

Chapter 3

Conceptualising an Anatomy of Transformations: DPSIR, Theorisation, Semiotics and Emergence



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3.1 Introduction

Archaeology and the study of past societies have undergone some of their most radical changes in the last decades. Meanwhile, archaeology advances so fast that it is difficult to capture the state of the art at any key moment. Some of the most radical changes concern how interdisciplinary research on human-environmental interaction has helped us understand and explain past societal transformations. Most of these changes were spurred by new funding schemes and the rise of new scientific, computational, and quantitative methods. These changes occurred in a rapid fashion – in fact, as David Killick (2015) documents, the rise of archaeological

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science was so quick that it led to several issues with regards to funding and training scientists and also assessing the scientific quality of this new type of research.

While archaeological science and the study of human-environmental interactions have improved and become quite successful in the meanwhile, they still carry issues inherited from past archaeological traditions as we shall explore further below. With the advent of postprocessual archaeology, human-environmental interaction was critiqued and accused of being determinist and overlooking human agency (e.g. Hodder, 1982; Shanks & Tilley, 1987) but these did not stop human-environmental studies from further development, remaining a prevalent way of doing archaeology today. Some of the developments that human-environmental studies have undergone include the incorporation of theories and have been more attuned to human agency and symbolism, however, the overall perception of human-environmental studies is one that recognises it as primarily determinist and focusing more on the environment side in detriment to the human side (Arkush, 2011; Stanton, 2004). Archaeological theory, as it has been practiced in the last decades, is partly to blame for this situation. More often than not, theorists have tended to avoid engaging directly with human-environmental studies with the aim of supporting or improving them. In fact, in recent decades, archaeological theory has fragmented into a plurality of mutually independent forms of discourse, most of which just ignore human-environmental interactions altogether (Gardner & Cochrane, 2011; Kristiansen, 2004). On a similar note, the role of semiotics in archaeology was to explore meaning and context in past societies, but this has been done only by a handful, none of whom have been primarily devoted to the study of human-environmental interactions.

In summary, archaeology has developed some new and interesting methods and insights, but it has done so in a splintered way. This chapter aims towards finding common ground by pursuing an integrative framework that combines the study of the transformation of past societies with the study of human-environmental interactions, archaeological theories, and semiotics. More specifically, we aim to outline a flexible model that allows us to understand how transformations occurred in the past, with a particular focus on the environmental sciences, by making a combined use of the DPSIR framework, archaeological theorising, semiotics, and emergence. We believe that this “anatomy of transformations” allows archaeologists to recognise and explain most of the aspects concerning how societies transformed in the past (and present, too).

Nonetheless, this anatomical framework is not meant to provide the only way to recognise or understand how transformation processes occur, nor shall it give a dogmatic perspective on past societies. It is above all a heuristic framework that assembles several powerful tools and integrates them as modules, some of which are already used by archaeologists, while some remain unknown. When we state that this framework is ‘flexible’, we are deliberately stating that parts of it can be removed or other modules might be added, depending on the circumstances and aims of the research in question. As we described above, archaeology is a very complex and multi-faceted discipline today, so it is unreasonable to expect that there can be a single and unified framework that can be used universally across the board. For instance, given that some regions of the world have more historical data, whereas other regions have richer environmental archives, it is only reasonable to expect that the anatomy of

transformations framework has to be adapted accordingly to what is available. Furthermore, it is also unreasonable to expect that the same amount of attention and funding can be devoted to the anatomy of transformation by different people and projects around the world. This means that it should be possible for the anatomy framework to be downscaled or upscaled proportionately to how much is invested.

3.2 The State of the Art

With regards to transformations, there is an ongoing discussion as to how one should describe human agency and action. Travis Stanton (2004) and Elizabeth Arkush (2011) have pointed out that archaeology of today, in most parts of the world, describes human action under two distinct frameworks: as systems-centred or agent-centred. Systems-centred research tends to focus on reconstructing past environmental conditions, with the aim of ascertaining how certain ecologies affected human behaviour, and in the process understanding how humans affected the environment in turn. From a methodological standpoint, this type of research relies primarily on the hypothetico-deductive approach (Kelley & Hanen, 1988) and/or inductive/quantitative methods, which involve the recognition of patterns that can be correlated with each other (Clarke, 1968, p. 20). Agent-centred approaches forgo the environment in favour of the social, political, and ideological contexts, which shape how humans behave. Unlike systems-centred approaches, some agent-centred approaches involve the study of how past social agents fought against the formation of hierarchies (e.g. Angelbeck & Grier, 2012; Crumley, 1995) or how social relations form identities and shape behaviour (e.g. Fowler, 2016). In summary, the difference between these two types of approach concern how much environment or intentionality one is willing to concede as the main driver of transformation in history (Arkush, 2011, p. 200).

However, there is much more to archaeological practice than just these two approaches to the past. Besides the dual way of describing human action, there is also the role of archaeological theory in providing context to those descriptions. Archaeological theory is perhaps where most fragmentation is noticeable because theories are now being generated and discarded following very short use-cycles (Mizoguchi, 2015, p. 16; Ribeiro, 2016). Thus, theories have become an arena of discussion for a select group, with most archaeological practitioners ignoring theory altogether. For example, many of the big theoretical movements in archaeology of the previous century have disappeared to give way to a more pragmatic way of thinking. The hermeneutic approach (e.g. Hodder, 1991, 1992), the phenomenological approach (e.g. Tilley, 1994), and all the critical/epistemological discussions (e.g. Kelley & Hanen, 1988; Kosso, 1991; Wylie, 1989) that characterised archaeology during the 1990s have gradually disappeared. Some theoretical ideas tried to make their mark during the turn of the millennium, such as practice and agency theory. These were based on different thinkers but relied largely on the work of Pierre Bourdieu (1977) and Anthony Giddens (1979, 1984); while these theories still have adherents in archaeology (e.g. Gardner, 2021; Kienlin, 2020) they have

largely fallen out of favour among practitioners. Another idea that gained some degree of popularity in archaeology was semiotics: even though many of the key ideas of postprocessual archaeology have lost popularity, the idea of an interpretive archaeology that focuses on symbolism and meaning was considered important to many archaeologists (e.g. Bauer, 2002; Crossland & Bauer, 2017; Preucel, 2006; also cf. Frerichs, 2003; Furholt & Stockhammer, 2008), yet semiotics never reached a mainstream status. In a similar fashion, the New Materialisms, relational ontologies, and posthumanisms (e.g. Harris & Cipolla, 2017; Olsen et al., 2012) have gained considerable attention, but like many previous trends, they have not managed to make a widespread or lasting impact on the practice of archaeology.

As stated by Stephen Shennan (2007, p. 220), it seems that after the hectic theoretical debates of the previous century, archaeology has simply gone back to conducting archaeology. It can even be claimed that outside of the anglophone world there were never that many theoretical debates to start with. As Reinhard Bernbeck (2007, p. 208) points out, the theoretical concerns we might have in Europe are certainly not felt in other parts of the world, such as the Middle East. There have also been calls for a ‘death of theory’ in archaeology, in the sense that theory should not be the dogmatic position it often appears to be but should rather be an eclectic and flexible exercise of reasoning about past societies (Bintliff & Pearce, 2011). Mizoguchi (2015, p. 16) has also pointed out that theory has generated some negative feelings among some archaeological practitioners because of the perception of archaeology consisting of contract archaeology (i.e. CRM), which is seen as tough, low-income, and practical, whereas academic archaeology is considered fairly easy, high-income, and theoretical. While there is certainly some truth to the differences between contract and academic archaeology, there is much misunderstanding about the role of archaeological theory and what it can contribute.

With this being said, archaeologists have also found some degree of common ground, rallying around certain objectives, such as the study of inequality, demographic growth, the role of conflict, mobility, etc. (Kintigh et al., 2014). At the same time, archaeology has become much more data-centric, with archaeologists focusing primarily on the recovery, analysis, and modelling of archaeological material rather than theory in the search for answers about past societies (Kristiansen, 2014). For instance, there has been widespread adoption of computational methods, akin to a ‘Big Data’ revolution, which have allowed archaeologists to access and model vast amounts of data (Gattiglia, 2015; Ribeiro, 2019). Isotope and genomic analysis have gone from niche to fairly standard methods that many projects now engage with (Killick, 2015). In addition, given the current prevalent use of C14 dating, Bayesian modelling and sum-probability distributions of C14 dates have become very popular (Otárola-Castillo & Torquato, 2018; Williams, 2012). It must be mentioned that this shift to more practical concerns, the use of new scientific methods, and the aggressive collation of data that characterises the archaeology of today has been thoroughly critiqued from several angles (Cunningham & MacEachern, 2016; Ion, 2017; Ribeiro, 2019; Sørensen, 2017, to name just a few).

Many of these critiques highlight very valid issues, some of which cannot just be hand-waved away. We need to address some of these critiques because the anatomy

of transformations is not simply a framework where different approaches are piled onto each other uncritically but rather a framework that aims to unify how we explain the transformation of societies (see Mandelbaum, 1977, for an attempt towards the unification of historical knowledge). But for this to be possible we need to address the difficulties we face and how they can be overcome.

3.3 Human-Environmental Interaction from the DPSIR Perspective

The themes and topics that have caught the attention of many archaeologists in the last decades seem to revitalise and rehabilitate many of the concerns of processual archaeology of the 1960s and 1970s. To refresh the reader's memory, processual archaeology was a large-scale movement in archaeology with particular prominence in the US and the UK, but it has influenced many archaeologists outside of these regions as well. It was, to use David Clarke's (1973) words, a period of 'loss of innocence', when archaeology underwent a series of changes making it focused less on raw data collecting but on developing new methods of explanation of past societal change. The changes to archaeology enacted by processual archaeologists have been discussed authoritatively elsewhere (e.g. Johnson, 1999; Trigger, 1989) so there is no point repeating them here; however, processual archaeologists subscribed to systems theory (Plog, 1975) which we will need to discuss in order to understand some issues concerning human-environmental interaction.

In general, systems theory conceives of society through an organic analogy, that is to say, as a cohesive system of interrelated parts, where changes in one part necessarily entail changes to other parts, very much like in the case of the human body. Systems theory also presupposes that societies have some degree of resilience (Redman, 2005), making it adaptable to changes of the external environment and keeping it in homeostasis, a status of balance between people and the environment. The understanding of systems theory varied to some extent among processual archaeologists (e.g. Clarke, 1968, pp. 42–83; Flannery, 1972), but many archaeologists followed Lewis Binford when it came to systems theory. According to Binford (1962), archaeology had the task of explaining culture change and in order to do this, culture needed to be recognised as a *system that adapts to the environment*. Following Leslie White's cultural evolutionism, Lewis Binford argued that culture is 'man's [sic] extrasomatic means of adaptation' (Binford, 1965, p. 205). *Prima facie*, what Binford argued was that the explanation of how past societies changed was contingent on how these adapted to their environment. This might seem like a form of ecological determinism (Arponen et al., 2019; Stanton, 2004), but as Binford argued, humans live in an ecological system where they can react within certain limits (Binford, 1962, p. 218). But systems theory was never applied with the coherency nor the consistency that the literature seems to denote – in fact, it has been used in archaeology in a rather liberal manner – by referring occasionally to terms such as 'feedback', 'equilibrium', or 'homeostasis' (Salmon, 1978, p. 182).

Nevertheless, processual archaeologists did devote a large part of their attention to the role played by the environment, highlighting environmental changes as the primary factor for how societies transformed in the past.

From the 1980s onwards, postprocessual archaeologists levelled a radical critique against processual archaeology in general, and the idea of culture as a system in particular. As Ian Hodder (1982, p. 3) points out, the idea that society is analogous to an organism is not necessarily a helpful way to think, since societies can undergo several transformations throughout its history, which an organism cannot. Additionally, Hodder points out how archaeologists who subscribe to systems theory automatically presuppose that past societies were primarily homeostatic, which means that the transformation of a society could only occur due to external factors, and measured by independent variables, such as environmental factors, long-distance trade, or demographic increase (Hodder, 1982, p. 3). But perhaps what postprocessual archaeologists were most troubled about was the fact that systems theory was *functionalist*, that is to say, it conceives of a culture in purely utilitarian terms. For postprocessual archaeologists, it was unacceptable that cultural elements, such as rock art, rituals, and idols, were designed with utilitarian principles in mind. But when a society and its culture is defined as the means of adapting to the environment (*sensu* Binford), then one is forced to explain how certain decoration patterns on pottery and rock art designs helped their society adapt to the environment.

With postprocessual archaeology's demise and its critique having lost most of its influence in recent years, there has been a return to processual archaeology. As stated earlier, there has been a rallying call by Kintigh et al. (2014) to pursue 25 grand challenges in archaeology. Most of these challenges mimic the concerns of processual archaeologists, and it has come as a surprise to some that these have been picked up again (e.g. Barrett, 2016). Following a systems-centred archaeology, the 25 grand challenges focus on measurable objectives, such as understanding how certain societies survived in certain environments, how the environment shaped resilience among human communities or led to their downfall, how humans shaped the environment, or what factors constrained and drove population dynamics. In addition to this, there has been a renewed concern with the evolution of societies (e.g. Morris, 2022; Shennan, 2018), as demonstrated by the growing popularity of niche construction theory – a theory that in archaeology involves recognising ecology and human culture as a process of constructing a niche that is inherited by subsequent generations (Laland & O'Brien, 2010). The resurrection of these concerns is due to many reasons, but certainly one of the most important is the increase in the quantity and quality of paleoenvironmental data, which in turn has provided more nuanced and refined reconstructions of past environmental landscapes.

At face value, there is nothing inherently wrong with this type of research, but oftentimes the study of past human-environmental interaction can appear to provide very oversimplified explanations of transformation processes. Just because postprocessual archaeology has fallen out of fashion, this does not mean that it was wrong in its critiques of processual archaeology. For example, Contreras (2017, p. 6) states that while processual archaeologists such as Lewis Binford argued that culture could only change because of the environment, research in human-environmental interaction of

more recent times is more nuanced, with studies focusing on changing climatic conditions that focus on contingency, behavioural diversity, and human adaptation. This is true and while some studies are in fact more nuanced, the vast majority still follow rather formulaic models in which some environmental factors act upon a human system and the humans act in response. As Alexandra Ion (2019, p. 11) points out, these types of studies tend to follow remarkably simple hypotheses, such as did the climate lead to the collapse of civilization *X*, yes or no? Naturally, reality is certainly more complex than ‘lack of food/climate/epidemics/wars led to the collapse of civilization *X*’, so we should consider a way of conceiving of human-environmental interaction that is not reduced to simple explanations such as factor *A* caused result *B*.

One way out of this issue is to employ the DPSIR framework. DPSIR is an acronym of Driver-Pressure-State-Impact-Response and DPSIR aims at describing processes that occur within human-environmental interactions. It was first developed from the Stress-Response model by Rapport and Friend (1979) and has gone through several iterations until it became known as DPSIR. Originally, this framework was not designed as a unified model for scholarly research but as an eminently practical tool that could be used for environmental assessments and policy creation by entities such as the OECD (1993) or the US Environmental Protection Agency (EPA, 1995). As such, the most important function of the DPSIR model has been to provide an analysis not just of cause-effect relations but also of challenge-response relations. Without replacing causal explanations, DPSIR provides the means that are necessary to speak of causations in a way that allows for a more complex and nuanced perspective of how human-environmental interactions operate. At the same time, DPSIR avoids the opposite scenario, namely that of overcomplicating the various causal relations involved in socio-environmental processes, which in turn could burden our understanding of those processes. Overall, DPSIR provides a way to recognise human-environmental interactions that is not reduced to two-way causal feedback loops (i.e. the environment affects a society, and the society affects it back) nor is DPSIR an overly complex model composed of countless causal interactions. The idea of DPSIR is to reduce complexity, as models often do, without falling prey to simplifications and reductionism.

The earliest iterations of the DPSIR model were quite simple and described human-environmental interactions as pressure on a social system, which in turn responds to that pressure (Burkhard & Müller, 2008, p. 968). These earlier iterations, however, are too reminiscent of the systemic and functionalist model of processual archaeology described above and rather too simple for our purposes. The more complete version of DPSIR that involves drivers, pressures, states, impacts, and responses is certainly more adequate. This being said, it is important to consider that DPSIR does not require all these elements in this order; the term ‘DPSIR’ refers to a conceptual framework that can have multiple elements and different categories, with the natural scientific disciplines focusing more on some elements and categories, and the social sciences more on others (see Patrício et al., 2016, for a survey of DPSIR and its derivatives).

The first element of the DPSIR scheme is ‘drivers’. In general terms, drivers can be both natural and human-induced. In modern applications of DPSIR, human

demand for goods and services, good health, security, education, and freedom can be considered drivers. This makes perfect sense in our current world, but some attention must be paid when applying the same notion of drivers to the past. Certainly, the past was populated by human groups that demanded certain goods, but probably not the same and not in the same scale as modern societies do. So, for example, the energy demands of today's civilisation puts pressure on ecosystems via the emission of CO₂, but this type of driver and pressure was largely irrelevant in prehistoric times. In the prehistoric past, a more relevant driver would have been something like demographic growth (see Shennan et al., 2013) which could have led to internal societal pressures and pressure upon the environment, such as overuse of land for agriculture. DPSIR, however, does not state that demographic growth leads to overexploitation, since that is something that can only be ascertained by testing this hypothesis against the available data; what DPSIR does instead is allow the identification of demographic growth as a driver, which might have put pressure on a society and/or the ecosystem. War is another example of a driver, namely in the sense that a war can drive a society into a state of pressure by burdening the wealth of the society and/or by leading to migration.

In ecological research, DPSIR is most commonly conceived to pave the way for policy change rather than as a tool for past human-environmental research. In these contexts, DPSIR tends to focus on those drivers that are socially and/or economically motivated, such as an increase in the human demand for goods and services or the human demand for freedom. In the past and in different regions, however, it is safe to say that the environment itself may be understood as a driver (Bidone & Lacerda, 2004; Pinto et al., 2013). Either way, both environmental and human drivers lead to 'pressure', the second element of the DPSIR model. Drivers are the direct cause of pressure, namely in the sense that a process such as the increase in the demand for goods and services will put pressure on the environment through the intensification of agricultural and industrial production and/or energy expenditure. In general, pressures tend to be easier to measure than drivers since pressures often have a variety of proxies and display parameters that can be more easily derived from socio-economic and environmental databases.

The third element of DPSIR is 'states', which often result from pressures on the ecosystem. Unlike pressures, which can be continuous processes upon socio-environmental contexts, states are usually conceived of as the consequence of pressures. Oftentimes, a state is a delayed response resulting from pressure, such as acidification caused by pollution or a pandemic on the economic status of a country.

The previous three elements of the DPSIR scheme sometimes lead to an 'impact' on socio-environmental systems, especially as relates to the effects on human life. In general, an impact as the fourth element of the DPSIR scheme is measured on how human lives are affected by drivers, pressures, and states, such as how the overuse of soil leads to poorer agricultural practices, which in turn leads to poorer nutrition either for the overall community or for specific groups. On a similar note, the natural or human destruction of habitats can lead to demographic pressure and difficulties with managing and distributing goods and services. The advantages of thinking in terms of impact as a result of the compound of drivers, pressures, and

states allow us to think of various processes of the past in a more dynamic manner and to conceive hypothetical processes which analytically unfold into various elements rather than to think in simple monocausal terms. For instance, demographic decline among prehistoric societies is commonly still framed in outdated Malthusian concepts, with wars and overexploitation of resources as the main causes: it is certainly true that these could have been the causes of demographic decline, but several key processes must have occurred in between wars or overexploitation, on one hand, and demographic decline, on the other hand.

This leads to the final element of the DPSIR scheme, namely ‘responses’. In the overall framework, responses account for those human actions that deal specifically with changes in the socio-environmental contexts that human societies occupy. From a modern perspective, responses might be conceived of as tending to be legislative and educational in character, but for our research purposes, a more adequate way to think of responses is in terms of what has been termed ‘resilience’ or ‘resilient strategies’ (Redman, 2005). As socio-environmental contexts change through time, due to drivers that are sometimes natural, oftentimes human, humans have engaged with resilient strategies to maintain the flow of natural, social, and economic capital. Shifts to more sustainable subsistence strategies, increased mobility, and the introduction of new technologies are all examples of the ways humans managed to adapt to changes in their contexts. Thus, we suppose that humans are responsive beings. Here, a cluster of responsive agency concepts come into play, such as ‘cope with’, ‘adapt to’, ‘react to’, ‘combat’, and ‘stimulate’. As responsive reactions suppose some capabilities on the part of agents, it makes sense to apply Sen’s capability approach to archaeology (Arponen et al., 2016). Responses may also bring about new and unprecedented societal states; if so, they are transformative.

With the five basic elements of the DPSIR framework described, it bears reminding that this scheme should be understood as a heuristic tool that aims to represent and categorise human-environmental transformations and not as an all-encompassing explanatory framework in the strict sense of the word. That is why DPSIR has been used in a very wide variety of ways, with many new elements included when it is justified, or with a reduced number of elements to facilitate categorisation. When researching the past, breaking down a process of transformation of society into four to five elements can be helpful from a methodological standpoint. This does not entail, however, that deep societal and environmental transformations in the past only involved four or five elements. Rather, DPSIR helps us to perceive transformations that are neither oversimplified (monocausal) nor overly complex and hard to capture. Furthermore, as a framework, DPSIR has some shortcomings, the most important of which is that it does not seem to easily lend itself to capturing complex long-term dynamics (Rappport et al., 1998; Rekolainen et al., 2003). This limitation is why DPSIR often focuses on the effects of less-complex short-term processes, such as how recent industrial practices affect water sources or how modern construction has affected shorelines, rather than multifaceted long-term processes, such as the effect of the industrial revolution on demographic growth and pressure.

Nonetheless, in and of itself, DPSIR can be a powerful tool to understand past transformation processes, but as a tool used primarily for modern cases and designed for environmental policy, one is limited in what it provides. In fact, even in modern use cases, DPSIR is usually combined with other methodologies (Gari et al., 2015). In the study of past human-environmental transformations, on the other hand, there is the danger of replicating systems theory and thus limiting oneself to conceiving past societies through a functionalist viewpoint. This, in turn, might lead to a perception of past human societies as mere causal chains that affect one another. For some scholars, this qualifies as human agency, especially as it relates to the 'response' element in the DPSIR framework; for other scholars, however, agency is much more than humans acting and reacting to their environment, with the notion of agency concerning social institutions, social identity, customs, and choices, which are conceived of as not just responses to changes in the environment. This above all holds true for those methodologies that emphasise the role of the human as an acting subject (Peebles, 1992).

For instance, when discussing issues such as demographic growth or decline in prehistoric periods, the prime methods tend to focus on the carrying capacity of a given society (cf. e.g. Zubrow, 1971), with overexploitation of subsistence resources leading to periods of famine. However, overexploitation of resources is only one explanation for famine, and in most cases, overexploitation requires understanding the complex processes of how past societies claimed ownership of resources and distributed them. Furthermore, the concept of carrying capacity has been adopted from zoology and it remains doubtful whether there are fixed carrying capacities for human-environmental systems. Overall, the relationship of demographic decline and famine is one that requires much more than just recognising a decline in subsistence, but also involves issues of power and restriction in accessing the commodities entailed by social living, such as certain capabilities (Arponen et al., 2016), with subsistence being one of the most important of those commodities (Sen, 1981). Another example is the concern over the emergence of modern human behaviour somewhere in Africa between 150,000 and 40,000 years ago (Kintigh et al., 2014, p. 14): while the emergence of modern human behaviour has been attributed to environmental triggers (Ziegler et al., 2013), other studies have cast doubt on such a perspective (Roberts et al., 2016); in fact, the very idea of the sudden emergence of modern human behaviour is somewhat suspect (McBrearty & Brooks, 2000).

3.4 Contextualising Behaviour Through Theory

It is central that the anatomy of transformations recognises the role of past communities in history without reducing them to robots following prescribed programmes. While certain models of human behaviour require assumptions that simplify human motivations, such as models that view sociality as altruistic behaviour or subsistence strategies as optimising energy expenditure, the anatomy of transformation realises that human behaviour is also meaningful (Hodder & Hutson, 2003).

This does not mean that there are two levels with regard to human behaviour, one that is mechanistic and functionalist, to which we simply add another layer composed of meanings. All action is simultaneously and integratively causal and meaningful in the sense that all action that might appear purely mechanistic also involves a purpose. For instance, a migration requires much more than just the physical movement from one place to another. Most people move on a regular basis, whether it is to commute to work, to plant something in the garden, from the kitchen to the living room, or to the next town to buy groceries, but none of these forms of movement qualify as migration. Sometimes even moving several hundred kilometres might not qualify as a migration, since to migrate requires the (semi-)permanent relocation to a new region. Concomitantly, this requires the recognition of what qualifies as a ‘new region’ and some sort of process of passage into that new region (van Gennep, 1960). Thus, while the pure DPSIR scheme can allow us to recognise migration as a pressure or a response, it does little to help us understand the intention of migration in the past. This is why, as a first supplementary ingredient, theory is important.

Theory refers to multiple things in the study of the past: it can refer to the scientific epistemology of research, it can be a synonym of ‘hypothesis’, and it can refer to methodological discussions. But for our current efforts, theory refers to the ideas that help us contextualise and understand human action of the past. As Henrietta Moore (2000) points out, ‘agency’ need not be a ‘real’ thing; it can simply be a concept-metaphor and as such, a way of acknowledging that past people were socially competent actors who knew how to behave in a social setting. Following this line of reasoning, theory aims at making the actions of past people explicit in their original social context. Anthropological theory and ethnoarchaeology remain two of the most powerful tools in providing context to the actions of past people. For example, the study of past societies that have relied on long-scale trade along Europe, especially via maritime routes, has been contextualised quite competently through the anthropological theory of Mary Helms (Helms, 1979, 1988; Kristiansen & Larsson, 2005). Similarly, with the advent of next generation sequencing, biological relationships in the past are now possible to reconstruct; however, in order to do this, it is required to understand how the structure of kinship in different societies could have shaped those biological connections (Brück & Frieman, 2021).

Some humility is necessary to apply theories to the past with some degree of success. This is because it is all too easy to fall into the trap of assuming that there can be a single theory by which one can understand all the relevant processes of transformation and human behaviour in its entirety. As a rule, it seems safe to assume that the more general a theory appears, the less applicability it tends to have. For example, practice theories (Bourdieu, 1977; Giddens, 1984) can be very useful at understanding the general process by which all practices are formed in society, but these theories tend to become more limited when trying to contextualise specific practices and a host of other social phenomena, such as slavery or hierarchisation. What is usually the case is that those theories that appear at face value to concern very specific social and/or economic phenomena are those that tend to be most useful but at the same time have less geographical and chronological incidence. The

aforementioned work of Mary Helms (Helms, 1979, 1988) on travel and long-distance trade, for instance, is certainly helpful to contextualise those regions and periods where long-distance travel occurred, such as the European Bronze and Iron Ages, but it is certainly less helpful in those places and times when long-distance travel was not a common occurrence. It is up to the researcher to realise when specific theories are useful and to determine which theories in particular are suitable for different periods and times.

Nonetheless, in general it is often beneficial to rely on theory in explaining human action. The past was not a simpler version of the present nor should past human action be conceived of by way of direct and oversimplified correlations: for example, climatic events did not, in all probability, lead directly to collapse, large-scale structures did not *per se* entail hierarchy and top-down power structures, and famine was not always connected with low subsistence resources. It is not so much that claims such as these are necessarily wrong but they do convey a view of past transformations in a very simplified manner and divest the humans of the past of their capacity for acting meaningfully within those transformations.

3.5 A Semiotic Perspective on Transformations

Taking up this last thought, let us turn back to the DPSIR scheme and see how it can be adapted to our purposes in such a way as to more adequately conceptualise the anatomy of transformations. Let us begin by recalling of some of its potential shortcomings that have already been addressed above. In particular, it might appear problematic that the scheme allows historical transformations to be conceived from the outside only, i.e. as some natural process that happens to occur within a purely empirical ‘reality’, in which humans are not only subject to the same natural forces as all physical objects such as rocks and stones, but in which they also display the same automatic patterns of quasi-robotic reaction as they do. In consequence, our adoption of the DPSIR scheme might seem to conceive of transformations involving humans as non-complex deterministic processes for which the description of the basic laws of physical nature are sufficient.

As important as the physical dimensions of transformations are, humans have, nonetheless, by way of their natural constitution as sentient and rational living beings, the capacity for perceiving and reflecting upon the outer world, both as individuals and within the synchronic and diachronic dimensions of the cultures they are part of; and this capacity for perception and reflection forms, as it is being actualised in the course of the historical events and processes, acts as the basis of the human interaction and manipulation of the environment. It follows that how humans interacted with the environment in the past not only depended on the ‘objective’ state and change of the environment itself and the subsequent influence this exerted *per se* as if this amounted to a fixed action-reaction scheme, but also how the humans as an independent part of the complex and irreducible system consisting of

themselves and the environment perceived, and reflected upon, the environment in turn, including their own place within it.

For example, for human action to have occurred in reaction to a change of the local climate it would have been neither a necessary nor a sufficient precondition that the change itself occurred in the natural world, but the change, and/or its impacts as proxies, had also to be perceived, in whichever way, before it could possibly have led to any response. We need not assume that the response in its concrete shape was anything prescribed and predetermined by physical nature, but we may hold that it was, to whatever degree, shaped by the individual and cultural preconceptions the humans involved in these processes held, as particular as those preconceptions which explicitly or implicitly defined those future states which were eventually chosen in order to cope with the perceived changes. For example, one response to a cooling of the overall temperature might have consisted in migrating to another, more suitable place; or in inventing a new technology like fire with the aim of making it warmer inside one's dwellings; or in just doing nothing because you accept that the eventual annihilation of the community resulting from the change of temperature would be fair divine punishment for not having worshipped the god of the sun enough. Obviously, which specific response was taken would have been informed, *inter alia*, by the prevalent belief system and the available knowledge in the given society that was confronted with the perceived change in the environment; and in addition, this was not a question of human action or intentionality *per se*, but first and foremost of perception and reflection that allowed for identifying, understanding, and responding to the relevant aspects of the environment and its change.

To complicate matters further, we not only have to acknowledge that the relation between humans and the environment, in principle, has such a non-deterministic and mediated quality, but there are, in particular, three more points to consider: first, if an objective change of the environment occurred, it might not have led to any cultural or societal transformation at all because the change was not perceived. For example, it may have occurred too slowly to be perceived, or it happened in an area that was not being looked at, or it was even deliberately ignored because it ran counter to the prevalent belief systems or was beyond the realm of available knowledge that guided the assessment of one's perceptions. In short, outward change had to be actually perceived, and at the same time adequately judged, in order to become a driving force etc. that eventually resulted in human action.

Second, an objective change of the environment might have led to a manipulation of the environment in response, which nonetheless in turn recursively changed the perceptions of the humans and, subsequently, recursively reshaped the interaction with the environment itself. In consequence, we have to conceive of a mediated and at the same time complex interrelation between the environment, its perception by humans, and any action resulting from it, and we also have to allow for irreducible (as the case may be, 'emergent') dynamic feedback loops within the human-environment system.

Third, it is apparently also possible, against this backdrop, that transformations of the human-environment relationship could have been initiated without any objective change in the environment itself, but only because, for example, ideological

world views had changed the perception, and the subsequent conceptualization, of the relation of the humans to the environment. That is, transformations need not only be conceived of as purely passive reactions by humans to changes of the environment, but they might equally well have had the form of spontaneous actions that were initiated by the humans themselves without any outward prompt. So it might have been the case that people began to change the agricultural environment because they somehow started to believe that the gods disliked trees and subsequently felled all the trees in their surroundings, with the consequence of this having a profound impact on the hydrological situation that might have made it impossible to feed the animals in this specific area, which in turn led to other consequences that initiated further transformative processes.

Notwithstanding further potential complications of the theoretical situation, which need not be addressed and explicated here, it suffices at this point to see that the relation between humans and the environment, and its dynamic transformations within time, does not have a unidirectional, hierarchical, monocausal, and deterministic character, but instead displays, at least potentially, a bidirectional, complex, mediated, and non-linear entwinement of its two constitutive components. Though there is, of course, a significant variation of the resulting situation with regard to each single transformation, whose concrete historical profile has accordingly to be assessed individually for each specific case, these additional dimensions of the notion of transformation have to be accounted for and must be adequately assessed in the theoretical dimension in order to holistically conceptualise the anatomy of transformations.

How then can we represent this state of things within the approach taken here, especially with regard to the adoption of the DPSIR scheme? First of all, we have to conceive of the relation between the environment and humans not merely in the way we conceive of the relation between physical nature and, for example, a stone as one of its parts. Even if this may, and should, form the basis for understanding transformative processes involving humans within an environment, we at the same time have to situate humans within a mediated relation to the environment that is generated by, and based on, the representation of the world in all of its pertinent dimensions within the humans themselves, both individually and culturally. First of all, this encompasses perceptual content, but then in particular also higher-level mental content on an individual and collective, societal, and cultural scale, including not only the basic meanings of words and linguistic content, but also complex phenomena like religious beliefs, cosmologies, ideologies, and imaginary worlds. It seems trivial to state that the world was meaningful to past humans, but this trivial statement opens the door for a series of difficult questions as to how to identify meanings at the emic level (cf. Furlholt & Stockhammer, 2008) – which, to be sure, is no easy task even in the case of cultures for which extensive written sources are still extant, such as the ancient Greco-Roman culture.

The presumptive key to account for such phenomena in a unified and coherent way is to bind the notion of ‘representation’ to the notion of ‘sign’, namely insofar as ‘to represent’ can be understood as ‘to stand for’ and thus ‘to relate to’ something, and to use the tools semiotics, as the general theory of signs, can provide us

(see Gardin, 1988; Frerichs, 2003; Furholt & Stockhammer, 2008; Parmentier, 1997), especially that form of semiotics that was initiated and developed by the American philosopher Charles S. Peirce (for an overview see, for example, Short, 2007; also Jappy, 2019; Keane, 2018; cf. Atkin, 2016; Colapietro & Olszewsky, 1996; for its recent use in archaeology see the overviews in Baron, 2021; Harris & Cipolla, 2017, pp. 109–128; and cf. the instructive applications by Bauer, 2002, 2013; Crossland & Bauer, 2017; Furholt et al., 2019; Kissel & Fuentes, 2017; Knappett, 2005; Lele, 2006; Watts, 2008). Of course, we cannot here delineate a comprehensive and full-fledged semiotic approach to transformations that covers them in all their various manifestations both in the theoretical and historical dimensions, but we can nonetheless give a rough sketch of how semiotics might significantly expand the basic DPSIR scheme – and thus address some of the latter’s previously mentioned shortcomings – by adding a semiotic layer that accounts for the pertinent aspects of the inner view of the humans involved in transformations.

Given this aim, the solution to the task at hand is straightforward; namely to not only account for the objective, measurable dimension of transformations – and this includes the human actions themselves, also in part their aspects of agency and intentionality –, but to also add to this physical layer an additional layer consisting of, and theoretically representing, the subjective representations of the pertinent dimensions of physical transformations in the semiotic realm of signs, and this with a view to both their static and their dynamic natures. In this expansion of the DPSIR scheme, the secondary layer directly, but in an independent and non-deterministic manner by way of independent entities that need not show any similarity, mirrors the objective (etic) dimension by a subjective (emic) dimension, with the additional stipulation that any element of any dimension might potentially exert an influence upon any element of any other dimension resulting in a highly complex and non-deterministic system. So it is important to note that the interconnected duality of the real and semiotic layers of the extended DPSIR approach is not only confined to the general levels *per se*, but that we can find this duality at play with every relatum of the scheme: to every ‘objective’ fact, there is a semiotic correlate expressed via, and in the form of, signs.

While it is clear that the primary layer can be described by way of ‘hard’ data that can, at least potentially, be measured by scientific or other means, either directly or via proxies, what nature does the secondary layer have? As stated above, a representation of (parts of) the environment is in principle nothing but a sign, which Charles S. Peirce abstractly defined as ‘something which stands to somebody for something in some respect or capacity’ (Hartshorne et al., 1931, 2.228; cf. 1.564 and 2.303; we need not go into the details with regard to the characteristics of the three relata of any sign relation, i.e. ‘sign’/‘representamen’, ‘object’, and ‘interpretant’; cf. 2.228 and 2.242).

This definition has an abstract and general character, which entails, first, that in principle *anything* can serve as a sign, including all physical objects of, as well as events and processes within the material world, and, second, that signs are not reduced to linguistic signs, i.e. natural language, but are primarily conceived of with regard to their use as signs, i.e. in a functional, ‘pragmatic’ way (for archaeology, cf.

Bauer, 2002; Preucel & Bauer, 2001, albeit both with a primary focus on things and objects; see also Furholt et al., 2019, for the eminent dimension of ‘practice’, as well as Bauer, 2013, with a view on meaning as mediated by ‘habit’ of use). This theoretical framework allows for describing all possible signs there might be and thus in particular provides, in a coherent and overarching framework, all the elements that are necessary and sufficient for setting up the second layer of our approach (on the generality of the Peircean notion of ‘representation’ especially with a view on archaeology, see Swenson & Cipolla, 2020; also Preucel, 2020). This further allows for conceiving of transformations not as rigid cause-effect relations, but to make room for the impact of what can be called the ‘meaning’ of things and events (with the notion of ‘meaning’ construed in the broadest way possible) all the while taking seriously the characteristic of humans as living beings for which the use of signs individually and collectively is constitutive and, in this capacity, plays a pivotal role in the transformative processes affecting societies of the past.

A sign, however, is not simply a sign. But while there are numerous ways to exhaustively classify all signs according to different criteria (for some insights see Jappy, 2017), for the present purpose one classification is relevant in the first place, namely that which exhaustively classifies all signs as ‘icons’, ‘indices’, and ‘symbols’ (for the semiotic basis of this classification, see Hartshorne et al., 1931, 1.369; 2.247–249; and 4.447–448 with 2.243 giving the criterion for distinguishing these sign classes). These three forms of sign together allow us to begin building a complex understanding of what a representation of the natural world within the description of transformations in the sense of the DPSIR scheme might imply and how it can be practically achieved: first, the class of icons comprehends in particular perceptual content (construed most broadly), such as what humans saw when they looked at the Acropolis at Athens in the year 430 BCE or when one group perceived that alien people migrated to their location (for the semiotic definition of an icon, see Hartshorne et al., 1931, 2.276; cf. Kralemann & Lattmann, 2013; Lattmann, 2012). Second, the class of indices comprehends signs that indicate the existence or ‘reality’ of something, for example, smoke as something that points to a fire existing somewhere or migrating people that indicate the lack of resources at their place of origin (on indices see, e.g., Hartshorne et al., 1931, 2.305). Third, the class of symbols comprehends abstract signs such as words, sentences, or texts, e.g. those relating to how people of the past themselves conceived of notions such as ‘migration’ or ‘overexploitation of land’, i.e. signs that in particular (though definitely not exclusively) fall within the scope of language, abstract thinking, and explicit knowledge (on symbols see, e.g., Hartshorne et al., 1931, 2.249).

This general semiotic framework allows the comprehensive description of all the elements that are relevant for putting together the secondary layer of the DPSIR approach to conceptualising the anatomy of transformations, namely by establishing a semiotic correlate to every relatum of the ‘objective’ human-environment relation that captures the inner perspectives of the involved humans. Semiotically speaking, this correlate acts as the ‘sign’ or ‘representamen’ to the ‘object’ that might be understood as that thing in the ‘real’ world the sign, as an in principle independent entity, relates to within the sign relation (while, however, this

‘historical’ use of the sign has to be analytically distinguished from the ‘use’, i.e. conception of the respective sign, in our modern-day research). As such, signs were used by humans of the past not only to passively represent (the perceptions of) one’s world in a direct way – representations which were, if we are lucky, expressed by the humans themselves and are still extant as drawings, figurines, texts etc. – but more importantly with regard to conceptualising transformations, they might have also actively, and potentially to a great degree, contributed to the dynamics of transformations, not least because humans direct their actions toward goals, which are, at least implicitly, expressed by signs in whatever form. For example, the perception of populated villages may have led to migration in response because of an expectation that there might not be enough food for all inhabitants in the years to come and the perceivers found that they must aim for the survival of themselves and their social group; alternatively, this perception could have led instead to innovation in order to avert the overexploitation of the land so that more people could survive in the long run.

While the concrete response would have been, as we have seen, to a greater or lesser degree dependent on more general and abstract parameters like belief systems, ideologies, knowledge, etc. – which themselves would also have been constituted semiotically – we can nonetheless gather from these examples one significant general mechanism that is at work with transformations from a sign perspective, namely how the different forms of sign interact within the semiotic realm in order to contribute, or lead, to real-world transformations. First, people perceive some change in the environment, be it grounded in objective facts or having just an imputed character. These perceptions constitute, in any case, basic iconic content. This forms the basis for the subsequent stages of the transformation processes, for these icons become involved in indexical sign relations wherein the iconic (perceptual) content is interpreted as having a connection to some ‘fact’ in the outer (natural etc.) world, namely based on the knowledge (or so imputed) of the people involved, in particular including their world views, ideologies and so on. In consequence, the icons are conceived of by the humans as a proxy for something that is, or happens in, ‘reality’ and as such they form the potential basis for further action insofar as, finally, these indices become embedded in complex symbolic signs such as propositions (i.e. ‘dicisigns’; cf. Hartshorne et al., 1931, 2.251 and 2.310; see Stjernfelt, 2015) that allow, for example, truth-apt statements about the state of things in ‘reality’ or in even more complex signs such as those that, for example, delineate logical conclusions or the setting of goals of action, or develop more complex imaginary worlds that put up a world different from that the people were living in, for example forming an ideal goal of human action as a utopia to be aimed at.

On the other hand, the semiotic description of transformation processes given above sheds light upon another mechanism that might equally have led to, or at least have been involved with, transformations, for it allows for the possibility that transformations did not start with bare iconic content (i.e. perceptions), but instead with a primary change within the realm of symbolic content, for example, as relating to the belief systems or societal ideologies or the knowledge available to the humans of the past. This change within the abstract realm then might have led to actively

searching for and identifying indexical or iconic signs within the ‘real’ world (with all the caveats noted above) with the aim of validating the spontaneous change on the symbolic level in turn. For example, having acquired the knowledge that carbon dioxide might contribute to the warming of the atmosphere, one might venture to measure the atmospheric concentration of this gas, from which measurement certain practical responses might follow, such as the attempt to reduce the production of this gas (this actual response itself, by the way, would be also included in the basic sign relation, namely as so-called ‘interpretant’, here with a practical nature). Such a mechanism might be involved with transformations which were not primarily induced by the external world, but were instead first initiated within societies of the past on the basis of semiotic processes and then had a secondary impact on the environment, which to be sure would not have taken place if the semiotic processes on the abstract level had not taken place beforehand.

Of course, these are only two exemplary and rough outlines of the mechanisms pertaining to the additional semiotic layer of the extended DPSIR scheme sketched here; additional case studies could significantly deepen our concrete understanding of the complexities of the entwinements of the objective and subjective dimensions of transformations. But what is clear in any case is that this approach, first, allows for understanding transformations as connected with, and informed by, complex semantic dynamics that evolve in a range from concrete perceptions to the most abstract thinking on both the individual and collective levels, also with a view on their genuinely practical consequences, and that at the same time are embedded within the overarching semiotic systems that were used by the humans of the past as, for example, given by the language they used or the belief systems they held or the knowledge they possessed. Second, this approach accounts for the non-deterministic complexities of human-environment interrelations and takes seriously the character of humans as not only entities with agency and intentionality but as beings for which semiotic processes are constitutive on the individual and societal levels (on this difference between agency and the semiotic dimension, see Harris & Cipolla, 2017, pp. 120–125, for a discussion of instructive case studies; cf. also Bauer, 2013; Preucel, 2016; Watts, 2008, with semiotic takes on material agency, which makes the theoretical situation even more complex). The semiotic relation involving ‘real’ world and sign therefore does not have a deterministic, quasi-naturalistic character, but it has to be conceived of as historically contingent within a range from the individual to the cultural parameters. Assessing transformations, then, involves the historical exploration of both layers of the scheme. Even if this might prove difficult in the particular case at hand, this integrative approach might help in finding and identifying the meaning within transformations and thus holistically combining their etic and emic dimensions.

3.6 Emergence

The final element of the anatomy of transformations outlined here is emergence. Employing an emergentist perspective on broader archaeological and historical contexts, and specifically in the undertaking of conceptualising an anatomy of transformations, has several upsides. The reasons for this are straightforward: first, the contexts analysed by the anatomy of transformations can be described as complex systems, that is, as systems involving humans, animals, and the immediate ecosphere. These systems are self-organising, involving dynamics that are non-linear and occur at different levels of interaction. Thus, complex systems concern a variety of phenomena occurring at various scales, recognising the connection between them, for example in the production of a pot and the diverse ways agriculture emerged (for an overview on complex systems see Bertuglia & Vaio, 2005; Sayama, 2015; for some philosophical takes on complexity see Hooker, 2011; Wimsatt, 2007). Second, in our combined efforts to detect and explain transformations in human history, from the viewpoint of several different perspectives between the sciences and the humanities, it would certainly be beneficial to have some sort of measure that allows us to understand the different levels and scales of organisation, and this holds also true with regard to the interrelations between the objective and semiotic layers of the anatomy of transformations sketched in the previous section. Lastly, we have – by virtue of the contexts we study – a narrow access to knowledge about all the constituent parts of these systems, but by focusing on a wide range of parts, it is possible to obtain a clearer picture. In short, emergence provides a much larger picture than what is provided by DPSIR, theory, and semiotics alone, especially by bridging different gaps in our explanations of a variety of phenomena which occur at varying scales. So, the big question at hand is how to effectively define emergence in this context and how to position it within an anatomy of transformations.

Several principles of emergence require parsing. Emergence needs to accommodate diachronic processes, since the transformation of societies cannot occur outside of the progression of time; emergence needs to account for differences on several scales in an integrative way, which means that it must accommodate some sort of synchronic ‘levels’ of organisation represented by specific sciences and their respective means to describe and explain (e.g. climatology, anthropology, biochemistry, archaeology, etc.); and finally, emergence should avoid striving for a status of being a ‘general theory of everything’ while being flexible enough to work as a guiding principle in the multidisciplinary undertaking that modern archaeology represents.

These principles have been discussed quite extensively in the literature (e.g. Bedau & Humphreys, 2008; Manzocco, 2018; Sartenaer, 2015), but for our purposes, it is central to recognise the difference between an ‘emergence basis’ and ‘emergent’. As the name indicates, the basis brings about emergence – in simpler words, it is the conditions from which emergence is possible. Emergents can then be understood as novel qualities that do not exist in the basis; that is, they denote a

situations where something new comes into existence. There is much more to emergence than these ideas, and not all is clear. For this reason, understanding emergence rather as a heuristic guiding principle to approach causal and scalar relations in an anatomy of transformations is the more pragmatic approach.

Taking the definition above, it is possible to translate it into such a principle that enables us to broaden our view of transformative processes such as ‘neolithisation’. The advent of agricultural practice and the overall development of agriculture becoming the dominant mode of subsistence in Europe viewed ‘from above’ on a large geographical and temporal scale seems to be directed, irreversible and, compared to the whole history of humanity, rather quick, even though from the human perspective it took a very long time (cf. Robb, 2013). However, the more we zoom in on smaller and narrower scales, the more it becomes apparent that ‘the European Neolithic’ as we would call it in total is located at a conceptual level of organisation which is not easily explained given the knowledge of lower conceptual levels of times, traditions, groups, families, or individuals. Viewed from ‘below’ possible interactions between, for example, groups of hunter-gatherer-fishers and groups of farmers in all their variability and in all of Europe do not sufficiently explain the directed and irreversible character of the higher level ‘European Neolithic’. This is simply because there are more factors at play than just interactions between people; each system we observe is open to influences outside of our view. In that light, we could say that the transformation we would subsume under the advent of agriculture – on a higher (conceptual) level – is emergent upon the interactions of lower (conceptual) level entities (humans, animals, climate, weather, geography, aesthetics, ideology, etc.), without us being able to trace the complete extent of its constitutional chain and likewise the complete set of causal trajectories that led to it. Synchronically as well as diachronically the dominance of agricultural practices emerged from the set of choices people made, possibilities people had, available resources, and so on. But also each of these (maybe except for resources, depending on how those are defined) could be said to be emergent upon other systemic interactions: possibilities inform choices, yet choices cannot be reduced to fundamental laws in the sense that every choice made has an element of unclear determinative traceability. Still, these choices form the basis for new – emerging – possibilities and the cycle continues, leading to qualitatively novel states of affairs.

To conclude, treating emergence as a guiding principle in this way does not mean we should stop striving for new insights into causes and effects regarding transformations, but it keeps us from falling back on oversimplified explanations by implicitly keeping our minds pliable to the openness and uncertainty of the systemic relations we try to uncover.

3.7 Concluding Remarks

The idea of an anatomy of transformations is much more than a methodological toolkit, containing a variety of methods and concepts; it is a programme that conceives the long journey of human history as something that cannot be understood in isolation nor under oversimplified models. The history of archaeology, the study of long-term changes in ways of life, and the study of human-environmental interactions have undergone considerable amounts of research and study but oftentimes in separate sub-fields with very different epistemologies, assumptions, and methods. This divergence is somewhat unavoidable given that there cannot be a single approach or methodology that can uncover and explain the entirety of human history. The understanding of past and present transformations cannot be subject to the unity of method, but it can be subject to a unity of purpose.

Throughout our common history, there were deep, structural, and long-lasting transformations, and despite their apparent disparity, the concepts and methods employed by the anatomy of transformations are unified when it comes to explaining how and why these transformations happened. As a heuristic tool, DPSIR has the advantage of being an open and flexible model that can explain specific phenomena of change, while avoiding the risk of oversimplification and overcomplexification. Theories go a little deeper by contextualising the behaviour of people within their specific social and historical setting and thus examine their agency. Semiotics provides access to the emic side of life and point to avenues of smoothly integrating it with its etic dimension. Whereas DPSIR uncovers the perspective of hard materiality, semiotics offers a tool to assess how this reality was represented in the human mind and how these mental representations in their turn had an impact on the historical transformation processes. Finally, from an ontological standpoint, emergence recognises how new behaviours, practices, and conditions emerge by establishing the connection between the various levels at which transformations occur and how these levels relate to one another.

Overall, the issue of incommensurability of methods and explanations will continue to exist; that is to say, no matter how much effort is invested into creating an overarching system of methods and theories, such as the one presented above, some contradictions and lapses will nevertheless occur. For instance, DPSIR, semiotics, and certain theories tend to have different definitions as to what “collapse” means; what is important is to recognise that these different definitions and forms of analysis allow for one to choose those definitions that work best for the case in question. Rather than thinking of the anatomy of transformations as a single, monolithic, and unified system, it is best to think of it as a very expansive toolkit, to which one can add and remove items. By perceiving the approach to human-environmental interactions through this large toolset, it becomes easier to recognise where overlaps in methodology and epistemology occur, resulting in a cleaner but nonetheless more holistic approach to research.

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