantic and philosophical debates of agency and ontology. This point made by Sørenson is important to recall as we move forward through the dense history of definitions, debates, arguments, and defenses surrounding the topic of material agency. As archaeologists, we observe and analyze the past through material culture, through objects and remains, and as such we must consider what role these things played in shaping human lives, society, and their landscapes. My aim is to uncover the role of material culture and material agency so that we may properly frame archaeological excavations, archives, and analyses. Moving forward, I would like to note that I will be using the terms "objects", "things", and "material culture" interchangeably and fluidly as they pertain to archaeology in this discussion. In reference to specific scholars' works, I will use their preferred terminology where appropriate.

The indexical approach

In opposition to a "purely cultural, aesthetic, 'appreciative' approach to art objects", Alfred Gell (1998) proposes a theory in which "*persons* or 'social agents' are, in certain contexts, substituted for by *art objects*" (Gell 1998, 5). Gell's work on agency within art and anthropology forms the basis for many scholars' studies of material agency – including archaeological studies. Gell explores art objects as they "merge with people by virtue of the existence of social relations between persons and things, and persons and persons *via* things" (Gell 1998, 12). Instead of viewing art through interpretive symbolism, representationalism, or semiotics, Gell instead places emphasis on agency, intention, causation, result, and transformation; insisting that art is a system of action "intended to change the world rather than encode symbolic propositions about it" (Gell 1998, 6).

Gell attempts to simplify his discussion (a rather lofty ambition) by reframing "art objects" as "indexes". He defines an index as a real, physical, visible, thing. In doing so, he excludes art forms like music and performance art for the sake of his argument. Citing Piercean semiotics, Gell states that an index is a sign through which an observer can make a causal inference (Gell 1998, 13). He offers an example which goes as follows: fire causes smoke; so, smoke is an index of fire. Smoke does not look like fire, doesn't resemble fire, but it is caused by fire (in many cases) and so it is usually associated with fire. As such, "... the sign (smoke) may be described as an 'index' of the referent (fire)" (Knappett 2002, 102). By reframing art objects as indexes, Gell endeavors to remove our preconceptions about art and art-like things in the discussion of agency. However, Gell's discussion remains centered around topics like style, aesthetic, the artist, etc. and so it is unclear how impactful the term index is in mitigating such preconceptions about art and art-like things. For Gell art objects can be seen as indexes for social agency because art objects are "caused" by their makers, just as smoke is caused by fire (Gell 1998).

An art object can be seen as capable of two abductions of agency according to Gell. Abduction is the term utilized to describe the mode of inference or "cognitive operation" which occurs when we define indexes such as smoke as an index of fire (Gell 1998, 14). Simply put, the identification of an index is not arrived at via deduction, induction, nor is it inferred, so it must necessarily be some other process, which Gell calls "abduction" after Eco (Eco 1976). The term is useful in that it separates the index-abduction relationship from linguistic semiotics so that we might not be tempted to apply linguistic models of inferences. Gell underlines the fact that within art we generally tend to, or have to, formulate notions about the "disposition and intentions of 'social others' via a large number of abductions from indexes which are neither 'semiotic conventions' or

‘laws of nature’ but something in between” (Gell 1998, 15). The term ‘abduction’ can account for these ‘in between’ notions and constructed relations made between two entities.

Returning to the two abductions of agency by art objects, Gell states that the index is itself “seen as the outcome, and/or the instrument of, social agency” (Gell 1998, 15). The first abduction of agency is a result of the art object indexing its maker or origin. The art object (as Gell describes them) does not simply come into existence, it is made by an artist. As such, the art object first indexes its maker, it is entwined in a social relationship with the artist and in this way art objects are in social relationships with their makers. The second abduction of agency is when an art object indexes its “destination” or its intended reception (Gell 1998, 24). Gell supposes that art objects are not made for no reason at all – they are made to be seen by the public or by a patron. Gell then determines that art objects are also in social relationships with their audience.

Primary and secondary agents

Gell offers to distinguish between primary and secondary agents. Primary agents are generally “intentional beings who are categorically distinguished from ‘mere’ things or artefacts…” (Gell 1998, 20). By his definition, secondary agents are then “… artefacts, dolls, cars, works of art, etc. through which primary agents distribute their agency in the causal *milieu*, and thus render their agency effective” (Gell 1998, 20). So, while Gell does offer up the notion of material agency, in the end he effectively demotes material culture to secondary agents through which human agency is distributed. He, however, does not see this as a demotion. Gell, as many will do, describes a scene involving violence to further his point. Discussion of agency often lends itself to contexts of violence because many wonder: If objects have agency, are we (humans) not responsible for the death and damage weapons cause? We will see these questions arise throughout this chapter, and as they are helpful thought experiments, we explore them where appropriate. While these thought experiments are engaging, they can trigger questions of morality, judgement, or justice; these themes will not be examined for the purpose of this chapter.

Gell’s answer to the question of material agency comes in the form of distributed personhood. In Gell’s scenario, anti-personnel mines are planted by Pol Pot’s soldiers in Cambodia and when they explode, we should not blame the mines because they are “… ‘instruments’ or ‘tools’ of destruction, not ‘agents of destruction’” (Gell 1998, 20). Gell reminds us that mines are built in a way that they cannot help exploding once they are triggered by footsteps, but the soldiers who

planted them *could* have acted differently. The soldier's weapons are "...*parts* of him which make him what he is" (Gell 1998, 20). As such, the soldier is capable of being in multiple places at once: not just where their bodies presently are, but where they *were* in different places and time. "Those mines were components of their identities as human persons, just as much as their fingerprints or the litanies of hate and fear which inspired their actions" (Gell 1998, 21). In addition, the mines are "objective embodiments of the *power or capacity to will their use*" and are therefore a component of the social identity and agency of the "soldier + mine" (Gell 1998, 21). In this scenario the soldier is the primary agent, and the mine is the secondary agent. Agency is originated and manifested through a causal *milieu* consisting of artefacts and humans. In Gell's own words, "The concept of agency I employ is relational and context-dependent, not classificatory and context free" (Gell 1998, 22). This is the basis for Gell's theory of distributed personhood.

Person-like agency

A point which has received many a contentious retort is that Gell treats objects as person-like. Gell positions material objects in the network of social relations normally applicable only to people. He describes "art-like situations" as situations in which a material index can permit a cognitive function which Gell calls "the abduction of agency" (Gell 1998, 13). The abduction of agency implies that objects themselves cannot have agency, instead they must borrow (abduct by indexing) agency from human agents. Advocates of material agency have argued that this type of anthropocentric view of agency cannot explain or fully encompass the active role of objects (Knappett and Malafouris 2008). By formulating material agency around person-like qualities, Gell encounters the same problem many continue to encounter – questions of intention and will. Arguments involving violence inevitably emerge from this discussion of intention and will; in this world of person-like agency, primary agency cannot be assigned to objects. If an object has primary, person-like agency, did that object *want* or *intend* to harm someone? Of course, if one's philosophy of life cannot reconcile an object having intention, the resolution must then be something along the lines of Gell's distributed personhood with primary and secondary agents. In this case objects can have agency distributed through them, or by abducting agency by indexing a human agent, relieving us of the notion that objects might have will or intention. Now, by this logic, objects can act only as the media of human social agency. So long as material agency is approached from an anthropocentric point of view and

consequently entangled with concepts of intention and morality the common conclusion is that objects can only play the role of a secondary agent.

Actor Network Theory

Latour states humorously, yet earnestly, "Much like sex during the Victorian period, objects are nowhere to be said and everywhere to be felt… they live on the margins of the social doing most of the work but never allowed to be represented as such" (Latour 2005, 73). Latour argues that objects are social in that they are "*collected* or *associated* together" and any social enquiry would be incomplete if objects were dismissed from the overall context (Latour 2005, 78). In contrast to Gell's theory which treats objects and humans as separate and unique, Latour begins his studies of objects from the position that both humans and objects should be viewed as propositions or things with functions (Latour 1999). In an effort to appease the general discomfort with naming an object as an agent, Latour calls objects, or non-human agents, "actants". This also encourages the reader to discard the subject-object dichotomy for an actor-actant symmetry which also allows for the discussion of collectives as actors or actants (Latour 1999, 180).

Again, as with Gell, his discussion arrives at a question of violence: do guns kill people or do people (with guns) kill people? In his words, "If we study the gun and the citizen as propositions…we realize that neither subject nor object (nor their goals) is fixed" and that when "…the propositions are articulated, they join into a new proposition" (Latour 1999, 180). In this sense, two agents (human and non-human) become someone or something else entirely, they become a third agent; in this case the human + gun become a "gunman". Latour settles the gun argument by concluding it is neither guns nor people that kill; the "responsibility for action must be shared among the various actants" (Latour 1999, 180). In other words, the person is modified by the gun or vice versa. Circumventing both the sociological (people kill people) and materialist (guns kill people) accounts of agency, this view redistributes actions and agency symmetrically. This is Latour's exploration of mediation of interference, the first of four meanings of technical mediation.

In Latour's words, mediation is "an occurrence that is neither altogether a cause nor altogether a consequence, neither completely a means nor completely an end" (Latour 1999, 153). In other words, mediation is term to describe an emergent *becoming* between one or more agents situated within a spatiotemporal environment. The case of the gunman is an example of Latour's first mediation: mediation of interference or "goal translation". Here agent 1 (person) falls back on agent

2 (gun), therefore agent 3 (gunman) emerges and *becomes* from the entanglement of the other two. Through this entanglement of agents, there is a drift or "the creation of a link that did not exist before and that to some degree modifies the original two" agents (Latour 1999, 179). The second is composition, wherein Latour explores the notion of a composition or association of actants and forces necessary to account for an action (Latour 1999, 182). He states that "provisional 'actorial' roles may be attributed to actants because actants are in the process of exchanging competences, offering one another new possibilities, new goals, new functions" (Latour 1999, 182). As such, agency must be distributed across all agents and actors involved in a composite goal. The achievement of that goal is attributed to all agents by way of successive "translation" (as defined above) where each actor draws on another in order to reach the goal. Third, Latour explores the mediation of "the folding of time and space" (Latour 1999, 183). In a broad sense, Latour observes the fact that in one moment, it is possible to trace an infinite line in time and throughout space to account for the many actions and actants involved in the process of arriving at that single point in time and space.

The fourth meaning of mediation is the crossing between signs and things. Latour describes the way in which techniques have meaning and also produce meaning therefore blurring the "commonsense boundary between signs and things" (Latour 1999, 186). Latour describes a speedbump: there is an initial shift in agency as an engineers' desire to slow down a moving vehicle is now delegated to the concrete bump itself, the shift is also spatial in that a new actant (the speedbump) is introduced on the road which slows cars, and finally there is a temporal shift as the speedbump remains in place day and night (Latour 1999, 188). According to Gell's distributed personhood, we would stop here with a primary agent (the engineer), and a secondary agent (the speedbump). However, according to Latour, what we ought to consider is an absent engineer, a constantly present speedbump, and a driver who becomes the user of the speedbump. In this scenario, the object "stands in for an actor and creates an asymmetry between absent makers and occasional users" (Latour 1999, 189). Latour concludes that the speedbump is not made only of concrete, it is "full of engineers and chancellors and lawmakers, commingling their wills and their storylines with those of gravel, concrete, paint, and standard calculations" he goes on to say that "the mediation, the technical translation, that I am trying to understand resides in the blind spot in which society and matter exchange properties" (Latour 1999, 190). This discussion of mediations may seem rather technical however the terms are useful in exploring agency within the *chaîne opératoire* approach and so deserve to be mentioned.

This search for the "blind spot in which society and matter exchange properties" led Latour to formally propose his Actor Network Theory (ANT) (Latour 1999, 190). ANT claims that humans and objects interact and co-act intimately and symbiotically, meaning that to create dividing lines within large networks of actors and actants is practically useless. The term "network" here does not imply a technical or social network, it is meant "to describe matter and bodies" in a way that avoids the Cartesian divide between humans and non-humans (Latour 1996, 370). Additionally, instead of thinking of things in terms of dimensions (whether two or three), ANT invites the reader to observe "in terms of nodes that have *as many dimensions* as they have connections" (Latour 1996, 370). "A network is not a thing, but the recorded movement of a thing" (Latour 1996, 378). While ANT aids in solving the problem of material agency by rethinking actors, actants, and their interconnectivity, he admits there this is still much work to be done.

> "ANT is a powerful tool to destroy spheres and domains, to regain the sense of heterogeneity, and to bring interobjectivity back into the centre of our attention (Latour 1994). Yet it is an extremely bad tool for differentiating associations. It gives a black and white picture, not a coloured and contrasted one. Thus, it is necessary, after having traced the actor-networks, to specify the types of trajectories that are obtained by highly different mediations. This is a different task, and one that will make ANT scholars busy for a number of years to come" (Latour, 1996, 380).

Using ANT as a logical basis for actor/actant network connections, Latour then returns to the initial problem of material agency and the notion of human-like agency and intention. Latour argues that if action is limited to what "intentional", "meaningful" humans do, then of course it is impossible to see how an object can have agency (Latour 2005, 71). These objects which lack intention within an anthropomorphic mindset can only exist in the realm of material causation, much like Gell's distributed personhood. However, if we can agree that anything that modifies "a state of affairs by making a difference is an actor… or an actant" via a network connection, then any object, entity, or being can have agency (Latour 2005, 71). The question which can be applied to discover whether or not someone or something has agency then is: "Does it make a difference in the course of some other agent's action or not? Is there some trial that allows someone to detect this difference?" (Latour 2005, 71). This is yet another way of asking the observer to trace the network, in other words the recorded movement of a thing. Latour is careful to note that although an object may make a

difference in a state of affairs, these objects do not necessarily determine the action, but they do signify the "many metaphysical shades between full causality and sheer inexistence" (Latour 2005, 72). More broadly speaking, network theories have been engaged to introduce connections between emergent, enactive, and relational agency (more on this in the following sections) and practical methodologies (Knappett 2008; 2011b; Knappett and Mol 2023). Network theories provide a strong basis for incorporating the notion of agency with the *chaîne opératoire* approach, which is explored in Chapter Six.

Objects' lives

Both Gell and Latour grapple with the problem of duality in agency (human versus non-human; actors and actants). For Gell, the anthropocentric view of distributed personhood attempts to place objects on the same plane as human agents, yet in the end his proposal of primary and secondary agents confirms this division or duality. On the other hand, Latour does away with the anthropocentric view, but the overall effect is a sort of dehumanization of both people and objects as they become connections or nodes. In this way, the problem of duality and anthropocentric agency is addressed. However, this has a sterilizing effect upon the liveliness, the vitality, of the interactions in everyday life which manifest change. Carl Knappett calls for investigation of the "potentially diverse *processes* whereby 'inanimate' objects come to be socially alive" (Knappett 2002, 97). Research has arrived at a new perspective; Knappett (2002) questions why it is necessary to distinguish between objects and agents at all.

This new perspective supposes that mind, body, and world can be seen as codependent, entangled, intertwined and that objects can rarely be understood without some sort of relation to the body or to its "underlying idea" (Knappett 2002, 98). What this means is that the mind is both extended and embodied. Latour's "sleeping policeman" (speedbump) is a key example which can be revisited and be further explained via this embodied and entangled material agency. Latour discusses the way in which the speedbump is not only a concrete bump in the road but is made up of engineers, city planners, drivers, and law enforcement and as such has agency by way of distributed personhood. Knappett takes this a step further: yes, agency has been distributed to the concrete bump, but it only then enacts agency when in contact with a driver who drives over the speedbump and is therefore engaged. Distributed personhood isn't necessarily incorrect, but it only answers one side of the equation: who did agency come from (engineer) and where did it go

(speedbump)? ANT answers the question: where is agency? For ANT, agency in this scenario lies at the connection between the engineer, the physical speedbump, and the user of the speedbump. The embodied and extended perspective asks not only where is agency, but *when* is agency? Through the embodied and extended perspective all parties involved (the city planners, law enforcement, engineers, the concrete, the driver, and the car) are all acting together, entangled and codependent in manifesting agency in the moment the driver makes contact with the speedbump. The behavior and the artefact are codependent and co-constitutional. In short, we see that agency is not only distributed but "inheres in the relationships between the various entities that constitute a field of action", and that agency comes about through associations and relationships rather than within each entity in and of itself (Knappett 2002, 100).

Knappett further develops a network theory approach similar to that of Latour's ANT in discussing how objects become socially alive. This development of network theory builds upon ANT from the object perspective (Knappett 2011a; 2011b). Knappett discusses artefacts as they are created by artisans in a manner similar to Gell's work on art and agency and utilizes the same lexicon of icons, indexes, and symbols. First, an artefact is imbued with agency by the artisan(s) who creates it, in the sense that the artefact becomes an index of "the artisan's productive investment and cultural sensibility", and that while objects on the surface may appear ontologically different, "... they nonetheless all involve a convergence of icon and index in the assemblage of agency and meaning" (Knappett 2002, 101,114). Building upon this indexical relationship first proposed by Gell (1998), Knappett then focuses on the life of the artefact. As the artefact lives through consumption (use, reuse, discard, repair, and so on), the artefact forms new connections with humans and non-humans, individuals, and groups. This life of the artefact becomes entangled in multiple networks which overlap due to the common feature, the artefact. In keeping with focus on the artefact, Knappett then concludes that the artefact as such has "no singular agency..., but dual or even multiple agency" (Knappett 2002, 101).

If as research suggests, objects do have agency, then what effect do they have on our lives? Adopting on an object-centered view of agency can help to develop this theory of material agency. Gosden (2005) states: "Ultimately, emphasizing the manner in which things create people is part of a rhetorical strategy to rebalance the relationship between people and things, so that artifacts are not always seen as passive and people as active" (Gosden 2005, 194). Can things behave in ways that are not derived solely through human intention? Gell (1998) posited that artefacts form a world

of their own somewhat independent of human interactions, and that there are some cases where new forms of abstract thought and mental representation can be affected by or suggested by objects. In many cases, such as Gell's work, artwork then becomes central to this question. Without realizing the depth of the question, we often ask, "what does this painting do?", or "how does this sculpture affect the space of the gallery?". Questions like this are exemplary of the ways in which we attach the capacity for power to objects, though it does not imply intention or will. A deeper philosophical debate may be able to answer why we balk at the idea of weapons having agency (without intention) yet accept quite easily that a painting may have agency (without intention).

Utilitarian objects, things that channel human action, such as a teapot can also help to illuminate this argument. Looking at teapots within the realm of teapots, rather than within a social context such as Hodder's textual reading of artefacts, can help to resituate this exploration. One teapot amongst a group of teapots may offer certain sensory experiences that the others do not, and may place obligations onto the user "in the ways we relate to objects and other people through these objects…Patterns of exchange or consumption derive partly from the nature of the objects themselves" (Gosden 2005, 196). Because material culture is so long-lasting, generations of people are born into worlds already occupied by objects. These objects inform us, shape us, and educate us from birth. As Gosden states so eloquently, "People crystallize out in the interstices between objects, taking up space allowed them by the object world, with our senses and emotions educated by the object world" (Gosden 2005, 197). With this object-centered perspective there is a massive shift in the theory of material agency. It becomes rather clear that from this perspective, previous issues of intention and will are removed and what we are left with is an entirely different set of questions: How can we define agency if not as a human quality? What has agency, but more importantly, *when* does agency occur? What do objects want and how do they communicate it?

Entanglement and relationality

Hodder offers a unique approach to material agency as an attempt to marry the views of Latour and Gell (Gell 1998; Latour 1996; 2005) with the materialist approach (Knappett 2002; Knappett and Malafouris 2008), an ecological approach (Ingold 2007; 2012; Knappett 2022), and his own linguistic approach. Through a linguistic approach material culture is observed within its context, or the "totality of the relevant environment", and is therefore read within its context as a "text" (Hodder 1992, 14; Hodder and Hutson 1986, 188). While this is not the first time linguistics have affected

archaeology (Leroi-Gourhan 1943; 1945; 1964a), Hodder positions material culture as an *active* element within social realities (Hodder 1982; Hodder and Hutson 1986; Hodder 1992)**.** From the marrying of these concepts, Hodder introduces *entanglement*. The aim of this theory is to address and underline the importance of the double-bind we find ourselves in when discussing material agency: humans depend on made things and made things depend on humans. A common theme throughout material agency literature up until this point is that the objects themselves are rarely described in detail, even within the materialist approach.

Archaeologist Ian Hodder works to rectify this in his research at Çatalhöyük, highlighting the ways in which clay is linked to the people's social and personal identity, cognitive development, housing, economy, and more, through their society's entanglement with clay. He argues that "things cannot exist for humans, in the way that humans want, without human intervention" (Hodder 2011, 162). Things are consistently changing and so they entrap humans in a cycle of repair, adjustment, revival, and so on so that these things can continue to exist as we need them to. Made things cannot reproduce themselves, so we are eternally entangled in a cycle of dependency on them and them on us. Things also depend on other things. Made things, require other things for their aforementioned repairs, adjustments, and reuse, things which leave marks indicating not only thing-thing entanglement but thing-thing-human entanglement (i.e., a pot (thing) which is repaired with a wet cloth (thing) which is handled by a person (human)). In the end, Hodder agrees with Latour and Gell that things can in some contexts can have secondary agency however, he confirms that things can "in their objectness" have primary agency in that "they act in the world as a result of processes of material interaction, transformation, and decay" (Hodder 2012, 216).

While Hodder's entanglement does offer a temporal element within agency, it is not fully developed. Within entanglement, as made things change and decay at unpredictable rates, there are unpredictable changes in the overall systems of entanglement. What if there is more to be unpacked relating to temporality and agency? After decades of debate surrounding material agency and the duality of human versus non-human qualities of agency, Malafouris proposes that the quality of agency itself is not a property at all but instead the emergent product of mediated activity (Malafouris 2008). Citing Latour's definition of an agent as an element which can bend space around itself and can make other elements dependent on itself, Malafouris proposes that both humans and things can achieve this status in the process of *material engagement* (Malafouris 2008, 34).

> Similarly, Ingold writes, "…things are active not because they are imbued with agency but because of the ways in which they are caught up in the lifeworld. The properties of materials, then, are not fixed attributes of matter but are processual and relational. To describe these properties means telling their stories" (Ingold 2007, 1).

We can agree that agency is not a fixed quality of any human or thing, but it is a property which at any given moment can *become realized* (it is emergent, enactive, and relational). Here there is a temporal element which is emphasized in that agency *occurs* and *becomes* at the intersection of brains, bodies, and things where they are engaged and active (Malafouris 2008, 34–35). Unlike Gell's distributed personhood there is no primary or secondary agent, and unlike ANT agency is not distinguishable as a node in a network, agency is "the flow of the activity itself", it is perpetually in a state of becoming (Malafouris 2008, 35). This view is similar to Barad's view of the intra-activity of becoming; materials materialize by participating into being (Barad 2007). In other words as Barad puts it, "we meet the universe halfway" (Barad 2007). In this view, materiality is not a quality but a product of *becoming* - similar to that of Malafouris' material agency.

Concluding remarks

So, what is agency? Who has agency? Where is agency? And when is agency? As Gell stated, "we cannot tell that someone is an agent before they act as an agent, before they disturb the causal *milieu* in such a way as can only be attributed to their agency" (Gell 1998, 20). This quote demonstrates quite clearly that all things (human and non-human) can be agents. And what's equally true is: all things (human and non-human) can also not be agents. Agency is not an attributable quality but an emergent property; it is co-constitutional, enactive, relational, and therefore becomes realized through engagement (Malafouris 2008, 34). Many of the problems outlined here about material agency are due to the historically accepted anthropocentric view of agency. This anthropocentric view of agency is inherently tied up in the qualities of intention and will which give rise to debates of morality and responsibility for actions. However, for those willing to "disentangle agency and intentionality" there are many intriguing and curious theories of material agency to be considered (Sørensen 2018, 96).

Of course, things and people are ontologically different. Things and people exhibit and experience differing modes of *being*. This does not mean that things and people cannot also be so

entangled that, through active engagement, those things and people create and realize agency between and through each other. This view of emergent, enactive, and relational agency is incredibly useful as we attempt to analyze the past with as much truth as possible; through material agency we aim not to subject anyone or any*thing* to the status of a stationary inactive role in history where there was once vitality. Remaining careful not to fetishize the artefact itself, we can consider the material and its agency in relation to the nature of *becoming* and *being*. Together things and humans co-construct each other through emergent, enactive, and relational entanglement.

CHAPTER SIX

A NETWORK-INFORMED *CHAÎNE OPÉRATOIRE:* CONSIDERING AN ACTOR NETWORK THEORY PERSPECTIVE OF THE *CHAÎNE OPÉRATOIRE* APPROACH

Introduction

In an effort to address emergent relational views of agency (the ability to affect change) within the *chaîne opératoire* approach, I propose a network-informed *chaîne opératoire* approach. Through review of theories of agency, the significant scope of the *chaîne opératoire* approach, and drawing on the practical case studies discussed in Chapter Three we consider how theories of agency can be integrated with the *chaîne opératoire* approach. I define the term "*chaînes*" for our purposes here and proceed to consider them as networks. Having established how *chaînes* can indeed be considered as networks, we explore networks of *chaînes* via Latour's mediations to realize emergent relational agency. Upon review of two recent applications of ANT to archaeological contexts, and additional applications of network theories more broadly, key points are illustrated in the practical application of ANT. Limitations and considerations of ANT approaches are outlined which lead to an approach which incorporates many theories such as Actor-Network Theory (ANT), network theory more broadly, typology, objects' lives, contextual reading of objects, entanglement, and relationality. Using examples of Bronze Age Aegean pottery from our case studies, I emphasize the ways in which a network-informed *chaîne opératoire* can benefit similar studies. With substantial evidence supporting its theoretical utility, I define a network-informed *chaîne opératoire* approach which offers an avenue toward incorporating and addressing emergent relational agency.

Agency in *chaîne opératoire*

In the early development of *chaîne opératoire* the term agency is not mentioned explicitly. However, in his third major work *Gesture and Speech* Leroi-Gourhan develops a view that gesture and tool are conflated - gesture and tool form a single whole - which signifies a shift toward non-anthropocentric agency. The topic is alluded to with regard to technics but not developed as an independent theory of agency, as in the case of the hand as an agent in Leroi-Gourhan's exploration of the use of tools

(Leroi-Gourhan 1964a, 237, 242). Additionally we see phrasing which can be interpreted as allusions to emergent and relational agency for example within Leroi-Gourhan's modes of action which are defined as the "intermeshing of tools and the motive gesture", and also that "the real significance of tools is in the gesture, which makes them technically effective" (Leroi-Gourhan 1964a, 237, 242). At the very least, this suggests support for what would later be developed into theories of entanglement (Hodder 2011; 2012; 2016) or material engagement (Malafouris 2013). He also states that "technique is both motion and tool" which again represents a shift away from anthropocentric agency in that motion (human action) potentially holds equal importance as the tool (object action or affordance) (Leroi-Gourhan 1964b, 323).

We clearly see an effort to develop a framework which can account for the entanglement of actions and objects. This proposal that gesture makes tools effective, the conflation of action and object to perform or affect change, reminds us of the later developed themes of co-constructive, entangled, emergent, relational agency. It is important to note that Leroi-Gourhan does not mention the term "agency" but proposes novel ideas regarding *ways of doing* as discussed in Chapter Five. However, as we have seen in the case studies analyzed in Chapter Three, these notions of the conflation of action and objects have not been fully integrated into the existing practical applications of the *chaîne opératoire* approach. Therefore, many applications of the *chaîne opératoire* approach operate under the lens of anthropocentric agency.

Agency in Use Types

Reviewing our Bronze Age Aegean case studies and the *chaîne opératoire* Use Types therein, a clear pattern of anthropocentric agency is established. Use Type One engages with the *chaîne opératoire* approach to uncover modes of action in isolation from their sociocultural context based on typological classifications which focus mainly on physical features of assemblages (shape, size, and clay fabrics for example). These physical features are examined for evidence of people doing actions *onto* or *toward* objects. Use Type One can be considered as a method for recreating the stages of a production process outlining a pattern of actions *onto* or *toward* passive materials. Use Type One case studies portray the process of making as recipes or action-and-outcome sequences. In the figure below (Figure 28) I have visually demonstrated the action-and-outcome sequence in making a Minoan larnax as detailed by Georgel-Debedde (2022).

Figure 28. Action-and-outcome sequence resulting in coil-built Larnax (after Georgel-Debedde Use Type One case study)

Use Type Two builds on this method by observing the relationship of modes of action across a broader geographic and temporal landscape leading to the identification of process trends. As outlined in Chapter Three, the Use Type Two approach most closely resembles Leroi-Gourhan and Lemonnier's proposal for *chaîne opératoire* by taking a wider lens with which to view modes of action over time and across regions. However, as an expansion of the Use Type One approach, production processes are established as an accumulation of modes of action (human actions *onto* or *toward* passive materials). I draw your attention again to the example of an action-and-outcome sequence determined by a Use Type Two case study of Bronze Age wheel-fashioned pottery (Figure 29) (Choleva 2012). We see the hands grasping a string tool and pulling it from one side of the wheel to the other, toward the potter, between the clay and the wheel head in order to separate the clay from the pottery wheel. Choleva discusses the markings left on the base of the vessel and describes this action-and-outcome sequence.

Figure 29. Action-and-outcome sequence resulting in wheel-fashioned vessel removed with string tool (after Choleva Use Type Two case study)

It is clear that by employing these *chaîne opératoire* Use Types, we inevitably arrive at simplified action-and-outcome production sequences resulting in recipes executed solely through anthropocentric agency onto materials. However, as has been laid out in Chapter Five, agency is not

necessarily a human quality. First, there is the notion of material agency. Material agency defines materials and objects as having the capacity for agency. In the case of pottery, many studies have proven that when asked about how a potter makes a vessel, they often cannot fully verbalize an answer and would rather "show how" than "say how" (Malafouris 2008, 19). Similarly, potters will often describe how clay does not conform even to the most well-laid plans (Malafouris and Koukouti 2018; 2020; 2022; Malafouris et al. 2023). Through practice the potter has accumulated a type of tacit knowledge which can only be demonstrated through engaging with the clay. In other words, the potter must continually realize their knowledge and skill in real time through active engagement with the material (Malafouris 2008). This is because, as I have argued, there is no anthropocentric way of doing. There is no replicable action-and-outcome sequence or recipe which can be enacted by the potter *onto* or *toward* the clay to achieve a desired result. The potter and the clay are symmetrically engaged in the potting process (also including the wheel and any additional tools or materials used). These elements are engaged spatially and temporally in real time where each element has an impact on the other. The quality of agency emerges and unfolds *through* and *with* material engagement (Malafouris 2008). Consequently, agency is an emergent property; it is co-constitutional, enactive, relational, and therefore becomes realized through engagement (Malafouris 2008, 34). This notion is illustrated in Figure 30 which attempts to capture the enactive, emergent, relational property of agency wherein each element is symmetrically engaged in the phenomenon of making.

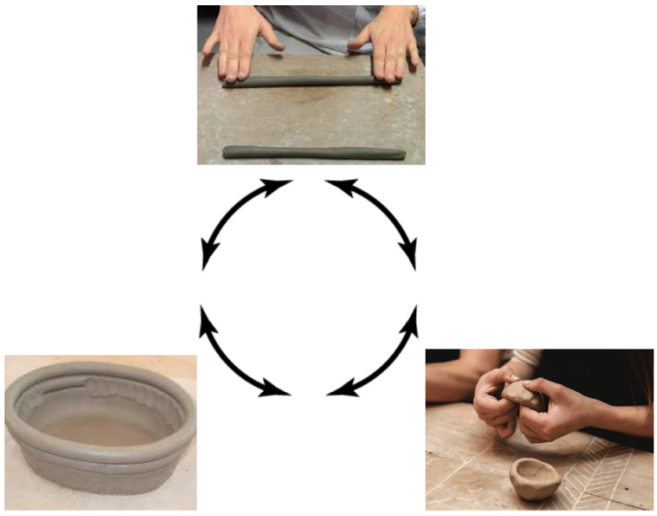


Figure 30. Emergent, enactive, relational, co-constructive material agency where all elements in the process have the ability to impact each other in active engagement

In the case of *chaîne opératoire* this must be taken a step further - beyond material agency. It is agreed that modes of action and process trends are socially, culturally, spatially, and temporally context dependent. If these modes of action and process trends are context-dependent, this wider context should have an equal effect (agency) on the phenomenon of making. How can non-anthropocentric agency be incorporated within the *chaîne opératoire* approach to include an ecology of social, cultural, spatial, and temporal agents? Furthermore, does doing so make a difference in *chaîne opératoire* studies? It is my view that yes, there is an ecology of agents (physical and abstract) which impacts the phenomenon of making and that incorporating this ecology of agents does have an impact on *chaîne opératoire* studies. How can we go about not only visualizing this but also incorporating it into the *chaîne opératoire* approach? I propose a theoretical approach which draws on Actor-Network Theory (ANT), network theory more broadly, typology, objects' lives, contextual reading of objects, entanglement, and relationality in order to adequately incorporate this ecology of agents within the *chaîne opératoire* approach.

Can networks be the answer?

In order to marry the *chaîne opératoire* approach with a framework for agency which can include the aforementioned vast ecology of agents which contribute to the broader phenomenon of making, a variety of approaches must be enlisted. The first approach which comes to mind is Latour's Actor-Network Theory (ANT). In his proposal for the *chaîne opératoire* approach, Leroi-Gourhan describes the gesture and tool forming a single whole (Leroi-Gourhan 1964a). This notion is closely related to Latour's gunman proposition in ANT wherein both the person and the gun are actants (agents) which modify each other and become one entirely new actant – the gunman (Latour 1999; Leroi-Gourhan 1964a, 242). Furthermore, in describing a network, Latour states that "…a network is not a thing but the recorded movement of a thing" which brings to mind Leroi-Gourhan's supposition that technique is equal parts motion and tool (Latour 1996, 378). While Leroi-Gourhan did not explore the topic of agency outright, it is interesting to note that his theories of people, objects, and action can be aligned with ANT.

In this chapter, by applying ANT to the *chaîne opératoire* approach we ascertain that agency emerges from within and between the movement of the gesture, tool, material, and world within the moment(s) of connection. The application of ANT to the *chaîne opératoire* approach is a compelling

thought experiment and we pursue the topic herein. In this chapter inspiration is drawn from Knappett's work discussing network theories in relation to archaeological methods (Knappett and Nikolakopoulou 2005; Knappett 2006; 2008; 2011b; 2011a; Knappett and Mol 2023). However, ANT has not been directly linked to the *chaîne opératoire* approach Use Types within archaeological research. Following the discussion of directly linking ANT with the *chaîne opératoire* approach Use Types, I raise concerns about the limitations of this approach. In order to resolve such concerns, I propose to integrate network theory more broadly, typology, objects' lives, contextual reading of objects, entanglement, and relationality to resolve any limitations of the ANT approach.

Networks and *chaînes*

Can a *chaîne* (*chaîne opératoire*) be considered as an element of a network (ANT)? First, a definition of *chaîne* is needed. While *chaîne opératoire* refers to the overall approach, I propose the term *chaîne* to be used more specifically. In this chapter, *chaîne* refers to a selected grouping of events which are entangled with the *becoming* of an object, thing, or process. In the case of pottery, a *chaîne* can refer to the process of procuring and preparing clay for use, or of the formation method of a vessel, or firing, or the use and repair of a vessel. A *chaîne* can also refer to any combination of some or all of these events depending on the nature of the analysis. A *chaîne* can and does intersect, overlap, and connect to other *chaînes* as well, so while we isolate one *chaîne* with a beginning and end arbitrarily for analysis, it is important to acknowledge that this is an analytical tool and is not indicative of the essential nature of *chaînes*. Let us then define a *chaîne* as a grouping of entangled events within a process of becoming, selected and delineated as a tool for analysis.

Proposing a *chaîne* as an element of a network offers much to explore. Latour searches for the "blind spot in which society and matter exchange properties" via ANT to explore agency, which is compositionally parallel to the capacity of the *chaîne opératoire* approach to uncover the manner in which a person(s) and material(s) exchange properties in the *becoming* of a manufactured object (Latour 1999, 190). In ANT, humans and non-humans interact and co-act, which makes efforts to divide large networks of actors and actants challenging. A network of *chaînes* will be similarly difficult to divide via boundaries, beginnings, and ends. Where does one *chaîne* end and another begin? In a study of Papua New Guinean yam farming, Coupaye (2009) states that "… it became clear that all the actions and events intervening in the work session could potentially be considered part

of the process…they could all be related to the purpose of the actor, and be integrated in the complex network of causes and reasons that surrounded the project" (Coupaye 2009, 444).

In this study of yam farming, many actions are included as part of the farming process which could otherwise be considered peripheral to the process such as lighting a fire at the outset of work, taking cigarette breaks, resting, participating in cultural traditions, and more (Coupaye 2009, 445). Furthermore, there are agents which do not play a strictly technical role but have an effect on material operations nonetheless such as "tutelary spirits, … butterflies, and earthworms" in the case of yam farming which are said to "act as facilitators of tuber development, both by softening the ground in which the tubers will grow (the actual agronomical role of earthworms), but also as observers of the gardeners' behavior" (Coupaye 2009, 447). Yam farmers are cautious of these entities while working and proceed in a calm, quiet, and respectful manner. So, we see that these butterflies and earthworms, which may be written off quite easily as they are not "inside" of the technical system necessarily, play a large role in farming by affecting the speed, efficiency, attitude, and culture of the farmers.

My digression to Papua New Guinean yam farming demonstrates an essential point applicable to *chaîne opératoire* studies: using a *chaîne opératoire* approach we must consider that the *chaîne* a scholar may choose to analyze is inherently entangled with a vast network or ecology of agents. While *chaînes* are selected as a tool for analysis, they are always intersecting, overlapping, and entangling, both spatially and temporally, with other *chaînes*. This is the nature of the *chaîne opératoire* approach which grants it its unwieldy nature. The beginnings and ends of *chaines* are arbitrary boundaries enabling researchers to view a process from a lens that suits the purpose of study, but in reality, we can say that a *chaîne opératoire* approach must be made up of a network of *chaînes* with nodes that "have as many dimensions as they have connections" as in ANT (Latour 1996, 370). Working with *chaînes,* the scale of description poses a problem due to the "fundamental relatedness of techniques…as technical acts are never isolated" (Coupaye 2009, 443). A *chaîne* understood as an element of a network, or as a network itself, can then be a way to "describe matter and bodies" in a way that avoids anthropocentric agency (Latour 1996, 370).

Mediations and *chaînes*

How can this unwieldy framework be understood in a way that is at once accommodating of the phenomenological nature of networks and also practically useful in research? Latour offers four

mediations in ANT. I summarize them here and explore how they can be applied in conjunction with the *chaîne opératoire* approach. Within the *chaîne opératoire* approach there is no outlined method for establishing or exploring agency. As outlined in Chapter Three, the *chaîne opératoire* approach Use Types are clearly applied as a study of human action onto matter to explore the production of a manufactured object through the process of action-and-outcome sequences. However, we can rephrase this understanding of the *chaîne opératoire* approach to be inclusive of non-anthropocentric agency. Instead, I propose for this thought exercise to redefine the *chaîne opératoire* approach as a study of co-constructing, relational, *action-and-matter,* and the resulting emergence of an object or thing (material or immaterial). By redefining the *chaîne opératoire* approach, we can explore direct links to ANT.

First, we have the mediation of interference (Figure 31) wherein one agent (the person) is modified by another agent (the gun), and a third agent (the gunman) emerges (Latour 1999). As a general example we might consider a vessel with string markings on the base. Who made the markings? What made the markings? The sociological account might demonstrate that a person holding a string tool made the markings. The materialist account might posit that a string tool made the markings. Via Latour's first mediation of interference, we can state that agent one (person) has been modified by agent two (a string tool) to create modified agent three (the tool-bearer). The agent in this scenario is the tool-bearer. Agency by this definition is a quality which occurs between and within the two agents modified by each other reciprocally thereby creating a third modified agent. This is reminiscent of Leroi-Gourhan's suggestion that technique is both gesture and tool. We could stop here and suffice to say that the tool-bearer is the agent. But we have not accounted for the clay itself, among other things.

Figure 31. Mediation of Interference. Agent 1 modifies Agent 2 and together become Agent 3.

Second is the mediation of composition (Figure 32). In this mediation a composition or association of actants and forces are necessary to account for an action. Building upon the previous example of the mediation of interference, let us explore the mediation of composition. According to this mediation, more properties can be included. It is not only the person and the tool who are agents but, according to the second mediation, actorial roles may be assigned to numerous agents because numerous agents are involved in the process of "exchanging competences, offering one another new possibilities, new goals, new functions" (Latour 1999, 182). Through this mediation of composition, we also assign actorial roles to the clay and its properties (for example: clay temper, elasticity, porosity), as well as the experience and memory of the person and tool, ecological factors, and any other related element. As Ingold warns, we must not overlook the material properties of things and objects in our focus on the relationality of humans and non-humans (Ingold 2007). The achievement of markings onto the vessel is now attributed to all of these agents by way of successive translation whereby each actor draws on another to reach said goal.

To some extent, Use Type One and Two *chaîne opératoire* approaches assume this successive translation by isolating each "step" in the recipe for action-and-outcome sequences. Every step is affected by, and has an effect on, the previous and subsequent steps which mimics composition of actors and translation of agency. It is clear that Use Type One and Two *chaîne opératoire* approaches account for various successive steps toward a perceived goal. There is an implication of sequential relationality (linear and one-directional). However, those steps and the actors and actants involved are not named as agents as they are in ANT's mediation of composition, and they are not regarded as equally and simultaneously relational. Again, we could stop here, applying mediation of composition to the *chaîne opératoire* approach to explore agency by newly assigning actorial roles to all material properties of the person, tool, clay, ecological factors, etc. to account for emergent relational agency. This would indeed be a novel approach to the *chaîne opératoire* approach in and of itself. I argue however that this mediation used on its own is teleological by nature, and however intuitive and appealing it may be, there are still factors unaccounted for.

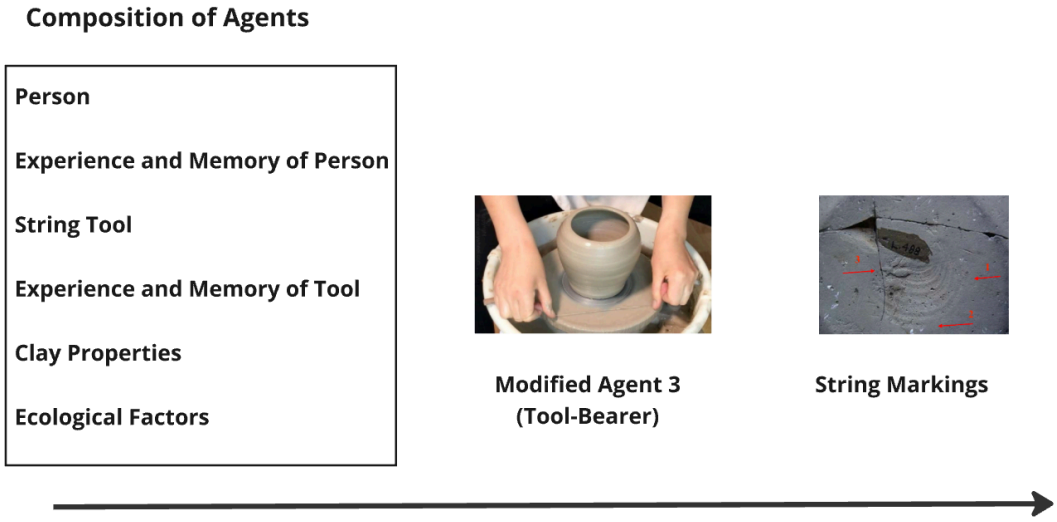


Figure 32. Mediation of Composition. The agents listed in the left panel modify each other through successive translation to become one single modified agent (tool-bearer) acting upon the material.

Third, we have the mediation of the folding of time and space. This mediation is not so much a practical framework as it is a theoretical clause or recommendation. Latour explores the mediation of the folding of time and space in a broad sense referring to scale and scope of agency. In one singular moment it is possible to trace an infinite line through time and space to account for the many actions and actants involved in the process which culminate in that singular moment. In a general sense, this means we must include the role of any actor or actant which bears a connection to the singular moment in question – so long as it is connected within the network according to ANT and despite its distance temporally or spatially. As stated previously, in ANT there is either a connection or no connection. If a connection is present, we must consider it.

The previous mediations (interference and composition) are relatively simple to represent visually in two-dimensions. A visual representation of the mediation of the folding of time and space presents significant challenges. Mainly, the depiction of time requires a fourth dimension which is challenging to visually represent on a two-dimensional page. Physicists and mathematicians have proposed various models for visualizing the fourth dimension which vary greatly in complexity and style depending on the theoretical and practical perspectives at hand. For the sake of simplicity, let us consider the following geometric visualization of four dimensions (Figure 33). Space is developed visually by three dimensions: one dimension (a line representing length), two dimensions (representing length and width), three dimensions (representing length, width, and depth). And

finally, time is represented by the fourth dimension. In the fourth dimension we observe the movement of a cube through time (along the yellow lines). Each dimension is given a color to differentiate them on our two-dimensional page. Now we consider how to represent agency using a similar four-dimensional visual representation.

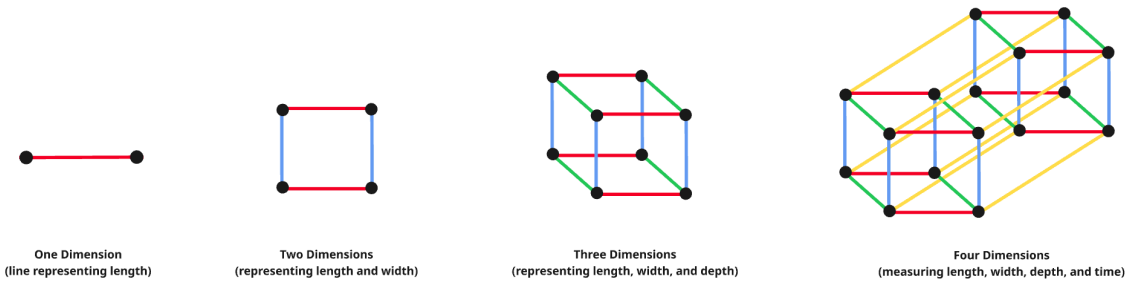


Figure 33. Visualizing the first through fourth dimensions beginning with a single line and ending with four dimensions measuring space and time

Agency, as described through Latour's third mediation is inclusive of the notions of time and space. As such, agency which Latour describes as "nodes in a network" is best represented by nodes in four-dimensional space. Let us consider a visualization of agency via Latour's third mediation using the geometric visual representation of four-dimensional spacetime (Figure 33). Think of our visual representation of four-dimensional spacetime as the network. As viewers and inhabitants of the present moment in time and space, the network is visually centered on the x and y axis. This is a snapshot of a moment in spacetime which is frozen for analysis. The nodes in Figure 34 are representative of actants and instances (in spacetime) where relational agency emerges and can exist in various localities in spacetime. Via the third mediation of the folding of time and space we account for *all* connections, both temporal and spatial, which are agents in the process of leaving markings on the vessel. Having combined mediations of interference, composition, and folding of time and space, we may form a relatively complete picture of agency to account for the emergence of the markings on the vessel from Lerna IV (Figure 34). Some nodes in this visualization are intentionally left unlabeled. Firstly, some of the nodes are left blank to be labeled in the following figure. Secondly, this is meant to inspire an understanding of the vast possibility of a network. In one's own research each node would be attributed to an agent. This may produce a unique, non-cubic, four-dimensional shape.

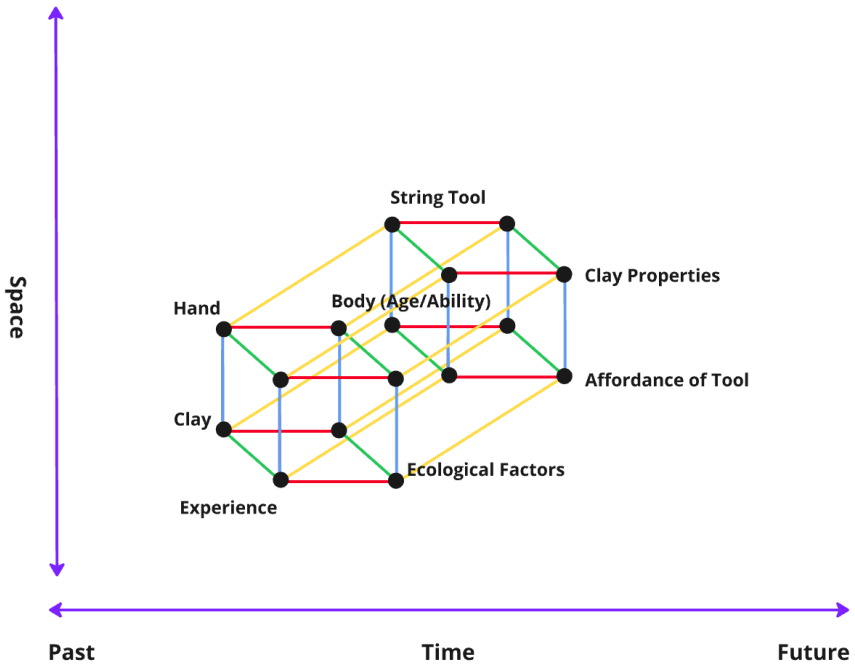


Figure 34. Mediation of Folding of Time and Space incorporating Mediation of Composition. Each node represents the emergent relational agency in the becoming of an object in spacetime. Nodes can be traced to each other forming a network of emergent relational actants and agency in spacetime.

Lastly, Latour urges us to consider a fourth and final mediation - the mediation of the crossing between signs and things (Figure 35). The fourth mediation is also a theoretical clause. According to this mediation we learn that objects, things, actions have meaning and also produce meaning. This mediation is described best by Latour's speedbump which is not simply made of concrete but is also "full of engineers, and chancellors, and lawmakers, commingling their wills and their storylines with those of gravel, concrete, pains, and standard calculations...the mediation resides in the blind spot in which society and matter exchange properties" (Latour 1999, 190). Similar to Latour's speedbump, we must consider that our clay vessel and with its markings is full of clay, tools, potters, pottery wheels, coils, and also its consumers, measurements, cultural practices, memories, regional styles, and cosmological views. The fourth mediation further develops the third mediation by ensuring that all aspects of the emergent becoming of the object are considered. We can visualize this by including additional nodes, connected to the others within the network, which represent cultural *milieus*, cosmological beliefs, and symbolically connected actors (Figure 35).

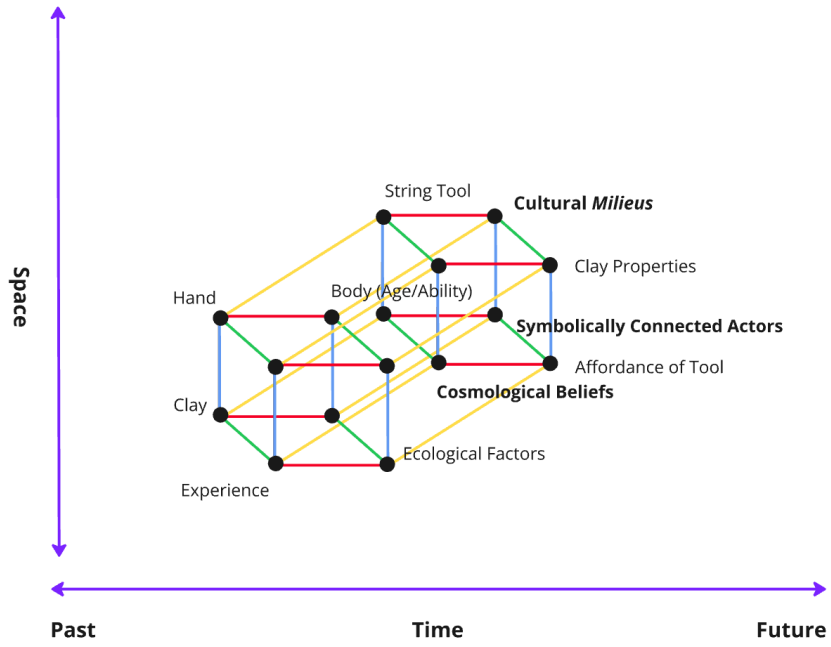


Figure 35. Mediation of The Crossing Between Signs and Things incorporating Mediation of Folding of Time and Space in addition to Mediation of Composition. Each node represents the emergent relational agency in the becoming of an object in spacetime. Additional nodes in bold represent signs and things which are connected to the emergent and relational becoming of the object in spacetime.

By visualizing Latour's mediations, we find that the Use Type One and Two *chaîne opératoire* approaches align somewhat with the first and second mediations. However, it is only by incorporating all four of Latour's mediations that we can grasp the full picture of emergent, enactive, co-constructive, relational agency that accounts for the becoming of an object. These elements are visualized in spacetime represented in Figure 34 and Figure 35. The Use Type One and Two approaches to *chaîne opératoire* approach ask, "who or what made these marks?". This question limits the answer to include only the actors in the first and second mediations – namely humans or humans modified by tools. I propose to instead ask, "how did these markings *become*?" so that the *chaîne* is not limited to the moments in space and time where the human body is engaged with the material (modes of action). We must consider "how did these markings and this vessel *become*?" by including the vast ecology of agents (physical and abstract) across spacetime wherever there is a connection, intersection, overlap, or comingling of *chaînes*. These visualizations of Latour's mediations are particular to the ANT perspective of agency. We will see them further developed in

Chapters Nine and Ten taking a *chaîne opératoire* perspective in an endeavor to incorporate theories of cognition.

Practical applications of Actor Network Theory

In order to fully realize how ANT can be considered in conjunction with the *chaîne opératoire* approach let us examine two examples. Network theory has been explored in relation to practical application in archaeology as in the topology of networks (Knappett 2008), enchainment in socio-technical networks (Knappett 2006), and the dynamics of material culture via networks, meshworks, and again via the theme of topology (Knappett 2011b). However, I focus this section on explicit practical applications of ANT to archaeological studies which involve the *chaîne opératoire* approach. Two applications prove to be interesting case studies (Van Oyen 2015; Vadala and Duffy 2021). Vadala and Duffy (2021) explore agency by the application of ANT through Mayan caches (deposits of votive objects), highlighting the ways in which caches were experienced as a durational process of social life in addition to the ways in which caches were built on human-object relationships (Figure 36). Their study offers a unique take on ANT by supplementing Latour's original theory with three theoretical operators: the "worknet", "extensive frame", and temporality. These proposed theoretical operators serve the purpose of supplementing ANT where it is weak (according to the authors). Namely, they state that ANT lacks a "focus on processes of temporality and infinite work extension" (Vadala and Duffy 2021, 1030).

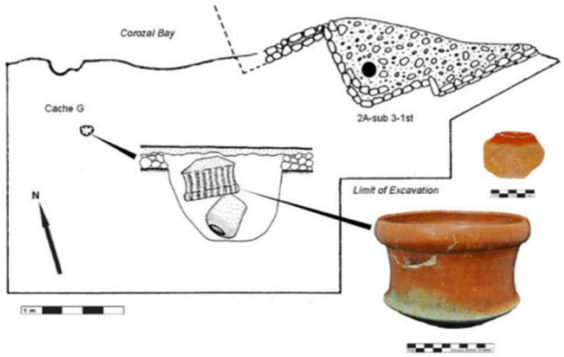


Figure 36. Mayan cache "G" mapped in the context of projected architectural constructions (Vadala and Duffy 2021)

The theoretical operator "worknet" is used purposefully as an inversion of Latour's network to highlight the role of work and social action; "worknets are special networks designed to set up and establish organized networks of social action" (Vadala and Duffy 2021, 1030). Especially in the case of Mayan caches, the term worknet is claimed to be appropriate as it reflects the ways in which "the cache process organized relationships that oriented future action" (Vadala and Duffy 2021, 1031). The worknet focuses on "initial generative actions that produce, organize, and maintain networks, while setting the stage to explore vectors of social affects connected to worknets" (Vadala and Duffy 2021, 1033). They also state: "delimiting networks in this manner is a key step in producing a solid and reproducible description of the worknets while also demonstrating how these networks are connected and thereby produce agency among actants" (Vadala and Duffy 2021, 1034).

It is inarguable that in working with both *chaîne opératoire* and ANT there is a need for delimiting networks (as I have explored using the term *chaînes*) in order to produce sensible, reproducible analysis. And while the term "worknet" certainly grabs the attention and reflects the aspect of social work, the term's specific emphasis on "social work" actually detracts from Latour's reason for selecting the term "network". Latour's aim was to place actors and actants (humans and non-humans) on equal footing. By emphasizing the "social work" in a network, actors and actants may once again be hierarchically ordered in a way that renders actants (non-humans) as secondary, even if only semantically. This is not a far cry from Gell's primary and secondary agents which is a parallel worth noting because this is precisely what is negated in ANT. In any case, it must be made clear not to revert to an anthropocentric bias or a primary-secondary agent perspective as it seems this is not the intention of the term worknet. In this specific case of Mayan caches, it seems the term worknet may be appropriate, but it is also worth noting that this term may not be widely transferrable in other cases.

Next, Vadala and Duffy introduce the theoretical operator "extensive frame". The extensive frame allows for the analyst to "maintain analytical focus while limiting the scope" of analysis (Vadala and Duffy 2021, 1031). The extensive frame does the work of restricting analysis only to the sequence of events directly responsible for producing cache events – the framing point is drawn from archaeological and ethnographic data to focus on the most decisive processes in cache production. Especially in the use of *chaîne opératoire,* there is a need for limiting the scope of one's analysis for the sake of practicality. As I have described previously using the term *chaînes,* there are networks of an infinite number of *chaînes* related to a production process which are intersecting, overlapping, and comingling both spatially and temporally. Lemonnier illustrates this point, "It is very difficult to

define or delimit a particular technique…Selecting the appropriate level of description remains a problem and one that the researcher himself or herself must address on a case by case basis" (Lemonnier 1992, 7). Lemonnier recommends that a researcher identify five basic components of a technical system including: action, objects, energy, matters, and knowledge which together form a technique (Lemonnier 1992).

In the context of ethnography and ethnoarchaeology these five components are helpful as guiding analytical tools, but researchers must be careful not to apply terms or categories which undermine local practices and language, or likewise overlook certain elements because they do not fit into one of the aforementioned categories (Coupaye 2022a, 16). Of course, in archaeological research where there is no access to local vernacular this poses less of a threat to the credibility of the study. Nevertheless, we may consider supplementing Lemonnier's five basic components with dates, places, durations, peoples, materials transformed, and local terms of phases and steps in ethnoarchaeological studies as suggested by Coupaye (2009). By using this framework suggested by Lemonnier, and expanded upon by Coupaye, we may create a more manageable *chaîne* to work with. Vadala and Duffy's extensive frame as a theoretical operator is meant to "solve the problem of 'cutting networks', which can technically go on forever", and while I think that they do achieve this, it seems as though they may have inadvertently reinvented the wheel – Lemonnier's wheel (Vadala and Duffy 2021, 1031).

The third theoretical operator is temporality. Mayan caches are intergenerational and so in order to highlight the complex temporal relationships, the decision was made to include the subjective focus of time and temporalities that articulate between and within processes. Additionally, this theoretical operator can help to highlight intergenerational relationships and memories of caching events. It does seem that while ANT's third mediation "the folding of time and space" focuses on space, scale, and scope in relation to time; in the case of Mayan caches there is an additional and exceptional temporal element of memory. So, the theoretical operator is effective and useful in this case. Latour has no reservations in calling to light the limitations of ANT, stating that it is necessary "after having traced the actor-networks, to specify the types of trajectories that are obtained by highly different mediations" (Latour 1996, 380). So, in the case of the Mayan cache study, Vadala and Duffy have achieved this effectively and creatively.

In their practical use of ANT on the Mayan caches, Vadala and Duffy demonstrate its utility. Using Latour's (1992) model for groups, they "follow actors' own ways and begin our travels by the traces left behind by their activity of forming and dismantling groups" (Vadala and Duffy 2021, 1036).

Groups are classified as preassembled actors or clusters of actors that are grouped together. Additionally, groups are identified through traces of their appearance *and* disappearance. To explore and characterize said traces, researchers characterized groups as sets of actors (including objects, materials, plants, animals, minerals, and places) that, when articulated, have the capacity to perform goal-oriented actions relating to the "caching worknets within a given environment" (Vadala and Duffy 2021, 1036). The difficulty in grouping as such is not to be underestimated, whether social, material, or abstract (memory). I offer a detailed discussion of grouping, classification, and typology later in this chapter. As Latour states, "relating to one group or another is an on-going process made up of uncertain, fragile, controversial, and ever-shifting ties" (Latour 2005, 28). Including the phrase "sets of actors" the definition of *chaîne opératoire*, according to Vadala and Duffy, would then read: *chaîne opératoire* is a framework for examining sets of actors and their capacity to perform goal-oriented actions relating to worknets. This definition remains centered upon goal-oriented actions in relation to a worknet (the production of an object, thing, or cache in this instance). It is reminiscent of the deterministic approach in Use Type One recipes for making and limits its application to networks of production.

Vadala and Duffy's approach presents an avenue to include non-human agency while focusing mainly on an object-centered or production-centered approach. This can be useful to a Use Type One study which aims to include non-human agency. However, I proposed in the beginning of this chapter that the *chaîne opératoire* approach can be reimagined as: the study of co-constructing, relational, *action-and-matter,* and the resulting emergence of an object or thing (material or immaterial). In this way, the *chaîne opératoire* approach can encompass various types of processes on small or large scales with a focus on *ways of doing* from which objects and things (material or immaterial) emerge. This reimagined *chaîne opératoire* approach only accounts for agency (*ways of doing*); cognition (*ways of thinking*) are explored in the forthcoming chapter. Nonetheless, let us explore another path toward the expansion of the *chaîne opératoire* approach through ANT.

In another notable application of ANT to *chaîne opératoire*, Van Oyen (2015) proposes a relational network ontology drawing upon ANT wherein agency is distributed and draws upon constellations of network "nodes" that are traced through connection regardless of the actor/actant's status as a person or thing (Van Oyen 2015). As such, modes of action would no longer have the potential to be separated from process trends (as in Use Type One) because they are interrelated and furthermore, agency exists in both the modes of action (in this case, material) and the process trends (in this case, sociocultural meaning). Van Oyen asserts that in applying ANT to

chaîne opératoire it is permissible to categorize artefacts by type so long as the category is viewed as a constellation that may tell us something about that category's "possibilities for action in the past – its material agency" (Van Oyen 2015, 66). Instead of viewing types, or *chaînes,* as separate and unique entities, we are able to trace connections via possibilities for consequential action.

Taking an ANT perspective on the *chaîne opératoire* approach, categories of artefacts still exist — Van Oyen is simply accounting for the way that they *became* categories rather than projecting our own inherent (and often unacknowledged) biases onto historical people, places, and things. ANT describes nodes (i.e., humans and non-humans) *in relation* to other nodes. As such, nodes are possibilities for action with emergent properties rather than static entities. All the same, researchers run the risk of approaching categories from a teleological point of view simply because we are in many cases obligated to unravel objects and processes in reverse (beginning with the object and extrapolating the production process thereafter). The point remains that taking an ANT perspective can draw attention to these teleological approaches, which are in some cases unavoidable, and reposition analysts to take an emergent and relational approach. When we reduce objects to categories via etic perspectives, those categories hold no weight in relation to their context. Van Oyen states, "As a result, [the category or object] becomes weaker and external actors with decisive autonomous agency need to be invoked to explain what happened to the passive category" (Van Oyen 2015, 69). Instead, Van Oyen argues we should view agency as distributed through the emergence of an object (or category of objects) through its enacted and situated production. In doing so, the emergent perspective of the object or category opens up new "conditions of possibility" through which to view them (Van Oyen 2015, 69).

By reducing objects or production processes to things lacking agency, as is done in Use Types One, Two, and Three *chaîne opératoire* approaches, archaeologists are bound to focus their attention on questions of causality, always searching for the human agent and their recipe for making. These kinds of questions, searching for causal agents, are in general unanswerable and lead archaeologists to dead-end, or circular, debates. Instead, considering the *becoming* of such objects or processes via ANT can lend itself to reconsideration of historical narratives which have been taken for granted and perpetuated; "…ANT also offers us the means to make our answer to the question of 'how' powerful enough to actually contribute to *explaining* past phenomena" by repositioning categories (i.e., networks or *chaînes*) as relational and situated which emerged due to their own agency (Van Oyen 2015, 74).

Limitations and considerations of an Actor Network Theory approach: agency

Having demonstrated the benefits of an ANT approach to *chaîne opératoire*, we must understand certain limitations of this approach. The first objection to an ANT approach to *chaîne opératoire* is the objection to non-human agency due to an apparent link between agency and intentionality. However, many have disentangled this link between agency and intentionality and in doing so diffuse this particular objection to material agency (e.g., Malafouris 2008, 28). If agency is limited to "intentional" and "meaningful" human actions, then of course it is impossible to see how an object can have such a human-like characteristic such as agency (Latour 2005, 71). These objects which lack anthropomorphic intention can only exist in the realm of material causation, separated from humans, much like the separation in Gell's distributed personhood (Gell 1998). However, if we can agree that anything which modifies "a state of affairs by making a difference is an actor… or an actant", then any object or person can have agency (via a network connection) (Latour 2005, 71). The question which can be applied to discover whether or not someone or something has agency then is: "Does it make a difference in the course of some other agent's action or not? Is there some trial that allows someone to detect this difference?" (Latour 2005, 71). It is important to note that although an object may make a difference in a state of affairs, these objects do not necessarily determine the action, but they do signify the "many metaphysical shades between full causality and sheer inexistence" (Latour 2005, 72).

Both Gell and Latour grapple with the problem of duality in agency (human versus non-human; actors and actants). For Gell, the anthropocentric view of distributed personhood attempts to place objects on the same plane as human agents, yet his proposal of primary and secondary agents confirms this division or duality in the end. On the other hand, Latour does away with the anthropocentric view, but the overall effect is a sort of dehumanization of both people and objects as they become connections or nodes. In this way, the problem of duality and anthropocentric agency is addressed. However, this has a dulling effect upon the liveliness, the vitality, of the interactions in everyday life which manifest change. As a counterproposal to this dehumanizing perspective, Carl Knappett calls for investigation of the "potentially diverse *processes* whereby 'inanimate' objects come to be socially alive" (Knappett 2002, 97). Knappett (2002) questions why it is necessary to distinguish between objects and agents at all and points out that research has arrived at a new perspective. This new perspective supposes that mind, body, and world can be seen as codependent, entangled, intertwined and that objects can rarely be understood without some sort of relation to the body or to its "underlying idea" (Knappett 2002, 98).

Latour's "sleeping policeman" (speedbump) is a key example which can be revisited and further explained via enacted, embodied, and entangled material agency. Latour discusses the way in which the speedbump is not only a concrete bump in the road but is made up of engineers, city planners, drivers, and law enforcement and as such has agency by way of distributed personhood. Knappett takes this a step further: yes, agency has been distributed to the concrete bump, but it only enacts agency when in contact with a driver who drives over the speedbump and is therefore engaged. Distributed personhood isn't necessarily incorrect, but it only answers one side of the equation: who did agency come from (engineer) and where did it go (speedbump)? For ANT, agency is found at the connection between the engineer, the physical speedbump, and the user of the speedbump. ANT answers the question: where is agency?

The enacted, embodied, and entangled perspective asks not only where is agency, but also *when and how* is agency? Through the enacted, embodied, and entangled perspective all parties involved (the city planners, law enforcement, engineers, the concrete, the driver, and the car) are all acting together, entangled and codependent in manifesting agency in the moment the driver engages with the speedbump. The behavior, the artefact, the relationship to all other actors past and present, are codependent. In short, agency is not only distributed but "inheres in the relationships between the various entities that constitute a field of action", and that agency emerges through associations and relationships rather than within each entity in and of itself (Knappett 2002, 100).

Knappett further develops a network theory similar to that of Latour's ANT in discussing how objects become socially alive. This development of network does not necessarily reject any part of ANT but builds upon it from the object perspective. In addition, Knappett discusses artefacts as they are created by artisans in a manner similar to Gell's work on art and agency and utilizes the same lexicon of icons, indexes, and symbols. First, an artefact is imbued with agency by the artisan(s) who creates it, in the sense that the artefact becomes an index of "the artisan's productive investment and cultural sensibility", and while objects on the surface may appear ontologically different, "… they nonetheless all involve a convergence of icon and index in the assemblage of agency and meaning" (Knappett 2002, 101,114). Building upon this indexical relationship first proposed by Gell (1998), Knappett then focuses on the life of the artefact. As the artefact lives through consumption (use, reuse, discard, and so on), the artefact forms new connections with humans and non-humans, individuals, and groups. This life of the artefact becomes entangled in multiple networks which overlap due to the common feature, the artefact. In keeping with focus on the artefact, Knappett then

concludes that the artefact as such has “no singular agency…, but dual or even multiple agency” (Knappett 2002, 101).

If as research suggests, objects do have agency, then what effect do they have on our lives? Adopting on an object-centered view of agency can help to develop this theory of material agency. Gosden (2005) states: “Ultimately, emphasizing the manner in which things create people is part of a rhetorical strategy to rebalance the relationship between people and things, so that artifacts are not always seen as passive and people as active” (Gosden 2005, 194). Can things behave in ways that are not derived solely through human intention? Without realizing the depth of the question, we often ask, “what does this painting do?”, or “how does this sculpture affect the space of the gallery?”. Utilitarian objects, things that channel human action, such as a teapot can also help to illuminate this argument. Looking at teapots within the realm of teapots, rather than within a social context such as Hodder’s textual reading of artefacts, can help to resituate this exploration. One teapot amongst a group of teapots may offer certain sensory experiences that the others do not, and may place obligations onto the user “in the ways we relate to objects and other people through these objects…Patterns of exchange or consumption derive partly from the nature of the objects themselves” (Gosden 2005, 196). Because material culture is so long-lasting, generations of people are born into worlds already occupied by objects. These objects inform us, shape us, and educate us from birth. As Gosden states so eloquently, “People crystallize out in the interstices between objects, taking up space allowed them by the object world, with our senses and emotions educated by the object world” (Gosden 2005, 197).

So, what is agency? Who or what has agency? And when is agency? As Gell stated, “we cannot tell that someone is an agent before they act as an agent, before they disturb the causal *milieu* in such a way as can only be attributed to their agency” (Gell 1998, 20). This quote articulates quite clearly that all things (human and non-human) can be agents, and what’s equally true is all things (human and non-human) can also not be agents. This is due to the fact that agency is not a quality that can be attributed but an emergent property, it is something to be realized (Malafouris 2008, 34). Many of the problems outlined here regarding agency are due to the historically accepted anthropocentric view of agency which is commonly entangled with the qualities of intention and will. In this view an agent should also have morality and responsibility for action (as with human agents, or so we hope). However, for those willing to “disentangle agency and intentionality” and approach agency without preconceived dictionary definitions, there are many intriguing and curious theories of material agency to be considered (Sørensen 2018, 96).

Of course, things and people are ontologically different in Western thinking. It is important to note that in non-Western societies and philosophies things and people may be more closely related ontologically. In Western thinking, things and people exhibit different characteristics and experience differing modes of existence. However, we may overcome this ontological difference imposed by Western thinking through an understanding that things and people are deeply entangled; that within active engagement with material, those things and people create and realize agency between and within them. This view of relational and emergent agency is useful as we attempt to analyze the past with as much truth as possible. Through material agency we aim not to subject anyone or any*thing* to the status of a stationary inactive role in history where there was once vitality. As such I take this approach to agency which marries ANT, network theory more broadly, objects' lives, contextual reading, and emergent, enactive, co-constructive, relational agency. In the following sections I deal with incorporating this approach with the *chaîne opératoire* approach.

Limitations and considerations of an Actor Network Theory approach: networks

There are certainly arguments criticizing the notion of networks, or that ANT does not accurately describe networks. Knappett argues that ANT does not explore network structures thoroughly enough at the micro or macro levels and furthermore does not explore the impact of said structures on overall network behaviors (Knappett 2008). At the macro-level we can say that there are as many nodes as connections in ANT, and therefore there exists a shifting landscape or topography. Knappett and others debate the structure of a network proposing terms like meshworks (Knappett 2008), fluid space (Mol and Law 1994), smooth space, or rhizomatic networks (Lee and Brown 1994). Knappett explores networks and meshworks to describe two different topologies of distributed personhood and things, stating that a network (of objects) is "a series of identifiable nodes with connections between them" while a meshwork (of things) is "a maze of overlapping and intersecting lines" (Knappett 2011b, 45).

On a micro-scale the behavior of networks and connections has been further explored as well. Taking a Gibsonian approach to networks, Latour notes that things (non-humans) can authorize, afford, and permit. This attempt to understand the *kinds* of connections or *characteristics* of connections within a network is certainly an avenue worth exploring. When speaking of network structure and behavior, we arrive again at a problem of duality, as with human and non-human agency… does a network have to be inherently structured or unstructured? Can a network not take

on more than one form or expression at any given time depending on its context? Does describing, or even prescribing, the structure to a network impose limitations? A discussion of the structure, topography, and behavior of networks as they relate to the *chaîne opératoire* approach is intriguing and worth exploring in future research. For the time being, the scope of this study is limited to the properties of emergence and relationality that network theory affords as it pertains to the reconsideration of agency and the *chaîne opératoire* approach.

The problem of typology

I digress to the problem of typology as it continues to arise throughout this work. What can we do or say about typology? One of the underlying issues is that in the search for modes of action within a production process, a typological system is used to classify objects according to physical features such as clay fabric, clay particle orientation, object shape, size, and markings on the surface of the clay. In Leroi-Gourhan's proposal for the *chaîne opératoire* approach he encourages the scholar to typologically classify artefacts based on *modes of action* (the intermeshing of tools and motive gesture) as opposed to physical characteristics of the object. This proposed typology of entangled tools and gestures is also ultimately related to the maker's *milieus* as tools and gesture are linked to the maker's sociocultural context. However, as we have seen in the *chaîne opératoire* Use Types, artefacts are first categorized typologically and/or morphologically (vessel size, shape, clay fabric) and then a *chaîne opératoire* approach is applied to understand the modes of action within each group (Roux 2019b). These groupings are created through our modern interpretation of traits. Not only is our interpretation biased especially toward a Western understanding of objects, tools, and production, this also can risk furthering the narrative that agency is anthropocentric depending on the scholar's modern perception of agency.

One problem with these typological classifications through *chaîne opératoire* approaches is that focus remains on the *archaeological* context (describing materials which have passed through a cultural system and are now the objects of investigation by archaeologists) instead of the *systemic* context (the condition of an element which is participating in a behavioral system) (Binford 1965; Schiffer 1972, 157). Binford (1965) proposes that culture (e.g., objects, things, tools) is an extrasomatic adaptive system that is integrated with society and its environment, and other sociocultural systems; culture is not necessarily a static entity to be shared from person to person but instead a practice which is *participated in and perpetuated by* people. This is not dissimilar to

Leroi-Gourhan's discussion of externalization of labor (in the general sense) by adapting "external organs" (i.e., tools, objects, things, and language) which is directly related to the maker's *milieus* (Leroi-Gourhan 1964a). Binford further argues that an approach which focuses on shared traits in a classification system masks important differences, and what's more, lumps together phenomena which are distinguishable via different methods.

Here we arrive at the crux of my argument which is that culture (e.g., materials, tools, processes, practices, cosmological beliefs) is not a univariate phenomenon and cannot be fully investigated by a classification system of one trait (or even multiple traits of the same broader taxonomy such as physical traits). Binford offers an approach wherein material culture be viewed as part of a system involving "…complex sets of relationships among people, places, and things whose matrix may be understood in multivariate terms" (Binford 1965, 209). Drawing on Binford, Schiffer (1972) offers a similar perspective of the systemic context, and emphasizes his dismay at the archaeologist's tendency to deal exclusively with chronological relationships. Schiffer proposes instead that objects are a part of interrelated subsystems which affect and are affected by each other. As such the systemic context of durable elements (surviving materials such as clay, stone, etc.) should be defined by the following interrelated processes: procurement, manufacture, use, maintenance, and discard (Figure 37) (Schiffer 1972). Each of these processes occur across and between temporal and spatial landscapes. Following this logic, we can see that the *chaîne opératoire* Use Types limit themselves to investigations of physical traits within only one of the five object systems (procurement, manufacture, use, maintenance, and discard). When categorizing through the normative archaeological context, as see in our Use Types, we are asking "what did they do to this material to achieve this trait?" instead of through the systemic context which asks, "how might these artefacts have been defined in the past…and also what bias am I bringing to this typological categorization?".

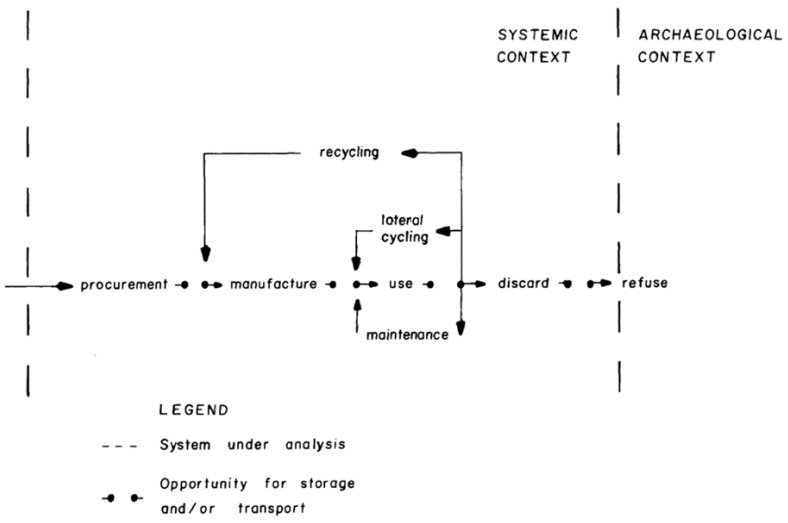


Figure 37. Schiffer's flow model for viewing the life cycle of durable elements (Michael B. Schiffer 1972)

While the New Archaeology of the 1960's and 70's is of course no longer new, Binford and Schiffer's perspectives retain relevancy. Hodder and Hutson (1986) draw on this dialogue to propose that material culture is meaningfully constituted, and that agency must be included in theories of material culture and social change; Hodder later argues for human-thing entanglement wherein things and humans are interdependent, entangled, and co-construct each other (human-thing and thing-human entanglement) and themselves (thing-thing and human-human entanglement) (Hodder 2000; 2011; 2012; 2016). It is this line of thinking which produces the poignant quote, "but to look at objects by themselves is really not archaeology at all" (Hodder and Hutson 1986, 4). Hodder states that material culture does not just exist, and it does not just reflect society; material culture *creates* and is *created* through the acts of "social agents" (although I suggest this be interpreted more broadly as a network of various agents).

Taking a different approach to the same problem of typologies and agency, Knappett (2022) proposes a typo-functional and phenomenological approach to connecting typologies. This would animate typo-functional object groupings, with agency, to be considered as groups of things which co-create the world in which we affect and are affected by objects and things. This approach imbues typologies with life, agency, and connection rather than passive distinction. The result is a process typology or ecological media typology drawing on Process Archaeology (Malafouris and Gosden 2015; Knappett 2022). This approach shifts the focus from a typology of passive, static, objects to a typology of interconnected types which are ontologically in flux and radically relational. As a

practical example of this approach we see Knappett begin with a functional criterion selecting vessels used for storage, pouring, and drinking liquids. We should not separate these vessels by their morphology (size, shape, handles, lips, or spout-types) because they are interrelated; the pithos fills the amphora which fills the drinking cup for example. On the larger scale, these vessels are also related to trade networks across the Aegean, transporting liquids from one location to another in the pithos or amphora to be poured into the drinking cup on a neighboring island (Bevan 2014).

Joining up typologies demonstrates the relationality of objects and how they are actively engaged, and engaging, through entangled and dynamic animating forces. Moving from functionality to composition – the ways in which types are made meaningful – we consider both functional use *and* the process of making where "types are composite entities which draw from various media" (Knappett 2022, 124). From this perspective we observe that the clay kantharos is related to the silver metal kantharos (Figure 38), and that clay with textile impressions, woven basketry impressions (Figure 39), or clay made to mimic basketry (Figure 40), is related to these media as well. In this case metal, textile, and basketry are cited in the clay vessel suggesting that these media are interrelated and entangled through – emergent, enactive, relational, co-constructive agency – they affect, and are affected by, each other via networks of connections across media, time, and space.

Figure 38. Silver kantharos from Gournia, Crete, and ceramic kantharos from Malia, Crete (Knappett 2022)

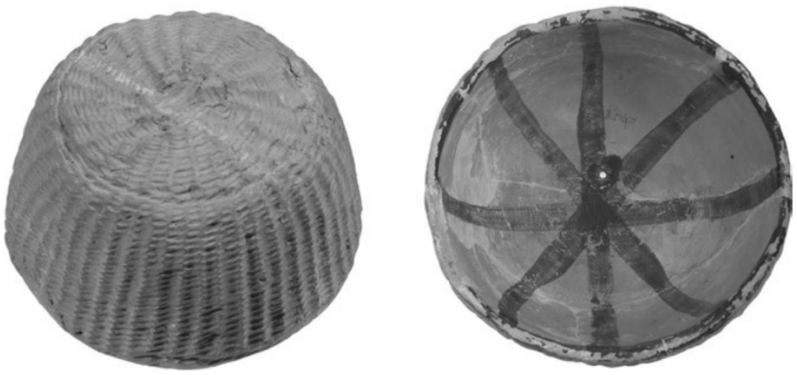


Figure 39. Miniature basket replica made with clay impression onto woven basket (Haas-Lebegyev 2014)

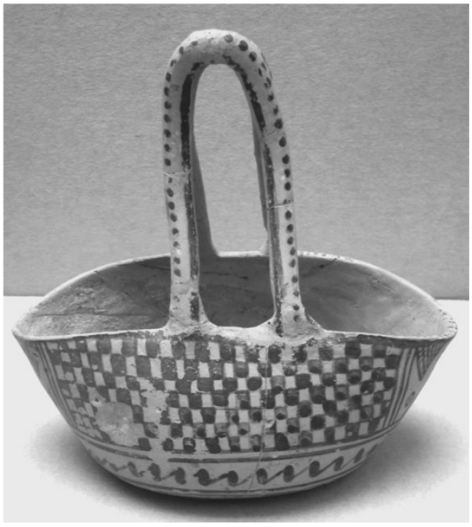


Figure 40. Clay vessel shaped and glazed to mimic basket (Haas-Lebegyev 2014)

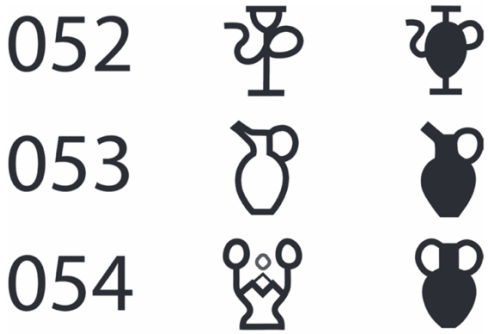


Figure 41. Beaked jug as Cretan Hieroglyphic sign (after Godart and Olivier 1996, table 16)

From composition to modelling, "connections are made across scales that establish the aesthetic connections that make an ensemble of types communicative" (Knappett 2022, 128). Beaked jugs for instance also exist as miniature models, as hieroglyphic signs (Figure 41), and also on carved stone seals. This ecological approach to types emphasizes the interconnected nature of functionality, making, meaning, and signification which in turn supports emergent, relational, co-constructive agency of non-humans and humans.

Returning briefly to ANT, we see that taking an ANT approach necessitates a contextual, entangled, network or ecology of agents in order to accommodate non-anthropocentric agency as demonstrated through Van Oyen's (2015) study which proposes constellations of connections rather than static groupings. Similarly Vadala and Duffy (2021), who take an ANT approach, investigate Mayan caches in their entangled spatial, temporal, and broader cultural contexts thus accommodating non-anthropocentric agency. I propose that based on the nature and context of the object or process under scrutiny, *chaîne opératoire* should draw on these contextual, entangled, ecological, and process archaeology approaches to typology. It is clear that when archaeologists take for example all of the beaked jugs from a trench, site, or region and organize them by a typology of physical traits (size, shape, clay fabric), the result is a set of decontextualized data regarding similarities or differences which pertain to only one quality. Whereas there are potentially infinite emergent, enactive, relational, co-constructive qualities (practical, social, historical, cultural) of beaked jugs. Furthermore, a typology of physical traits reduces the object to a passive recipient of human actions. How can we understand the phenomenon of making, and the meaning behind the making, if objects are reduced to static, passive, mechanical components void of their animating forces?

Chaînes, Actor Network Theory, and *chaîne opératoire*

As has been reiterated throughout, agency is an emergent, enactive, relational, co-constructive, co-constructive property. Both humans and non-humans can be agents, and they can just as well not be agents. Things and people are of course ontologically different, but they are also deeply entangled. They co-create agency within active engagement with each other. It is important to expand the notion of emergent relational agency so that we can consider not only 1:1 relationships of humans and non-humans, such as the human and the string tool our example. The limitation of

1:1 relationships leaves us at the first mediation of ANT. We should consider actors and actants as nodes on a network, or as connections within and through *chaînes,* which can extend and contract, overlap, succeed, and precede any number of other networks and nodes both spatially and temporally. The permutations of types of relationships between actors and actants are infinite, so let us not limit ourselves to a 1:1 or human:non-human framework. As in Hodder's entanglement theory we must also consider relationships such as thing:thing, thing:human:thing, and all other possible permutations. Utilizing all four mediations outlined in ANT, broader network theory, entanglement theory, object's lives, contextual reading, as well as rethinking the approach to typologies, can help to achieve this limitless perspective with respect to the *chaîne opératoire* approach. Additionally, the concepts of actors should be "allowed to be stronger than that of the analysts" (Latour 2005, 30).

To understand where enactive, emergent, relational agency intersects with *chaîne opératoire* we can draw on the aforementioned theories to rethink the *chaîne opératoire* approach*,* proposing *chaînes* as networks. ANT and the *chaîne opératoire* approach integrate well for a number of reasons previously outlined, the most obvious of which is that both frameworks take large, interconnected phenomena and simplify them for analysis by tracing the trajectories or connections between nodes while maintaining the vast nature of the network from which it stems. Considering the limitations of ANT, I have highlighted additional approaches which can help to eliminate these shortcomings. I offer a novel marriage of these various theories and methodologies to account for non-anthropocentric agency within the *chaîne opératoire* approach. In the following section, I outline a methodology to reinforce the practicality of this solution, as well as highlight the impact it can have on studies of ceramic production processes. What follows is my proposal for a reconsidered *chaîne opératoire* approach: a network-informed *chaîne opératoire* approach.

A new proposal: a network-informed *chaîne opératoire* approach

Given this discussion of agency and typology, let us rethink the *chaîne opératoire* approach. Taking an ANT approach informed also by network theory broadly, typology, objects' lives, contextual reading of objects, entanglement, and relationality I propose the following reconsiderations to core elements of the *chaîne opératoire* approach. Alongside the reconsiderations of these elements, I also introduce new visualizations here which are further developed throughout this project. These visualizations are partly inspired by visual concepts developed by physicists to depict theories of

Quantum Entanglement and Loop Quantum Cosmology. I have consulted these visual concepts due to the similarities in visually linking discreet elements (Classical and Quantum Mechanics), with broad phenomenological elements (Quantum Entanglement and Loop Quantum Cosmology) of our universe.

1. **Typology and classification**

   Taking an ecological network approach to typology, we may emphasize the interconnected nature of functionality, making, meaning, and signification which in turn supports emergent, relational, co-constructive agency of non-humans and humans. Furthermore, modes of action (motive gesture) must be included with careful attention not to prescribe anthropocentric agency. For instance, instead of asking "what action did a person do to this object?"; we can ask "what does this remaining trace of gesture tell us about the object's *becoming,* and how does this *becoming* relate to other human and non-human agents involved in the process?" As Van Oyen suggests, applying ANT to the *chaîne opératoire* approach we ought to view categories as constellations that may tell us something about that category's enactive, emergent, relational agency. Instead of viewing types, *chaînes,* or networks, as separate entities, we are able to trace connections wherever or whenever they occur. With this ANT perspective on the *chaîne opératoire* approach, we can now account for the way that *chaînes* or categories *became*. By repositioning categories deduced via this *chaîne opératoire* approach as relational and situated *chaînes* which emerge due to emergent, enactive, relational, co-constructive, co-constructive, we have a more powerful tool for examining past phenomena.

   The researcher may insist their interest is in pithoi specifically, nothing else. This is of course valid and if the aim is to understand the modes of action involved in making pithoi at the basic level of anthropocentric agency it will make for an interesting study, so long as this is acknowledged. This is a Use Type One *chaîne opératoire* approach. If the researcher does wish to engage the *chaîne opératoire* approach's capacity for insight into production processes to better understand pithoi, they must take an ecological network approach to typology as I have described. This typology may include the collection of pottery excavated from one trench (including but not limited to pithoi), or all of the storage vessels (including but not limited to pithoi) from the site, or all large vessels with flat bottoms for example. Additionally, the researcher might consider other materials related to storage vessels such

as textiles and metallurgy. This approach allows for a *chaîne opératoire* approach which will include *all* aspects of the framework. Taking a *chaîne opératoire* approach does not necessitate a knowledge of all related materials prior to the study, because this information is not always readily available. One can however examine the context of finds and create a typology based on traces of gesture. For example, in a pit with various pottery one might select *all* of the objects with traces of removal of the vessel from the pottery wheel. Furthermore, through taking a *chaîne opératoire* approach with the recognition of the context of materials, the study will not only begin with but also result in an ecological network of things.

2. Modes of action

Modes of action can also be considered as related to this ecological network of agents discovered through the first typological step. Modes of action can be helpful in describing ways of doing as we have seen in the Use Type One approach to *chaîne opératoire*. I propose to reconsider modes of action to accommodate for non-anthropocentric agency in a way which illustrates the goal of observing the intermeshing of object, gesture, and tool. Modes of action as distinct actions which are fixed spatially and temporally and can be observed. Through our Use Types it is clear that this has been interpreted through the lens of anthropocentric agency (Figure 42). However, as we have seen, the *chaîne opératoire* approach has the capacity to incorporate non-anthropocentric agency. Instead, let us consider modes of action as *traces of enactive, emergent, relational agency wherein the related agents co-construct each other*. We may trace connections of agents following the logic of ANT – wherever there are connections there is emergent, enactive, relational, co-constructive agency. However, there is a significant difference between the ANT logic (relational and co-constructive agency), and the proposed approach herein. The proposed approach must include and account for broader network theory, entanglement theory, object's lives, and contextual reading.

The appeal of modes of action is that they appear to be quantifiable measurable components performed in a linear mode toward a final outcome. This linear, recipe-like, approach can be depicted by the action-and-outcome sequences typical of a Use Type One or Two *chaîne opératoire* approach (Figure 42; Figure 43). Further simplified, the action-an-outcome sequences result in the following visualization wherein each action is performed

linearly, in isolation from the other, and composes the final outcome ("A" + "B" = "C") (Figure 44).

Figure 42. Action-and-outcome sequence of modes of action resulting in coil-built Larnax according to anthropocentric agency (after Georgel-Debedde Use Type One case study)

Figure 43. Action-and-outcome sequence resulting in wheel-fashioned vessel removed with string tool (after Choleva Use Type Two case study)

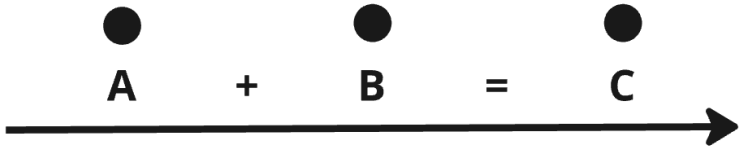


Figure 44. Action-and-outcome sequence simplified for visual representation. "A" and "B" represent individual actions while "C" represents the final outcome or object.

However, each technical fact must be understood to be part of a broad network, entangled, and contextual. Therefore, our "outcome" ("C") can be renamed as the "emergent becoming" of an object or process. This emergent becoming is not the outcome of a linear computation or action-and-outcome sequence. It is instead central to the observer in the present moment which is entangled with all traceable connections to other agents and modes of action through the process of becoming. Drawing inspiration from

physicists' visual concepts of Quantum Entanglement, we can visually represent this in the following figure utilizing an infinite loop to indicate entanglement in spacetime (Figure 45). The emergent becoming of an object "C" is co-constructed, relational, emergent, and enacted by modes of action "A" and "B". We may now revisit our example of using a string tool to remove a vessel from the wheel head by replacing the abstract set ("A", "B", and "C") with the entangled modes of action "grasping string tool" and "removing with string" (Figure 46). Each of the modes of action is entangled with the other.

While this example is simplified for the sake of clarity, this visualization can include all relevant modes of action. We achieve this by expanding or "zooming out" in spacetime to visualize additional modes of action in a process. In this instance, I draw on physicists' visual concepts of Loop Quantum Cosmology to visualize "grasping string tool" and "removing with string" as networks of entangled modes of action (nodes) resulting in the emergent becoming of the object (Figure 47). The nodes within each field are entangled with each other (as in Figure 45) as well as the fields themselves. Furthermore, all nodes and fields are entangled with the object becoming (Figure 48).

We must also note the limitations of using a 2-dimensional figure to represent a 4-dimensional phenomenon. As we will see in the forthcoming figures, there are nodes and networks which are side-by-side and connected through central elements. This is **not** intended to imply a sense of binary, linearity, symmetry, or a specific dimensionality. These nodes and networks exist in, and are made up of, 4-dimensional space and time. The nodes and networks could hypothetically be placed anywhere on the forthcoming pages, reversed, inverted, shuffled, or rotated and retain the same relationality and entanglement.

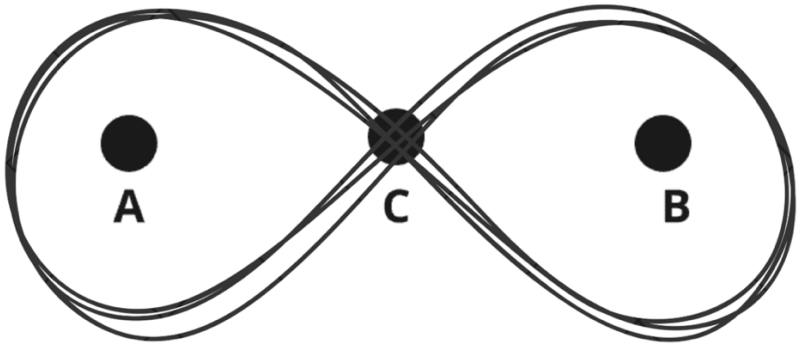


Figure 45. An infinite loop depicts modes of action "A" and "B" entangled in the emergent becoming of "C"

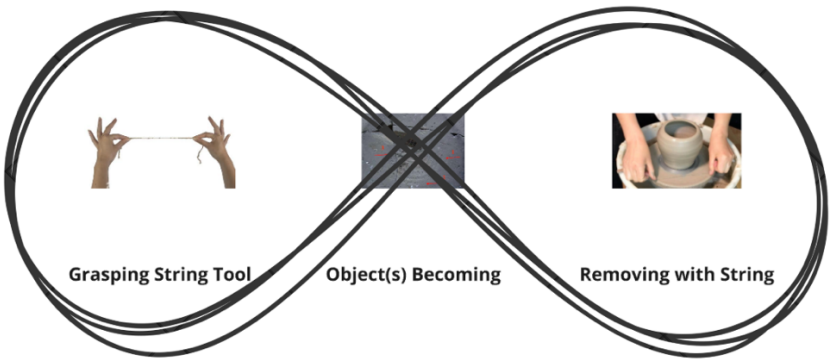


Figure 46. Using the example of removing a clay vessel from the wheel head, modes of action "grasping string tool" and "removing with string" are depicted on the left and right. These modes of action are entangled with each other and also with the central element - the emergent becoming of the object or action.

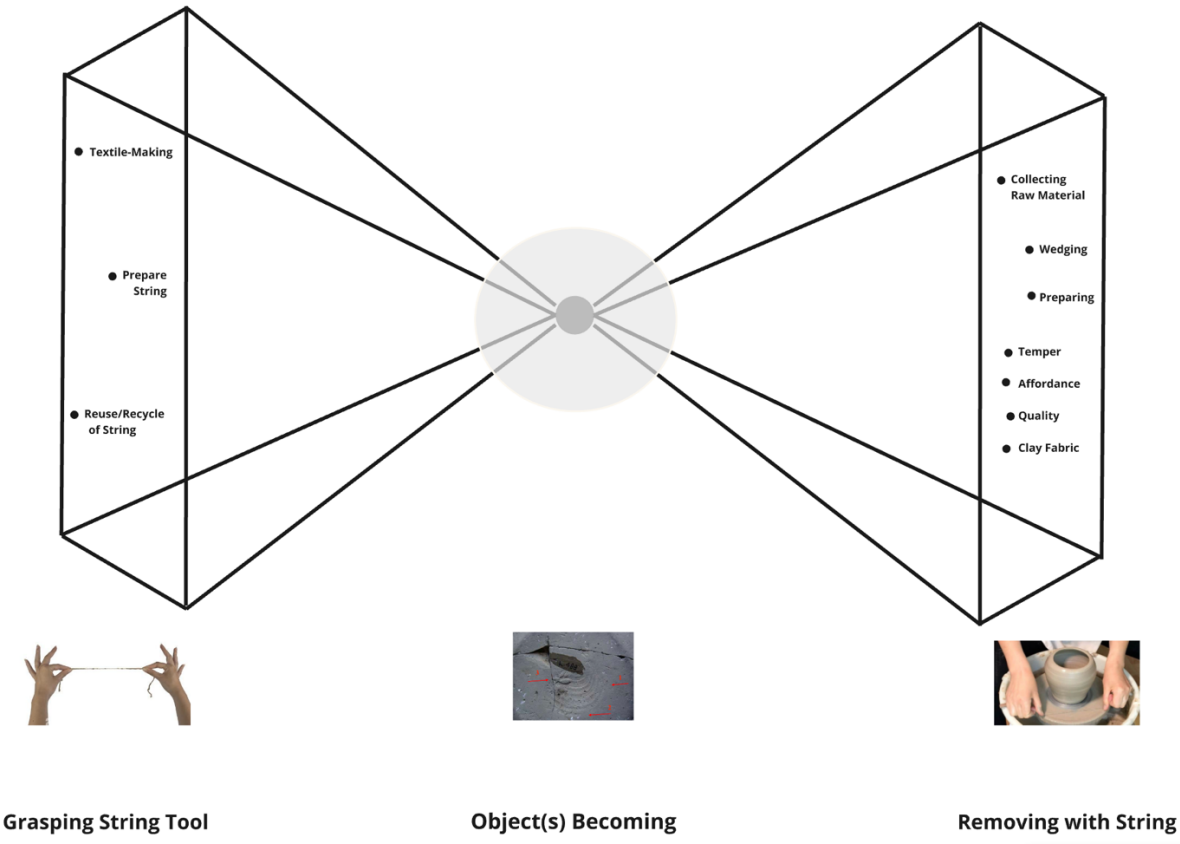


Figure 47. Entangled modes of action from the previous figure are expanded upon to represent a network of related modes of action which culminate in the emergent becoming of the object(s). This figure further develops the previous figure by incorporating additional modes of action (nodes) which are connected by way of entangled, emergent, relational, co-constructive agency.

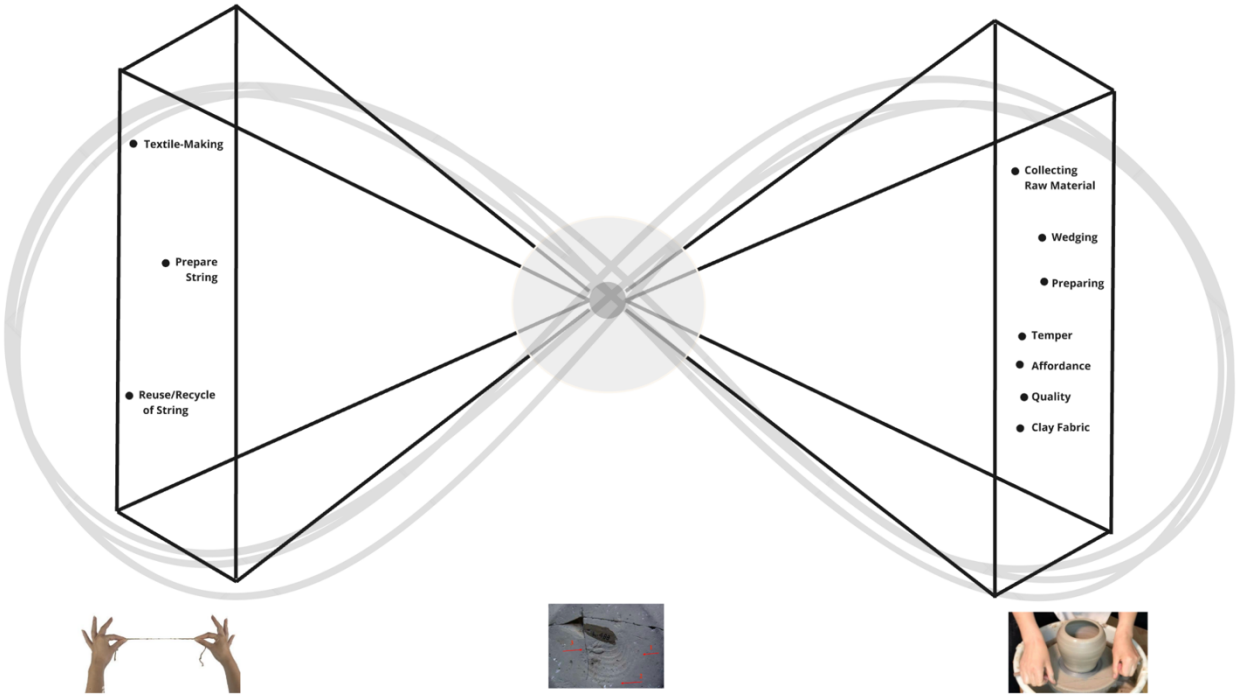
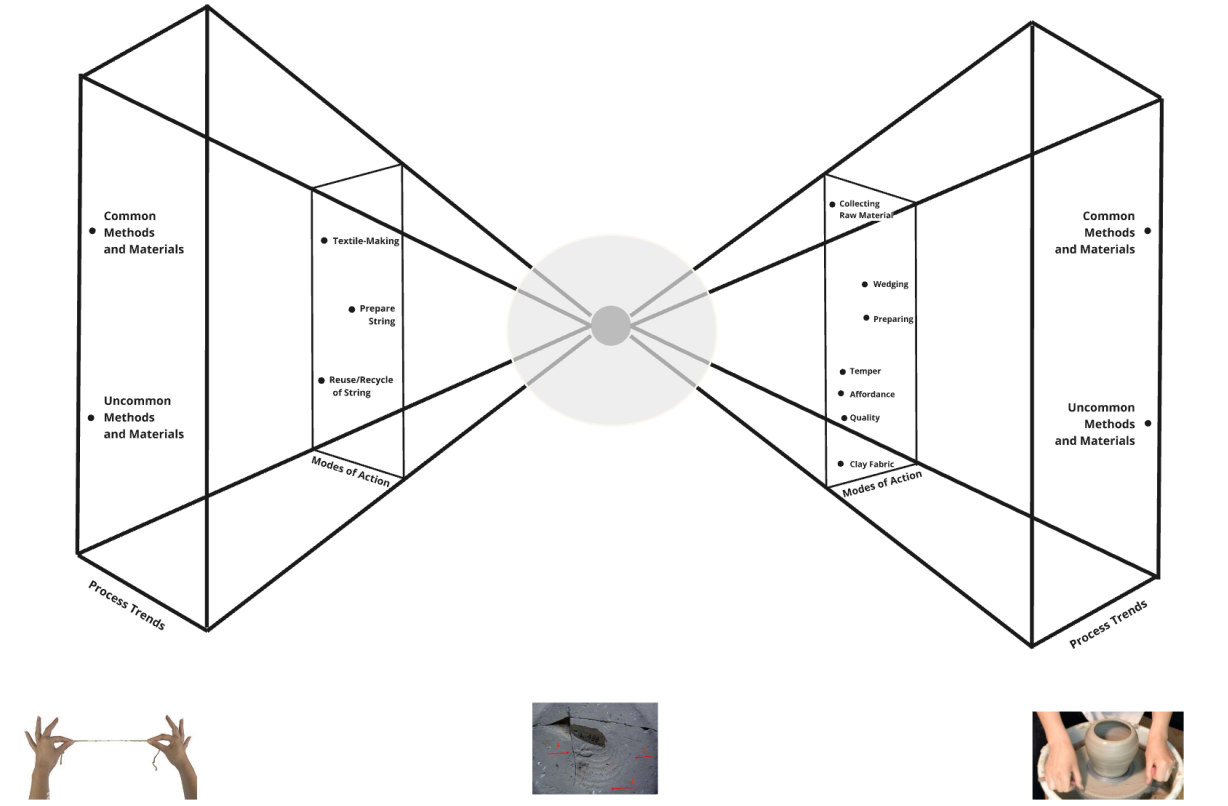


Figure 48. The infinite loop which represents entanglement is included to indicate the entanglement not only of the nodes but also the fields of modes of action.

3. Process trends

Additionally, each technical fact ought to be further recognized as a component of a broader phenomenon which is related to a group's proclivities for certain ways of doing (process trends). Through our Use Types we see process trends are viewed as patterns of modes of action, this data is gathered by broadening the scope of a study to incorporate additional temporal or spatial landscapes. This can include data which shows that over time large quantities of pottery are produced using similar methods. However, by interpreting process trends only in this way, unique objects or processes are eschewed as anomalies. These anomalies such as the "core method" should not be cast aside as they can actually speak to instances of resource scarcity or the adoption (or rejection) of new methods for example. Trends in the data are equally as important as anomalies. Process trends indicate the group's socio-technical elasticity (willingness to adopt or adapt). As such, uncommon methods and materials can be given equal weight as common methods and materials.

The figure below builds upon the network of modes of action previously illustrated by including process trends as additional entangled fields (Figure 49). In the figure we see common and uncommon methods and materials represented abstractly as nodes. In one's own study, these will indicate specific findings and there may be as many nodes as there are process trends. The nodes are entangled within each field of process trends, with the fields of modes of action, and with the object becoming (Figure 50). Finally, a group's process trends are informed by, and inform, their economies, resources, cultural and generational traditions, and cosmological beliefs (the group's *milieus*).



Grasping String Tool

Object(s) Becoming

Removing with String

Figure 49. Fields containing process trends are added to the process of the object becoming. Nodes are entangled with each other within fields as well as across all fields.

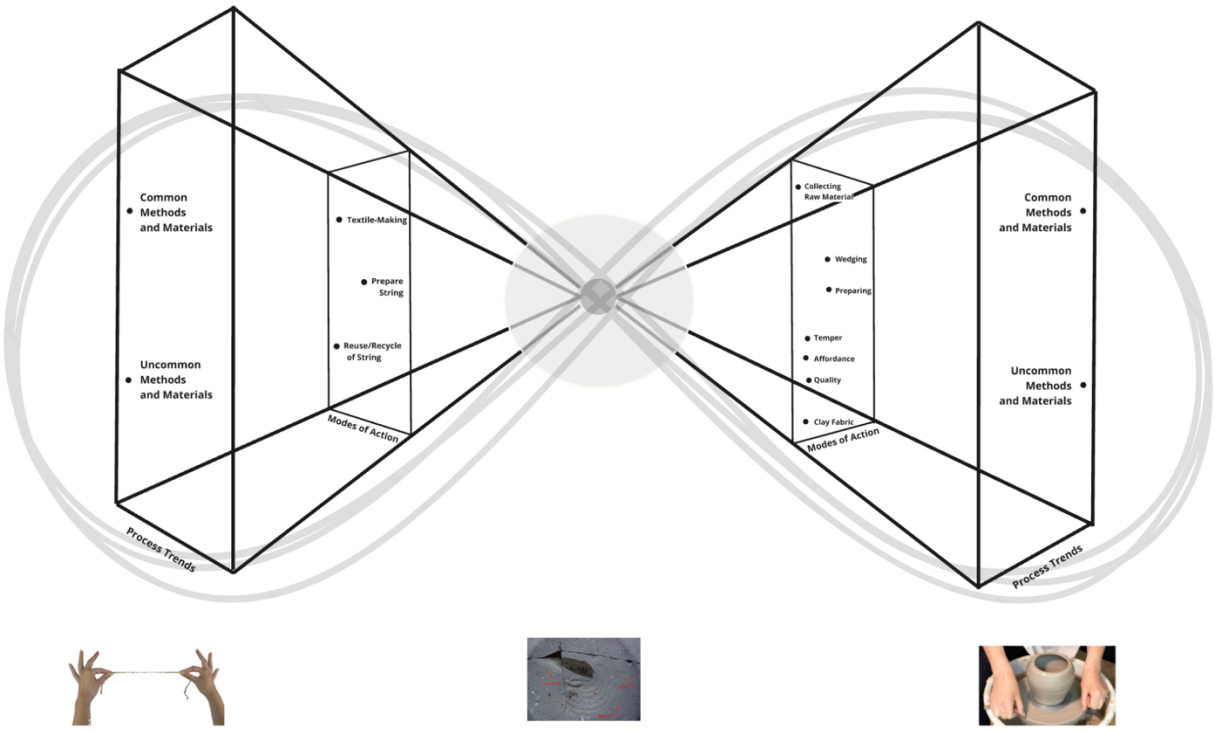


Figure 50. An infinite loop has been added to the figure representing process trends. The infinite loop emphasizes the entanglement of all nodes and fields in the emergent becoming of the object.

4. *Milieus*

Milieus affect, and are affected by, the interconnectedness of typologies (ecological network approach), modes of action (tracing enactive, emergent, relational agency), and process trends (which can include trends in modes of action, but also anomalies). There are three *milieus*: *milieu extérieur* (an all-encompassing term which includes the natural environment, material culture, and ideas of other groups of people); *milieu intérieur* (the overall intellectual capital of a group); and *milieu technique* (traditions and perpetuated modes of action, accumulated over time, continually evolving in response to things such as borrowing from other groups intellectual or physical, or external pressure such as resource scarcity) which is part of the *milieu intérieur*. The notion of *milieus* is another example of Leroi-Gourhan's forward thinking and equally an example of an aspect of the *chaîne opératoire* approach which is often excluded from the practical use of the framework. *Milieus* can be linked to many of the theories I draw on to reconsider the *chaîne opératoire* approach. These *milieus*

are essentially theoretical operators which connect, entangle, and enmesh the physical environment with objects, people, beliefs, traditions, skills, knowledge, resources, and more. Emphasizing *milieus* as a theoretical lens can help to encompass the phenomenon of *ways of being*, and in doing so can help to understand the phenomenon of *ways of doing*. Building upon modes of action and process trends, the *milieus* have been added to our figure representing the emergent becoming of an object (Figure 51). Some elements of the *milieus* may be directly related to one technical fact or technical tendency, as such they can be placed on the "side" of the figure related to it. However, we must remember that the figure has two sides only for the purpose of analysis. In the end, all elements are entangled through the phenomenon of the object becoming (Figure 52). Connections can be traced in any direction to isolate *chaînes* for investigation. In Figure 53, nodes (available data) are connected through the networks of *milieus,* process trends, and modes of action from the enaction of both "grasping string tool" and "removing with string" toward the emergent becoming of the object. The *chaîne* and the connections traced are subject to the interest of the study and the available data. While a *chaîne* is isolated, we retain the ability to acknowledge the broader network and phenomenon of making.

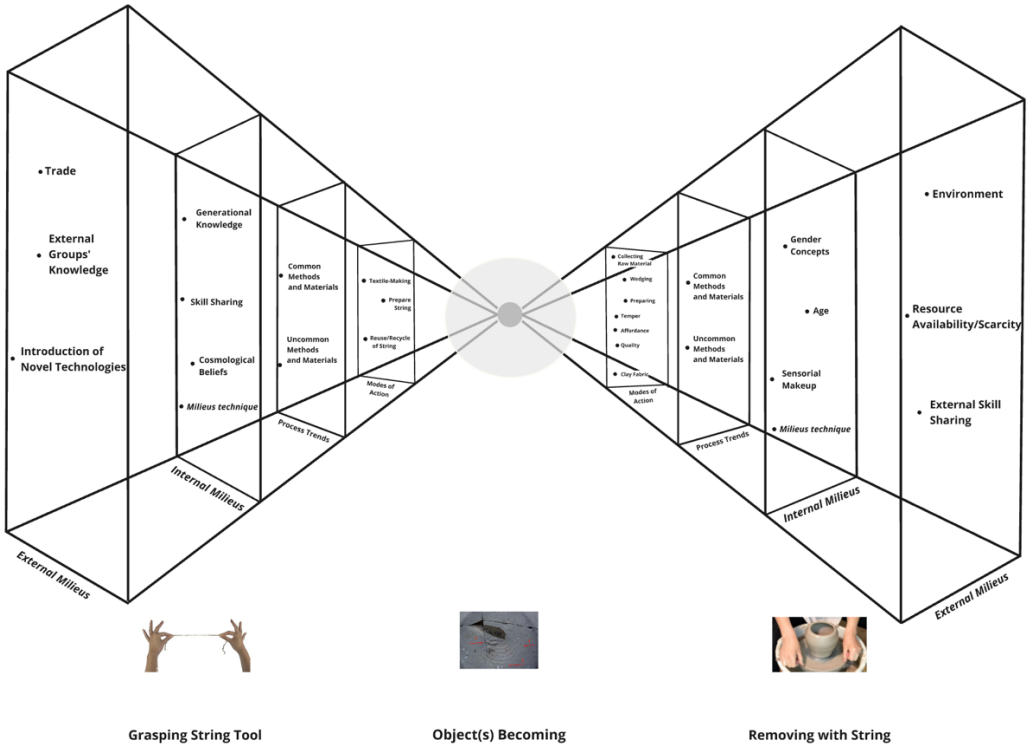


Figure 51. Internal and external *milieus* are added to the visual representation accounting for the emergent, enactive, relational, co-constructive agency of all entangled elements within the *milieus*.

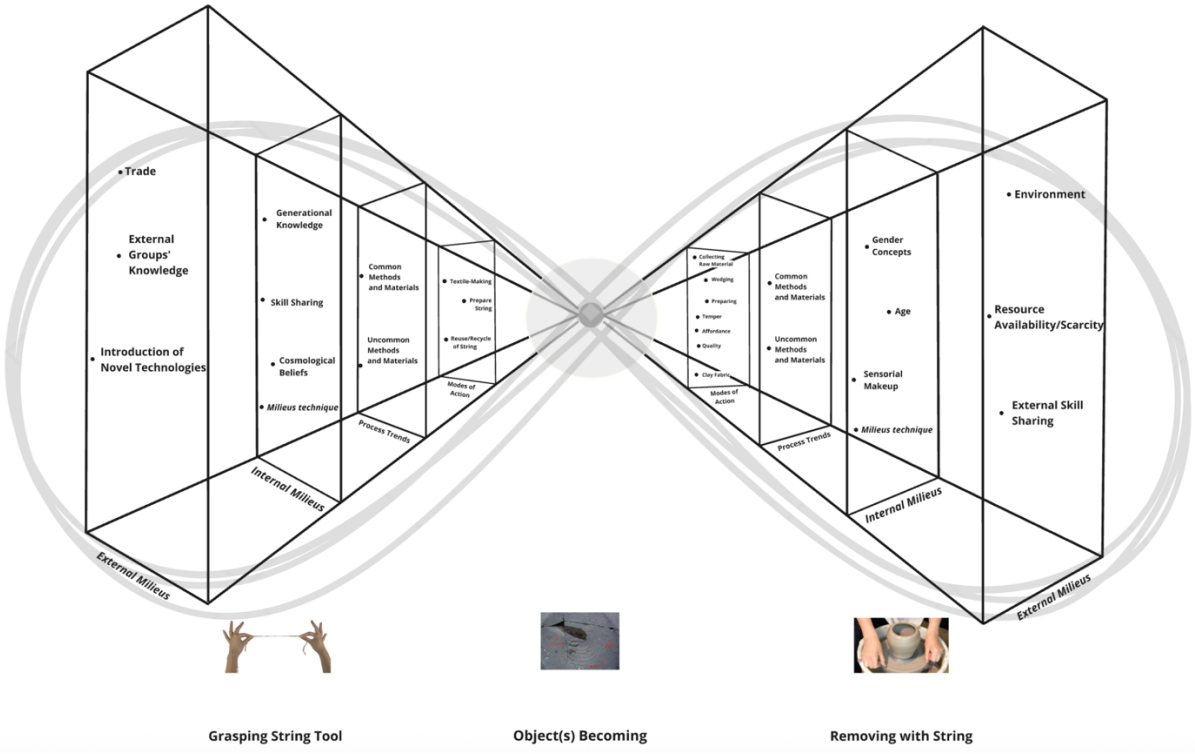


Figure 52. An infinite loop has been added to the previous figure. The infinite loop emphasizes the entanglement of all nodes and fields in the emergent becoming of the object.

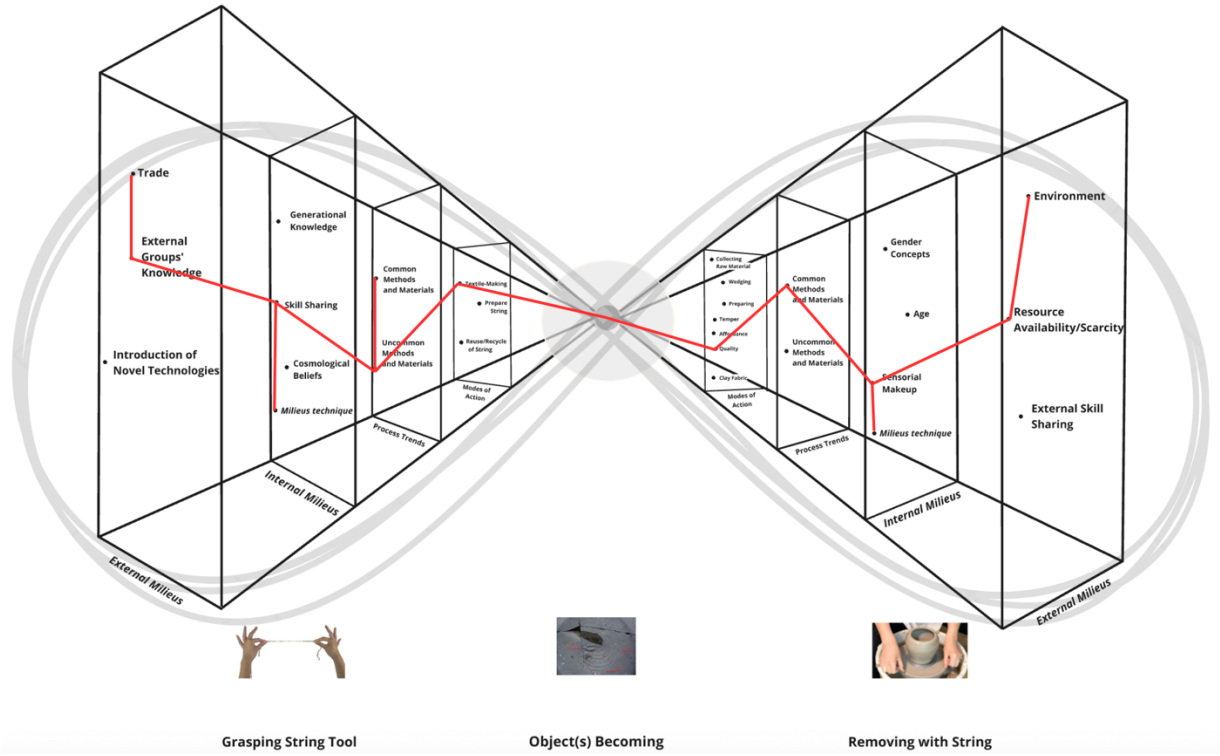


Figure 53. Connects between nodes are traced to isolate one *chaîne* within the network operatoire. This *chaîne* can be analyzed while acknowledging its place within the broader phenomenon of making.

Concluding remarks

When thinking about agency especially in the case of the *chaîne opératoire* approach it is important to consider the question at hand. For instance, if the study is regarding string markings on the base of a vessel, let the question be framed as "how did these marks *become*?" rather than "who or what made these marks?", and let the *chaîne* not be limited to the moments in time where the hand is engaged with the material. Framing the question this way allows the framework to unearth answers about the maker of the object, but also many more factors involved in the emergent becoming of the object. Framing the question is equally as important as the theoretical framework we use to answer it; my proposal for a network-informed *chaîne opératoire* approach is unique in that it does both. Using the string markings on the base of a vessel to illustrate the point again let us then ask, "how did these marks *become*?".

By adopting my theoretical reconsiderations, we begin tracing actor-actant connections as demonstrated in ANT Mediations 2-4 (Figure 31, Figure 32 Figure 34, Figure 35). Examining the connections via ANT's mediations supported by network theory broadly, typology, objects' lives,

contextual reading of objects, entanglement, and relationality, we uncover traceable connections that outline the *systemic context* of the archaeological find. These connections furthermore are based in, and account for, current emergent, enactive, relational, co-constructive theories of agency. Despite the material nature of *chaîne opératoire* studies, approaches retain an anthropocentric view of agency. *The chaîne opératoire* approach can benefit from my approach not only in terms of accommodating human and non-human actors alike, but it can also contribute to a wider discussion of what the *chaîne opératoire* approach is and how it is utilized. My proposal for a network-informed *chaîne opératoire* approach broadens the scope of the *chaîne opératoire* approach while accounting for emergent, enactive, relational, co-constructive, co-constructive agency.

CHAPTER SEVEN

MIND AND MATERIAL: COGNITION AND ARCHAEOLOGY

Introduction

An understanding of cognitive functionality plays a key role in analyzing phenomena such as the development of tools, symbols, numeric systems, and other key aspects of material culture. If the mind's capabilities for ideas, memory, and innovation are some of the major elements of our nature which make us unique, it must also be important to understand these phenomena in relation to material culture via archaeology. At the intersection of cognitive science, social science, and material culture studies lies cognitive archaeology. As Overmann eloquently puts it, "cognitive archaeology is the not-so-simple art of squeezing minds from stones" (Overmann and Coolidge 2019, 2). According to the APA Dictionary of Psychology cognition includes all forms of knowing and awareness, such as perceiving, conceiving, remembering, reasoning, judging, imagining, and problem solving. However, I do not ask "what" cognition is, but instead ask "where", "when" and "how" cognition is – in relation to material culture and *ways of doing*.

As mentioned in Chapter Four, *ways of doing* are intrinsically linked to *ways of thinking*. Answering these questions can make a significant contribution to archaeological studies, analysis of material culture, and to our understanding of human nature past and present. In light of contemporary cognitive theory, how does our understanding of the mind affect archaeological methodologies? The aim of this chapter is to understand contemporary cognitive theory in association with material culture. In order to answer these questions of "where", "when", and "how" cognition is, I will present an overview of the development of contemporary cognitive theory and methodology especially in relation to material culture. I will use the aforementioned questions as a guide to understand reoccurring themes and pervasive issues throughout the literature. In the following chapter the conversation is extended to explore how theories of cognition can impact the *chaîne opératoire* approach.

The mind inside the skull: the cognitivist model

Cognitive sciences are deeply connected to philosophical debates surrounding the nature of thought and of the mind. Questions about the nature of thought and of the mind begin as early as Socrates' Theory of Knowledge, Plato's Theory of Forms, and Aristotle's Concept of Mind. However, we may skip ahead to the 1640's when Descartes began addressing the *relation* between mind and body, language and thought, perception and objects. The Cartesian (after Descartes) approach proposes that the mind and body are entirely separate:

> "This point is likewise of the greatest moment, inasmuch as by this means a distinction is easily drawn between the things which pertain to mind— that is to say to the intellectual nature—and those which pertain to body." (Descartes 1993, 41)

Now, this is in part due to Descartes' view that the mind (or soul – he uses these interchangeably) is a "pure substance" which is immortal and can never be changed whereas the body is comprised of distinct components, formed by "accidents" and can change or perish (Descartes 1993, 42). Despite the fact that Western philosophers have moved beyond this reasoning, Descartes' work has been greatly influential. The Cartesian dualism of mind-body has persisted even into modern debates of cognition. In the modern Cartesian approach, the mind performs internal computations in the way that a computer does. According to the Cartesian approach (also called, and hereafter referred to as, the cognitivist approach) the mind functions by manipulating internal abstract representations. In other words the mind receives input from the external world and processes it internally by manipulating symbols that represent said features of the world (mental representation) (Varela et al. 1991). Additionally, processed information can be stored and drawn upon when the need arises in the future. This cognitivist approach places the mind firmly within the skull - all thoughts, processes, computations, and representations take place internally.

The framework used by such cognitivists, rational reconstruction, involves proposing each problem or computation as an abstract input-output map wherein the mind seeks the optimal solution (Clark 1997, 80). Transforming information (input and/or output) into symbols used in an equation-like process creates an image of the mind as a passive engine for computing, a disembodied pattern-recognizer and de-coder. In fairness, this model is suitable to some cognitive functions such as solving an algebraic equation, but it quickly falls apart when considering cases that involve things such as epistemic action. Epistemic action defines instances where cognitive

output is: (1) a physical action meant to discover new information or (2) a physical action meant to improve memory, reduce time spent, or reduce probability of error (Kirsh and Maglio 1994, 514). Epistemic actions happen outside or through the body and contribute to the successful completion of a problem (Kirsh and Maglio 1994). Some examples might include leaving a key in a shoe to remind oneself to lock a door, pre-sorting nuts and bolts before an assembly project, or scouting unfamiliar terrain prior to a camping trip (Kirsh and Maglio 1994, 515).

The existence of epistemic action is one example of a cognitive function which proves that not all cognitive functions take place internally as abstract computations. There are three main obstacles which appear in the use of rational reconstruction: (1) the replacement of physical quantities or things with symbols can obstruct opportunities to exploit the physical world as a tool for problem-solving, (2) conceptualizing a problem in terms of input-output mapping invites a view of cognitive processes as *passive computation*, and cannot accommodate situations as mentioned previously wherein the output involves epistemic action, and (3) that simplifying information into symbols to search for an optimal solution does not account for, or can obscure, the role of history in solving the same or similar problems. As Clark states, "new cognitive garments seldom are made of whole cloth; usually they comprise hastily tailored amendments to old structures and strategies" (Clark 1997, 81).

When we look closely at the real-world behaviors of planning agents, it is clear that there is a complex interplay between perception, planning, action, and the surrounding environment. In some cases, a mental blueprint is partial and problem-solving or carrying out this partial plan is dependent on the local environment. It's also important to note that in many cases problem-solving requires re-thinking and re-planning. Instead of cognitivist models, a multi-factor, decentralized, approach to cognition is needed. This is not to say that cognition has zero computational activity. Instead, there is a complex interplay of multiple forces through which the brain is embodied and emerges: bodily, mechanical, some fully external, and some internal. To be sure, the brain (the organ) is constrained by the nature of the evolutionary process, and it must create new solutions and form adaptive strategies on the basic existing cognitive functionality and resources. However, the *mind* (ways of thinking) is empowered by its ecological surroundings which allows us to exploit other agents, actively seek input, manipulate computational tasks, and offload acquired information into the world.

More radical phenomenological approaches to the mind had gained traction before cognitive sciences moved to the West and were taken up in the American schools where cognitivism was

favored for much of the 20th century. Now cognitive sciences are revisiting those earlier and more radical philosophical approaches to the mind such as Merleau-Ponty's work which emphasizes the human experience, or ways of human *being* (Merleau-Ponty 1963; 2002). In order to explore the mind from a phenomenological perspective, including the brain, body, and environment, we will explore a number of theories and methodological applications to highlight their potential within archaeological studies.

The mind beyond the skull: embodied, embedded, extended, and enactive cognition

If the mind is not inside the skull, then where is it? The brain (the organ) obviously remains within the skull. However, we have determined that the mind (cognition or ways of thinking) is a multi-factor decentralized process which also involves the local environment. In a sense then, the location of the mind depends on the context of the cognitive process in question. A better question than *where* is the mind, may be *how* is the mind? The answer to this question is complex and there are numerous approaches to consider. To support my development of the *chaîne opératoire* approach I combine cognitive, anthropological, and ethnographic approaches with additional influence from feminist theory and theoretical physics. The forthcoming sections on embodied, embedded, extended, and enactive cognition in addition to the aforementioned approaches represent a philosophical school which is complemented by the 'Sensory Turn', an anthropological approach which I draw on to support my hypotheses.

The Sensory Turn attempts to reconcile the dynamic, emergent, phenomenological relationship between people and the world around them (Howes 1991). This Sensory Turn can be described as a departure from the five-sense structure relied upon by scholars of the Euro-American persuasion. Through the Sensory Turn it is emphasized that the five-sense structure is historically and culturally specific to Western philosophy (Howes 1991; Stoller 1989). While the scholars who played a role in the Sensory Turn do not explicitly engage with the embodied, embedded, extended, and enacted theories of cognition, their work can support these theories. Where culture is implied in the enactive cognitive approaches, sensory anthropology addresses the notion of culture directly. Rather than dissecting the question of *where* the mind is and how it works, the sensory anthropological approach emphasizes the ways of *being in the world*. Within this anthropological approach there is no distinction between mind and body. Furthermore, there is a move away from the computational results-based analysis of cognitivist works. From here we can begin to explore a

few of these dynamic, emergent, phenomenological approaches to the mind and ways of *being in the world*.

Embodied

The embodied mind approach to cognitive science is sometimes cited as an origin of the movement toward a number of subsects of current cognitive theory including: embedded cognition, extended mind, enaction, grounded cognition, situated cognition, nonrepresentational cognition, emergent cognition, and others (Varela et al. 1991). But first, how is the mind embodied? The term is meant to underline the very simple fact that cognition is affected by being in a body and by functioning as a part of human *being* (Csordas 1990; 1994; Overmann and Coolidge 2019).

Gallagher (2005) argues that the cognitivist model will always be overly simplified no matter how complex the model may become, because the cognitivist model plainly disregards or cannot accommodate the non-conscious acts which directly precede conscious acts (prenoetic acts). These prenoetic acts are the effects of embodiment. The existence of these prenoetic acts underscore that the mind is affected by being in a body and by functioning as part of human *being*. In other words, "the body shapes the mind" (Gallagher 2005). Additionally, some argue that cognitive processes can be strongly or weakly embodied based on their constitution of, or dependence on, extracranial and/or extrabodily processes (Newen, Albert and De Bruin, Leon and Gallagher, Shaun 2018). Extracranial processes can be understood as strong or weak, and can be categorized in two ways: (1) involving a brain-body unit, or (2) involving a brain-body-environment unit (Newen, Albert and De Bruin, Leon and Gallagher, Shaun 2018).

Clark (2008) describes two strands of embodiment theory which parallel these two characterizations of extracranial processes. The first which parallels the aforementioned brain-body unit in which the body is seen as "intrinsically special, and the details of a creature's embodiment as a major and abiding constraint on the nature of its mind: a kind of new-wave body-centrism…". The second theory, which parallels the aforementioned brain-body-environment thread, sees the body as "one element in a kind of equal-partners dance between brain, body and world…" (Clark 1997, 56). Clark argues, and I agree, that the second theory ought to be favored. We should consider that the body plays one part in an ecology of the mind which includes neural, bodily, and environmental resources. And furthermore that while the body plays a special role in determining the balance of these three elements at any given time, it should not be separated or considered

central (Clark 2008). I would add that culture also plays an integral role in the ecology of the mind – more on that in the forthcoming discussion. In other words, the body acts "as a bridge enabling biological intelligence and the wider world" to cooperate toward the goal of adaptive success (Clark 2008, 57). The image of a bridge is misleading as it connects two points along a linear path. Not only is the embodied mind a bridge from one point to another, the embodied mind is deeply entangled and embedded in its environment (Wheeler 2011a). I suggest considering a network in which each physical entity or abstract notion can be infinitesimally interconnected. Before moving on to discuss embedded cognition I feel it's necessary to make a quick digression here to consider the role of dualities and bias in the philosophical background of these theories of the mind.

The problem of dualities

We have seen with cognitivism and embodiment the problem of dualities. This problem of dualities is pervasive throughout the literature (it will arise also in the forthcoming sections regarding embedded, extended, and enactive cognition). Merleau-Ponty's theory of perception encounters the duality of subject-object whereas Bourdieu's theory of practice encounters the duality of structure-practice; both engage with embodiment as a framework for collapsing these dualities. Ingold warns however that simply inserting the word "embodied" before a certain topic in question cannot unequivocally erase the "specter of binary thinking" (Ingold 2023, 100). Ingold goes on to say that although the dualism between the two concepts still exists regardless of the term embodied, it can alleviate the vast schism between the two (Ingold 2023). I suggest therefore that the reader view embodied cognition as a paradigm shift which is meant on the one hand to remind us of this duality, and on the other hand to use it as an aid to consider what can be beyond this duality. I argue therefore that embodiment should be considered as only one part of a multipart phenomenon including embedded, extended, and enactive cognition which will be discussed in the forthcoming pages. But is this idea of embodiment novel? Or is it a way to describe and circumvent a Euro-American philosophical duality that may not exist within other sociocultural groups? Have Western scholars toiled for decades to provide an answer to a question which does not exist within, nor occur to, other groups?

For example, the Anlo-Ewe-speaking people in West Africa already possess the sensibility, naturally or unconsciously, that being a human *being* is a synesthetic, round, emergent, and experiential state (Geurts 2003). While the Sensory Turn may represent a reflective awareness of the

five-sense bias of Euro-American scholars, we must be careful not to reject the importance of senses altogether. According to Geurts (2003), many individuals from the Anlo-Ewe-speaking group were not aware of any delineated system of senses, nor were the senses (when asked to describe them) limited to that of five-sense system of the Euro-American tradition (sight, sound, touch, smell, taste). However, when asked what senses make humans human, members of the Anlo-Ewe-speaking people offered balance as an example of a sense. Balance is a sense the Anlo-Ewe-speaking people teach their babies to practice as an essential part of being human.

I mention this to exemplify the fact that many questions, problems, and concepts in cognitive science have been created and introduced by adult male Euro-American scientists. Furthermore, either they are based on a five-sense system that we claim make us human, or they turn away from the five-sense system altogether while neglecting to ask – does this group or person have a unique sensorial makeup which may affect their sensorial ontology? The senses affect our cognition, perception, and interaction with the world around us. A group's sensorial makeup influences the ways in which their bodies "hold and manifest a historical residue of personal and cultural habits and the ways they represent (in language and in folkloric motifs) everyday experiences"(Geurts 2003, 5). So maybe we should not trade in a five-sense sensory approach for a relational phenomenological approach neglecting the senses altogether. It may be productive instead to work to understand the unique sensorial makeup of a group or person before drawing conclusions about their way of *being in the world*. We will see that a generalized phenomenological approach does not account for differing cultural sensory makeups and, moreover, it can be argued that these relational approaches remain biased by potentially neglecting a group's sensorial ontology altogether.

A second example of embodiment proves that this Euro-American view of cognition and embodiment is quite simply *not* universal. Various groups of people understand embodiment not only in the sense of their own bodies, but also of materials embodied by energies or spirits. For instance, the Kayapo (indigenous to modern-day Brazil) practice an ideology in which ideas of bodiliness are founded on the notion that embodiment occurs within the relationship between bodies, things, and energies (Mascia-Lees 2011, 103). Here we see that agency and cognition are inherently entangled as ways of doing, thinking, and being are co-constructive. It has been my aim thus far to disentangle these concepts of agency and cognition and to present them separately for the sake of clarity. However, we later consider them as I argue they ought to be considered – as entangled elements of human *being*. Returning to the example of the Kayapo people, we see that embodied cognition is related to embodied agency. Their ways of thinking are guided by patterns of

activity (ways of doing) which are affected by the objects and forms in the environment, which they furthermore believe to have spiritual agency. The term "karon" is used by this group, which is understood equally as image, form, shadow, spirit, soul, or ghost of a person or other entity. The Kayapo understand themselves and their bodies to be affected by karon, but also other mammals, birds, fish, many trees, vines, plants, ghosts of the dead, and other inanimate forms or objects also possess karon.

The term "animism" (a term used by Western researchers) refers to the idea that spirit essentially guides people, it is the animating force, and intentional goal, of the developmental process of the bodies (animate and inanimate) in which it is produced (Mascia-Lees 2011, 103). Animism is a spiritual property which is shared and embodied within the relationship between bodies, objects, and spirits which is common to many peoples indigenous to the Amazon (Bird-David 1999; Descola 1994; 2014). Through animism, embodiment is not only confined to the person or persons and their ways of thinking but also extended to the connections that body may have with other *embodied things* which affect their ways of thinking and doing. In the case of the Kayapo, the body should not be considered as a mere container for the spirit or karon (reproducing a sense dualism). Instead, the body is a relational space. Furthermore, adornment and body modification can be understood as ways of thinking about and interacting with their cosmological views, sense of bodiliness, and also the wider "social body" which includes other forms, spirits, practices, identity, the cosmos, and so on (Mascia-Lees 2011, 104). In the case of the Kayapo, the body is the product of the *interaction* between and through inner powers and senses of the body, modes of knowledge, capacity for growth and activity, *and* the external world of things, social relations, and activities (Mascia-Lees 2011, 105).

This study of the Kayapo reiterates the importance of ethnography: the Euro-American senses and ideologies of duality are not universally applicable. In fact, if we return briefly to Mauss, we see that he defines techniques as *effective* and *traditional* (Mauss 1934, 75). He describes techniques as inherently entangled with not only the body but also the mind and tradition (practices, beliefs, values) (Mauss 1934). He offers, as an example, the relations between magical procedures and hunting techniques which are "too universal to need stressing" (Mauss 1934, 75). This link between magic and techniques is also found in Mauss' work *On Prayer* in which he attempts to understand the role of prayer (through the lens of anthropology, sociology, psychology, philology, and theology) in the practices of non-Western people (Mauss 2008). Additionally, we recall Mauss' definition of technical actions as both socially and historically context dependent. The *habitus* of a

people is formed through the ways of thinking and doing within the world around them – informed by norms, values, and behaviors which are internalized as a way of *being* which is common to a group (Bourdieu 1977). This *habitus* affects, and is affected by, not only cognition and the body (embodied cognition), but also by the relationships between the body, mind, objects, forms, magic, spirits, and more.

Western ideologies which define the dualities of mind-body and body-thing, do not apply in many cases and ethnography (or sensory archaeology/anthropology) must be carried out with an awareness of these biases (Pink 2015). Even in carrying out sensorial archaeologies, the work "cannot be done without a self-reflexive awareness of multisensorial elements in every experience of modern archaeology and the imagined past" (Tringham and Danis 2020, 1). By mentioning these examples of non-Western groups whose cognition affects, and is affected by, their sensorial makeup, cosmological views, practices, objects, magic, ghosts, and so on I hope to underline that embodied cognition, and cognition more generally, cannot be understood solely through a Euro-American lens. It is important to consider our own biases in research broadly, but especially when working to understand a group's ways of thinking, ways of doing, and their sense of being.

Biased embodiment: which bodies are writing *about* which bodies *for* which bodies?

A question which has arisen during my excavation of relational cognitive approaches, especially embodiment, is about bias. Is embodiment biased? Many (not all) of the cognitive studies relied upon in this chapter are written by cishet white men of a certain background who have had certain sociocultural upbringings. We can classify these researchers as **W**estern, **E**ducated, **I**ndustrialized, **R**ich, and **D**emocratic (WEIRD) (Muthukrishna et al. 2020). These WEIRD scientists perform studies involving WEIRD people, finding truths which are mainly applicable to WEIRD people. Sometimes the narrowness of the study is acknowledged, although often these WEIRD studies sidestep the issue by insisting that they write about generalized bodies in generalized spaces, *in general* (e.g., Baumard and Sperber 2010). While this may be an attempt toward inclusivity, at times it has the opposite effect. Given the example of the Anlo-Ewe-speaking people and their sensorial differences to Euro-American senses, I wonder also about how studies may produce different results based also on how senses are heightened or dulled in specific contexts.

If the senses, as we have said, make up the ways in which people's bodies hold and manifest personal and cultural experiences, this notion of embodiment must be vastly different across many

groups and contexts. It is relatively easy to acknowledge that a group in West Africa will have a different experience than a group in America. However, equally important are the various nuances within and throughout communities. Varying contexts may influence the sensorial experience of a person and therefore the cognitive experience. Not only are senses gendered (consider the male gaze for example), they are also racialized and modulated by class (Howes 2022). Large abstract ideas such as gender, politics, race, and religion, among other things, can affect the structure or engagement with the sensory makeup of a person or group, and therefore their embodiment.

Consider how women are systematically expected to endure more pain in medical procedures than men are, especially black women. For example, women experiencing heart attacks are more likely to be misdiagnosed because of factors related to sensorial expectation or exploitation of women in male-dominated research (Jaclyn Carberry 2023). "Widening racial and ethnic gaps in health, and gender-related differences in biomarker analyses contribute to the incongruency of diagnosis and medical coding of [heart disease], leading to unnecessary costs and death" (Hilliard et al. 2020). Women's sensorial and cultural experience of pain is entirely different than other groups of people. Furthermore, ethnographic studies have illustrated quite clearly that:

> "…the agency of gender is inscribed onto the material world of resources and power, thereby affording certain individuals control of the objects produced, control of the technologies and technicians involved, control of the value systems that regulate the status of gendered technicians, and control of both esoteric and practical knowledge" (Dobres 1999, 129).

The point Dobres makes about gender, agency, and cognition is imperative to consider as we discuss cognitive theories especially in relation to agency. The way that minds are embodied, and that bodies have access to information, is intrinsically linked to a culture's value systems and gender ideologies. In many cases, gender plays a significant role in a groups' ways of thinking. This is NOT to say that cognitive abilities are affected by gender or biological makeup. What I am underlining here is that the way in which a mind is embodied is affected by the type of body, the physical space it exists in, and the ontological context it exists in (i.e., how that body is socially understood or constructed via political, racial, and gender ideologies).

I have strayed slightly to make a very important point. The embodiment of a generalized body in a generalized space (as per the relational phenomenological approach) is vastly different than the

embodiment of a female body in a male space, or a black body in a white space, or a trans body in a cishet space, or an impoverished body lacking basic necessities in *any* space. We cannot lump together the aforementioned bodies in spaces with a male body in a male space. Specifically, we cannot lump together unique groups and their embodiment with the embodiment of white cishet men in a world wherein they hold the most power, safety, and security in both the physical and abstract sense. These generalizations can ultimately cause harm as seen in the statistics of misdiagnosed heart attacks especially in black women. Power dynamics, gender, politics, and race play deeply into the way that a body is embodied through its senses and environment, and the way that cognition is affected by being in that body. We cannot take for granted that many studies of embodied cognition rely on generalized bodies in generalized spaces studied by WEIRD white male scientists.

Embedded

Embedded cognitive theory, part of the family of extended cognitive theories, proposes that cognitive processes are entangled with, and dependent on, the bodily actions within the environment (Kiverstein 2020). This indicates that while cognition is affected by being in a body, it is also affected by being situated in an environment (Malafouris and Renfrew 2010). We now turn to environmental and ecological affordances. Gallagher's enactive coupling which involves both neural and non-neural factors that affect each other in an ongoing way while engaged can be used to highlight the ways in which cognition can be embedded and drawn upon or enacted through the environment (Gallagher 2013). The question here is *how* is the mind and, more specifically in this case, what counts as part of the workings of the mind? Let us consider the Parity Principle:

> "If, as we confront some task, a part of the world functions as a process which, were it to go on in the head, we would have no hesitation in accepting as part of the cognitive process, then that part of the world is (for that time) part of the cognitive process" (Clark and Chalmers 1998, 8).

This notion was quite a leap forward in 1998 though it is now seen as a conservative interpretation of embedded cognition. The Parity Principle essentially outlines that if there is a functional equality between internal and external elements, and if the internal element in question already qualifies as

part of a cognitive process (according to the cognitivist approach), then the external element should be granted the same status – it is part of the cognitive process. According to the Parity Principle, the mind remains computational, and cognitive processes are carried out via symbolic representation inside of the brain, while also sometimes relying on the environment which is engaged by the body (Adams and Aizawa 2001; Rupert 2009).

There is an issue which arises though; what about contexts where a part of the world plays a role in our cognitive process but *is not* something which could also occur "in the head"? Is it not part of the cognitive process? This problem is the point which separates a conservative interpretation of embedded cognition from a liberal understanding of it. It can be argued that the embodied approach does not resolve the mind-body duality problem but instead expands the ontological boundaries resulting in a sort of embodied cognitivism wherein the material remains external and "epiphenomenal to the cognitive structure" (Malafouris 2013, 65).

A more liberal reading of the embedded cognition theory suggests that cognitive processes are entangled with bodily actions within the environment even if the processes do not mimic symbolic representational cognitivist processes inside the mind; this leads us to extended cognition. If the mind is embodied (affected by being in a body and by being a part of human *being*), then is it also by proxy affected by the environment in which the body exists from moment to moment, even if some of these factors are not equivalent to internal cognitive processes? And if the embodied mind is affected by the environment (embedded), is the environment itself not a partial constituent of the mind? This is the philosophical leap necessary to depart from a conservative interpretation of embedded cognition and to turn toward a more radical interpretation. The extended mind approach is the rather radical interpretation of this question. This extended mind approach advocates that when the environment is engaged with, it does in fact constitute part of the cognitive process, regardless of any equivalency with internal cognitive processes.

Clark and Chalmers did argue the case for a sort of extended cognition (active externalism) in 1998, however this proposal was based on the Parity Principle and therefore is nearly the same as a conservative reading of embedded cognition (Clark and Chalmers 1998). The Parity Principle demonstrates a coupled system, which according to the case for active externalism, is a system which links the human mind with an external entity. Were the external function to be changed or eliminated, the overall cognitive process would diminish or become non-functional. By this explanation, "the brain is empowered by the availability of a real-world arena that allows us to exploit other agents, actively seek inputs, to transform out computational tasks, and to offload acquired

knowledge into the world" (Clark 1997, 88). However, the Parity Principle simply allows for physical input into a nevertheless computational, input-output, cognitivist, system for cognitive processes (Adams and Aizawa 2001; Rupert 2009; Wheeler 2011b).We should not mistake active externalism for extended cognition.

Extended

Extended cognition makes two major claims: (1) what is outside the brain is not necessarily outside the mind, and (2) cognition is not only a matter of internal representation (Malafouris 2013, 66). Within the extended mind theory there are debates regarding the limitations of the mind and further disagreement about how to define extended cognitive processes. Conservative views of extended cognition engage with this theory in terms of functional properties of cognition. In this way cognitive processes are still essentially computational in nature although through extended cognitive processes the mind can draw "input" from the physical world (Wheeler 2011a; Kiverstein 2020). By positioning the theory in this way, the mind is still Cartesian by nature – the mind is inside the skull and follows an input-output style of computation. Moreover, this parallels a conservative reading of embedded cognition. A liberal reading of extended cognition, "active externalism", receives the criticism that extended and internal cognitive processes cannot be functionally equivalent (Kiverstein 2020). This need not be the case. Insisting on a hierarchy of elements seems rather short-sighted, and an attempt to cling to Western positivist scientific reasoning.

From a Material Engagement Theory (MET) perspective, cognition is not about what happens inside or outside of the brain; it draws on a relational and emergent approach to conclude that a cognitive process is what happens *between* a mind and a thing (Malafouris 2013, 67). There is no hierarchy of elements in MET. Taking the MET approach, we think *through* and *with* things. Considering objects' materiality and affordances in the Gibsonian sense, objects can be equally cognitively affectatious as people. What I consider to be so poignant about MET is that through Malafouris' approach, the unit of analysis is broadened significantly to encompass interactions among, between, and through people, artifacts, space, and time (Malafouris 2013, 67). Malafouris also expands upon this stating that people are STRANGE; by this he means that brains, bodies, and things co-construct each other in flow through **S**ituated, **TRAN**sactional, **Ge**nesis (Malafouris 2024).

Gallagher (2013) also broadens the boundaries of the extended mind theory specifically in relation to the immaterial - the socially extended mind. For the socially extended mind, cognition

should move beyond physical environmental elements to include social affordances and enactive processes. This includes social interactions with others but also ways that involve institutional structures, norms, and practices. Some protest this concept arguing that if cognition extends to all processes, there is no limitation and therefore must result in "cognitive bloat" (Rupert 2004). Gallagher's response, which I find persuasive, is that for social affordances to be considered constituents of a cognitive process, they must be actively engaged. This is further defined as an enactive coupling: an enactive coupling involves both neural and non-neural factors that affect each other in an ongoing way while engaged or cognitively activated (Gallagher 2013). While this may sound similar to the Parity Principle, it differs in the fact that there is no equivalency or dependency on a cognitivist model of internal processing. In fact, through embodied cognition, extended cognition, MET, and the socially extended mind one thing remains the same: wherever we find cases of extended cognitive processes, the agent and its environment are only treated separately as a matter of convenience - in actuality they are so closely integrated they should be considered instead as a single extended "brain-body-world system" (Silberstein and Chemero 2012).

Enactive

Enactive cognition puts the previous three cognitive theories into action. Our world is constantly moving, as are we, and it follows that the ways that we interact with the world are therefore taking place not in a static vacuum, but through engagement and in motion. The enactive approach emphasizes the dynamic interactions between and through the brain, the body, and the environment in cognitive processes. Furthermore, the dynamics of action and the interplay of emergent relational agency bring forth the notion that thinking is not internal, static, or representational but in fact thinking *is* doing. According to Malafouris' Material Engagement Theory and subsequent work on enactive cognition, humans are not such much *thinkers* as we are *thingers* – we think through and with things (Malafouris 2014; 2019; Malafouris and Röhricht 2024; Alessandroni et al. 2024). Enactive cognition is best described as "the enactment of a world and mind on the basis of a history of the variety of actions that a being in the world performs" (Varela et al. 1991, 9).

The enactive approach is made up of two key hypotheses: (1) perception consists in perceptually guided action and (2) cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided. With the enactive view, the mind is part of an embodied, embedded, and extended system which takes place *in action* in time and space. Enactive

cognition is furthermore a way to describe engagement with the world through which we are able "to solve problems, control behavior, understand, judge, explain, and generally do certain kinds of things – much of that constitutionally shaped by tools, environmental factors, social practices, etc." (Gallagher 2013, 8; 2017). Enactive cognition attempts to resolve the dualities of cognitive theory (mind-body, mind-environment, environment-mind) by introducing a phenomenological approach which takes the lived body as an entangled and emergent system wherein "cognition and action arise together, dialectically forming each other" (Malafouris 2013, 74). I would reiterate though that the lived body should not assume a generalized form but should be considered in relation to the social constructs in which it exists (sensorial makeup, material affordances, and embodied sociocultural systems such as power dynamics, gender, race, politics, division of labor, and so on).

Scalable and applicable culturally grounded models of cognition

Turning away from WEIRD cognitive science, and away from the Euro-American five-sense model, without neglecting the anthropology of culturally unique senses, Geurts follows the tradition of phenomenological anthropology with central themes of embodiment and orientation (Geurts 2003). Her work is prompted by an effort "to excavate the sensory order of a cultural community, because in the first instance [she believes] that sensing cannot be understood or defined in any universal way, but involves cultural variation" (Geurts 2003, 29). Geurts offers an approach rooted in cultural psychology and cultural phenomenology in an effort to produce a framework for reconciling the sensorial experience of being human with culturally specific notions of personhood, identity, and meaning-making grounded in the interrelational nature of the embodied experience, thought, feeling and cultural-psychological orientations. Her ultimate claims are: (1) sensory structures differ based on cultural traditions and therefore a group's sensorial makeup is unique from one culture to the next; furthermore, (2) a group's sensorial makeup also encodes moral values in child socialization therefore embodied senses are learned, acquired, and developed at an early age; (3) sensorial makeup shapes notions of identity; (4) sensorial makeup also shapes the understandings and experiences of people (Geurts 2003). In other words, a group's sensorial makeup affects, and is affected by, their cultural values which they literally carry in their bodies which in turn effects the mind-body-world experience.

Geurts' approach involves the established embodied, embedded, extended, enactive paradigm while also advocating for an anthropology of senses which should be unique to each

individual group of people, as well as cultural psychology and phenomenology. Geurts' framework draws from the philosophical and theoretical works of her predecessors in order to compose a framework which can be grounded in practical fieldwork. This framework considers all aspects of being human and is therefore well-suited to application in anthropological, ethnographic, and archaeological contexts. Pink proposes sensory ethnography which can be taken as an extension of Geurts' approach (Pink 2015). Pink discusses ethnography as a participatory practice which proposes learning as embodied, *emplaced*, sensorial, and *empathetic*, as opposed to ethnography which occurs simply through participation and observation. She is careful to acknowledge the ethnographer's sensory experience which can affect studies at an additional sensory ethnographic level – a poignant observation akin to my criticism of studies by WEIRD people, of WEIRD people, for WEIRD people, and my call to acknowledge biased embodiment.

Another notable effort to understand cognition from a culturally-grounded or practically applicable standpoint is the "Four-Field Co-evolutionary" model (Lombard and Högberg 2021). Through a grounding in well-developed models such as embodied, embedded, extended, enactive cognition, MET, among others, and her own studies of evolution and anthropology, the Four-Field Co-evolutionary model suggests taking into account all relevant biological aspects, technology, society, and ecology as four dynamic reciprocal influences which feedback resulting in causal influence of each other's evolution (Lombard and Högberg 2021, 144). In this model all aspects of culture including social learning and the socio-economy of a group (e.g., diet, technology, and so on) are included. These elements, according to this model, are constantly being shaped and shaping how we understand the world and how we engage with it. The Four-Field Co-evolutionary model very carefully draws from the driving theoretical forces in contemporary cognitive studies, an outdated selectionist approach, technique and technologies, and finally takes a similar approach to Geurts in emphasizing the important role of society and culture (at both a small and large scale) in cognition.

Concluding remarks

What can be said about cognition then? First, the mind is not bound by the skull. The basis of the aforementioned approaches to cognition (embodied, embedded, extended, and enactive) is to understand cognitive actions as they relate to a structure while also acknowledging the primacy of the human experience of *being* and its fundamental role in cognition. This is to say that cognitive studies (especially as they pertain to material culture) should not be limited to neural activities inside

the skull but instead need to incorporate aspects of human *being*. Engaging with embodied, embedded, extended, and enactive cognition is a well-rounded, if not generalizing, place to start. However, as we have seen, many cognitive studies which make up the background of embodied, embedded, extended, and enactive cognitive approaches rely heavily on a psychology perspective which has a WEIRD bias. It is absolutely imperative to consider the context of these studies. There should, and can, be a methodology which equally considers these cognitive models alongside unique culture, identity, the socialization of cognition, and material agency. Geurts quite brilliantly summarizes this problem and its solution by proposing her methodology which marries psychology and her ethnographic, sensorial, relational, enactive approach:

> "My ultimate aim is to fill in the gap between cognitive models of perception and the phenomenal level of sensation, experience, and bodily existence by first examining how culture affects the very basic, fundamental stages of this whole process and by then using the analytic categories of practice, embodiment, sensibility, and identity to trace how these fundamentals affect more abstract processes" (Geurts 2003, 6).

As I move forward discussing the links between cognitive theory, material culture, and *chaîne opératoire,* it will be clear that models for cognition grounded in WEIRD psychology and generalized phenomenology will not suffice (Muthukrishna et al. 2020). Even Ingold's well-respected and oft-cited approach fails to address the sociality of perception and cognition. Howes' astutely critiques Ingold's attempt to avoid dualisms, stating that he takes both a "pre-cultural and post-social" position which can make only for a generalized philosophical argument (Howes 2022, 443). I agree this pre-cultural and post-social (generalizing) approach should not be too liberally applied in practice, especially when attempting to understand ways of thinking, doing, and meaning-making. Instead of becoming entrapped in this Ingold-Howes feud we ought to consider the MET and Strange approaches to cognition alongside Geurts' proposal for bodily ways of knowing and Pink's sensory ethnography, which brings a groundedness to this philosophical debate, arguing the importance of cultural specificity over generalizing representationalism (Pink 2015). We must be careful of cognitive theorists who rely too heavily on psychology and who distance themselves from socially minded and culturally grounded sensory anthropological approaches especially when connecting cognitive theory to material culture studies.

Pertinent to Leroi-Gourhan's *chaîne opératoire* are his notions of external, internal, and technical *milieu* which include the phenomena of a group's unique ways of knowing, cultural identity, material ecology, and the perpetually evolving nature of a group's techniques. While embodied, embedded, extended, and enactive cognition provide a strong background with which to approach cognition in material culture I would urge scholars to take Geurts' and Pink's approach seriously, especially when linking cognition with a specific cultural group or material culture, and to implement all or some elements of both approaches. I propose to incorporate Malafouris' MET and STRANGE approaches as a starting point for investigating the problem of embodiment I previously outlined. To understand contexts in which power dynamics and division of labor play a role in cognitive processes, we must first understand how we engage with materials and experience materiality (MET) as well as the context of the activity (STRANGE). From here, how does a hierarchy of roles or distribution of labor impact a cognitive event? Embodiment as a form of cognitive function is affected by the body as it has been socialized, politicized, and as it is responding to the environment physically (e.g., a trans body in a cishet space, or a black female body in a white male medical practitioner's space). These situational (STRANGE) circumstances impact the cognitive function.

This approach allows us to consider the relational structure at hand and examine the elements which are linked through this structure. These links may include power dynamics, gender, politics, and the like play a role in extended cognition. I propose that if we incorporate MET and STRANGE approaches with sensory anthropology, material affordances, and embodied sociocultural systems we may have a fuller picture of embodied and extended cognition which can be incorporated into the *chaîne opératoire* approach. In the forthcoming chapter I develop a *chaîne opératoire* approach which encompasses these culturally grounded approaches in addition to the relational phenomenology of embodied, embedded, extended, and enactive cognitive theories (drawing on MET and STRANGE approaches). I underline how Leroi-Gourhan's somewhat forgotten *milieus* relate to contemporary cognitive theory, and additionally how contemporary cognitive theory can be incorporated into a *chaîne opératoire* approach which includes *ways of doing* and *ways of thinking*.

CHAPTER EIGHT

CHAÎNE OPÉRATOIRE AND COGNITION

Introduction

How can contemporary theories of cognition, such as embodied, extended, and enacted cognition, aid archaeologists? Additionally, can the integration of these theories reframe the way we think about the links between prehistoric minds and the production of material culture? I set out to discuss how the aforementioned theories of cognition can, by way of integrating with the *chaîne opératoire* approach, accomplish this. Through understanding production processes one can gain a glimpse into the mind through understanding how people navigate the world around them, especially through interaction with and production of tools and material culture. The *chaîne opératoire* approach is therefore used to facilitate discussion of prehistoric minds and material culture. However, the *chaîne opératoire* Use Types do not often involve theories of cognition explicitly, barring a select few studies which are discussed herein (e.g., Eren et al. 2005; Walls 2016). This is odd, given the aforementioned correlation between the mind, the maker, and the making. Instead, we often see experimental or heuristic projects using a *chaîne opératoire* approach which infer cognitive capabilities through traces left in the material record. While Leroi-Gourhan attempted to link the mind, tool, and body in a phenomenological sense, the *chaîne opératoire* approach was formulated based on a somewhat deterministic and teleological view of an envisioned "evolution" of techniques (Schlanger 1994b, 145). Leroi-Gourhan's *milieus* can be interpreted as non-cognitivist, but these notions are generally left out of discussions of cognition and *chaîne opératoire* approaches as we will see.

This chapter develops the links between theories of embodied, extended, and enacted cognition and the *chaîne opératoire* approach. This is achieved by the exploration of two propositions. First, I explore how the *chaîne opératoire* approach takes a cognitivist approach to the mind, the maker, and the making. I underline the links between cognitivism and the *chaîne opératoire* approach through thorough review of each concept and the material case studies from Chapter Three. I discuss methods which take a non-cognitivist approach to modes of action which can be useful. Next, I discuss how process trends and *milieus* can be understood as the link between

theories of embodied, extended, and enacted cognition and the *chaîne opératoire* approach. Methods for linking process trends, *milieus,* and embodied, embedded, extended, and enacted cognition are developed through methods which incorporate sensory anthropology, culturally sensitive ethnography, and ecological perspectives. Thorough discussion follows including examples of models which incorporate such theories of cognition with methodological frameworks. Exploring methods for linking methodological frameworks with the phenomenological nature of human *being*, I outline a unique approach to the *chaîne opératoire* approach drawing on the aforementioned approaches and network theory. I argue that the *chaîne opératoire* Use Types rest on a cognitivist approach to the mind. Linking embodied, embedded, extended, and enacted theories of cognition with sensory anthropology and an acute awareness of WEIRD perspectives, we may form a link between cognition and the *chaîne opératoire* approach which accommodates non-anthropocentric ways of doing as well as non-cognitivist ways of thinking.

The evolutionary and cognitivist foundations of *chaîne opératoire*

So, how does the *chaîne opératoire* approach relate to cognition, if at all? If we accept the logic that all technical gestures are conscious and emerge from individual and collective practical reason, this information can lend itself to an intimate view of the ancient producer's logic, tool-usage, and complex cognitive processes involved in production processes (Lemonnier 1992, 1; Schlanger 2005, 19). However, Leroi-Gourhan used a selectionist evolutionary model to approach the interrelated nature of mind and material, which according to Leroi-Gourhan are products of the biological and social realms (Leroi-Gourhan 1964a). This selectionist evolutionary model rests entirely on a cognitivist understanding of the mind. A discussion of the selectionist evolutionary approach to the *chaîne opératoire* approach, followed by examples of *chaîne opératoire* approaches based on modes of action (as in Use Type One and in many cases Use Type Two), will prove that modes of action are the link between cognitivism and the *chaîne opératoire* approach.

Leroi-Gourhan discusses evolution in great detail as it relates to the use of tools. He frames tool-use as a part of the natural evolution of Homo sapiens. According to Leroi-Gourhan, with the advent of bipedalism came the freeing of the "anterior field" (the hand, mouth, and brain) (Leroi-Gourhan 1964a). Mobility is the result of this freedom - now the hand can act directly through motor function to engage with the environment (e.g., digging with the hand) (Audouze 2002, 290). In discussion of tool-use and production processes, the freeing of the hand is paramount. The second

term Leroi-Gourhan discusses, liberation, refers to the freedom of the hand to act separated from the motor function, as in the ability to act through and with tools (e.g., digging with a shovel). As Leroi-Gourhan states, the freedom of the hand offers liberation which "almost necessarily implies a technical activity different from the apes... and commands the use of artificial organs, that is, of implements" (Leroi-Gourhan 1964a, 90). Exteriorization features again in *Gesture and Speech* when describing the human ability to exteriorize information via memory and language. Leroi-Gourhan argued that human intelligence (as it pertains to technological transmission, diffusion, and innovation) developed alongside the interaction of the body and its physical environment (including material culture). Leroi-Gourhan further defines the tool as a "testimony of the exteriorization of an efficient gesture" and that it is "the materialization of the interaction of matter with the means to transform it" (Leroi-Gourhan 1971, 319; 1973, 333 as cited in Audouze 2002, 287-8). Mobility, liberation, and exteriorization are concepts which emphasize the link between cognition and the *chaîne opératoire* approach. While Leroi-Gourhan takes a selectionist evolutionary approach which results in cognitivism within his proposed *chaîne opératoire*, we see here again (as we did with agency) that his interest in concepts such as "exteriorizing information" and "materialization of the interaction" and his emphasis on the interrelated nature of gesture, tool, environment, and mind, are indicative of a phenomenological approach. Nonetheless, a selectionist evolutionary approach to cognition limits the *chaîne opératoire* approach to a cognitivist interpretation of production processes.

Through a quick glance at any of his works the reader finds tools such as arrows and hand axes hierarchically arranged by levels of complexity. These classifications based on perceived complexity can unfortunately lead readers to the conclusion that one group is more highly evolved (cognitively speaking) than another. For example, Gesture and Speech illustrates in great detail the link between the evolutionary model and the development of the *chaîne opératoire* approach (Leroi-Gourhan 1964a). One could open the book to any page and find something along these lines:

> "[The] enmeshing of tools and gestures in organs extraneous to the human has all the characteristics of biological evolution because, like cerebral evolution, it develops in time through the addition of elements that improve the operational process without eliminating one another. Earlier we saw that the brain of Homo sapiens still preserves all stages acquired since the fish stage, and that each stage, overlaid by the next,

continues to play a role even in the most sophisticated forms of human thought." (Leroi-Gourhan 1964a, 242).

This selectionist evolutionary model clearly utilizes a cognitivist lens in its approach to integrating the *chaîne opératoire* approach with the mind. Let us consider Leroi-Gourhan's theory that the Homo sapiens preserve all stages of cognitive development acquired since its early evolution from the "fish stage". This quote, and the passage overall, exemplifies the notion that our mind functions like a receptacle for storing information, and as a central planner which allows for the function of manipulating symbols or internal representations. This cognitivist approach places the mind firmly within the skull - all thoughts, processes, computations, and representations take place internally.

Following Leroi-Gourhan, Lemonnier develops a *chaîne opératoire* approach through the lens of anthropology (Lemonnier 1986; 1992). Despite also relying on a cognitivist approach, Lemonnier's *chaîne opératoire* proposal remains a popular method. The following figures display two (of six) methods Lemonnier suggests for description and analysis. These methods reduce a technological process to a predetermined order of operations based on mental representation (or blueprint-thinking). The actor has an internal representation of the object or task at hand, they execute the actions *onto* or *toward* the matter (anthropocentric agency), and the output results in the change in material from its original state to its manufactured state. Figure 54 illustrates a model for description and analysis of a blueprint-thinking sequence.

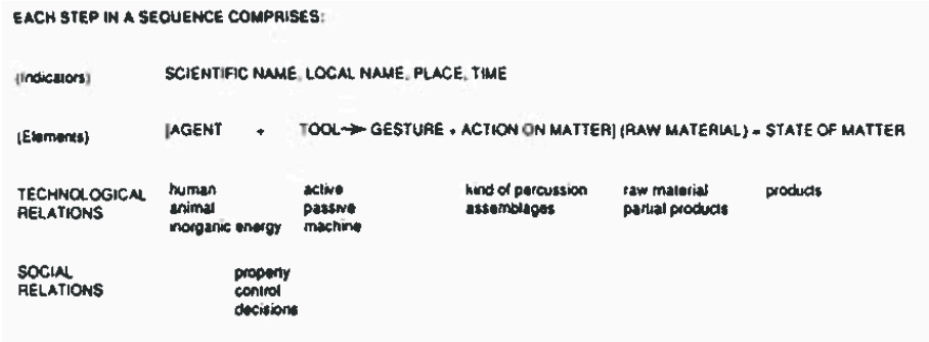


Figure 54. Description and analysis of a sequence (Lemonnier 1992, 31)

Another figure (Figure 55) demonstrates the same style of a predetermined operations based on mental representation (blueprint-thinking) to describe two carpenters' processes:

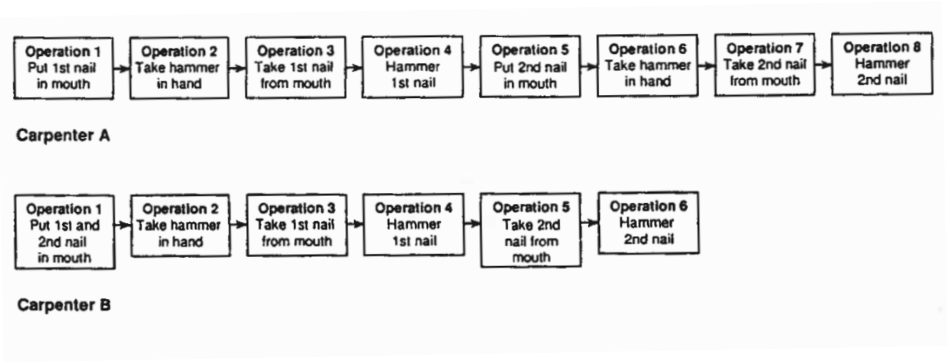


Figure 55. Description and analysis of a sequence (Lemonnier 1992, 33)

Interestingly, the two carpenters have subtly different approaches which could be influenced by a number of sociocultural or environmental factors. However, this cognitivist approach limits the inclusion of such factors and their agency. These figures demonstrate a clear approach to a technological process which accounts only for modes of action through anthropocentric agency (recipe for doing) and internal representation (blueprint-thinking). There is no depiction of the interrelated nature of each technical fact in this cognitivist *chaîne opératoire* approach. Let us recall the three issues with cognitivism outlined previously: (1) the replacement of physical quantities or things with symbols can obstruct opportunities to exploit the physical world as a tool for problem-solving; (2) similarly, conceptualizing a problem in terms of input-output mapping invites a view of cognitive processes as *passive computation*, and cannot accommodate situations wherein the output involves epistemic action; and (3) that simplifying information into symbols to search for an optimal solution does not account for, or can obscure, the role of history in solving the same or similar problems. In Lemonnier's *chaîne opératoire* approach it is unclear how one can include the exploitation of the physical world for problem-solving (issue 1). There is passive computation and furthermore no accounting for epistemic action (issue 2). Finally, although in Figure 54 there is a row designated for "social relations" in the *chaîne opératoire* approach, it is unclear how these social relations affect the ways of thinking or ways of doing (issue 3). It becomes clear that the link between cognitivism and the *chaîne opératoire* approach is an approach which is based on modes of action.

Non-cognitivist approaches to modes of action

How can a *chaîne opératoire* approach made up of modes of action *not* be cognitivist? Is there a way to analyze modes of action in a non-cognitivist manner? In Lemonnier's figures depicting his *chaîne*

opératoire approach one issue which is particularly noticeable is that epistemic action is not accounted for. By accounting for epistemic action (instances where cognitive output *is a physical action* meant to discover new information that contributes to the successful completion of a problem), there can be a non-cognitivist approach to the *chaîne opératoire* approach. Cognigrams exemplify a *chaîne opératoire* approach made up of modes of action which *does* account for epistemic action (Haidle 2010; Lombard and Haidle 2012; Haidle and Stolarczyk 2020; Haidle 2024).

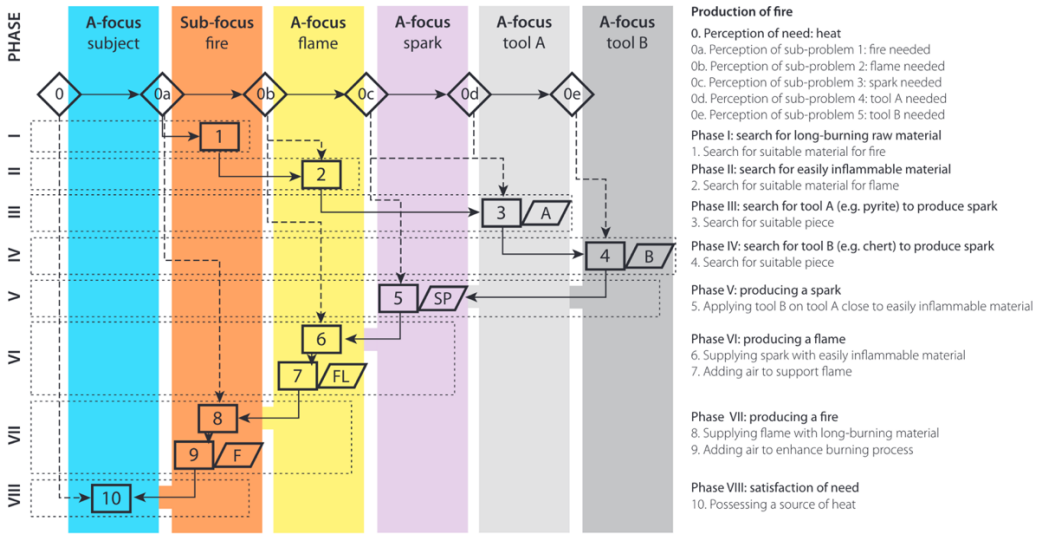


Figure 56. Cognigram for the production of fire (Lombard and Haidle 2012)

The above Cognigram (Figure 56) for the production of fire depicts eight phases of modes of action employed in producing fire. It is clear that while this Cognigram may only illustrate modes of action, we see that there are multiple foci involved, each of which contains phases which are related to other foci. For example, within the initial focus (production of fire) there are subsequent perceptions of sub-problems (such as fire, flame, spark, tools, and raw material) which need solving in order to satisfy the initial focus. Epistemic action is evident in this Cognigram. Cognitive output *is a physical action* (such as "Phase 1" search for long-burning raw material) meant to discover new information (search for suitable material for fire) that contributes to the successful completion of a problem (procuring raw material suitable for a source of heat). Each of the phases in this Cognigram illustrates epistemic action. It is clear that while there is an initial perception of a need, and some partial planning, there is no predetermined blueprint for satisfying the need (production of fire). This Cognigram approach demonstrates a non-cognitivist approach to a *chaîne opératoire* made up of

modes of action. However, I submit that this Cognigram approach still does not account for process trends and *milieus*.

Another noteworthy approach is Fairlie and Barham's *chaîne opératoire* approach which takes a Gibsonian perspective of task structuring and tool-making events alongside cognition (Fairlie and Barham 2016). Born out of ecological psychology, Gibson's theories of affordances and perception-action accounts for perceptual information gathered from the environment wherein responses are learned through experience or action (Gibson 1979). Through this perspective, variables in task structuring and tool-making can be notated as relevant data in understanding cognition (Fairlie and Barham 2016, 646). Fairlie and Barham criticize the Cognigram approach as overly hierarchical and modular (Fairlie and Barham 2016, 647). They state that the Cognigram approach overly simplifies the nature of task-structuring, and that it cannot account for the long-term perceived needs of multiple individuals or groups with differing motivations. They also argue that the increasing complexity of Cognigrams may incorrectly suggest a gradual linear change in cognitive evolution. Their perception-action approach is meant to address and overcome these issues. The methodology involves video recording tool-making activities and using visual observation to identify behavioral variables such as posture, mobility, tool, and object moving, tool/object choice, and tool organization, among other variables. Later, "Task Diagrams" are constructed to show potential modular structure for each task and behavioral variables. An example of a Task Diagram is shown below (Figure 57).

Oldowan Core and Flakes	Tools Objects and Final Affordances
Mobilize; choose raw material	Medium hs and core
Mobilize; assume seated posture	Hammerstone & raw material stable
Tilt core to search	Suitable area located visually
Prepare striking platform, tap, strike	Flake detached
Assess flake visually and haptically	Keepers stored separately
Repeat previous 3 action sets as a unit until end of Stage	Enough keepers collected (6) Put down medium hs Put down core
Select flake for retouch	Flake
Retrieve small hammerstone	Small hs Hammerstone and flake stable
Small unifacial removals from ventral side around perimeter	Retouch completed Hammerstone and flake put down

Figure 57. Task Diagram of Oldowan Core and Flakes (Fairlie and Barham 2016)

Task Diagrams are meant to illustrate each task divided into units and further divided into Action Sets (groupings of similar gestures such as "mobilize"). On the left we see gestures, whereas

on the right we see changes in behavioral variables as well as the affordances which allow for the toolmaker to progress to the next Action Set. This approach is effective in observing the relationship between an action, related affordances, and the subsequent action. This gives us more information about the modes of action involved in a process as well as the way in which materials inform our way of thinking and doing. This approach does not underscore epistemic action in the same way that Cognigrams do, but the notion is clearly present in the sense that our actions (cognitive output) affect and are affected by affordances, from which information is available to the toolmaker, which furthermore leads to the completion of a task.

One concern I have with these Task Diagrams is that although there is suggested movement or linking from one action set to another, there is an apparent emphasis on the 1:1 relationship of an action or group of actions and the related affordances. This 1:1 relationship of action and affordance can limit the analysis of highly complex production processes. In contrast, I appreciate the visual enmeshment of foci, phases, perception, and action that the visualization of Cognigrams offers. Task Diagrams and Cognigrams are both admirable efforts toward a framework for integrating embodied, extended, and enacted cognitive theories into tool-making sequences. However, I maintain that both Task Diagrams and Cognigrams only support a *chaîne opératoire* approach made up of modes of action (Use Type One). There are still process trends (Use Type Two) and *milieus* which, once incorporated, will offer a way to relate both concrete and abstract elements of ways of thinking and ways of doing with a framework such as *chaîne opératoire*.

When we look closely at the real-world behaviors of planning agents, it is clear that there is a complex interplay between perception, planning, action, and the surrounding environment. It's also important to note that in many cases, actions do not have the desired effect and problem-solving requires re-thinking and re-planning. Additionally, in some cases, a plan or blueprint is only partial and therefore carrying out the partial plan is dependent on the local environment. Instead of cognitivist models, a multi-factor decentralized approach to cognition is needed. This is not to say that cognition has zero computational activity. Instead, there is a complex interplay of multiple forces through which the brain is embodied and emerges: bodily, mechanical, external, internal, cultural, and relational processes make this possible. Cognition is not about content or internal representations; it is an active process through which we are able to understand the world, solve problems, judge, explain, and more generally speaking - do things (Gallagher 2013). To be sure, the brain (the organ) has always been constrained by the nature of the evolutionary process, and it must create new solutions and form adaptive strategies on the basic existing cognitive functionality and

resources. However, the *mind* is empowered by its ecological surroundings which allows us to exploit other agents, actively seek input, manipulate computational tasks, and offload acquired information into the world.

Leroi-Gourhan's impetus for developing the *chaîne opératoire* approach was to uncover the intermeshing of gestures and tools, an idea which lends itself naturally to phenomenological theories of cognition. Leroi-Gourhan stresses through discussion of process trends that tasks can be carried out not only through blueprint-thinking but through socially learned behavior. It's clear that Leroi-Gourhan struggled to reconcile his forward-thinking theory with his grounding in a cognitivist, deterministic, teleological background. His intention was to develop a framework based on a paradigm which did not yet exist. So, the *chaîne opératoire* approach relied on what was considered to be a sound basis – cognitivism, biology, and evolution. While a *chaîne opératoire* approach made up of modes of action can, as we see now, take a non-cognitivist approach, I argue that it still cannot support the phenomenological nature of cognition as described in the *chaîne opératoire* approach. It should be obvious now that there is indeed room to explore how we might broaden the scope of the *chaîne opératoire* approach by moving away from the cognitivist model through including elements such as process trends and *milieus*.

Process trends and *milieus*

As we have seen in the previous section, a *chaîne opératoire* approach made only of modes of action (Use Type One) illustrates a predetermined order of operations based on a mental blueprint (mental representation) which is deterministic, and cognitivist. Use Type Two includes process trends but broadly relies on modes of action. We must disentangle modes of action and process trends in order to view how process trends can be linked with cognition. Leroi-Gourhan also offered another perspective, one which is often left out of *chaîne opératoire* use cases because it has yet to be integrated into what we consider the *chaîne opératoire* approach. Leroi-Gourhan posited that transmission, diffusion, and innovation (cognitive functions) could be analyzed through his three key concepts *milieu extérieur, milieu intérieur,* and *milieu technique* (Leroi-Gourhan 1945). Outlining these concepts, I develop the connections between process trends, *milieus,* and theories of embodied, extended, and enacted cognition.

How are process trends linked to theories of embodied, extended, and enacted cognition? As previously defined, process trends are long-term socially informed choices. Lemonnier defines

process trends as socially relevant choices which can appear arbitrary in the production process – but are in fact meaningful (Leroi-Gourhan 1945; Lemonnier 1992, 21). While modes of action can be neatly organized and observed within the Processual, cognitivist, paradigm, process trends on the other hand are nuanced and include sociocultural factors which make them difficult to analyze as empirical data. These process trends as *socially informed* choices contain aspects of cognitive function which are affected by the social ecology, gender and bodily ideologies, institutions, practices, and beliefs. We can therefore easily draw connections between process trends and the embodied mind and the socially extended mind (including extended and enacted cognition as well as social affordances) (Gallagher 2013). According to Gallagher, cognition is an "enactive [physically through the body - embodied] and emotionally embedded engagement with the world", much of which is shaped by tools, technologies, ecological factors, and social practices (Gallagher 2013, 8). Process trends are therefore linked to socially embodied, extended, and enactive cognition and cannot conform to a cognitivist framework. They are dynamic, embodied, extended, and enactive processes rather than a static mental state, computation, or internal representation. It is for this reason I believe that the cognitive aspect of process trends have not been incorporated within the *chaîne opératoire* approach. To do so would be to create a fold in the otherwise one-dimensional cognitivist interpretation of the *chaîne opératoire* approach.

Similar to the broad perspective of process trends, Leroi-Gourhan theorized that transmission, diffusion, and innovation should be analyzed from the greater perspective of a social group in its entirety, not only the individual. He posited that these cognitive functions (transmission, diffusion, and innovation) could be analyzed through his three key concepts previously outlined in *chaîne opératoire*: *milieu extérieur, milieu intérieur,* and *milieu technique*. *Milieu extérieur* enables us to observe the entanglement of a group's cognitive function with the natural environment, material culture, and ideas of other groups. Does this not bring to mind embodied, extended, and enactive cognition (Varela et al. 1991; Wheeler 2011a; Gallagher 2013; Malafouris 2013; Kiverstein 2020)? So long as a person or group is *engaged* (Malafouris 2013) with an element of the environment, that element is a constituent of the cognitive process (Gallagher 2013). This *milieu extérieur* can include the material cultural ecology (Ingold 2012) as well as sociocultural practices, ideas, or beliefs. In the case of *milieu extérieur*, we specify ideas or beliefs. Similar to process trends, *milieu extérieur* offers a link between *chaîne opératoire* and socially extended, enacted cognition. *Milieu intérieur* describes the ideas, beliefs, and memories held within a group. Where *milieu extérieur* describes cognitive functions affected by things and others outside of a group, *milieu*

intérieur describes cognitive functions affected by things and others *within a group*. Again, this brings to mind theories of socially extended, enacted cognition. Finally, the *milieu intérieur* contains traditions and perpetuated modes of thought and action which are the group's *milieu technique* (or technical *milieu*) – the third key concept.

As previously outlined, the *milieu technique* is perpetually changing. It is posited that acquisitions to the *milieu technique* are seldom erased (Pfaffenberger 1992; Clark 1997; Malafouris and Koukouti 2018). In other words, technology and techniques (within the *milieu technique*) often show an "imprint" of the context from which it arose because they must be built upon or with influence from existing sociocultural resources (Pfaffenberger 1992, 500). The *milieu intérieur* is not static, in order to "keep the network [of a sociotechnical system] functioning" it may require technical or social modification (Pfaffenberger 1992, 502). This idea of a perpetually changing *milieu technique* was unique at the time Leroi-Gourhan proposed it, and is relevant to recent studies of cultural memory and skill which will be addressed in the forthcoming discussion (Lombard and Haidle 2012; Walls 2019). I propose that these three *milieus* can be understood through theories of embodied, embedded, extended, and enacted cognition.

Was the *chaîne opératoire* approach cognitivist to begin with, or did we make it that way? To be sure, in the development of the *chaîne opératoire* approach a cognitivist proposal was offered for the analysis of modes of action. Scholars have used this methodology successfully for many decades now. However, some have come to criticize the *chaîne opératoire* approach in that it lacks the capacity to grapple with Post-Processual and Process Archaeology paradigms (Schlanger 1994b; Dobres 1999; Audouze 2002; Schlanger 2005; Malafouris and Gosden 2015). And while Leroi-Gourhan certainly struggled to reconcile the quantifiable modes of action with the nuanced nature of process trends and *milieus*, they have been there all along. Unfortunately, these aspects of the theoretical background of the *chaîne opératoire* approach remain to be integrated. This signals to me that there has not been a thorough assessment of the theoretical development of the *chaîne opératoire* approach and of Leroi-Gourhan's philosophy. I propose that by integrating process trends and *milieus* with the *chaîne opératoire* approach we may find that embodied, extended, and enacted theories of cognition find their places easily within this framework.

Methods for incorporating process trends and *milieus* (or embodied, extended, and enacted cognition)

As we have seen, a Use Type One *chaîne opératoire* approach based on modes of action takes a cognitivist approach. But the *chaîne opératoire* approach has the capacity to incorporate broader phenomenological concepts. We must consider Leroi-Gourhan's process trends and *milieus* and their relation to cognition. There is in fact plenty of forward-thinking cognitive theory nested within the *chaîne opératoire* approach, it only needs defining and integrating. I submit that the theories of process trends and *milieus* developed by Leroi-Gourhan encompass many current approaches to cognition. These approaches include: (1) embodied cognition which proposes that the mind is affected by being in a body (Clark 1997; Gallagher 2005; Clark 2008; Varela et al. 1991), (2) extended cognition which claims that what is outside the brain is not necessarily outside the mind and furthermore that cognition is not only a matter of internal representation (Rupert 2009; Wheeler 2011a; Silberstein and Chemero 2012; Gallagher 2013; Malafouris 2013; Kiverstein 2020), and finally (3) enactive cognition puts the two aforementioned theories into action – literally cognition takes place as it is enacted in time and space (Gallagher 2013; Malafouris 2013; Kare Stokholm Poulsgaard 2019; Walls 2019). Methods for incorporating embodied, extended, and enacted theories of cognition with analytic frameworks are discussed hereafter. These methods serve as examples I draw upon later in proposing a *chaîne opératoire* approach which incorporates theories of embodied, extended, and enactive cognition.

These theories of embodied, extended, and enacted cognition in relation to material culture have been approached via methodologies including sensory anthropology, ethnography, and Four-Field Co-evolution which I find particularly compelling. As opposed to Cognigrams and Task Diagrams which address modes of action, these two approaches offer insight into how we might integrate sociocultural nuances (i.e., process trends and *milieus*) with an analytical framework (e.g., *chaîne opératoire*). Along with the Sensory Turn in anthropology, as described in Chapter Seven, comes a phenomenological approach to the study of *ways of being* human in the world (Howes 2019; Stoller 1989). This sensory approach to anthropological, ethnographic, and archaeological studies offers a unique lens through which to approach distinct community's sensorial makeup, cosmological views, and practices. For example, we recall from Chapter Seven Geurts' turn away from WEIRD cognitive science, and away from the Euro-American five-sense model while still recognizing an anthropology of culturally unique senses, Geurts follows the tradition of phenomenological anthropology with central themes of embodiment and orientation (Geurts 2003).

This approach is rooted in cultural psychology and cultural phenomenology in an effort to produce a framework for reconciling the sensorial experience of being human with culturally specific notions of personhood, identity, and meaning-making grounded in the interrelational nature of the embodied experience, thought, feeling and cultural-psychological orientations.

Walls also takes a phenomenological approach to cognition and the *chaîne opératoire* approach incorporating MET and ethnoarchaeology in his work studying Inuit kayak-making (Walls 2016). Walls proposes that the Inuit kayak-making practices are learned not through internal schema (blueprint-thinking) but instead learned and shared through active engagement, generational memory, and situated cognition – learning is a didactic process which is highly social and situated not only in physical spaces but in the generational memory and beliefs of the Inuit people (Walls 2016). Not only is the cognitive aspect of production situated in this way, but also hunting skills are informed by the sensorial experience of making the kayak. The kayak must glide straight forward into range in order to harpoon the target – this skill is acquired not only through gliding practice on the water but also through the sensory experience, knowledge shared during, and memory of the didactive process of making a symmetrical kayak (Walls 2016). In continuation of this work, Walls and Malafouris propose that "knowing is a fundamentally creative process involving social, material, and environmental dimensions that are situated in intergenerational praxis" based on a study of the knowledge and improvisation of Nattilingmiut caribou hunts (Walls and Malafouris 2016, 625). They argue that the skill involved in the caribou hunt is not learned through internal representations (blueprint-thinking) but through creative improvisation, sensory awareness, physical fitness, and personal experience (individual and generational memory).

Again, we find that cognition is not an internal process. It is specific to each individual or group's experiences, sensorial makeup, beliefs, and skill-sharing practices. In Walls' (2019) work, he draws on a postphenomenological and Material Engagement Theory approach to propose that human ways of *being* were not developed based on their "pre-evolved" capacity for symbolic representation (blueprint-thinking) but on technical experience which is developed through a transformational process wherein hunters develop the self and intentionality by "attuning subjective capacities for sensory awareness and creative responsiveness" in the dynamic field of environmental practices which make up a hunt (Walls 2019, 265). In other words, the self, cognition, and therefore the skilled use of the bow and arrow is an emergent property of technical practice. This emergence of self and cognition arises between and through the hunter and the technology, situated

in the dynamic environment of the hunt, enacted and embodied through *doing*, all of which is inherently social.

It is important to recall the bias of the analyst in such ethnographic or ethnoarchaeological studies. We must consider Gosselain's critiques especially on the origins of ethnography (Gosselain 2016). Gosselain's states that the origins of ethnoarchaeology are rooted in what are ultimately racist Western views of non-Western peoples. These views describe non-Westerners as exotic, primitive, more closely related to prehistoric peoples, and who are furthermore perceived as "living fossils" (Gosselain 2016, 219). It is imperative that the analyst be aware of these origins and to not exoticize others, or to consider non-Western groups as "untouched" by Western technology. Despite whatever awareness the analyst may have of these issues, Pink warns that the observer may also fall into the trap of becoming sensorially engaged in the ethnographic study themselves; therefore ethnography must also become a reflexive and reflective science (Pink 2015).

Another notable effort to understand cognition from a culturally-grounded standpoint is the "Four-Field Co-evolutionary" model (Lombard and Högberg 2021). Through a grounding in well-developed models such as embodied, extended, and enacted cognition, in addition to Malafouris' MET and STRANGE approaches, and their own studies of evolution and anthropology, the Four-Field Co-evolutionary model suggests taking into account all relevant biological aspects, technology, society, and ecology as four dynamic reciprocal influences which feedback resulting in causal influence and evolution of each element (Lombard and Högberg 2021, 144). In this model, all aspects of culture including social learning, the socio-economy, and technology are included.

The ambition of the aforementioned approaches to cognition is to understand cognitive processes broadly as they relate to a structure while also acknowledging the human experience of *being*. This is precisely how the *chaîne opératoire* approach must be reconsidered: to understand production processes as they relate to a structure while also acknowledging the enmeshment of the human *being* with gesture, tool, material, mind, as well as both the abstract and physical environment (which, if you recall, was the initial proposal for *chaîne opératoire*). I propose that Leroi-Gourhan's process trends and *milieus* should be considered as crucial elements of any *chaîne opératoire* approach alongside the already well-represented modes of action. These process trends and *milieus* are the link between the *chaîne opératoire* approach and embodied, extended, and enacted cognition.

An overdue overhaul

How can the *chaîne opératoire* approach be reconsidered in a way that reflects the immensely abstract nature of human *being* and the phenomenon of cognition, while also relating to a methodological framework? First, I propose we re-envision *chaîne opératoire*. Despite the name, we should not consider *chaîne opératoire* as a framework for visualizing a singular chain of operations, or predetermined blueprint-thinking. This one-directional, one-dimensional, sequential concept is so central to the framework that to break away from it we must reimagine the framework visually. Once again, I consult network theory as a means of bringing together the various elements which I argue must be included within a *chaîne opératoire* approach to develop a unique visualization of the *chaîne opératoire* approach. Using a network approach, we may re-envision the *chaîne opératoire* approach using visual concepts of entanglement and emergence as we have done with theories of agency.

Recalling the discussion of networks and *chaînes* in Chapter Six, we understand *chaînes* as elements of networks. The term *chaîne* refers specifically to a selected sequence of events (modes of action) *and* enmeshed elements (process trends and *milieus*) within a technological process which are entangled with the *becoming* of an object, thing, or process. This can include any combination of events which affect, or are affected by, another element in the network of *chaînes*. In the case of pottery, a *chaîne* can refer to the process of procuring and preparing clay for use, or of the formation methods of a vessel, related textile practices, enmeshed gender ideologies or politics, or even the cosmological views related to firing. A *chaîne* can also refer to any combination or all of these events and elements depending on the nature of the study. Furthermore, *chaînes* overlap, intersect, and comingle. So, while we can isolate one *chaîne* with a beginning and end for analysis, it is important to acknowledge that this is a tool for analysis and is not indicative of the nature of *chaînes*. Let us then define a *chaîne* as a selected sequence of events (modes of action) *and* enmeshed elements (process trends and *milieus*) within a technological process, chosen for analysis. This term *chaîne* allows us to delineate the part of a production process under consideration, while acknowledging the larger network of *chaînes* within which it exists.

If we consider *chaînes* as elements of entangled networks, we may incorporate process trends and *milieus* (aspects of embodied, extended, and enacted cognition) more effectively within the framework. Engaging with a network approach to *chaîne opératoire* I propose to consider each technical fact, technical tendency, or element of the *milieu* as a node with infinite possibility for connections to other nodes on a multi-dimensional network. This network of entangled *chaînes*

replaces the traditional one-directional, one-dimensional, linear depiction of blueprint-thinking that *chaîne opératoire* approaches are often associated with. It is important to amend the usual visualization of the *chaîne opératoire* approach because it's popular depiction can encourage a cognitivist approach, mental representationalism, and blueprint-thinking. Envisioning *chaîne opératoire* as a network comprised of entangled *chaînes*, it is possible to add connections to nodes wherever there are connections to any technical fact, technical tendency, or element of the *milieus*. This allows for a scalable "*network-informed approach*" comprised of *chaînes* which is inclusive of all crucial elements of the *chaîne opératoire* approach.

To compare the one-dimensional visualization with this network-informed *chaîne opératoire* approach, we begin with a typical depiction of the cognitivist *chaîne opératoire* approach. It is noteworthy that this depiction (Figure 58) is quite similar to the depiction of anthropocentric agency; this is due to the inescapable entanglement between ways of *doing* and ways of *thinking* noted in Chapter Four. The main difference is the order of the symbols in this figure. Figure 58 outlines removing clay from a wheel using a string tool. This cognitivist *chaîne opératoire* approach assumes an internal mental representation of the object outcome, as well as isolated modes of action which make up the internal mental blueprint for making. These modes of action are depicted along a one-directional, one-dimensional, plane indicating blueprint-thinking based on a predetermined goal. Each node represents an individual technical fact - isolated from process trends (socially informed choices) and the *milieus* (physical and abstract ecology) of the maker(s). From the left we identify the potter's internal mental representation of the object outcome (clay removed from the vessel). We see the object outcome achieved by following two steps: holding a string taught and applying force to remove the clay from a pottery wheel. These steps have been preconceived as internal mental representations which make up a blueprint for making. For further simplification, this figure can be replicated using only symbols as seen in Figure 59.

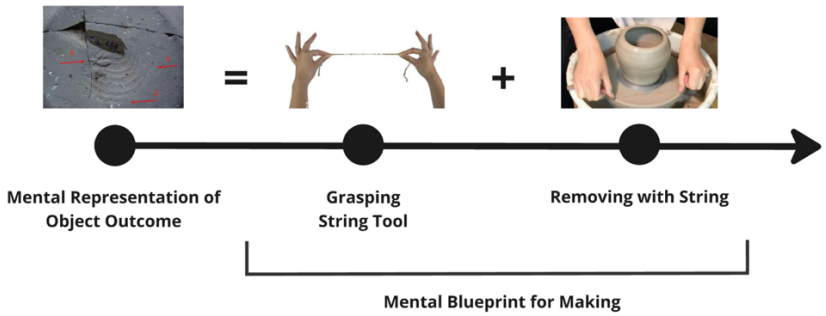


Figure 58. Cognitivist approach to *chaîne opératoire* in the case of removing clay from a wheel using a string tool. The object is preconceived via internal mental representation. The actions are completed as steps which have also been preconceived as part of a mental blueprint for making.

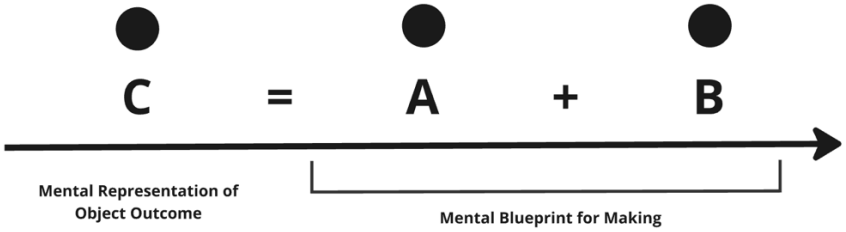


Figure 59. The mental representation of the object outcome "C" is achieved by completing steps "A" and "B" in succession according to a preconceived blueprint for making.

Instead, we again re-envision the *chaîne opératoire* as a network-informed *chaîne opératoire* of entangled nodes. Similar to the resolution of the agency problem, we begin by introducing the notion of entanglement to this visual representation. As with agency, we reposition the object outcome as central to the equation. “Mental Representation of Object Outcome” (“C”) can be renamed as the “Emergent Becoming” of an object or process (Figure 60). Reintroducing the modes of action from our example we arrive at the stage of entanglement of “grasping string tool” and “removing with string” (Figure 61). Again, as with agency, we may trace connections to additional modes of action by visualizing these nodes on networks wherein the nodes and the networks are entangled (Figure 62).

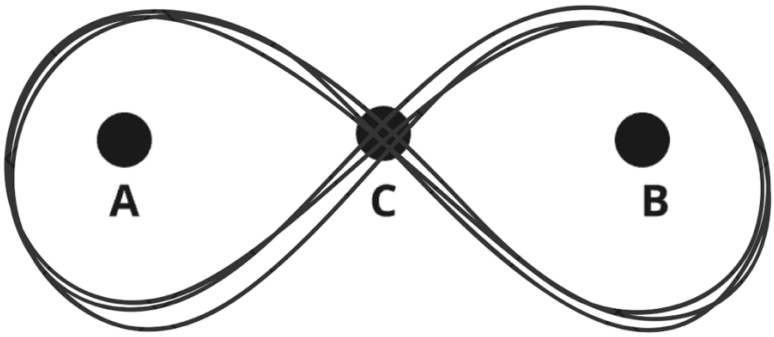


Figure 60. An infinite loop depicts modes of action "A" and "B" entangled in the emergent becoming of "C".

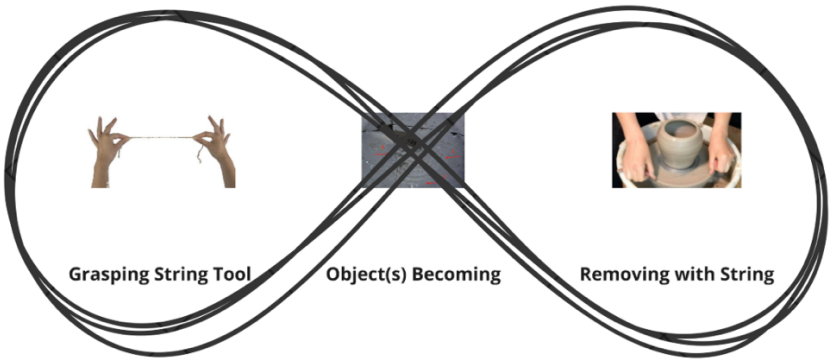


Figure 61. Using the example of removing a clay vessel from the wheel head, modes of action “grasping string tool” and “removing with string” are depicted on the left and right. These modes of action are entangled with each other and also with the central element.

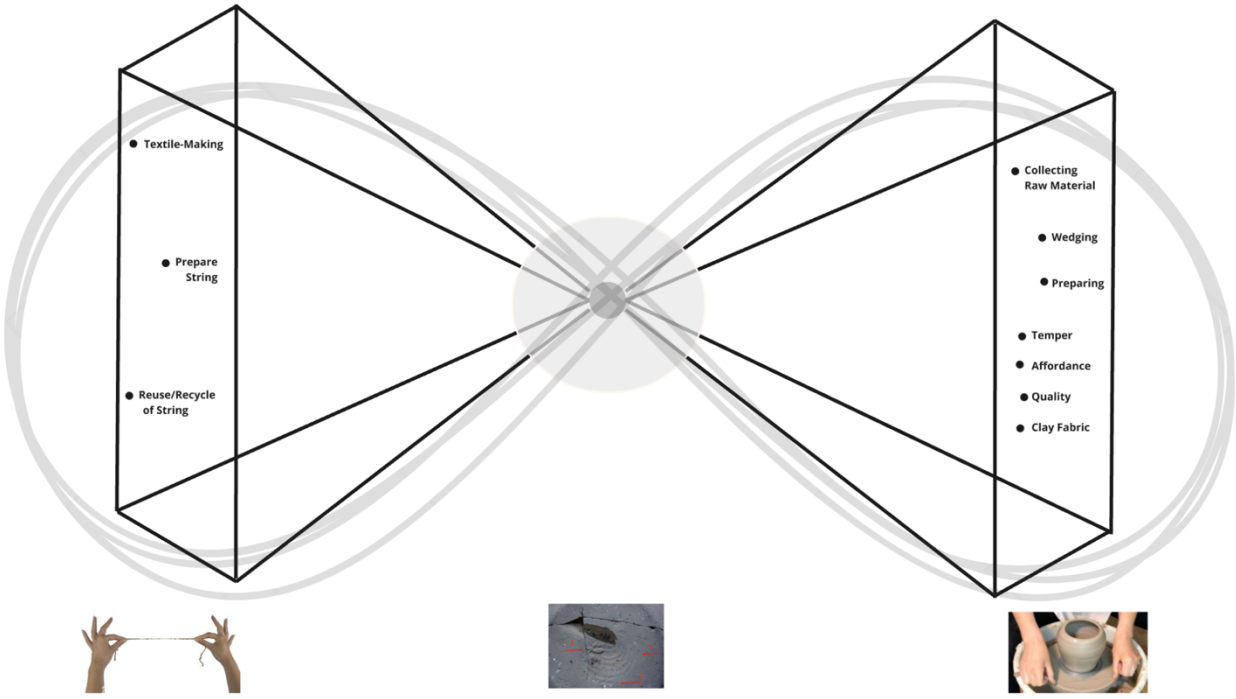


Figure 62. Similar to the discussion of agency, the non-cognitivist approach is further developed to include entangled nodes as parts of networks. The infinite loop again represents the entanglement of the nodes and the fields of modes of action.

However, process trends and *milieus* are central to a non-cognitivist approach to the *chaîne opératoire* approach. Taking the same approach to cognition as we did with agency, I present the following figure which represents process trends and *milieus* as part of the broader entangled network resulting in the emergent becoming of an object (Figure 63).

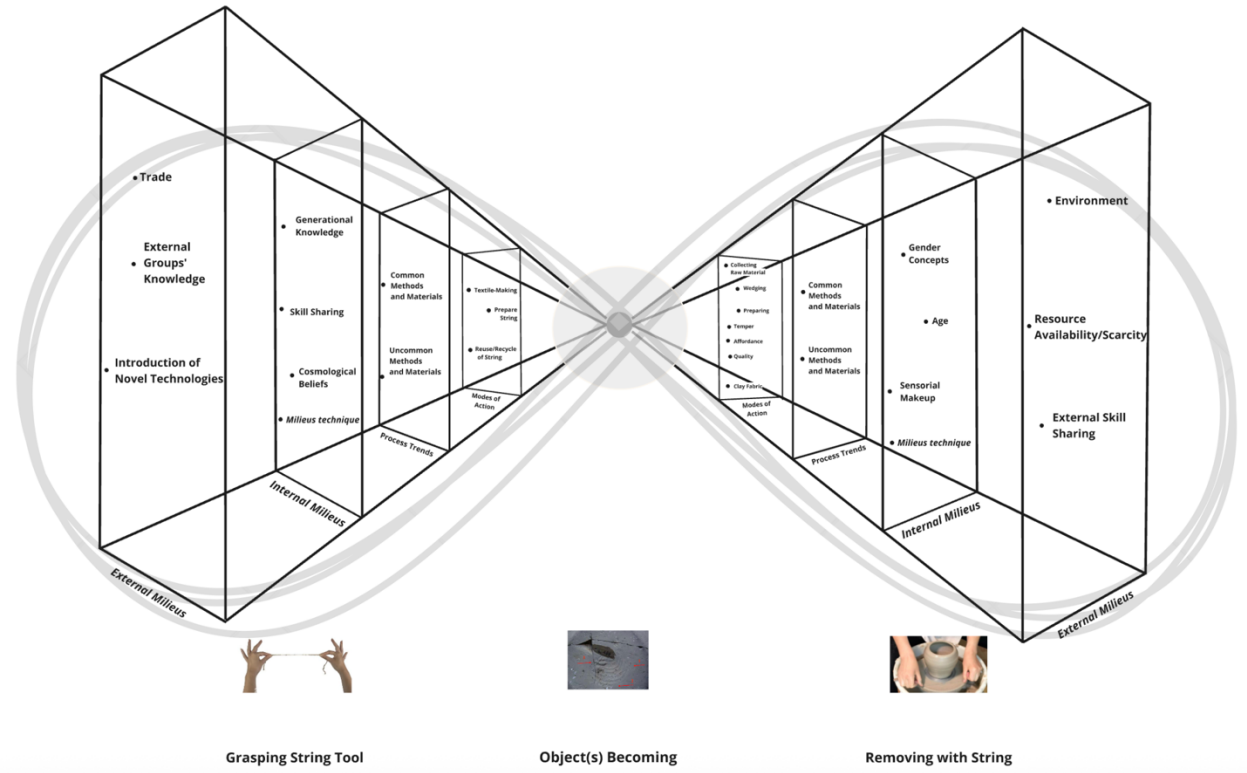


Figure 63. Process trends, internal and external *milieus* are added to the visual representation to represent a non-cognitivist approach to the *chaîne opératoire* approach. An infinite loop infinite loop emphasizes the entanglement of all nodes and fields in the emergent becoming of the object.

Elements of process trends and *milieus* are included wherever they may be connected to the process of making. Where there are intersections between modes of action, process trends, and *milieus*, we see how embodied, extended, and enacted cognition can be integrated. We may now also trace connections in any direction to isolate *chaînes* for further investigation. For instance, in Figure 64 we may trace nodes (available data) through the networks of *milieus,* process trends, and modes of action from the enaction of both "grasping string tool" and "removing with string" toward the emergent becoming of the object. The connections traced are subject to the interest of the study and the available data. While a *chaîne* is isolated and traced, we retain the ability to acknowledge the broader network and phenomenon of making.

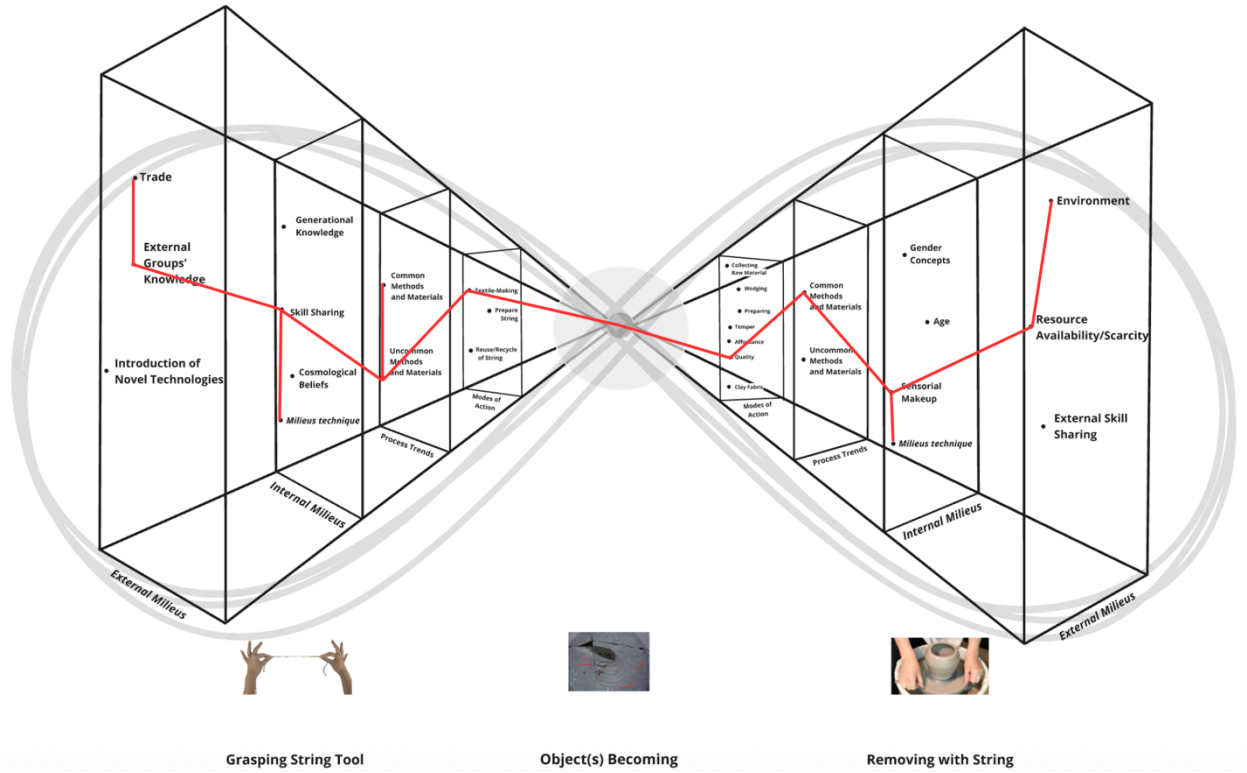


Figure 64. A *chaîne* is isolated for investigation by tracing connections between nodes within networks. The *chaîne* can now be understood as part of a broader phenomenon.

This re-envisioned *network-informed approach* offers a non-cognitivist perspective of the *chaîne opératoire* approach. This *network-informed approach* accounts for a multi-dimensional scalable network of entangled *chaînes*, while also allowing for the isolation of individual *chaînes* for analysis. This is one of infinite visual representations possible, for wherever there are nodes, there can be connections. While this specific *network-informed approach* highlights the emergence of an object, this framework is not object-centered. The proposed *network-informed approach* framework can apply to any process and is not limited to *chaînes* which have a clear beginning and end. Furthermore, this is a two-dimensional visualization, however, we should imagine this network in three-dimensions to include the possibilities of space and time as elements of a *network-informed approach*.

After redefining *chaînes* and re-envisioning *chaîne opératoire*, we must understand how this can function in practice. Additional methods must be introduced in order to incorporate process trends and *milieus* (embodied, extended, and enacted cognitive theories) within the *chaîne opératoire* approach. Utilizing the concepts of process trends, *milieus,* sensory anthropology,

ethnoarchaeology, bodily ways of knowing (Geurts 2003), and the Four-Field Co-Evolutionary model (henceforth Four-Field model) (Lombard and Högberg 2021), I propose to reconsider the methodology of *chaîne opératoire*. Instead of analyzing processes through modes of action according to the cognitivist approach (Figure 59), or through modes of action although through a non-cognitivist approach as in Cognigrams and Task Diagrams (Figure 56, Figure 57), we should regard *chaînes* as *phases* of *becoming* via this network of modes of action, process trends, and *milieus* (Figure 63). In doing so, agents (objects or non-objects) and their cognitive functions are reframed as *in process* through and with each other. A process, agent, or object, is henceforth in a constant state of *becoming* (Malafouris 2013). In order to integrate these process trends and *milieus,* I have proposed to draw on approaches such as sensory anthropology, ethnoarchaeology, bodily ways of knowing (Geurts 2003), and the Four-Field model (Lombard and Högberg 2021). I offer below a network-informed *chaîne opératoire* approach which includes the aforementioned elements. This framework is comprised of six elements, succinctly listed below, which have been developed throughout this chapter.

(1) Consider *chaînes* as a as a selected sequence of events (modes of action) and enmeshed elements (process trends and *milieus*) within a technological process, chosen for analysis.
    a. Identify where other related elements of the process may intersect with this *chaîne* to create a network of *chaînes*.
(2) Gather pertinent anthropological and ethnographic data related to process trends and *milieus* (following methodologies such as Geurts' bodily ways of knowing and the Four-Field model).
(3) Consider how process trends and *milieus* (entangled materials, the environment, sociocultural ways of knowing, learning, and remembering) may affect elements of the *chaînes*.
    a. Include these as additional *chaînes* wherever they intersect.
(4) Examine and analyze this decentralized multi-dimensional network in relation to all aforementioned connections and intersections, as opposed to one singular *chaîne*.
(5) Utilize the ability to trace connections throughout space and time ad infinitum so long as there are connections via modes of action, process trends, and *milieus*.

(6) This *network-informed approach* (a network of *chaînes*) now demonstrates modes of action, process trends, and *milieus*. Through incorporating these elements, we appreciate that the *network-informed approach* represents a continuous *process of becoming*. Furthermore, we see where theories of embodied, extended, and enacted cognition are reflected in this re-envisioned *network-informed approach*.

Concluding remarks

The approach I have outlined is a re-envisioning of the *chaîne opératoire* approach which accounts for non-cognitivist approaches. While there have been theoretical discussions regarding cognition and the *chaîne opératoire* approach (Schlanger 1994b; 2005), and discussions of integrating non-cognitivist approaches with a *chaîne opératoire* composed only of modes of action (Lombard and Haidle 2012; Fairlie and Barham 2016), I hope to have offered a methodology which is useful in practice and which also includes theories of embodied, extended, and enacted cognition by way of incorporating process trends and *milieus*. I propose that there is no need to reinvent the wheel so to speak; *chaîne opératoire* has always possessed the capacity for integrating theories of embodied, extended, and enacted cognition. By revisiting the theoretical background upon which *chaîne opératoire* was conceptualized, we see that process trends and *milieus* encapsulate the cognitive theories known as embodied, extended, and enacted cognition.

The re-envisioned network-informed *chaîne opératoire* approach I propose stands alone in that it takes a non-cognitivist approach while also addresses process trends and *milieus*. It is clear that theories of embodied, extended, and enacted cognition can aid archaeologists greatly in rethinking existing methodological frameworks such as *chaîne opératoire*. I have illustrated here that while the *chaîne opératoire* approach has been seen as a cognitivist framework, it has the capacity to be interpreted in the context of contemporary theories of cognition. *Chaîne opératoire* came into existence through groundbreaking notions of the phenomenological nature of human *being* and the enmeshment of gesture and tool. While *chaîne opératoire* approaches have emphasized a cognitivist framework, a network-informed *chaîne opératoire* approach has the capacity to offer much more. In this case, a network-informed *chaîne opératoire* approach which includes process trends and *milieus* as connections to embodied, extended, and enacted cognitive theories reframes the way we think about the links between prehistoric minds and the production of material culture.

~ Part Three: The Resolution ~

CHAPTER NINE

RETHINKING *CHAÎNE OPÉRATOIRE*, AGENCY, AND COGNITION IN BRONZE AGE AEGEAN POTTERY PRODUCTION:

FRAMEWORK AND CASE STUDY

Introduction

The overall aim of this work is to rethink and re-envision the *chaîne opératoire* approach and to consider avenues for incorporating theories of agency and cognition within it. My hypothesis from the outset was that while the *chaîne opératoire* approach is not inherently anthropocentric (agency) and cognitivist (cognition), the ways in which *chaîne opératoire* approaches are used (Use Types) limits the framework to an anthropocentric and cognitivist perspective. I have proven this hypothesis to be true through analysis of twenty three case studies of Bronze Age Aegean pottery production. In Use Type One which is used to analyze modes of action, we find that the production process is outlined through recipes for making (anthropocentric agency), following blueprint-thinking (cognitivism). Use Type Two includes process trends however they are established upon modes of action viewed from both micro- and macro-scales, resulting in a largely similar framework to Use Type One based on anthropocentric agency and cognitivist lenses.

Theories of agency and cognition have developed significantly, and yet the *chaîne opératoire* approach - a framework used to understand the craftsperson, their way of doing (agency), and their way of thinking (cognition) - has not been developed alongside these theoretical milestones. Through review of the theoretical literature, analysis, and rethinking the *chaîne opératoire* approach I have shown that these theories of agency and cognition have a place within a *chaîne opératoire* approach. In chapters Five through Nine I have resituated theories of agency and cognition within the *chaîne opératoire* approach separately for the sake of clarity. The aim of this chapter is to bring this work together to propose a *chaîne opératoire* approach which can link the finite aspects of production

with the phenomenological nature of ways of doing and ways of thinking through rethinking the *chaîne opératoire* approach. Rethinking the *chaîne opératoire* approach in this way can broaden the scope of the framework philosophically and theoretically by drawing on frameworks which aim to explain agency and cognition and furthermore materially. This in turn makes it applicable to a wider range of production processes, materials, and things (material and immaterial). This rethinking of the *chaîne opératoire* approach attempts to resolve the profound chasm between the practical use of the framework which seeks to uncover the discreet units of the process of making (the mechanics of making), with the ambition of the *chaîne opératoire* approach which must also describe the relational, relativistic, in-flow, essence of human *being* and the phenomenon of making. In what follows I outline how to bring this work together into one framework and provide a case study analyzing Bronze Age Aegean pottery to emphasize the impact of rethinking the *chaîne opératoire* approach.

The significant scope of the framework

Accepting emergent, enactive, relational, and co-constructive agency as presented in Chapter Five, we understand that peoples' *ways of doing* involve acting through and with objects or things where any person or thing can be an agent or equally not be an agent. In Chapter Six I proposed framework for incorporating theories of emergent, enactive, relational, and co-constructive agency with the *chaîne opératoire* approach. This involved drawing on an ANT approach informed by network theory broadly, typology, objects' lives, contextual reading of objects, entanglement, and relationality. The notion of typology and classification was reimagined. And furthermore, definitions of modes of action, process trends, and *milieus* were revisited and emphasized. Similarly, accepting theories of embodied, embedded, extended, enacted cognition and sensory anthropological methods as outlined in Chapter Seven, we understand that peoples' *ways of thinking* involve thinking (and acting) through and with objects or things. In Chapter Eight, I proposed a framework for incorporating theories of embodied, enacted, extended cognition and sensory anthropology with the *chaîne opératoire* approach. This was accomplished by drawing on theories of cognition, a critique of the concept of embodiment, network theory, ecological approach, sensory anthropology, and ethnography.

At this point I remind the reader of the discussion in Chapter Four which outlined the entangled nature of *ways of doing* and *ways of thinking*. While I have thus far presented the topics of

agency and cognition separately for the sake of clarity and to offer a thorough review of each, it is clear that the two are inherently linked. The two concepts and related proposed frameworks must be brought together in order to achieve the goal of resolving the disconnection between the practical use of the framework which seeks to uncover the discreet units of the process of making (the mechanics of making), with the ambition of the *chaîne opératoire* approach which must also describe the relational, relativistic, in-flow human *being* and the phenomenon of making.

Bringing agency and cognition together: the framework

Drawing on the proposed frameworks outlined in Chapter Six and Chapter Eight, I set out to combine the two. With an understanding of both concepts, I take the framework for agency in *chaîne opératoire* proposed in Chapter Six and supplement it with my framework for cognition in *chaîne opératoire* proposed in Chapter Eight. In doing so, we arrive at a *chaîne opératoire* approach which includes emergent, enactive, relational, co-constructive agency and embodied, enacted, extended cognition. This can later be considered against the capacity of the *chaîne opératoire* approach to account for not only the process of making (the mechanics of making), but also its capacity to describe the relational, relativistic, in-flow, essence of human *being* and the phenomenon of making. Let us recall the image of emergent, enactive, relational, co-constructive agency based on network theory, ecological perspective, objects' lives, and context (Figure 52). The connections between entangled nodes within further entangled networks of modes of action, process trends, and *milieus* represent the interconnectedness of all elements which contribute to the emergent becoming of an object. Emergent, enactive, relational, co-constructive agency viewed through the lens of network theory broadly, typology, objects' lives, contextual reading of objects, entanglement, and relationality provides us with a fuller picture of how new theories of agency can be situated within the *chaîne opératoire* approach.

How can we incorporate and represent cognition within this framework? Let us recall the image of embodied, extended, and enacted cognition linked through *milieus* and *chaînes* (Figure 63). Considering Figure 63, we recognize that the mind is not something inside the brain but rather cognition "emerges from contextualized processes that take place 'between' brains, bodies, and things" (Malafouris 2013, 78). It can be said also that thinking takes place not only "between" but also *through* and *with* brains, bodies, and things *which have the capacity for agency*. Furthermore, we recall that not only objects or materials have the capacity for agency, but also the environment

and ecology, cultural practices and belief systems, generational knowledge and skill-sharing traditions, politics, and institutions. So wherever cognitive processes (ways of thinking) are enacted, embodied, and extended they are also affected by ways of doing, objects, and things with the capacity for agency. Looking at Figure 65 we can consider each node as an object or thing with the capacity for agency, having the capacity for affect wherever connections can be traced *across* and *through* space and time. Each node is imbued with emergent, relational, co-constructive agency which has affect when it is engaged with physically, cognitively, or spiritually (cosmologically).

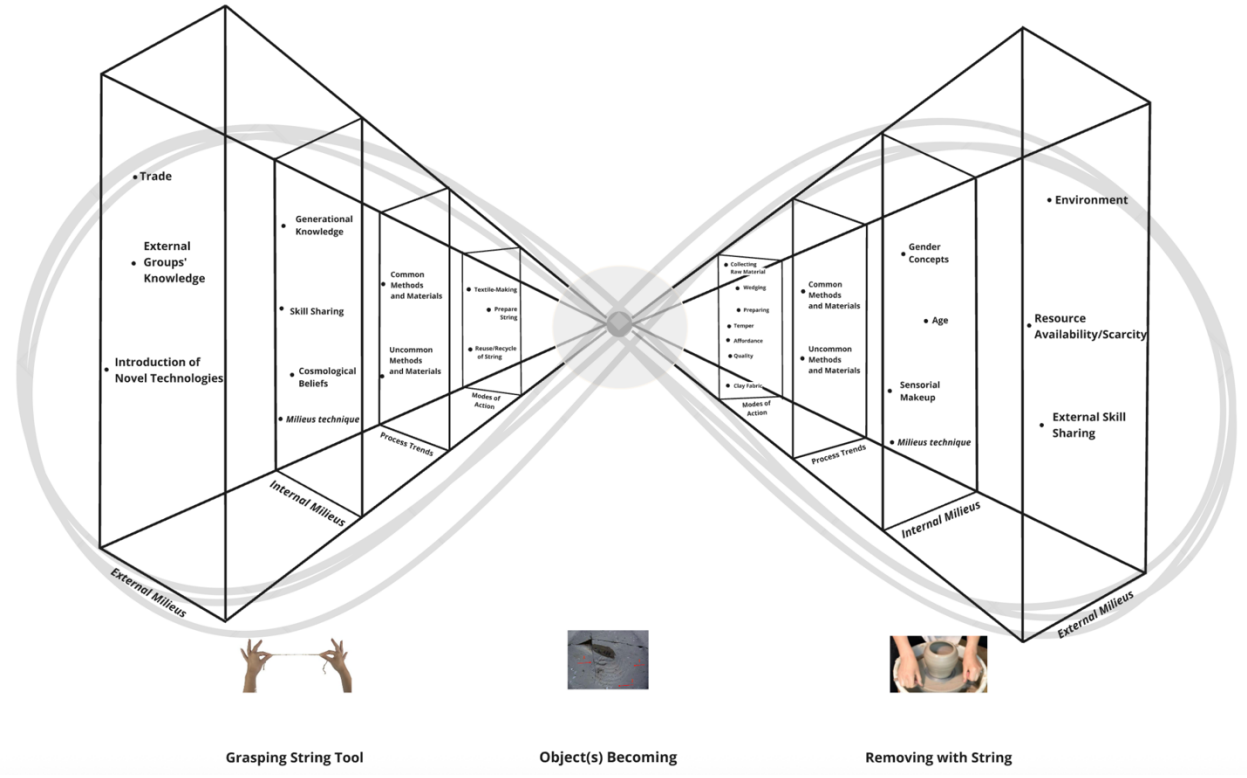


Figure 65. The figure represents a visualization of the *chaîne opératoire* approach wherein entangled nodes occupy entangled networks which result in the emergent becoming of the object. Each node has the capacity for emergent, relational, co-constructive agency which has affect when engaged with physically, cognitively, or spiritually (cosmologically).

The two visualizations of a *chaîne opératoire* approach to agency and cognition in Chapter Six and Chapter Eight respectively include the same elements due to the fact that ways of doing and ways of thinking are entangled. As such, the cumulative visualization of the *chaîne opératoire* approach (Figure 65), also includes the same elements. Thus far I have developed visualizations of agency and cognition in the *chaîne opératoire* approach separately for the sake of simplicity. At this

point, we bring the two together. Ways of doing and ways of thinking are inherently entangled, and these concepts are ontologically quite similar as laid out in Chapter Four. It should be noted that the figures are also similar because of my network-informed approach to both concepts. Additionally, it is worth noting that my visualizations of the concepts are influenced by an interest in physics, metaphysics, philosophy, feminism, and art. In order to understand how these two images of agency and cognition are brought together we only need to recall that modes of action, process trends, and *milieus* are the foundational basis for both concepts. We further recall that each of these elements of the *chaîne opératoire* approach have been redefined to account for agency and cognition. Through the re-envisioning of the *chaîne opératoire* approach (Figure 65) we understand each connection is not only representative of emergent, relational, co-constructive agency but *also* representative of embodied, enacted, extended cognition.

The rethinking of *chaîne opératoire*: a trial

Having reconsidered the key elements of the *chaîne opératoire* approach and redefined them to account for new theories of agency and cognition it is a worth-while exercise to test this new approach. I have selected for this exercise an early excavation report from the Bronze Age Aegean site Zakros (sometimes also called Zakro or Kato Zakro). Zakros is located on the eastern coastline of Crete (Figure 66). It is a harbor site which most likely participated in the vast trade routes of the Aegean, Near East, and mainland Greece. This Zakros excavation report is conducive to the exercise at hand for a number of reasons: (1) the report includes pottery found at distinct locations (pits associated with a shrine and houses); (2) the report references similar finds from near and far (Palaikastro, Phaistos, Psychro, Knossos, and more); (3) the report references finds of non-ceramic materials (e.g., metals) (Dawkins 1903); and (4) there is ethnographic and anthropological research regarding modern potters on Crete from which we may draw supplemental information. Utilizing the Zakros report, I outline an example of how pottery from this site might be approached from a Use Type One and Use Type Two *chaîne opératoire* approach. As we recall Use Type Three does not engage with *chaîne opératoire* in a meaningful way, so it is unnecessary to outline an example. Next, I approach the same excavation of pottery following my proposal for a reconsidered *chaîne opératoire* approach to explore how it can be applied.

The Zakros excavation report provides the context necessary to apply this reconsidered *chaîne opératoire* approach. A majority of the case studies presented in Chapter Three draw data

from various unspecified excavation contexts, while others focus on one specific context (e.g., funerary containers, household pottery, or peak sanctuaries). Many of the case studies I describe in Chapter Three focus on morphological traits or functionality; they do not differentiate between distinct excavation contexts (e.g., pits and houses). While the contextual findings of these studies are limited, the Use Type Two studies do draw on data from various regional sites (e.g., Aegean and Anatolia, Mycenae and Crete, etc.). Additionally, of the twenty three case studies presented in Chapter Three, none reference non-ceramic materials. This underlines perhaps how popular the framework is within pottery production studies, as well as the sheer volume of pottery finds, and also the tendency to utilize *chaîne opératoire* approaches in a narrow manner excluding related material culture and production processes. This omission of non-ceramic materials makes the application of the proposed *chaîne opératoire* approach to any of the twenty three case studies challenging. And finally, while ethnographic and anthropological data is available regarding Aegean pottery production, it is not integrated within the Use Type One and Use Type Two *chaîne opératoire* approaches utilized in the twenty three case studies presented.

The Zakros report is therefore unique in that it encompasses each of the four aforementioned elements (distinct contexts, regional data, non-ceramic material, and availability of ethnographic or anthropological data). The case studies in Chapter Three can of course be re-analyzed using my proposed network-informed *chaîne opératoire* approach with the additional work necessary to gather the supporting data. In order to utilize the proposed framework on the Chapter Three case studies, the work involves cross-referencing extensive literature - a sizeable task. The research presented here therefore lends itself to ongoing research and examination of previously published data. However, in this project I tackle many broad topics, so for the purpose of this study the Zakros excavation report which encompasses all of the necessary elements simplifies the exercise at hand.

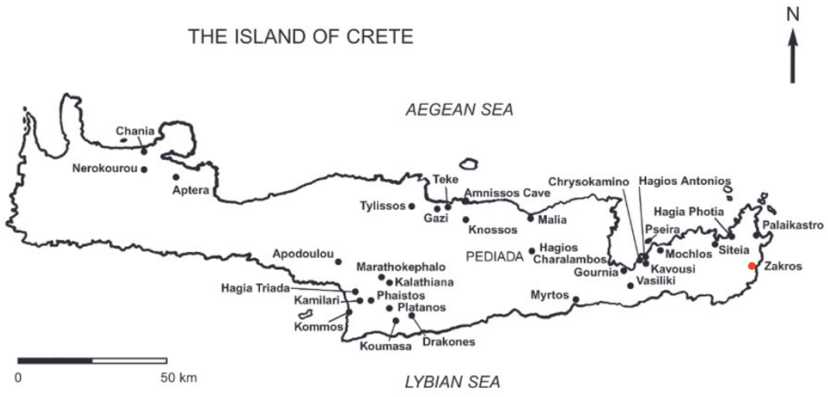


Figure 66. Map of Crete, showing Zakros on the eastern coast (Betancourt 2007)

Within this excavation report of Zakros, pottery is separated by site source (pits and houses). The pottery is further separated by style (Kamares or Mycenaean wares). As we might see in a typical Use Type One *chaîne opératoire* approach, the researcher may take for example the pottery found in the pits and classify the vessels by shape, size, and style. They may select small cups found at the pits, decorated in the Kamares style for example. They would find that all small cups of the Kamares style have string marks on the bottom (Figure 67) revealing they have been made on a pottery wheel and later removed using a string (Dawkins 1903). The researcher may then outline the process of forming a cup on the pottery wheel based on modes of action as outlined in similar studies of wheel-fashioned vessels (e.g., Choleva 2018). In a typical Use Type Two *chaîne opératoire* approach, the researcher may use this data from Zakros which reveals that apparently all small cups in the Kamares ware style have been made using the pottery wheel. They may compare this data with assemblages of small cups at other sites in the region to find that small cups are either made similarly or differently across the region (for example wheel-fashioned versus wheel-thrown) (e.g., Choleva et al. 2020). These approaches isolate the small cups from one location from one site to form the basis of their data (modes of action). As we saw with the "core method" it is also clear that this method cannot account for anomalies within these isolated subsects of pottery (Burke et al. 2021). These isolated typologies and their related modes of action are then used in Use Type Two which are then used to compare with similarly isolated data sets to gauge regional patterns (process trends). These approaches do not engage with the actual significant scope of the *chaîne opératoire* approach and cannot account for emergent, relational, co-constructive agency or embodied,

enacted, extended cognition. Instead let us attempt my proposal for a network-informed *chaîne opératoire* approach which is inclusive of emergent, relational, co-constructive agency or embodied, enacted, extended cognition.

Figure 67. Small cup in Kamares style with string marking on base (Dawkins 1903)

Typology

In our framework we begin with a broader and more inclusive *typology of gestures* such as "vessels with string markings" (Figure 68). Instead of isolating vessels with string markings from one location (e.g., pits), or by size and shape (small cups), we take a look at *all* vessels with string markings (Figure 69). Drawing on theories of emergent, relational, co-constructive agency we know that these string markings indicate a gesture which emerges *between*, *through,* and *with* the material. Drawing on embodied, enacted, and extended theories of cognition these string markings furthermore exemplify the cognitive activity of thinking *through* and *with* the body (embodied and enacted), the material and ecology (extended), and other concepts, beliefs, or institutions (extended). Now when we come across anomalies, we may find connections to other objects, things, materials, processes, concepts, beliefs, or institutions. We must trace connections where they exist according to the proposed *chaîne opératoire* approach in order to discover these links.

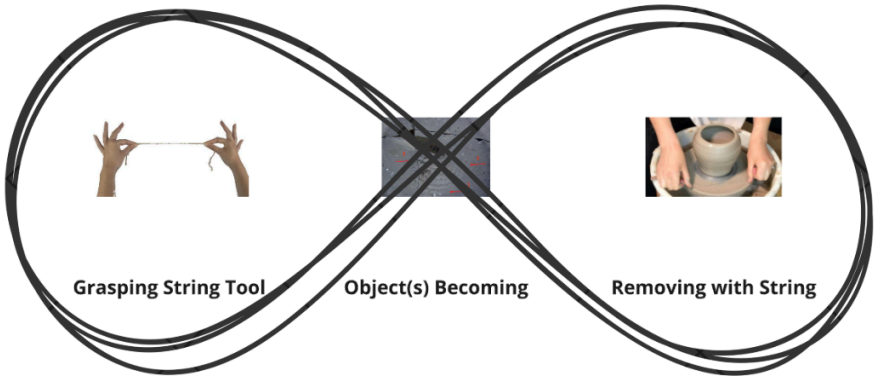


Figure 68. Considering gesture as a typology to account for agency and cognition

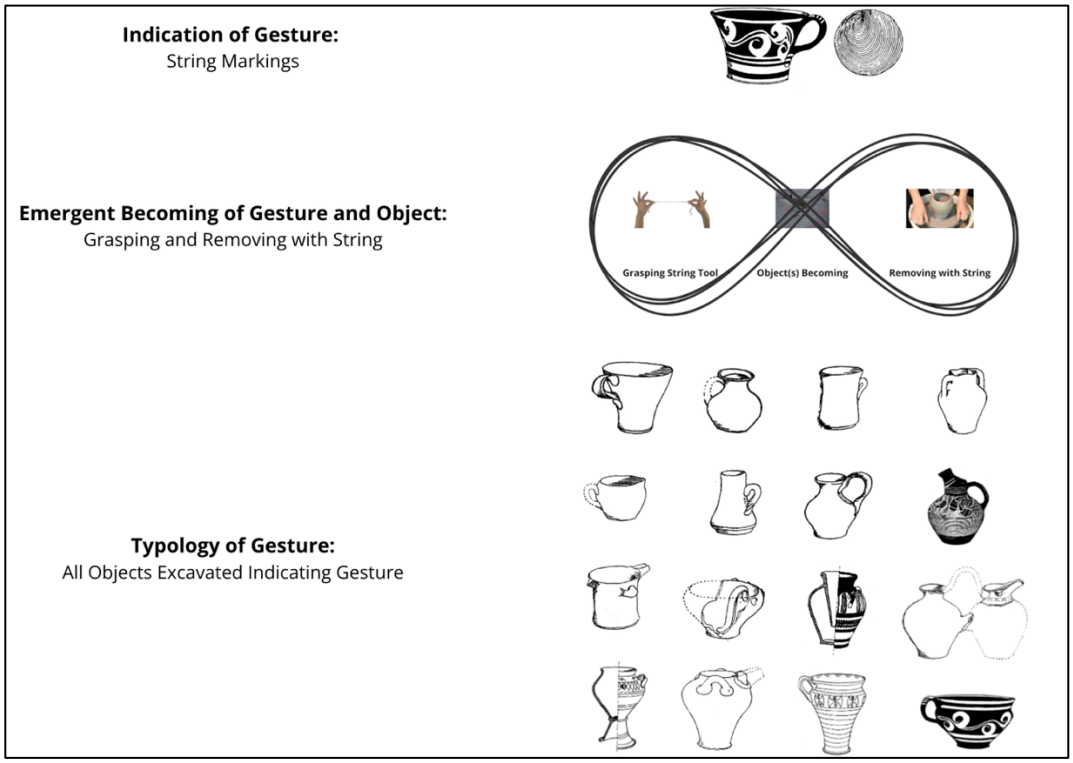


Figure 69. A typology of gesture. This example highlights vessels with string markings at Zakros showing variety of forms, sizes, and styles (vessel illustrations from Dawkins 1903)

Modes of action

As mentioned, if we classify objects based on a typology of traces of gesture according to emergent, relational, co-constructive agency, and embodied, enacted, extended cognition, we find that modes of action offer more than simple recipes for doing or blueprints for thinking. Instead of asking "who or what make these markings?" we ask, "how did these markings *become*?". Rather than modes of action being limited to a single moment in time and space where the hand is engaged with the clay, we consider tracing connections between nodes within and between networks to outline the systemic context of these objects (Figure 70).

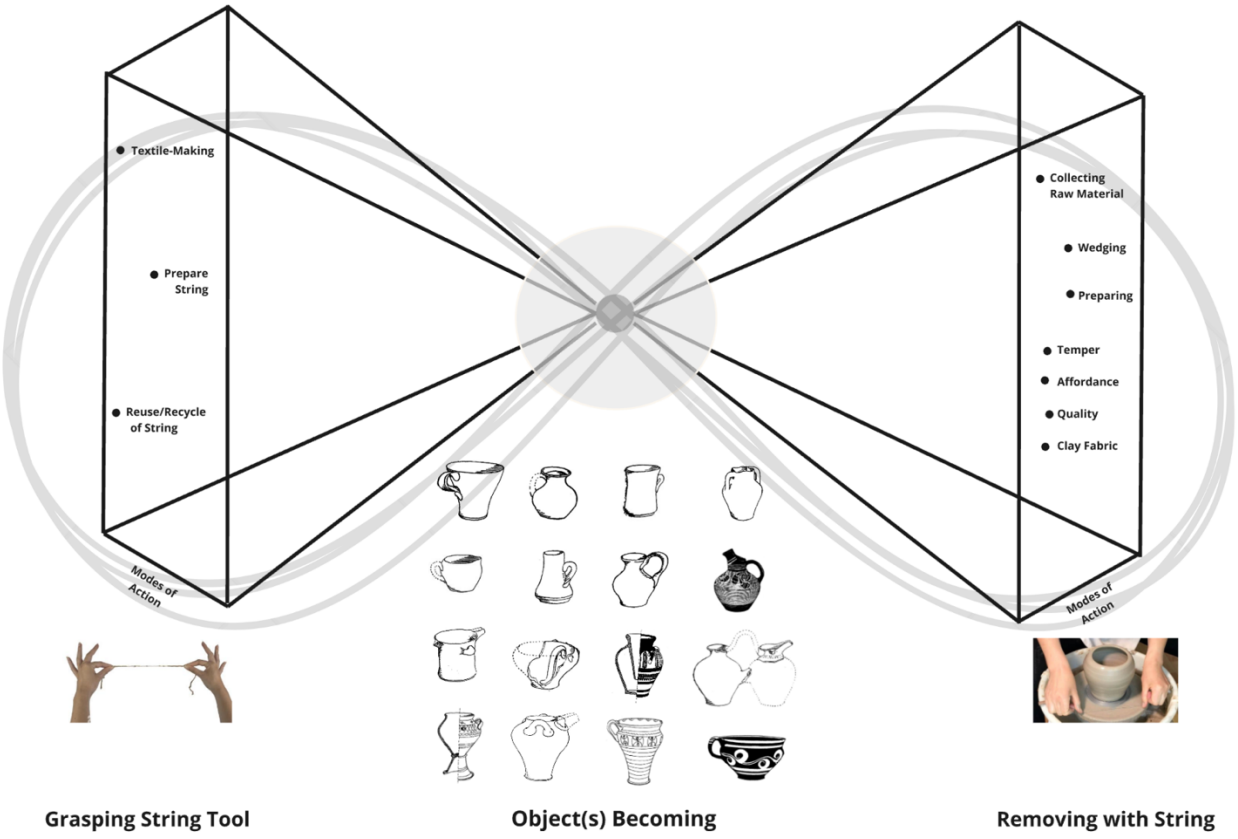


Figure 70. Modes of action accounting for emergent, enactive, relational, co-constructive agency and the various objects becoming from this process

Process trends

Using this same set of vessels which all indicate a string marking on the base, we build upon the modes of action to consider process trends such as common and/or uncommon methods and

materials (Figure 71). Figure 71 provides a general visual outline for the inclusion of process trends. In this case study though, we must use the resources available from the excavation at Zakros, data found across the wider region, sensory anthropology, and ethnography to understand the process trends specific to this study. We know that within this assemblage one commonality is of course the string marking. We then analyze process trends at Zakros compared with the wider region, seeking further similarities and differences.

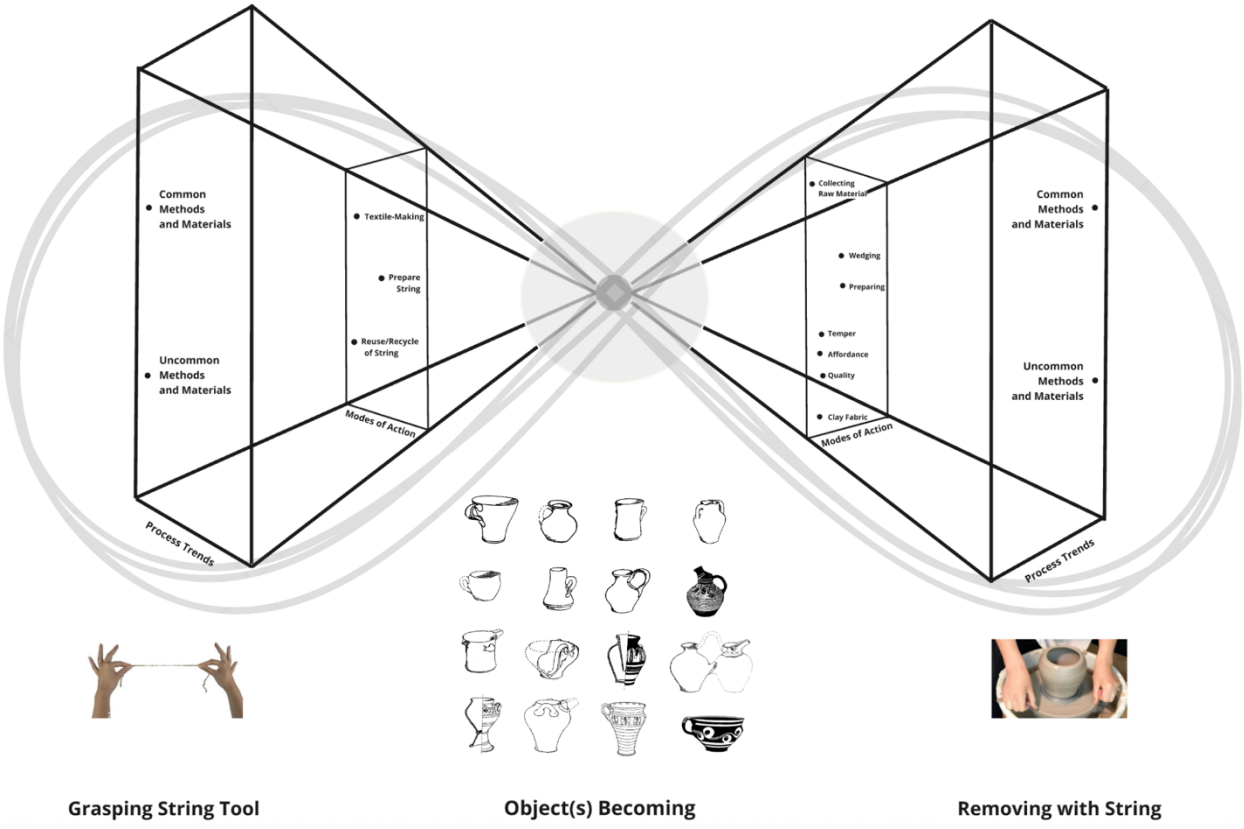


Figure 71. Visual outline for considering process trends related to the object(s) emergent becoming based on a typology of gesture.

Across many other sites we also see vessels with string markings on the bases; this technique is not necessarily unique (e.g., Choleva 2012). However, based on the excavation report we find that some of the Kamares ware vessels at Zakros are uniquely formed using techniques reminiscent of metalworking where a cup is comprised of straight sides joined at a sharp angle (Dawkins 1903). This join is marked by a thickening in the clay as with a join between two metal plates, and the handle is made similarly to a flat metal strap handle. Similarly, Dawkins describes

(but unfortunately does not illustrate or cite) a Mycenean bowl also made in a technique reminiscent of metalworking except that where the handle joins the base of the bowl there is a small boss of clay added at an angle to mimic a rivet in metalworking. According to the Zakros excavation report many of the vessels with string markings have handles, yet some of them have handles strangely placed inside of the vessel (Figure 72). There is also a vessel which has a funnel beginning at the mouth pointed downwards inside the vessel but not reaching the base; Dawkins remarks that this unique vessel parallels one found at Palaikastro (Figure 73) (Bosanquet and Dawkins 1923).

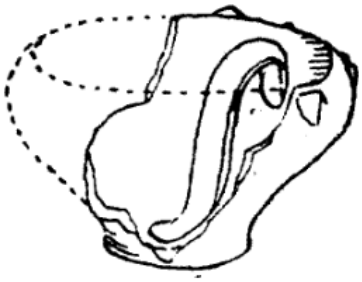


Figure 72. Vessel with handle placed inside (one of two vessels in this style) (Dawkins 1903)

Figure 73. Vessel with funnel inside the body parallels a similar form excavated at Palaikastro (Dawkins 1903)

Having observed process trends which are related to the form and gesture of the emergence of this typology we may visualize them as entangled nodes on networks which are, of course, entangled with the modes of action. These process trends are related to the typology of vessels which present the string markings – our typology of gesture. The figure below highlights the process

trends in formation and gesture discussed so far (Figure 74). Because these process trends are related equally to all previous elements discussed, they are noted symmetrically on both sides of the figure.

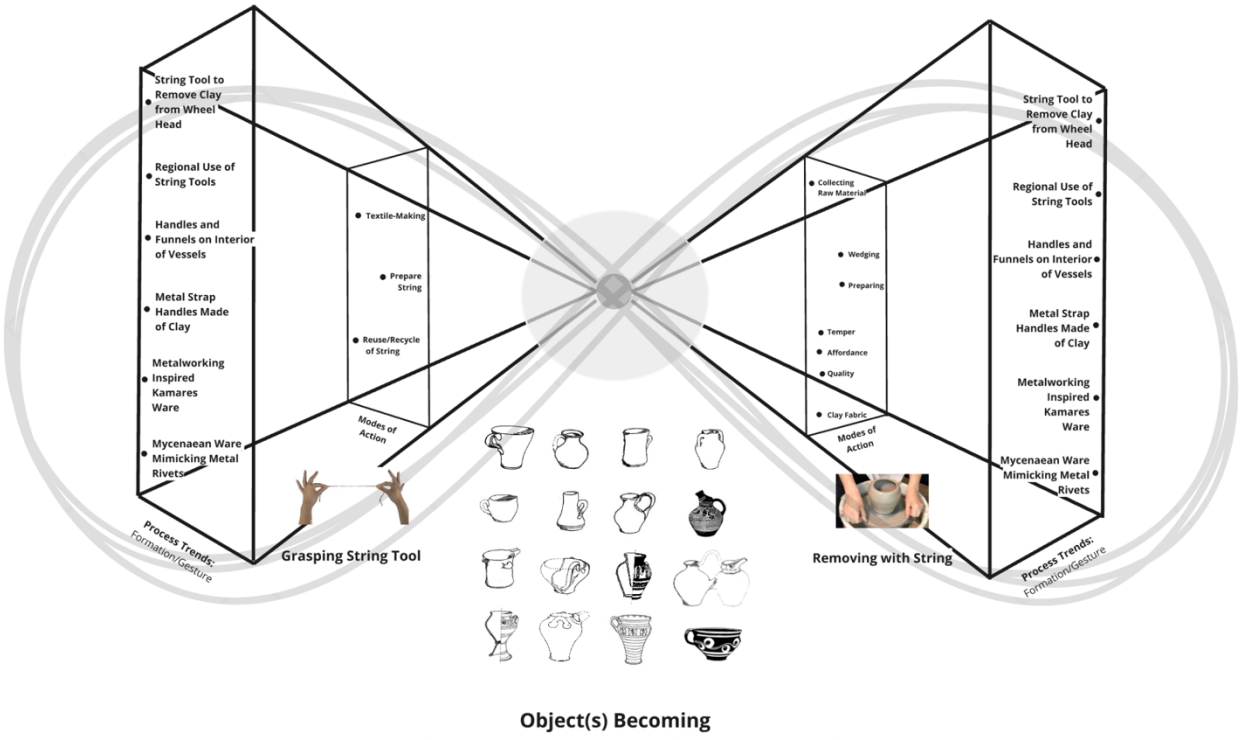


Figure 74. Process trends related to formation and gesture are included in the emergent becoming of this typology of gesture.

While considering this grouping of vessels with string markings, we must also investigate the context of both intra- and inter-site finds to learn more about the process trends associated with this grouping of vessels. First of all, we must consider that these vessels were found across two different contexts at Zakros: (1) pits associated with a shrine; and (2) houses. In the pits located near a shrine, Dawkins notes that mainly small straight-sided cups with both Kamares and Mycenean wares are present (some mimicking the techniques of metalworking). Dawkins notes that due to the proximity of the two sites, pottery in the pits may have been cleared out of the shrine and discarded into the pits. This allows us to potentially link the making of these cups with their use and discard. It also signals that these cups may have been used only once as there is no evidence of repair and reuse, only discard. Again, taking a network theory approach and contextual reading, we are able to link the

most basic information (vessels with string markings) to cosmological views and practices (use at or near a shrine).

In the houses at Zakros, Dawkins notes that the pottery is mostly late Mycenean ware and while we maintain a focus on flat-based vessels with string markings, we must note that many of the vessels in the houses also have perforations on the bases. Some are thought to be strainers and they stand out as common finds from this context although they are much larger than similar strainers found at Gournia and Palaikastro (Figure 75) (Dawkins 1903, 255; Bosanquet and Dawkins 1923). Similarly, Dawkins notes vases with perforated bases (Figure 76). Another unique vessel is found at the houses at Zakros – the double-vase – which have also been found at Gournia and Palaikastro (Figure 77) (Bosanquet and Dawkins 1923). There are numerous interesting commonalities and "anomalies" across Zakros and other regional sites, but these examples suffice for this case study. The point is quite clear that while the flat-based vessels with string markings in the houses may in some sense fall into the same typology, they exhibit unique features such as perforations. Through a contextual reading we can attribute these vessels to household usage. But it is also interesting to note that these vessels exhibit similar modes of action (string markings) as the cups used at a shrine. A technique which is utilized in making both ritual *and* household items is significant and provides context to the production process involved in two functionally distinct objects.

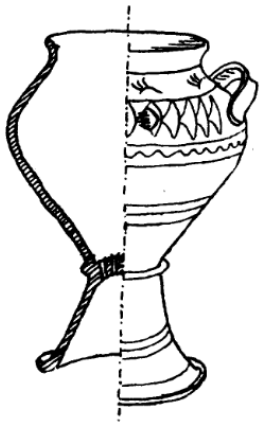


Figure 75. Strainer with perforations (Dawkins 1903)

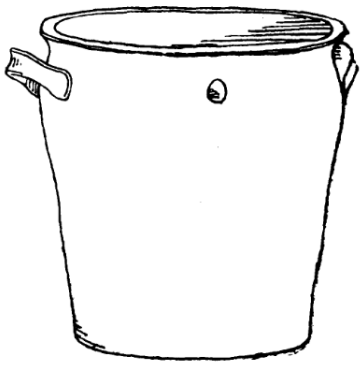


Figure 76. Vase with perforations through base

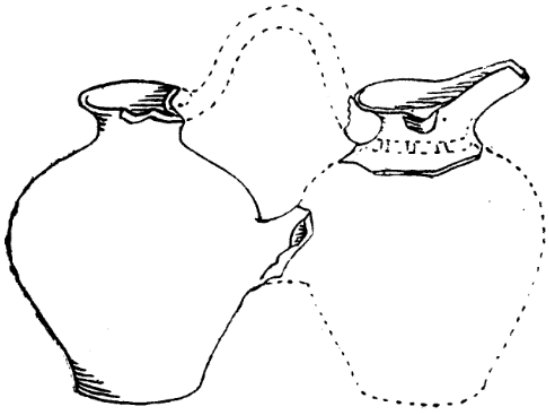


Figure 77. The double-vase (Dawkins 1903)

Having considered this grouping of vessels with string markings, their commonalities and anomalies, at both intra- and inter-site levels, we can reimagine the network of process trends as they are now shown in Figure 78. This figure clearly shows that taking this typological approach, paired with theories of emergent, relational, and co-constructive agency alongside embodied, enacted, and extended cognition, we are offered a more nuanced understanding of process trends. In Figure 78, I have "abbreviated" the visual representation of modes of action and process trends (regarding formation and gesture) so that additional networks may be included. The added networks represent process trends at the intra- and inter-site levels. These are socially informed choices made within a site and throughout the region highlighting not only commonalities but also emphasizing that methods and materials which seem to be anomalies at Zakros are actually found to be common at other sites (Palaikastro and Gournia). Through the process of my proposed approach to typology, modes of action, and process trends our proposed *chaîne opératoire* approach now accounts for

new theories of agency and cognition. Within this proposed *chaîne opératoire* approach commonalities and anomalies are equally accounted for and contextualized. In this case I have chosen to include intra- and inter-site process trends as delineated networks for the sake of clarity. However, one of the benefits of this visual representation is that it can be abbreviated and expanded dependent upon the aim and scope of the research as well as available data.

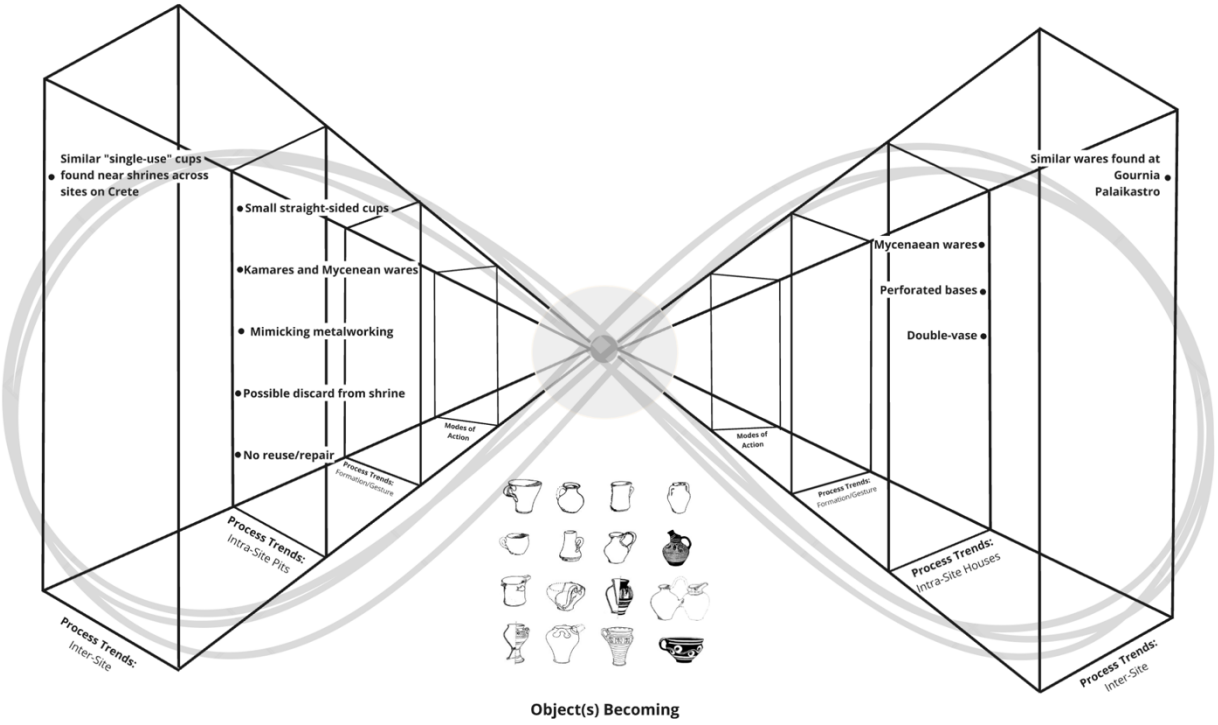


Figure 78. Additional networks have been designed to include process trends at Zakros and across the region. This is accomplished by including additional networks of entangled nodes. The networks are named here "Process trends: Intra-Site Pits", "Process trends: Intra-Site Houses", and "Process trends: Inter-Site".

Milieus

After considering the connections between commonalities, anomalies, and archaeological contexts within and across regional sites, let us consider how Leroi-Gourhan's *milieus* can help to expand on these process trends. *Milieus* can be divided into three categories: (1) *Milieu extérieur* which describes the natural environment, material culture, and the knowledge or ideas of other groups; (2) *milieus interior* which describes intellectual capital of a given group; and (3) *milieu technique* which is perpetually growing and shifting – it contains a groups' traditions and perpetuated modes of

thought and action. As outlined in Chapter Eight, the *milieus* all together can be discussed parallel to concepts of embodied, enacted, and extended cognition (and therefore also emergent, relational, co-constructive agency). The *milieus* can account for the environmental ecology, trade networks, process trends, cultural practices and cosmological beliefs among other things. In essence, *milieus* bring together the data gathered from modes of action and process trends, and through additional contextual reading, as well as sensory anthropology and ethnography, offer us an enlivened vision of the process in question.

In order to consider the *milieus* associated with our vessels with string markings we must build upon our modes of action and process trends and later bring in anthropological and ethnographic data as well. First, we consider the *milieu extérieur* which at Zakros includes that it is a harbor site, based on the coast in a protected bay, with a Minoan palace and town protected by hills which would have been a port for trade (Hogarth 1901; Dawkins 1903). While the geographic features have changed due to the ongoing climate crisis, the prehistoric shoreline and mainland features have been reconstructed very carefully by Mourtzas and Kolaiti (2017). Considering the *milieu intérieur* we draw upon the skills and knowledge displayed by materials and practices at this site (such as wheel-fashioned pottery as evidenced by the vessels with string markings). The *milieu intérieur* also contains the *milieu technique*, which is defined as groups' traditions and perpetuated modes of thought and action. We can discuss the *milieus* through further understanding the context of the site and its elements.

This site was most likely a place where people lived (as evidenced by excavations of houses and domestic pottery) and also functioned as a point of administration and leadership (as evidenced by excavations of the palace – understood to represent some political or administrative power as well as storage for goods and trading), and finally as a cosmological center (as evidenced by excavations of shrines, lustral basins, and burials) (Mourtzas and Kolaiti 2017). These facts can contribute to the understanding of the groups' *milieus*: (1) *milieu extérieur* this is a diverse environment made up of a protected coastal bay, rocky shoreline, grassy and rocky flatland areas, and tree-covered hills, they will have contact with other groups and their ideas as a key sea-trade location; (2) *milieu intérieur* this group has knowledge of handmade and wheel-fashioned pottery, metalworking, textiles, large-scale architecture, and skills for trade by land and sea; (3) *milieu technique* we find evidence of perpetuated modes of thought and action across all material media (pottery, metalworking, textiles, architecture), as well as the influence of other groups' knowledge and skills.

We can gather further information regarding potters' traditions by carefully reviewing decades of ethnographic studies of potters at Thrapsano (e.g., Xanthoudídes 1927) and Margarités (e.g., Georgel-Debedde 2022), regions in Crete where potters continue to produce traditional ceramic wares such as *pithoi* (Figure 79, Figure 80). These communities of potters share knowledge intergenerationally, within their community, and also with other groups. For centuries these communities of potters persist in (re)enacting "the skills and knowledge accumulated through generations of previously made… vessels" by engaging *with* and *through* the material and their "transgenerational memory" (Prezioso 2024). However, this is not an insular knowledge-sharing tradition. There is evidence of pottery styles which are unique to one site or small region spreading across the wider Minoan landscape and beyond. For example, there are Kamares and Mycenean wares found across different locations (geographic and temporal) on Crete (Dawkins 1903; Day 1997; Knappett and Nikolakopoulou 2005). Kamares ware and Mycenean wares are both found at Zakros indicating two traditions present at once; and additionally there is evidence of a small number of vessels which *combine* the two styles (Dawkins 1903). Furthermore, there is "Minoanizing" pottery excavated on mainland Greece which is non-Minoan pottery made to mimic Minoan styles (e.g., Broodbank and Kiriatzi 2007; Hilditch 2012). So, we know that knowledge is shared directly through people interacting and indirectly through (re)enacting and imitation. The potters teach embodied and enactive making *through* and *with* the material, as well as engaging with "making as remembering" (memory refers here to the potter and the clay) (Malafouris and Koukouti 2018; Prezioso and Alessandroni 2023; Prezioso 2024). The skills are taught beyond the confines of the cognitivist boundary of the skull – they are taught in person and engaged with the clay (embodied, enacted, and extended cognitive processes).

Figure 79. Potter producing a *pithos* near Thrapsano circa 1927 (Xanthoudídes 1927)

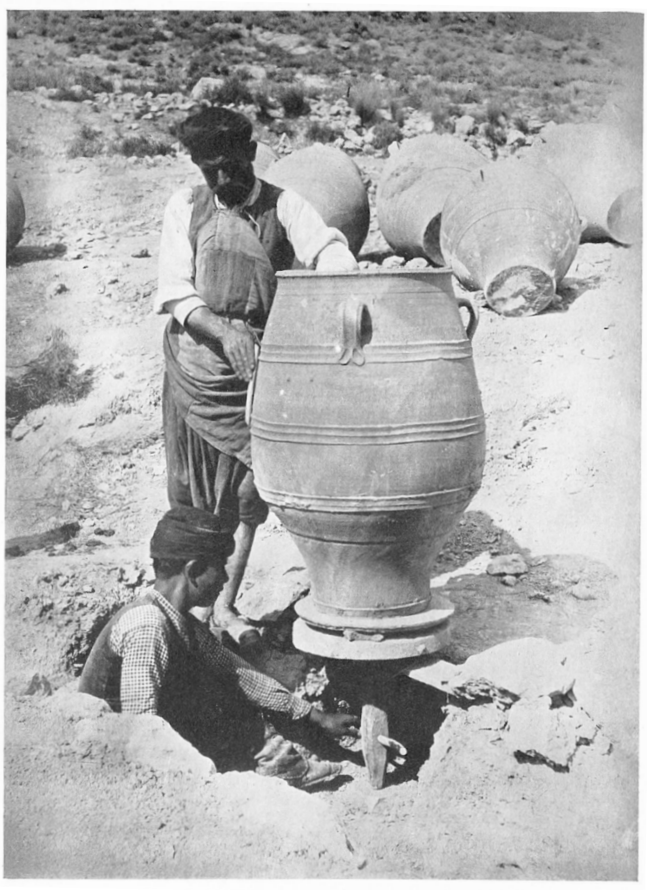


Figure 80. Two potters producing *pithoi* near Thrapsano circa 1927 (Xanthoudídes 1927)

Regarding cosmological beliefs we can definitively say that pottery has been located across the region at shrines, peak sanctuaries, and at palaces so there must be *some* connection between pottery, rituals, and cosmological beliefs (Betancourt 1985). These are only a few examples of data which can inform our understanding of a groups' *milieus* (embodied, enacted, and extended cognition). Depending on the significant scope of the study, one might require more information regarding the ecology, economy, politics, socially constructed gender concepts, labor division, and cosmological views. Reconsidering the figure of process trends to include the *milieus* evident at Zakros and connected with the sites of Palaikastro and Gournia we are presented with a dynamic, interconnected, if not slightly overwhelming, view of ways of doing and ways of thinking (Figure 81). This *chaîne opératoire* approach can be scaled appropriately to the focus of the study at hand. Figure 81 demonstrates an avenue to rethink and re-envision the *chaîne opératoire* approach to include *milieus*.

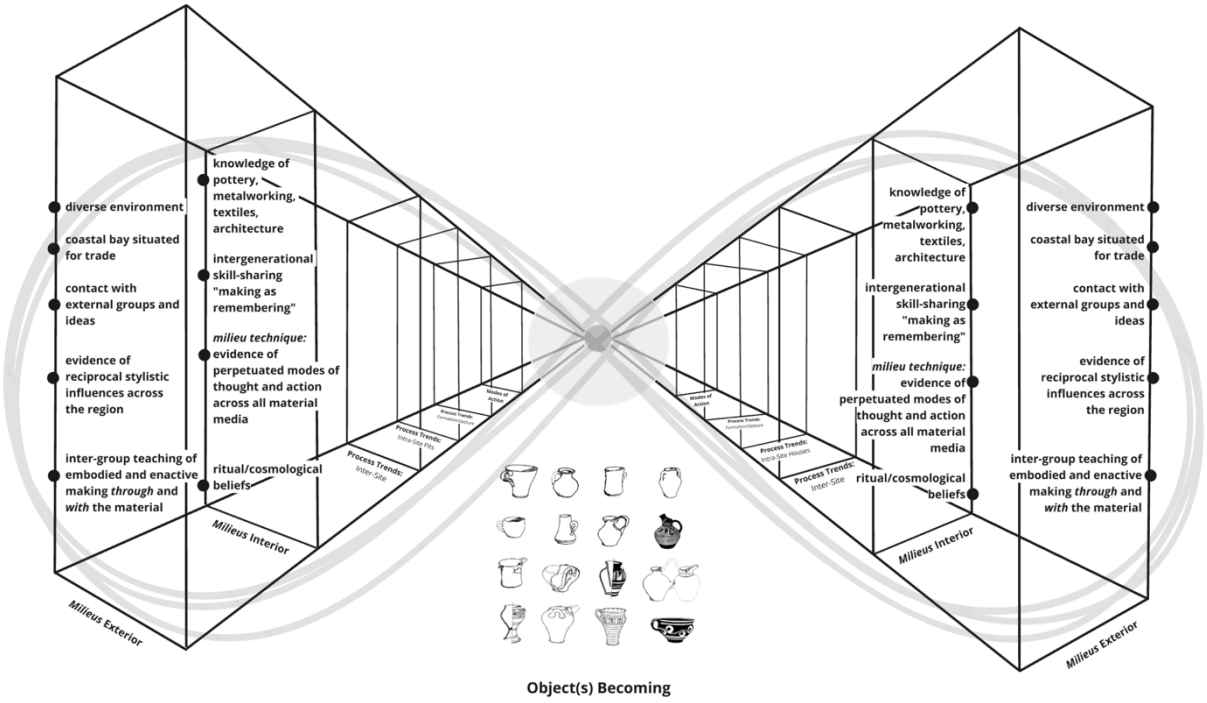


Figure 81. Proposed *chaîne opératoire* approach incorporating modes of action, process trends, and *milieus* according to theories of emergent, enactive, relational, co-constructive agency and theories of embodied, enacted, and extended cognition. Modes of action and process trends are abbreviated for simplicity in this figure to draw focus to the *milieus*, yet they should be understood to retain all nodes and data from the previous figures.

Tracing a *chaîne*

At this point in our study at Zakros, we have collected and incorporated all data (nodes) into the re-envisioned, reconsidered, network-informed *chaîne opératoire* approach. The framework now accounts for emergent, enactive, relational, co-constructive theories of agency as well as theories of embodied, extended, and enacted cognition by way of incorporating process trends and *milieus*. For the sake of simplicity, the figures thus far have been illustrated and abbreviated to emphasize each major element of the *chaîne opératoire* approach. While a researcher may wish to acknowledge the broad network of entangled networks and nodes which demonstrate the phenomenon of making, they may also wish to trace one specific *chaîne* for investigation of one aspect of making. In order to demonstrate this, all nodes are listed below and labeled numerically. Each number representing a node, will be placed on its respective network in the visual representation of the *chaîne opératoire* approach. This numerical system is meant to simplify the visual representation but may not be necessary in other studies which involve fewer nodes. Figure 82 depicts our network informed *chaîne opératoire* including all entangled nodes represented by their assigned numbers upon the entangled networks.

Modes of action: Grasping String Tool

1. Textile making
2. Prepare string
3. Reuse/recycle string

Modes of action: Removing with String

4. Collecting raw material
5. Wedging
6. Preparing
7. Temper
8. Affordance
9. Quality
10. Clay fabric

Process trends: Formation/Gesture: Grasping String Tool

11. Handles and funnels on interior of vessels
12. String tool to remove clay from wheel head
13. Regional use of string tools

14. Metal strap handles made of clay

Process trends: Formation/Gesture: Removing With String

15. String tool to remove clay from wheel head
16. Metalworking inspired Kamares ware
17. Mycenaean ware mimicking metal rivets

Process trends: Intra-Site: Pits

18. Small straight-sided cups
19. Kamares and Mycenaean wares
20. Mimicking metalworking
21. Possible discard from shrine
22. No reusing/repair

Process trends: Intra-Site: Houses

23. Mycenaean wares
24. Perforated bases
25. Double-vase

Process trends: Inter-Site: Pits

26. Similar "single-use" cups found near shrines across sites on Crete

Process trends: Inter-Site: Houses

27. Similar wares found at Gournia and Palaikastro

***Milieus* Interior**

28. Knowledge of pottery, metalworking, textiles, architecture
29. Intergenerational skill-sharing; "making as remembering"
30. *Milieu Technique:* evidence of modes of perpetuated action across all material media
31. Ritual/cosmological beliefs

***Milieus* Exterior**

32. Diverse environment
33. Coastal bay situated for trade
34. Contact with external groups and ideas
35. Evidence of reciprocal stylistic influences across the region
36. Inter-group teaching of embodied and enactive making *through* and *with* the material

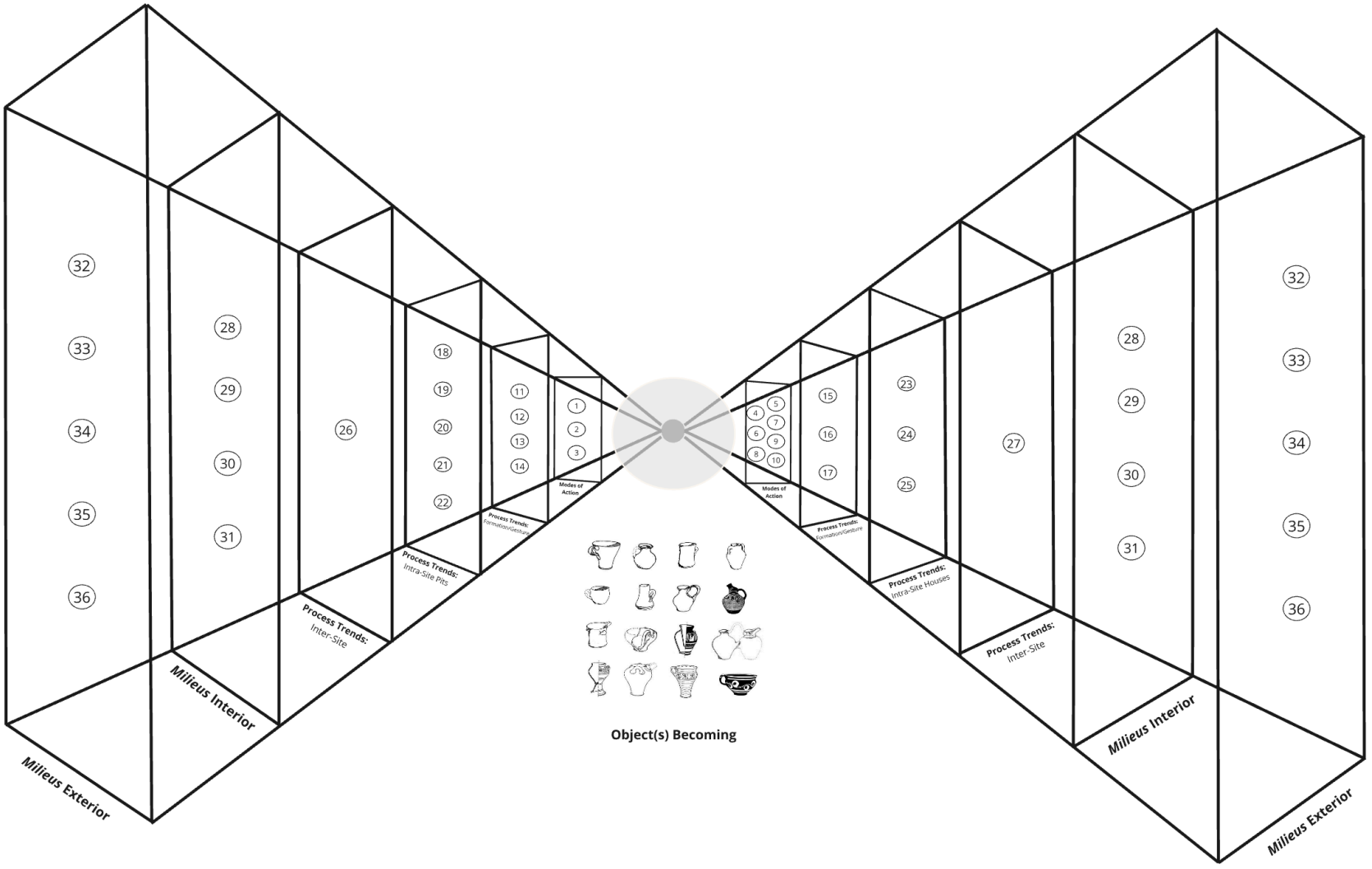


Figure 82. All entangled nodes are represented by their assigned numbers upon the network informed chaîne opératoire.

As an example, one may wish to trace a *chaîne* to investigate the influence of metalworking on pottery making at Zakros. In order to achieve this we trace from the object(s) becoming through our typology of gesture, through the networks of entangled modes of action (1-10), to the gestural process trends which indicate metalworking influences (14, 17), to the intra-site process trends which indicate stylistic influences and metalworking influences (19, 20, 23), to their inter-site process trends indicating regional similarities (26, 27), and finally to the *milieus* interior and *milieus* exterior indicating elements related to embodied, extended, and enacted cognition (28-36). Figure 83 demonstrates visually how this *chaîne* may be traced through the aforementioned nodes within the proposed network informed *chaîne opératoire* approach. By tracing this *chaîne* we see the influence of metalworking in the practice of pottery making at this site and other regional sites. Metalworking influences are seen not only through modes of action (mechanical elements of making) but also the process trends and *milieus* (the broader phenomenon of making). At each connection between nodes and networks we recognize emergent, relational, co-constructive agency as well as embodied, enactive, extended cognition. While this *chaîne* may be isolated for the investigation of metalworking influences, we retain the capacity to acknowledge the broader phenomenon of making. In some cases, the nature of the research may impose limitations upon the scope of the study, or the researcher's interest may be limited to a single element of the process of making, in which case they may elect to engage with only part of this network informed *chaîne opératoire*. However, this project rethinks and re-envisions the *chaîne opératoire* approach in its entirety, and so *all* elements of the *chaîne opératoire* approach are considered here.

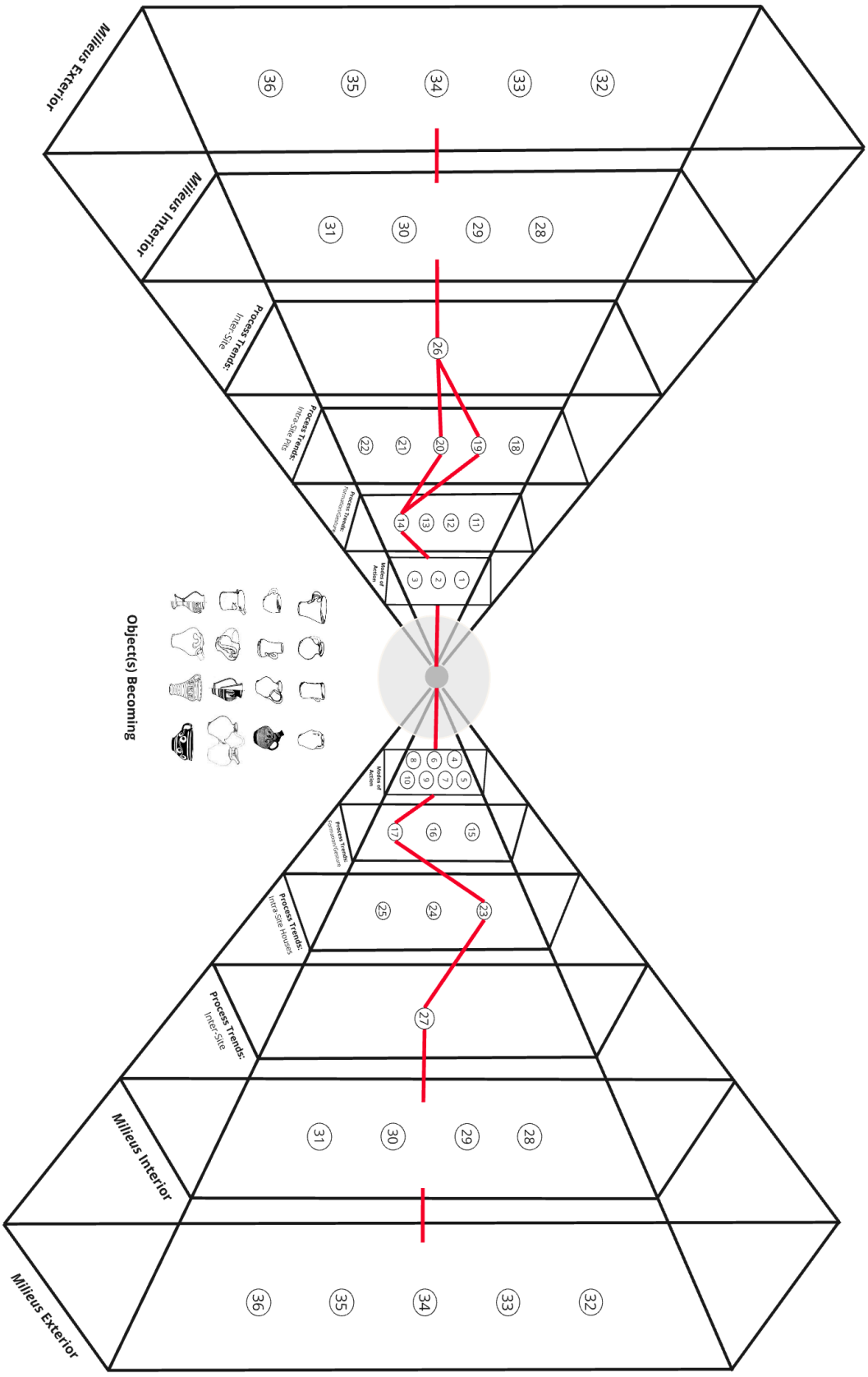


Figure 83. Tracing a *chaîne* to investigate the influence of metalworking on pottery

Concluding remarks

The application of the proposed *chaîne opératoire* approach to our study at Zakros has brought together the previous chapters regarding agency and cognition. This case study demonstrates the rethinking and re-envisioning of the *chaîne opératoire* approach in a way which can connect the finite aspects of production with the phenomenological nature of ways of doing and ways of thinking. Rethinking and re-envisioning the *chaîne opératoire* approach in this way has significantly broadened the scope of the framework philosophically by drawing on metaphysics (the nature of reality, existence, objects, and properties) and theoretically by drawing on frameworks which aim to explain agency and cognition and furthermore materially - making it applicable to a wider range of production processes, materials, and things (material and immaterial). For example, through this proposed *chaîne opératoire* approach we discover and trace connections between pottery, textiles, and metalworking (Figure 83). Implementing this approach, one can trace *chaînes* between modes of action, process trends, and *milieus* to find not only the links between these concepts but also at each connection discover emergent, relational, co-constructive agency as well as embodied, enactive, extended cognition.

The proposal for a network informed *chaîne opératoire* can be seen as a further development in the long history of the *chaîne opératoire* approach. Building upon Leroi-Gourhan's proposed elements of the *chaîne opératoire* approach as well as the significant developments and contributions by those such as Lemonnier and Roux, this network informed *chaîne opératoire* incorporates theories of emergent, relational, co-constructive agency as well as embodied, enactive, extended cognition. These theories are incorporated not only theoretically, but also visually through a novel visual representation of the *chaîne opératoire* approach drawing on physicists' visual concepts of quantum entanglement and loop quantum cosmology. Furthermore, the network informed *chaîne opératoire* approach is applied to the case study at Zakros providing a practical example of its use. It is evident that through rethinking the *chaîne opératoire* approach, its capacity for a phenomenological approach, and redefining the major elements (typology, modes of action, process trends, and *milieus*) according to new theories of agency and cognition we arrive at a dynamic, enlivened, interconnected view of not only the process of making but also the meaning of making.

This rethinking of the *chaîne opératoire* approach attempts to resolve the profound chasm between the practical use (Use Types) of the framework which seeks to uncover the discreet units of the process of making (the mechanics of making), with the broad capacity of the *chaîne opératoire*

approach to describe the relational, relativistic, in-flow human *being* (the phenomenon of making). The proposed *chaîne opératoire* approach and the newly developed visualization effectively connects the finite aspects of making with the larger phenomenon of *becoming* as well as the associated meaning and makers.

CHAPTER TEN

CONCLUDING REMARKS AND FUTURE DIRECTIONS

Concluding remarks

At the outset of this project, I was interested in integrating theories of agency and cognition into the *chaîne opératoire* approach. Upon delving into the literature, it became clear that the scope of the *chaîne opératoire* approach extends far beyond a methodological framework for understanding production processes. One of the strengths of the *chaîne opératoire* approach is its capacity to observe the *social phenomenon* of making. In my research I found that some of the very theoretical notions I planned to "introduce" to the *chaîne opératoire* approach already existed (however underdeveloped). Leroi-Gourhan's forward-thinking work on the *chaîne opératoire* approach was clearly aimed at understanding the relational nature of the brain, hand, and tool and the larger phenomenon of processes. Leroi-Gourhan's work was profoundly influential and impacted scholars who further developed these relational theories of gesture, technology, and technique (e.g., Gibson 1950; 1979; Lemonnier 1992; Simondon 2011). Within Leroi-Gourhan's poetic language regarding body and tool working together as one I found and developed this existing notion of relational agency. Furthermore, I discovered that the notion of non-cognitivist cognitive theory also lay resting in Leroi-Gourhan's postulations regarding process trends and *milieus*. At this point my task became clear: it was necessary to not only develop these notions from poetic descriptions into tangible theoretical analysis of agency and cognition, but also to test my theories in a case study and to visualize these concepts. Ultimately, the aim is to highlight the *chaîne opératoire* approach as it is used by archaeologists and to develop the approach further for this field.

It became apparent that the ultimate problem I faced – finding a way to link the mechanics of a process to the larger phenomenon of a process – mirrored the ultimate problem in the field of physics quite closely. While I had at first critiqued Leroi-Gourhan for drawing inspiration from so many scientific fields of inquiry, I found myself completely absorbed in physicists' arguments over the possibility (or impossibility) of bridging the gap between Quantum Mechanics and General Relativity. These two fundamental theories in the field of physics are seemingly incompatible in the same way that the fundamental elements of *chaîne opératoire* are seemingly incompatible. Classification, typology, and modes of action rely on measurable mechanical actions and reactions

on a small and absolute timescale (as with Quantum Mechanics). Process trends and *milieus,* on the other hand, describe relativistic, malleable, intangible and largely unmeasurable behavior on an infinitely broader timescale (as with General Relativity). Physicists have been hard at work to resolve this schism for decades. Luckily, I do not need to resolve the problem of Quantum Mechanics and General Relativity – I will leave that to the physicists. I found this parallel noteworthy and therefore drew inspiration especially from physicists' visual concepts of Quantum Entanglement and Loop Quantum Cosmology. I have attempted here to connect the discrete mechanical elements of making with the broad phenomenological elements of becoming and being and to bring these two disparate concepts together within the *chaîne opératoire* approach. I believe I have done this successfully by rethinking and re-envisioning the *chaîne opératoire* approach to account for relational theories of agency and cognition.

It seems fitting that the *chaîne opératoire* approach have one more chapter in its life story and I hope that there are many more. The *chaîne opératoire* approach has been interpreted and reinterpreted in various ways for many decades as illustrated within these pages. *Chaîne opératoire* approaches have been utilized not only in archaeological studies but also anthropological and ethnographic studies as discussed throughout this work. It has been used to observe modes of action and process trends. It has also been used simply as a shorthand term to refer to a production process, or group of specific operations, or to conjure a mental image of an object. In Part One of this work, a brief history of the *chaîne opératoire* approach detailed its developments and major uses. A set of case studies was presented and analyzed to outline the three main *chaîne opératoire* Use Types. Through understanding the significant scope of the *chaîne opératoire* approach and these *chaîne opératoire* Use Types, it became clear that while yes Leroi-Gourhan alludes to theories of relational agency and cognition, these theories remained undeveloped and as such the practical use of *chaîne opératoire* (the Use Types) rely on anthropocentric ways of doing and cognitivist ways of thinking.

In Part Two of this work, the concepts of relational agency and cognition were developed. Through a thorough review of each subject, it is plain to see where these theories can be useful in rethinking the *chaîne opératoire* approach. By analyzing their practical applications in archaeological contexts, substantial evidence was presented that these theories can in fact be incorporated into methodological frameworks. The next step was to develop an avenue for incorporating theories of emergent, enactive, relational, co-constructive agency and also theories of embodied, extended, and enacted cognition within the *chaîne opératoire* approach. This was

accomplished by recapturing Leroi-Gourhan's original intent, by revisiting the basic elements of the *chaîne opératoire* approach, and by integrating these relational theories within the foundational elements of the *chaîne opératoire* approach: classification/typology, modes of action, process trends, and *milieus*. By the end of Part Two, we are left with two distinct *chaîne opératoire* approaches – one which accounts for relational theories of agency, and one which accounts for relational theories of cognition.

In Part Three, the resolution, we see these two frameworks brought together. By addressing the *chaîne opératoire* approach through its foundational elements and bringing agency and cognition together within these, we discover a pathway to link together the mechanical and phenomenological elements of production processes within a methodological framework. This is further developed in a series of figures which build upon each other to generate a glimpse into the "universe" of each production process. And while this "universe" of production can be infinitely expansive – wherever there are connections between nodes there are further elements of the process – it can also be appropriately scaled to the size of the study at hand. This rethinking of the *chaîne opératoire* approach which simultaneously accounts for the finite aspects of production processes (mechanical elements) with the larger phenomenon of ways of doing and ways of thinking (phenomenological elements) is unique. This project has brought the *chaîne opératoire* approach forward to the present-day. It is now aligned with other contemporary and complex methodologies such as Material Engagement Theory and Process Archaeology. While my work is grounded in the field of archaeology, this project can also be considered to sit within the field of contemporary theoretical physics, inspired by scholars such as Karen Barad, who brings together the topics of agential realism and feminism to discuss universal phenomena.

While rethinking the *chaîne opératoire* approach is the ultimate aim of this work, the re-envisioning the *chaîne opératoire* approach became equally as important. Upon reviewing the literature, it was clear that not only are there various Use Types of the *chaîne opératoire* approach, but there are also various efforts to visualize the approach as outlined in Chapters One and Four. These visual representations differ based on the research question, material focus, and the researcher's personal preference. This is outlined in the Introduction Chapter and expanded upon throughout this work. There are three problems with the existing types of visualizations which are outlined in the Introduction: (1) much like the various Use Types, each of the visual representations of *chaîne opératoire* serves specific epistemological purposes however no single visual representation could serve all purposes; (2) these visual representations (illustrations, graphs, tree

diagrams) indicate one-directional approaches which focus teleologically on the final outcome; and (3) none of these visual representations can meaningfully accommodate non-functional or non-material elements such as agency, cognition, tradition, environment, or cosmological beliefs. Through rethinking the *chaîne opératoire* approach I have simultaneously re-envisioned it with the goal of resolving these three problems. The proposed visualization (Figure 81-83) can encompass all possible contributors to a process of production. It illustrates the complexity of process, while also offering full scalability. This visual representation also reflects the non-linear, multi-directional, relational nature of processes. The ways in which we visualize our methods is imperative as it guides our thinking, and as such these visualizations must continue to develop alongside the methods. This reimagined visual representation of *chaîne opératoire* which I offer visually represents complex theoretical concepts and furthermore it informs and reflects ways of thinking, ways of doing, and ways of being.

Future directions: what comes next?

Having proposed a *chaîne opératoire* approach which simultaneously accounts for the finite aspects of production processes (mechanical elements) with the larger phenomenon of ways of doing and ways of thinking (phenomenological elements), there are a number of directions in which this research may proceed. First of all, this framework can be applied to existing studies. While I tested this framework against one existing study from the excavation at Zakros, it would be a fruitful exercise to apply this to numerous studies across the Bronze Age Aegean and to uncover what novel data may surface. It is my suspicion that by applying this proposed *chaîne opératoire* approach to any or all of the twenty three case studies presented in Chapter Three, one might further contribute to archaeologists' understanding of the pottery production of the Bronze Age Aegean civilization. Beyond this, the proposed *chaîne opératoire* approach can be applied of course to *any* geographic area, time period, or material. It would be quite interesting to understand how this framework behaves when applied to other materials such as lithics, textiles, and metals as the primary focus (yet still including other materials where there are connections). Materials contain unique affordances which must be taken under consideration and may necessitate adjusting the framework which would be interesting to consider. I hope, in closing, to have placed *chaîne opératoire* at the forefront of archaeological method and theory and furthermore positioned this framework so that continued theoretical and practical development is possible.

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