The French-Anglophone divide in lithic research: A plea for pluralism in Palaeolithic Archaeology

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Chapter 4

Analyticity unpacked: Anglophone approaches between formism and mechanism

> *"Hypotheses are developed to relate observed properties to one another by means of a structural concept. In this way an hypothesis, or an hypothetical model, is constructed for the sake of predicting certain correlated regularities"*
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> – David L. Clarke (1968: 643)

> "[...] [A]*ll factual knowledge of the archaeological record is created at the time persons make observations on the archaeological record. Factual knowledge, or knowledge claims regarding properties of the archaeological record are always contemporary with the observation-documentation event.* [...] *Circumstantial evidence is very different from factual "evidence." If one can give an explanation, then they have a strong argument that is descriptive of a necessary relationship between something seen and some prior dynamic process. That is circumstantial evidence of the best form. It's not a different phenomenon. It is simply an explanation carrying the most reliable details of causally relevant procedural information. The latter plays the role of the most powerful form of argument, because it provides the relevant information regarding causal linkages. As such, the process may be duplicated experimentally, and/or identified as having acted by patterned empirical phenomena derived from anticipated causal events and thus linked to observations indicative of secure causal sequencing."*
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> – Lewis R. Binford (2013: 9)

Abstract

This chapter analyses a number of case studies drawn from Anglophone lithic inquiry and examines whether research in this tradition can be grouped into 'formistic' and 'mechanistic' strands of investigation. The structural categories of the two respective world theories are brought to bear in order to demonstrate that this question can be answered in the affirmative. Four cases of 'formistic' and three cases of 'organicistic' research are identified and discussed in detail. Lithic 'formism' turns out to promote 'taxonomisation' and revolves around the analysis of patterns and associations of 'particulars,' 'characters,' and 'ties.' It is shown what hypothesis-testing in 'formism' amounts to and that 'subsistent' categories are often crucial in lithic explanations. Anglophone lithic 'mechanism,' by contrast, revolves around the 'specifity of response' principle and seeks to explain in terms of causality and other forces of directed determination. It tends to rely on 'prediction' and typically involves negotiating the 'observable'-'unobservable' boundary. Pepper's epistemology thus helps clarifying its cognitive status of the French-Anglophone divide and provides new insights into the internal structure and dynamics of the lithic analysis it hosts. The chapter substantiates the view that Anglophone lithic inquiry propagates a 'part-centred' approach to the available evidence.

The foregoing chapters have demonstrated that any approach to lithic evidence relies on pre-casting the world into a world hypothesis. It was shown that Anglophone researchers tend to deploy a particular type of such unrestricted world theories – theories which we have termed 'analytic' because they prioritise parts. The goal of the present chapter is to further explore this 'analytic' orientation and to examine its internal variability. Can lithic inquiry in the Anglophone world be broken down into 'formistic' and 'mechanistic' strands of reasoning? And if so, does this help us in understanding the logic of the Anglophone discourse – why scholars disagree, what they disagree on, and how? Responding to these questions requires the application of Pepper's structural categories to particular instances of lithic practice. To put it differently: it requires an *empirical* evaluation of the utility of the specific structural categories of the two world theories for illuminating the activity of Anglophone scholars.

The following two sections are designed to complete this task. I present a number of individual case studies and smaller fields of discussion which I take to be paradigmatic for Anglophone lithic research in Palaeolithic archaeology and analyse them in terms of Pepper's epistemology (see **Appendix III.4** for an explanation of the underlying rationale of case study selection and design). I will begin with illustrating the 'formistic' aspects of the Anglophone research enterprise by drawing on four different case studies. These are then complemented by an examination of three instructive cases of 'mechanistic' reasoning. The aim is to show that these examples substantiate the relative *unity* of Anglophone approaches insofar as all of them are committed to 'analytic' premises, yet they also clarify counteracting forces and sources of internal diversity that characterise the larger Anglophone research endeavour in lithic analysis.

If the application of Pepper's categories of 'formism' and 'mechanism' to these case studies turns out to be successful, this would drive home the claim that 'Anglophone' circumscribes a meaningful category in lithic research. Different schools, approaches, and more subtle research orientations *within* this Anglophone sphere of inquiry could then profitably be re-described as varying interpretations of two conflicting modes of reasoning – 'formism' and 'mechanism' – which nonetheless share a common 'analytic' conviction.

4.1 **Tropes of formism in Anglophone practice**

4.1.1 ***Scerri et al.'s multivariate approach to population structure***

Scerri et al.'s *Unexpected technological heterogeneity in northern Arabia indicates complex Late Pleistocene demography at the gateway to Asia* (2014) provides a recent glimpse into formistic aspects of reasoning in Anglophone lithic research. The principal objective of this paper is to test scenarios of dispersal and population dynamics at the gateway between Asia and Arabia during MIS 5. These scenarios are constructed as 'hypotheses,' but the latter are not derived from general high-level theory or model-based specifications of causal-determinative factors that may have produced the relevant empirical signatures under varying conditions. Instead, the respective hypotheses reflect the nature of the ongoing discourse on the role of peopling and population structure in shaping lithic technology. They remain rather general and are formulated in terms of *similarity* expectations (*ibid*.: 138). In order to test the status of their Saudi Arabian lithic material from the Jubbah basin, the authors compare metric and attribute data with the evidence from other sites in southern Arabia and the Levant. In terms of potential dispersals and population structuring effects, the guiding assumption is that dispersal should produce inter-site signatures of similarity, whereas population dynamics, depending on their nature, would either produce mixed signatures or reinforce dissimilarity among lithic assemblages. This logic is made explicit in Table 1, which specifies what the authors term "model expectations" (cf. *ibid*.: 128, 139).

While Scerri et al.'s (2014) approach is thus clearly hypothesis-driven and develops the respective test-implications before any lithic evidence is examined, a hypothesis is corroborated simply by demonstrating its *structural conformity* with the revealed data-signature. The authors, in other words, seek to establish a general *correspondence* between a hypothesis and the evidence thought to confirm it. The strategy is thereby not to eliminate all but one of the invoked scenarios, but rather to compare the results of data-analysis with the implications of the different scenarios in order to assess which conforms the most to the encountered lithic patterns. This mode of bringing formal hypotheses to bear is clearly formistic and relies on the 'correspondence theory' of cognitive criticism.[364]

The regulative idea is to certify that there exists a relationship of *form* between at least one hypothesis and the investigated set of lithic data – i.e., that the type of similarity that is entailed in the hypothesis is also encountered in the data:

[364] See Chapter 2; cf. Pepper (1942: 180-185).

> "The theory of truth which grows out of the formistic categories is the correspondence theory. Truth consists in a similarity or correspondence between two or more things one of which is said to be true of the others. In the extreme, truth might be ascribed to any one of a lot of similar concrete objects, as when we say of apple taken out of a box that it is a true sample of the whole lot. But ordinarily the term is reserved for such objects as pictures, maps, diagrams, sentences, formulas, and mental images. These are all concrete existents and the objects they are said to be true of are not exactly similar to them, but only in respect to the form under consideration or in accordance to certain conventions." (Pepper 1942: 180)

Since the relationship between hypothesis-construction and data-analysis is fairly 'loose' – neither do the model expectations specify which variables to select for analysis, nor do they enable a categorical discrimination between relevant and irrelevant lithic information – the approach to the data is largely unconstrained. Scerri et al. (2014) collect as much comparable lithic data as possible and analyse this data in multidimensional space.[365] The strategy is clearly 'dispersive.' All available lithic facts are picked up *as they are* and included in the analysis, the only exception being statistically non-comparable data (*ibid.*: 127). The aim is not to monitor the specific interactions between a limited number of variables, but rather to map out the general patterns of *association*, *correlation*, and *co-variation* that exists between different variables.[366] The looked-for similarities and differences between the studied assemblages are described in terms of the *participation* of 'particulars,' 'characters,' and 'ties' – expressed in artefact types, attributes, metric values, and ratios (cf. *ibid*: Supplementary Online Material [SOM]Table S1-S6) – in the data-patterns they create (*ibid.*: Fig. 2-8).[367] Thus, the analysis is mainly oriented towards exploring the *structure* of the different data sets – what the authors (*ibid.*: 129) describe as the "orthogonal dimensions of variability in the data" – and the relative overlap between these sets. *Unexpected technological heterogeneity* represents a maximally broad, 'part-centred,' 'bottom-up,' and largely 'inductive' study of lithic inter-assemblage affinities. This analytical focus on aspects of 'pattern participation' and the implicit reliance on 'set theory' to arrange patterns in multivariate space are consistent with the hallmarks of formism.

The authors generally note:

> "Within this broad approach, we also recognise that in order to avoid the pitfalls of intentionality and the construction of abstract schemas, it is desirable to have a priori reasons for choosing particular units of study, such as particular attributes (Tostevin, 2012)." (Scerri et al. (2014: SOM, 6)

They further assert that

> "[e]ach test and accompanying variables used in our analyses reflects related and interdependent knapping actions that can be compared between themselves. Some of these clusters are recognised to be affected by one or more processes (see Tostevin, 2012 for discussion). In this way our methodology permits the comparison of comparable stages in the chaîne opératoire of blank and core classes to achieve a whole structure of similarity and difference. By using multivariate statistics to isolate different, uncorrelated sources of variability driving the diversity seen in these classes of objects and their domains of manufacture, we can robustly assess whether learned behaviours may be isolated in analysis." (*idem*)

and argue

> "[…] that repeated patterns of similarity observed between the different classes of objects studied in this way (i.e., cores and flakes) is therefore a meaningful measure of similarity and difference in comparisons of the type presented in this paper." (*idem*)

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[365] Although Scerri et al. (2014: Supplementary Online Material [SOM], 2-6) discuss some theoretical aspects of lithic technology, their main concern is to justify the broad approach to the lithic data they have adopted and to employ common and approved recording schemes. The goal of the discussion is not to narrow down the set of relevant data points.

[366] Scerri et al. (2014: SOM, 3) explicitly note that this approach allows them "to understand the relationships between several variables simultaneously by accounting for their effects on each other."

[367] For the centrality of pattern-recognition in archaeological research, see also Shennan (1997 [1988]: 3): "[…] inasmuch as all interpretation of the archaeological record is concerned with identifying patterning, it is capable of benefiting from a quantitative approach. The point that, within certain constraints, we are *identifying* patterning rather than creating it is an important one to which we will return later. Without such an assumption archaeological evidence would not tell us anything, but one of the virtues of the quantitative approach is that it can tell us in particular cases what a lack of pattern actually looks like." (original emphasis)

These statements confirm that *Unexpected technological heterogeneity* is committed to 'analytic' principles and seeks to identify the interaction of as many lithic variables as possible, some of which represent predefined 'classes' of objects. The value of each data point which can reasonably be recorded is *a priori* identical. The various multivariate analyses performed to determine the degree of association between different variables exemplify this situation.[368] All included variables, independently of their kind, are treated as if they are equally informative. This proclivity to equalise or normalise the evidence is also reflected in the transformation of continuous variables (i.e., metric data) into discrete categories by algorithmic clustering techniques. The latter is for example required when the kind of input data precludes 'principal component analysis' (PCA) and instead requires a 'correspondence analysis' approach (cf. Scerri et al. 2014: 134). Algorithmic transformation represents a classic formistic manoeuvre of data-driven classification.[369] Continuous variables are assigned a discrete value by analysing the overall structure of these variables and statistically determining inter-variable groupings. In other words, continuous variables are examined in terms of the patterns created by their values. This operation clearly relies on the 'Theory of Types'[370] – even if the resulting types are of course *probabilistic* entities.

Whether different assemblages host 'similar' or 'different' constellations of variables is established by measuring the relative *distance* between individual variables or the resulting clusters of variables in multivariate space. The important aspect of this multivariate approach is that it enables "*ordination* – the representation of relationships between items and between variables in a space of a small number of dimensions which still retain most of the information in the original descriptive variables" (Shennan 1997 [1988]: 265, original emphasis). The assessment of assemblage similarity is 'objective' in this sense – it directly *results* from the characteristics of the mapped out lithic parts.[371] Different clusters of variables – the patterns created by the recorded trait-sets of different lithic assemblages – can then be statistically compared in terms of their relative constellational affinity (Scerri et al. 2014: 130-138).[372]

The fact that Scerri et al. (2014: Figs. 6, 7) employ 'correspondence analytical' techniques is particularly informative. The virtue of such an approach, as Shennan (1997 [1988]: 308) clearly points out, is that 'multiple sets of object-values can directly be compared without the intervening information-losing step of creating similarities/distances.' The statistical description of these relationships results in the identification of *norms* in the data structure which can rigorously be compared. This screening of part-constellations for 'regularities' and 'norms' and their subsequent juxtaposition with other higher-order patterns is typically formistic. The variability in the encountered data-set is regarded to point to a certain 'ideal' regulating this variability. How patterned 'regularities' and 'norms' are realised is a question of varying 'principles of exemplification.'[373] The conducted correspondence analysis, for example to isolate patterns in core exploitation variables or the techno-morphology of Levallois flakes, reveals that the lithic data is analysed in terms of its *similarity* implications. This concerns the similarity of correlated variables, but also the similarity of their overall variability (cf. e.g. *ibid.*: 137f.). *Unexpected technological heterogeneity* is therefore clearly powered by the formistic root metaphor.

But how do the authors interpret the various similarities and differences they have unearthed? They conclude that their analyses

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[368] For a discussion of the principles and ramifications of multivariate analysis, especially 'principal component analysis' and 'correspondence analysis,' see Shennan (1997 [1988]: 265-360). Cf. also Olsen and Morgan (2005) for a general epistemological defence of multivariate analytical statistics.

[369] Cf. Shennan (1997 [1988]: 216-264) and Rapkin and Luke (1993).

[370] See Chapter 2; cf. Pepper (1942: 165-162).

[371] Scerri et al. (2014: 126) stress that "[...] multivariate analyses allow to quantify the relationship between constellations of features including the presence of various methods and concepts without giving typological bias to named industries or techniques."

[372] The use of unconstrained multivariate techniques marks a potential point of divergence between 'formistic' and 'mechanistic' lithic analysis. The unconstrained exploration of multivariate interaction is typically viewed with extreme suspicion by 'mechanists.' They typically complain that such a mode of marshalling the evidence clouds the view for what is actually important in terms of data and interactions, and thus 'prevents us from seeing the wood for the trees.' McPherron's (1994) instructive discussion on advantages and disadvantages of multivariate statistical procedures is a point in case. McPherron (*ibid.*: 54f) provides arguments for why multivariate statistics tend to be inferior to narrower, but theoretically pre-informed approaches such as 'linear regression.' The main point is that most multivariate techniques are too 'dispersive' for the 'mechanist' and she/he would therefore typically favour more 'integrative' statistical approaches.

[373] See Chapter 2: esp. **Box 6** for definitions of the 'formistic' concepts.

> "[…] find significant technological overlap between northern Arabia and northeast Africa in particular, which may indicate either evidence for modern human dispersal or cultural diffusion between dispersing modern humans and existing archaic populations in northern Arabia. While a dedicated comparison of these assemblages with Levantine assemblages […] may provide greater clarification, we suggest that the structure of the observed similarities shows that demographic complexity was already a key feature of populations at the gateway to Eurasia" (Scerri et al. 2014: 140).

Together with the earlier statement of the authors that

> "[t]he premise underlying such a comparison is that technological similarities, particularly where recurring through several domains of analysis, can be hypothesised to represent shared population histories" (*ibid.*: 126).

this clearly suggests that they infer an intimate relationship between technological expressions and the history and structure of populations in the respective regions. They argue that the evident complexity of these technological expressions likely indicates that the corresponding population-level processes were equally complex (*ibid.*: 140). This is then interpreted as additional evidence for the fact that human populations indeed moved in and out of Africa in a much more frequent and multidirectional manner than previously assumed. They further suggest that their results support the idea that Arabia was a key region of human dispersal and are consistent with the emerging recognition of the complexity of modern human biology at the time – a thoroughly 'correlationist' take on the evidence.[374]

The first aspect to note is that a complex data-pattern is thought to reflect a complex underlying process. This drives home the point previously made, that some form of *structural congruence* between evidence and explanation is assumed. The second point is that the process producing the pattern is thought to be of a different nature than the pattern itself. Stones, in other words, cannot be explained by stones themselves, but always refer back to their human producers. Since Scerri et al. (2014) examine 'populations of stones,' the idea seems to be that the delineated 'patterns,' 'norms,' and 'regularities' tell us something about 'populations of people.'[375] This suggest that there is a basic structural *co-variation* between human demography and technological expressions. Instead of framing this relationship in causal-determinative terms, it is described fairly generically – the link between lithic technology and the structure of human populations is regarded to be of a *general* kind. This 'looseness' of the explanatory relationship reflects the formistic conception of the world as a weakly determined place.[376] With Pepper (1942: 168-170, 177), we can add that *demographic processes* thereby come into view as 'subsistent' factors. They themselves do not participate in the observed patterns but are identifiable as sets of not fully particularised 'complex characters.'[377] The 'subsistent' category of demography is distinguished from the categories of 'existence' – i.e., the lithic variables – and thereby satisfies the formistic intuition that *matter* takes specific *forms* because it exemplifies particular *norms*.[378] Matter, in other words, takes these forms because of factors not related to matter. This general configuration of reasoning clearly demonstrates that *Unexpected technological heterogeneity* embodies a formistic approach to the lithic evidence. The analysis of the African and Arabian Middle Palaeolithic

[374] For a similar interpretive ambition, see for example Scerri et al. (2018).

[375] This amounts to a Neo-Platonic manoeuvre. Just like Plato identified the 'phenomenal' world as a collection of shadows whose creators are not directly graspable, Scerri et al. (2014) consider lithic evidence as a proxy for human populations which are not directly observable. Lithic data is essentially viewed as the 'shadow thrown by intangible populations.' Obviously, this interpretation involves aspects of transcendental reasoning, since it depends on the general assumption that the *conditions for the possibility* of lithic artefacts include human presence and production. 'Formistic' patterns of reasoning are therefore often masked as generic inferences by *abduction*. [Abduction is typically defined as inference to the best or most self-evident explanation (cf. Putnam 1981; Poston and McCain 2017).] In general, the compositional structure of the observed phenomena is explained by a different entity which, in some relevant sense, can be said to have existed prior to the phenomena in question, and to lie beyond the 'horizon of sensation.'

[376] See Chapter 2.

[377] See Chapter2: **Box 6**.

[378] Because of the generally open pool of potential 'subsistent' candidates, 'formistic' reasoning typically relies on excluding other such potentially relevant candidates. This elimination or rejection of competing 'subsistent' categories is thereby also a 'formistic' strategy to deal with the problem of *equifinality* – in 'formism,' the problem that similar patterns may point to different 'subsistent' categories or that similar forms may participate in different 'laws,' 'regularities,' or 'norms.' Scerri et al. (2014: 128), for instance, not only try to hold constant the eco-zone from which their study material derives (Saharo-Arabian subtropical grassland and shrubland biomes), but also make sure that their sites have been selected according to river, lake, or raw material adjacency. Furthermore, they make some specific arguments in order to reject the possibility that simple reduction effects may account for their observations (*ibid.*: 129-131).

data is motivated by a correspondence conception of truth and explained by first exposing the structures of 'existence' and then putting them into perspective by invoking a particular category of 'subsistence.'

4.1.2 ***Conard et. al.'s core reduction taxonomy***

The second example of the formistic orientation of Anglophone lithic research is *A Unified Lithic Taxonomy Based on Patterns of Core Reduction* by Conard et al. (2004). This short paper tackles the issue of core classification in a manner characteristic of formism. The authors present a generalised taxonomy for organising the variability of cores encountered at Palaeolithic sites from Africa. While the paper is not so much concerned with the application of the proposed classification, the authors regard their 'taxonomic work' as an indispensible prerequisite for engaging with more specific lithic research questions and to facilitate scholarly communication both within the community of lithic Africanists and African and European approaches. Accordingly, the chief objective of *A Unified Lithic Taxonomy* is described as

> "[...] defining a taxonomic system for chipped stone artefacts that can be applied to materials from the Early, Middle and Later Stone Age. The motivation for defining a 'unified taxonomy' stems from the need to develop a system for classifying multi-component surface assemblages. The proposed taxonomy revises southern African systems by applying ideas and methods from European approaches to lithic technology. Given that much confusion exists on the classification of cores and core reduction, the lithic workshops focused on this class of artefact." (Conard et al. 2004: 13)

Based on the examination of the lithic material from a range of especially Southern African sites, Conard et al. (2004: 14) suggest that the most part of the observed variability of cores can be satisfactorily captured by three "main taxa," encapsulating 'Inclined,' 'Parallel,' and 'Platform' core-types (**Fig. 11**). These are complemented, if necessary, by core categories termed 'Initial,' 'Multidirectional,' 'Intermediate Broken,' 'Bipolar,' and 'Other' (*ibid*.: 15). Cores are defined as 'objects from which potentially useful flakes have been removed' and following Deacon (1982) must exhibit at least three deliberate removal scars (*ibid*.: 14). Individual cores are then classified based on well-defined sets of shared characteristics. These include the number of preserved flake negatives, the number of adjacent removal surfaces, angle(s) of flake detachment, aspects of general morphology (i.e., 'conical,' 'biconical,' 'asymmetric cross-section,' 'polyhedral,' etc.), the direction of preserved removals, the presence and location of core preparation, and the number of striking platforms (*ibid*.: 15f.). The overall constellation of these characteristics, with a particular emphasis on core morphologies and the organisation of removals on the exploitation surfaces, determines the taxonomic group into which an individual piece is placed (cf. *ibid*.: Table 1).

The logic of classification is 'atemporal' and revolves around the identification of *necessary and sufficient conditions* for grouping artefacts.[379] It is atemporal because the archaeological context including the dating of the artefacts but also the particular attitudes and research interests of the examiners do not matter. The goal is to devise effective core categories that can be used to describe core variability of "all ages" (Conard et al. 2004: 14). The unit of classification is the self-sufficient 'atomised' piece. Each single core is analysed in terms of its individual features and then compared to the list of characteristics tied to each taxonomic grouping. An artefact is assigned to a specific core taxon only if it fulfils all of the listed necessary conditions. Classificatory practice therefore follows a clear 'if-then' logic determining which core is ascribed to which group of objects under which conditions. The authors themselves repeatedly emphasise that they aim to provide a system of organising lithic evidence that is 'unambiguous' and easily 'reproducible' by different lithic workers. The independent evaluation of the reliability of the devised categories by a series of blind tests illustrates this point (*ibid*.: 16). These analytical standards, of course, ought to apply to individual objects, not to assemblages or other object totalities.

The authors explicitly point out that

[379] The search for necessary and sufficient conditions can be a 'tool,' 'heuristic,' or 'regulative idea' to help specify the application of a definition or concept under scrutiny (cf. e.g., Brennan 2017).

> "[…] the taxa described below represent a high-level classification and that within the main groups of Inclined, Parallel and Platform many subclasses exist and can be recognized using the key variables discussed at the end of the paper." (Conard et al. 2004: 15)

According to Conard et al. (2004: 16f.), these additional key variables comprise the morphology of the core endproducts, the degree of reduction between initialised and exhausted cores, the degree of utilising core circumferences, frequency of striking platform and removal surfaces expressed in numerical values (i.e., integer data), and the degree of platform preparation reflected in both cores and *débitage*.[380] The result is the ability to discriminate between different *degrees* of inter-core similarity. The higher-order taxonomic groupings provide more general descriptions of core types entailing a range of lower-order, more specific groupings, such as Levallois cores (*ibid.*: 16). This illustrates that different 'classes' of cores, established based on varying granularities of resemblance, can be *ranked* within a larger system of classification.[381] This system, in turn, reveals the natural *hierarchy of facts*.[382] In other words, those characteristics which define the higher-order groupings are considered to be more important in understanding core reduction technology than those discriminating the lower-order classes.[383] The hierarchy of object groupings also tells us whether a grouping is relevant on a general level of inquiry or whether it is more likely to be effective in specialised research contexts. The higher-order core categories – the 'taxa' in the words of Conard et al. (2004) – are thought to have this *general* bearing, whereas the finer-grained categories – what the authors call 'subclasses' – should help addressing more specific issues and questions in lithic research. This logic is distinctively formistic. Not only are differences in lithic parts – objects, traits, attributes and relationships between the latter two – systematised according to Pepper's 'Theory of Types,' the explicit goal of *A Unified Lithic Taxonomy* is the creation of a *universal classification*, ordering the lithic facts from the more general to the less general.[384] A 'class,' in this view, is nothing less than "a collection of particulars which participate in one or more characters" (Pepper 1942: 159). The point is that these classes are regarded to reveal something substantial about the *structure* of lithic reality, as well as about the particular 'norms' that must have guided the transformation of 'matter' into recognisable lithic 'forms.' More generally speaking, the interpretation of *lithic typology as taxonomy*, in particular if the latter is viewed as an independent domain of scholarly activity, is a highly diagnostic condiment of formistic reasoning.

A few remarks on the epistemology of 'taxonomic reasoning' may be useful here. Taxonomies seek to portray patterned regularities in observable reality; they capture how reality is compositionally organised, that is, how one can dismember it into parts. Taxonomies thereby identify and define the entities that can be said to populate this reality on various levels of existence – they respond to the intuition that 'unless reality contains some order, we can find no order in it' (Grene 1990: 239). The first aspect to note is that 'taxonomisation' is thus typically an 'analytic' operation. The second aspect is that many different classifications are always possible and taxonomies thus depend on some form of *external* significance. Many taxonomies, for instance, seek to delineate classes that figure in laws or facilitate the formation of such laws (cf. Hull 1998; Honenberger 2015: 28). Some authorities would

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[380] Two aspects are remarkable here. First of all, some of these variables have already been covered, at least partially or in a slightly different format, by the initial list of core classification (cf. Conard et al. 2004: Table 1, 15f.). The specified additional variables meant to create sub-classes therefore feel redundant at times. Secondly, although the proposed classificatory scheme focuses exclusively on cores (*ibid.*: 13), the authors now suddenly introduce non-core features. This invocation of endproducts and *débitage* preparation is surprising at best. The authors, for instance, leave it completely open how the corresponding *débitage* pieces can reliably be identified. These difficulties almost certainly generate some interpretive problems.

[381] The prototype of a ranked system of classification is the nested hierarchy of nature encapsulated in Linneus' *Systema Naturae*. This classificatory system discriminates between 'family,' 'order,' 'genus,' and 'species' (see also Simpson 1961; Schuh 2000). The general idea in lithic studies has always been to come up with an analogous way of classifying lithic objects and to learn something from it about the general organisation of human stone technology.

[382] The distinction between the three 'main taxa' of cores and five complementary taxa as well as the differential interpretive treatment of the groups suggests that the former are regarded to embody a degree of "truth" or "certainty" that the latter are lacking. It indeed appears as if the complementary taxa represent "half-truths," a genuine category of 'formism' (see Chapter 2).

[383] This 'hierarchy of facts' may be interpreted as specific way of theorising the classic 'formistic' distinction between *essential* and *accidental* properties (cf. Robertson and Atkins 2018). An essential property is a property that an entity, typically an object, must have. Accidental properties, by contrast, are properties that entities happen to have but could lack. Classifications can be interpreted to reveal the grading between these categories of properties: the more general the class, the more likely is it to delineate essential properties. This is why more general classes are sometimes said to be more 'real.' This way of using classifications entails some form of 'essentialism.'

[384] See Chapter 2: esp. **Box 6**; for the role of *classification* as a primary analytical operation in 'formism,' see Pepper (1942: 159-161).

indeed argue that 'true' classes are distinguished precisely by their participation in these laws. This conception not only reflects the formistic understanding of laws as 'strong norms which regulate occurrences in nature and render them regular' (cf. Pepper 1942: 166),[385] it may also result in the identification of classes as *natural kinds*.[386] 'Natural kinds' are groupings that echo the *natural structure* of the world (e.g., Bird and Tobin 2018). Classification, conversely, supplies a tool to detect such 'natural kinds.' Yet, the fact that different classifications compete for knowledge and that classification itself usually fails to provide the ultimate means to reach out to the genuine structure of reality can be taken as evidence for the formistic idea that reality is only weakly ordered. The same formistic belief in the lack of 'integrative determination' motivates a strong reliance on classification in the first place. The creation of taxonomic systems is typically a reflex of 'dispersive' modes of handling evidence, in which the primary emphasis lies on the *proliferation* of fact and the *incorporation* of as many disparate facts as possible.

A number of observations suggest that Conard et al.'s (2004) grasp of classification and its role in lithic studies is in accordance with this general characterisation of 'taxonomic reasoning.' The authors for example note:

> "Here it is worth reiterating Brew's (1946) observations that there are no perfect or ideal taxonomies in archaeological systems, and that the field has more often suffered from having too few rather than too many taxonomies. As new knowledge accumulates and new problems are defined, new taxonomies will be needed. While all new systems should be viewed with a healthy dose of scepticism, one should not resist attempts to develop new approaches. Taxonomic systems that do not prove to be useful can and should be discarded. Conversely, to a certain extent, the existence of multiple mutually intelligible systems presents no significant problems to researchers and can enrich archaeological discourse." (*ibid.*: 13f.)

They also emphasise that

> "[c]lassifying lithic artefacts does not constitute an end in itself; it should be seen as one step in the overall analysis of lithic artefacts in relation to patterns of human behaviour." (*ibid.*: 13)

and add:

> "It should, however, be stressed that cores change as they are reduced so that it is possible for cores to reflect different patterns of reduction at different stages of knapping. […] Equally important is the observation that there is continuous variation between the three main patterns of reduction." (*ibid.*: 15)

These enunciations make clear that the authors regard 'taxonomisation' as important coordinate of scientific progress in the field. They similarly indicate that the interpretation of taxonomic groupings depends on the kind of background theory adopted.[387] This last point is evident when one reads the individual descriptions of the different core taxa, in which recurrent reference is made to 'stages of knapping' and a 'continuous process of lithic reduction' (cf. *ibid.*: 15f.).[388] Already the description of the taxa includes interpretive suggestions what these might mean in terms of reduction dynamics and a continuous space between 'early' and 'late' reduction stages. The taxon 'Initial' is for example identified as likely reflecting earlier stages of lithic knapping (*ibid.*: 15). The generally continuous character of lithic reduction also regarded to explain some of the observed borderline variation. The authors explicitly state that we should "not be surprised that some cores are difficult to classify because they fall within the 'grey zone' between the main types" (*idem*). Individual cores may either deviate from

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[385] Cf. Chapter 2: **Box 6**.

[386] Hull (1969: 169f.) for example notes: "[t]raditionally the notion of type entails that membership in a natural kind is determined by one set of characters which are severally necessary and jointly sufficient."

[387] Although Conard et al. (2004) admit the theory-ladenness of scientific classification (cf. Schurz 2011: 63), they determine the key classificatory variables on the basis of the structure of their evidence. Theory, therefore, plays only some vague and rather *post hoc* role in their taxonomic approach. Clearly, the primary emphasis of the authors lies on *phonetic* classification, that is, classification based on the resemblance of traits. Following Schurz (2011: 66-70, Abb. 2.11), *phonetic* classification can be distinguished from *phylogenetic* classification which may either take the form of *cladistics* (after Henning) or *evolutionary* systematics (after Mayr). The latter are methods of 'top-down' classification. Note that although 'formists' generally tap into the full spectrum of classificatory means, the more 'functional' taxonomies are typically also accepted by 'mechanists,' especially if classification reflects their principles of causality and 'primary laws.'

[388] Needless to say, the tacit adherence to a 'continuum' conception of lithic reduction is highly significant, but it is not the main concern of the present analysis. We will return to this issue in the second part of the present chapter, when various incarnations of Anglophone lithic 'mechanism' are scrutinised.

the reduction pattern they *normally* embody or they may represent in-between reduction stages. This insistence on the 'normality' of pattern and the idea that individual core taxa represent 'norms' of lithic knapping which are materialised by particular 'principles of exemplification' (i.e., methods of reduction) is a classic formistic figure of interpretation.

Because such 'norms' of lithic reduction are inferred on the basis of 'complex sets of characters,' a norm itself is rarely fully particularised and thus typically transcends its complete materialisation.[389] The author's assertion that their lithic core taxonomy somehow resonates with different 'methods of reduction' (*ibid.*: 14, 16) is only intelligible if we accept this interpretation of reality and identify the *behaviour of reducing cores in various ways* as the 'subsistent' category of their analysis. The idea would be pretty simple: if there are different knapping plans or norms of reduction, these would result in a differential treatment of 'matter' which, in turn, would result in varying lithic 'forms' – that is, varying constellations of the physical characteristics of cores. 'Methods of reduction' are exemplified by particular part-configurations but resist complete materialisation – they "subside" as Pepper (1942: 177) would say. Whether the 'method of reduction' throwing its material shadow into the world of 'existence' is thereby conceptualised strictly as a 'technical norm' or a 'technical law' in the formistic sense of these notions does not matter much. The key point is that the correlation between 'methods of reduction' and 'complex lithic patterns' is effectuated by the distinction between a directly observable domain of lithic objects and a veiled realm of 'subsistence.'[390] The latter supplies the conditions for the possibility of encountering particular patterns in 'concrete' reality and must therefore 'exist' in some sense itself. Conard et al.'s (2004) 'methods of reduction' therefore assume an almost Platonic status – as *abstract entities* with concrete material correlates.

A Unified Lithic Taxonomy generally occupies similar epistemological ground as Monnier (2009: 122), who has recently given a strong voice to the formistic argument that there can be no lithic knowledge without explicit classification:[391]

> "I submit that we cannot, in fact, escape typology. Regardless of one's ultimate goal, artifacts still need to be organized in some way before they can be analyzed. The search for technological patterns cannot begin until lithic artifacts are organized into coherent categories based on technological attributes and features. The creation of a typology of technological attributes should be done carefully and should be informed by the science of classification (e.g., Adams and Adams 1991). Most of all, this typology should avoid confounding description with interpretation. […] In conclusion, although many would agree that the ability of Bordian typology to inform us about human behavior in the Middle Paleolithic is limited, *typology* itself is not a "bad approach." It is a necessary tool of archaeology because our first task is to organize the artifacts we are studying. We must simply do it explicitly and carefully." (original emphasis)

The importance of this formistic argument for the indispensability of the 'Theory of Types,' classification, nomenclature, and taxonomy can hardly be overrated. The issue of "typological reasoning" – to use the words of famed biologist Ernst Mayr (1976 [1959]: 27f.) – has divided 'mechanistic' and formistic camps of scholarship ever since. This division is for instance expressed in the authorative 'Grene-Hull debates' on the status of typology and the concept of species in evolutionary biology (cf. Honenberger 2015). While David Hull (1965a, 1965b, 1976, 1989 [1986]) joined the ranks of Mayr and others arguing that typological reasoning and hollow taxonomies represent relics of a pre-Darwinian and essentially 'non-scientific' era of research (cf. Winsor 2006), Marjorie Grene (1958, 1974, 1989, 1990, 2002), by drawing on a solid Aristotelian foundation, defended the obligatory status of 'typologisation' and 'taxonomisation' in understanding both nature and evolution. Grene (1990) in particular argued that the kind of 'population thinking' propagated by Mayr, Simpson, and other architects of the 'New Evolutionary Synthesis' inevitably leads to self-contradiction – to all kinds of logical absurdities – and is thus untenable;[392] she also stressed the need to take serious the observable *structure* of reality which, according to her, is typically explained away by Neo-Darwinian approaches (cf. Grene 1958:

[389] Cf. Chapter 2: **Box 6**.
[390] 'Mechanists' are typically sceptical about this form of pattern-explanation mirroring. They tend to insist on the 'specifity of response' principle and argue that explanations need to remove any vagueness in the relationship between the *explanandum* and the *explanans*. An explanation, in other words, cannot only be adequate by its form, that is, structural congruence between observed patterns and more abstract concepts driving these patterns.
[391] See also Clarke's (1968: Chapter 12) invocation of 'numerical taxonomy' as an early, yet influential expression of taxonomic reasoning in Anglophone archaeology.
[392] For the role of the debate on 'essentialism' and 'typological thinking' on the development of the 'New Evolutionary Synthesis,' see Chung (2003), Amudson (2005), and Winsor (2006).

125-127). The debate is thus a classic instance of the clash between formistic and mechanistic standpoints. The formistic view highlights the need to pay heed to the organisation of facts in both their phenomenal horizontality and verticality and assumes that the distinct kinds identifiable in this way refer back to the 'subsistent' qualities responsible for their 'existence.' The mechanistic view, by contrast, insists on a more specific, necessity-governed link between the observable and the unobservable and tends to conceptualise the matrix of causality as a 'field structure' (cf. Chapter 2). Within this 'field structure' of reality, all residual discreteness must be resolved because any remaining discreteness would ultimately undermine the singularity of cause-and-effect.[393] Arguably, the discussion in Palaeolithic archaeology can be reconstructed along similar lines. The supposed formistic 'essentialisation' of reality, for instance, is regularly criticised by more mechanistically-inclined researchers (e.g., Shea 2011b).[394] We will recurrently come back to this issue in the course of the present chapter.[395]

A brief look into the latest work of the first author of *A Unified Lithic Taxonomy* further reassures us that formism, for the most part at least, provides the relevant cognitive framing in this context. In a paper on behavioural variation and change throughout the Middle Stone Age sequence of Sibudu cave (South Africa), for instance, Conard and Will (2015) identify patterned regularities and trends in lithic technology based on an explicit 'attribute analytical' approach. Their measure to establish 'regularity' and 'focused' patterns of change is *statistical similarity*. They directly link the emerging patterns in the lithic data to 'patterns of behaviour.' Again, the idea is that the lithic evidence reflects back to hominin behaviour in rather generic, yet nonetheless intimate ways. Hominin behaviour and lithic patterning, in other words, are thought to substantially *co-vary*.[396]

Similarly, the author's generalised and fairly abstract hypotheses (*ibid.*: Fig. 16) are evaluated in terms of the latter's *structural similarity* with the patterns observed in 'concrete' reality. The same tendency of structurally aligning empirical findings and advocated explanations results in the emphasis of the purported 'complexity' of the behavioural strategies under investigation. Thus, 'behaviour' clearly accounts for the 'subsistent' category of the study – a category that is illuminated by an extremely detailed examination of the lithic evidence, yet remains deprived of equally rich characterisations. Metaphorically speaking, this situation clearly attests to the formistic recognition that the details of 'subsistent' qualities typically remain 'hidden' and 'stored away' behind a wall of 'existence.'

Furthermore, the 'subsistent' category of behaviour, in classic 'correlationist' fashion, is ultimately secured by demonstrating that potentially competing 'subsistent' categories such as external environmental or ecological conditions are not significantly correlated with the lithic patterns in question and can thus faithfully be excluded as candidates of explanation.[397] The reasoning is thus as follows: if there is no evident external correlation, the relevant 'subsistent' category must be 'internal' – i.e., it must be a category intrinsically bound to the 'primary existence' of the lithic artefacts in question. This logic of research, overall, is undoubtedly formistic.

4.1.3 *Morphometrics and cultural phylogeny*

A third window into Anglophone formistic thought is opened by the application of elaborate morphometric approaches to lithic artefacts (e.g., Lycett 2007a, 2009b, 2010, 2016; Iovita 2008, 2011; O'Brien 2010; Archer and Braun 2010; Eren and Lycett 2012; Lycett and Cramon-Taubadel 2013, 2015; Archer et al. 2016, 2017; Iovita et al. 2017).[398] 'Morphometrics' is commonly referred to as the quantitative study of *shape*, *morphology*, or *form*. In contrast to more traditional methods of describing these features in archaeology, morphometrics uses an array of statistical tools to determine object geometries, often using 'landmark' and 'semi-landmark' approaches (cf. Iovita 2008; Lycett 2009b; Eren and

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393 See also **Appendix II.2** for a discussion of this issue.
394 Indeed, the entire 'human modernity' discourse can be reconstructed along these lines.
395 To counter a potential scepticism of the attentive reader, it should already be noted that the present author argues that the French tradition has largely departed from its initial 'formistic' trajectory. Even though the 'Bordian era' (*sensu* Sackett 1991) was clearly build on 'formistic' reasoning, the 'technological revolution' co-initiated by Leroi-Gourhan and Tixier in Paris marks a definitive break with 'formistic' epistemologies. This will become clear when the role and status of lithic typologies in French technological inquiry is examined (cf. Chapter 5, first part).
396 Cf. "Cultural taxonomy should not be regarded as a static tool, but as a way to qualify and quantify degrees of behavioural variation." (Conard and Porraz 2015: 129)
397 Cf. Conard and Porraz (2015: 128).
398 I use a relatively broad definition of morphometrics here to include the work by Stephen Lycett and others.

Lycett 2012: S1).[399] The main concern of these techniques is 'shape realism,' that is, the idea that object-shapes represent 'rich' and 'complex' phenomena which need to be measured and compared as what they are – as *morphological totalities*.[400] The general contention is that significant variation in the morphometric properties of lithic artefacts is easily overlooked when adhering to methods that tend to reduce the multidimensionality of shape-data to a limited set of variables or simply capture different kinds of shapes by distinct descriptive categories. These approaches are regarded as 'reductionist' by proponents of morphometric analysis. Morphometrics seeks to bring the 'three-dimensionality' of objects to the fore of lithic inquiry and to carve out data that takes the 'plasticity' of lithic forms seriously into account. The basis of morphometric approaches is provided by an explicitly 'analytic' understanding of 'geometry,' 'shape,' and 'size,' so that these vectors of object variability can be modelled and compared "with the precise language of mathematics" (Thompson 1961 [1917]: 269, cited by Lycett 2009b: 79; cf. Lycett and Cramon-Taubadel 2013: 1509):

> "'Morphometrics' is now seen as a major field of growth in biology and palaeontology, including physical anthropology (e.g., O'Higgins 2000). Put simply, morphometrics is the application of the principles of geometry to the study of shape. Others have pointed out that morphometrics may also usefully be termed 'statistical shape analysis' (e.g., Dryden and Mardia 1998)." (Lycett 2009: 79f.)

As Lestrel (2000: 59f.) correctly notes, the morphometric approach owes a great debt to Plato and Aristotle. First, it recognises the fundamental distinction between *matter* and *form*. Shaped matter assumes certain 'shapes,' 'sizes,' and 'morphologies' and has a particular 'structure.' Access to the *form* of an object is provided only by sense perception, but *form* always relates back to something non-sensory. The reason is that *form* presupposes the actualisation of altered matter and this, in turn, implies a shaper other than matter itself. Forms therefore throw a 'shadow' on non-spatiotemporal aspects of reality – aspects that cannot directly be observed and must be inferred. In formism, these aspects are identified as 'norms,' 'laws' or other patterned regularities. The crux, as we learned before, is that these are never fully materialised and can therefore only be *pointed at* – they 'subside' (cf. Pepper 1942: 177). That morphometric research often has to retain a notion of the 'ideal' in order to move 'beyond' the sensually given, can for example be seen in the fact that researchers typically isolate trends of 'normality,' calculate complex statistical averages, and utilise visualisation techniques such as 'group centroids' to compare different data-sets (cf. Lycett 2009b: esp. Figs. 1, 2). The entities that come into view in this way are not directly observable.

Morphometric research is guided by the conviction that a more careful, precise, and detailed analysis of artefact form puts researchers into a better position to interpret the significance of the variability of lithic form. What is thereby tacitly assumed, of course, is that *discrete form* is a basic facet of 'concrete' reality. Notwithstanding, morphometric results may for example be harnessed in order to re-investigate shape patterns among lithic artefacts and to re-address questions of co-variation between artefact geometry and other artefact-external variables. Another commonly used possibility is to rigorously explore the *structure* of lithic shape variability and to compare the results to the structure of other domains of reality. Since morphometric approaches tend to improve both the quality and quantity of geometric lithic data, they can supply novel typologies and other more specialised object classifications. All of this helps placing classic formistic reasoning onto firmer empirical grounds.

Gowlett (2010), for example, self-consciously embraces this new opportunity for lithic research:

> "New is often better, and the Morphometrics has many possibilities. For instance, its techniques allow the analysis of form free of size variation (effects), with particular benefits for archaeology's yearning to explore templates. Such an "ideal" form should not exist in biology, as natural selection is primarily undirected, but in cultural phenomena (and here we hark back to Plato's Ideals) the pressures towards norms can create the situation where everyone agrees about the same thing ("it should be just like this"). The implication is that we need to know a great deal more about stereotypes and templates, and how they operate in modern humans, to get even more out of these [...]." (*ibid.*: 310)

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[399] The methodological and conceptual background of 'morphometrics' has been developed in biology and palaeontology (cf. O'Higgins 2000; Slice 2005, 2007; O'Higgins and Jones 2006). Even more specialised methods such as 'Fourier Analysis' derive from biological or physical anthropological applications (e.g., Lestrel 1997).

[400] This, of course, does not necessarily mean that a different type of data is used altogether. Neither does it mean that these approaches are 'synthetic.' What changes, however, is the *density* of geometric information that is used to analyse the form of objects.

Gowlett's statement is remarkable, for it explicitly contends that morphometric approaches cannot only facilitate the search for 'templates,' but also help isolating 'ideals' and 'norms' of hominin behaviour. He even evokes Plato's *ideas*. Needless to say, all of this attests to a deeply formistic mode of reasoning (cf. Chapter 2: esp. **Box 6**).

A specific way of putting morphometric approaches into perspective is by using their results to answer phylogenetic questions (e.g., Lipo et al. 2005; O'Brien et al. 2013; Lyman 2015). The recorded variability of lithic forms can be studied as the result of evolutionary processes producing non-random patterns of geometric development through time. Morphometrics, then, serves the explanatory goals of Darwinian evolutionary theory, which often changes the looked-for units of analysis (Lyman and O'Brien 2000) – typically 'populations of artefacts' that evolve over time (e.g., Shott 2011; Edinborough et al. 2015; Lycett 2016).[401] Lycett (2016: 83-88; cf. Lycett and Taubadel 2015), for instance, explicitly argues that inherited changes in behaviour, culture, and social transmission will affect how one *makes* tools and thus inevitably alter at least some dimensions of artefact form.[402] This is why changing patterns of form can be used to infer trajectories of hominin behaviour, culture, and possibly social transmission.[403] Form-based data of discrete lithic parts is used to reveal developmental patterns pointing towards the unobservable horizon that lies behind empirical reality. The important point is that although evolutionary mechanism that fulfil the 'specifity of response' requirement are often discussed, they are not strictly needed to explain the observed regularities since 'neutral variation,' 'drift' and other stochastic effects may be similarly invoked. In the extreme case, 'time' itself may be conjured as a sufficient 'subsistent' category.[404] This leads to 'historical' interpretations of morphometric change and reintroduces the dimension of *cultural history*.

Even though the majority of morphometric and phylogenetic studies to date has been conducted in New World research contexts (e.g., Buchanan et al. 2014), similar approaches become also increasingly popular in studying the Palaeolithic of the Old World. The work of Lycett (2007, 2009a, 2009b, 2010, 2016) and, more recently, Archer et al. (2016, 2017) exemplifies this emerging trend. Two of these papers – Lycett's (2009a) attempt to make use of phylogenetic analysis in order to track hominin dispersal in the Lower Palaeolithic on the one hand, and Archer et al.'s (2016) investigation of the regionality of point technology in the South African MSA on the other – will be analysed in more detail in the remainder of this section. As case studies, they will help throwing further light on the formistic conditions of lithic knowledge production in Anglophone lithic inquiry.

[401] These approaches are typically modelled on biological or cultural evolutionary theory. An expression of the former school of thought is *Darwinian Archaeology* seeking to understand artefact phylogenies by means of concepts and methods borrowed from biology and/or palaeontology (Dunnell 1989; Lyman and O'Brien 2000; cf. Donald and Maschner 1996). The second strand heavily draws from principles of cultural evolution in order to understand the patterns of the past (cf. Shennan 2009; Mesoudi 2016). Shennan's *Genes, Memes and Human History* (2002) is surely one of the founding texts of this second approach-type. In contrast to *Darwinian Archaeologies*, cultural evolutionary models emphasise role of social transmission as a general mechanism of evolutionary change. In practice, of course, biological and cultural evolution are often combined to provide an integrated perspective on the past (O'Brien and Lyman 2003; Shennan 2008; O'Brien and Shennan 2010). Mesoudi et al.'s (2006) plea for a unified science of cultural evolution still resonates with the agendas of many of these approaches (cf. Mesoudi 2011). More generally speaking, the important manoeuvre has been to re-define the concept of culture and to recast it as a patterned process of social transmission – a view that generally aligns with the proposals of 'Dual Inheritance Theory' (Boyd and Richerson 1985; Richerson and Boyd 2005).

[402] Cf. "[…] The key point here is that many quantitative traits of artifacts segregate across several different heritable causal factors, just as in the case of multifactorial quantitative traits examined in biology. Yet also, some aspects of attribute variability may result from the type of clay to which these socially learned factors are applied – in other words, the "environment" in which the inherited components operate may influence variability in observable attributes too […]. Hence, observable archaeological traits will invariably be influenced by multiple unobservable and "pleiotropically" operating cultural elements, while also simultaneously being influenced by "environmental" effects […]." (Lycett 2016: 80)

[403] There is a large body of theoretical literature on different types of social transmission that may have played a role in bringing forth different patterns of continuity and change. This general theory is sometimes called 'cultural transmission theory' (Eerkens and Lipo 2007). It is noteworthy that different *types* of social transmission are usually discriminated in order to enable correlational procedures. Different processes and mechanisms of transmission are also thought to have different observable consequences. Depending on the mode of mobilising this body of theory, approaches may develop into 'formistic' or 'mechanistic' strands of inquiry.

[404] Cf. Chapter 2: **Box 6**.

Lycett's phylogenetic approach to Acheulean dispersal

Lycett's *Understanding Ancient Hominin Dispersals Using Artefactual Data: A Phylogeographic Analysis of Acheulean Handaxes* (2009a) tests the 'African Acheulean Hypothesis,' that is, the idea that the presence of Acheulean handaxe technology in non-African contexts is the result of hominin dispersal out of Africa. The author invokes the 'serial founder effect' as a potential mechanism to account for changes in handaxe technology as a result of dispersal events. The 'serial founder effect' describes a bottleneck situation that typically occurs when sub-populations separate from their larger mother-population. The result is a correlated reduction of in-group variance with increased geographic distance from the source population's point of origin (*ibid.*: 2). It is asserted that, by analogy, processes of social transmission should be equally affected by this reduction of in-group variance. In other words, some general changes in the structure of hominin populations are predicted to have a *proportional* impact on the structure of handaxe assemblages. Already this structural analogising is suspiciously formistic: not only are population-level and assemblage-level characteristics regarded as 'reflecting each other,' the link between the two is conceptualised as a rather generic type of undirected co-variation.[405] What holds populations and technologies together is a 'social inheritance' of artefactual traits, so that a modification of population structure will impact what is possibly 'inherited' by the artefacts:

> "In recent years it has been increasingly recognized that the manufacture of artefacts such as handaxes results from the process of social transmission of knowledge between individuals and across generations [18-21]. It is also been increasingly recognized that social transmission may be modeled as a mechanism of inheritance broadly analogous to that of genetic transmission [22-27]. This is not to say that these two inheritance mechanisms are identical in all respects. One obvious difference is that in the case of social transmission the ability to acquire information is not limited solely to copying biological parents; there is also the opportunity to copy more distantly related kin and unrelated individuals. Nevertheless, attention has increasingly been drawn to the fact that the evolution of cultural traditions involves a process of social inheritance, variation in the details of practice, and differential representation of given variants in subsequent generations (i.e. sorting due to various selection processes and cultural drift) (e.g.[28,29])." (Lycett 2009a: 1f.)

Reality is viewed to be ordered, but only weakly so and in a general sense of the word. Moreover, the various compartments of reality close ranks according to a 'symmetry principle.' The test-implications of this construal are the following: if the compositional structure of Acheulean handaxes traces dispersal patterns, non-African assemblages should exhibit significantly lower in-group variance than their African counterparts. This decrease in intra-assemblage variance should, moreover, mirror increasing geographic from Africa (*idem*).

Lycett (2009a) conducts a 'phylogeographic' analysis to examine whether intra-assemblage variance of handaxes informs us about the assemblages' geographic origin. For this purpose, the author records a total number of 72 individual characters on each lithic object within the 10 studied lithic assemblages. Each character documents either a distinct metric measurement, a shape coefficient, an index, a discrete value, or a feature count (*ibid.*: SI Table S1; cf. Lycett et al. 2006; Lycett 2007a, 2007b). After screening the resulting data set for artificial variable interdependencies using 'Pearson product-moment analyses,' 66 of these lithic characters are identified as independent enough to warrant further scrutiny (*ibid.*: 4). Taken together, these data are regarded to proxy the detailed object geometry of the handaxes in question. The author then employs a cladistic 'maximum parsimony analysis' to arrange the data sets according to their distance from one another (*ibid.*: 2, 4, Figure 1). In this process, all characters were treated equally, that is, were given similar weight.[406] Subsequently, a 'bootstrap analysis' is performed to assess the robustness of the identified relationships (*ibid.*: 4; Fig-

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[405] As already indicated in Chapter 2, this conception of generic co-variation illustrates the formistic inclination to interpret the relationship between 'subsistence' and 'existence,' or between the 'indirectly' and 'directly' observable, as a form of *supervenience*. To recall, 'supervenience' is when two correlated, yet discrete domains of reality are stitched together in such a way that change in one domains implicates change in the other. These different domains are sometimes also termed 'levels of existence.' Change is thereby not necessarily specified and may concern merely aspects of structural organisation. 'Supervenience' is typically called upon to explain interdependencies between brain and mind (cf. Kim 1984) – it is thus a prototypical formistic strategy to circumvent the mind-body problem that results from the differentiation of reality into discrete parts.

[406] An important detail of the cladistic analysis is that quantitative measures need to be transformed into 'discrete character states.' Lycett (2009a: SI Text S1) uses a 'divergence coding method' to achieve this. This is a statistical method that helps determining the most suitable way of breaking down the recorded variability of character states into discrete units. Obviously, this entails *classification* and a 'Theory of Types,' although the latter is of course interpreted statistically.

ure 2). This test is followed up by the creation of a 'model' tree designed to represent conditions of severe raw material constraints (*ibid*.: 4f.: Figure 3). This 'model' tree is compared to the most parsimonious tree returned by the original cladistics approach. The purpose is to determine whether the results of the conducted phylogeographic analysis significantly differ from a model scenario, in which the structure of the tree is known to be shaped by locally varying raw material conditions.

Lycett (2009a) finds that his phylogeographic tree generated by the cladistics analysis is robust and conforms to the formulated geographic expectations, namely that non-African and African handaxe assemblages should group together. All African assemblages are situated at the base of the tree, whereas the non-African assemblages occupy positions higher on the tree (**Fig. 12).** The author interprets this finding as evidence for the fact that handaxe intra-assemblage variance reflects geographic distance from Africa, and the non-African assemblages must therefore represents 'derived' phenotypes (*ibid*.: 2). Since the output of the 'bootstrap analysis,' a majority-rule consensus tree, is generally consistent with this finding and the raw material 'model' tree differs statistically, i.e., in terms of the Kishino-Hasegawa test (*ibid*.: Table 1), from the original parsimonious tree (*ibid*.: 2f.), he concludes that the handaxe evidence ultimately supports the 'African Acheulean Hypothesis':

> "Parsimony analyses of the Acheulean handaxe dataset, which includes samples from Africa, the Near East, Europe and the Indian subcontinent, produced a tree consistent with the phylogeographic prediction derived from the African dispersal hypothesis. Importantly, a randomization procedure (phylogenetic bootstrapping) provided further evidence that the major African versus non-African phylogeographic pattern depicted in the maximum parsimony (MP) tree is robust. Moreover, the MP tree was also shown to be statistically different from a comparative tree constrained by the raw materials used to manufacture the stone artefacts. This latter result demonstrates that raw material parameters (long known to be a potential influence on the form of stone tools) do not constitute a confounding factor in these analyses. These results demonstrate that nested analyses of behavioural data, utilizing methods drawn from biology, have the potential to shed light on ancient hominin dispersals." (Lycett 2009a: 3)

Altogether, the phylogeographic distance between handaxe groups is reconstructed solely on the basis of the *structural similarity* among shape-based characters. The employed 'maximum parsimony analysis' thereby delivers a method of *hierarchical classification,* arranging the lithic assemblages in the multidimensional space of variables.[407] Furthermore, all of the *post hoc* assessments, including the 'bootstrap analysis' and the 'model' tree, address the 'contingency' of pattern and search for the 'normality' thereof. The goal is to detect strong 'norms' in the data-structure and, in the case of the raw material 'model' tree, to juxtapose these *empirical norms* with *theoretical norms* derived from competing scenarios. These 'ideals' are simply compared in terms of their structural congruity, indicating that lithic knowledge is corroborated following a 'correspondence conception' of truth. The fact that Lycett (2009a) puts so much effort into demonstrating that alternative candidates of explanation – i.e., locally differing raw materials – can be excluded further suggests that 'raw material' is treated as a potential 'subsistent' category; it can safely be excluded because its empirical consequences do not correspond to the patterns of the observed 'concrete' reality. All of this signals that 'population-level social transmission' and 'geographic location' work together as the explaining 'subsistent' categories. They are shown to regulate the structure of the evidence and to create strong patterns in the data but remain partially 'concealed' – the actual hominin populations and their social transmission capacities are not fully actualised in the lithic material; yet, they remain necessary to explain the discovered data-structure. That 'space' is interpreted as an ultimate 'subsistent' is not uncommon in formism.[408] It is also not unusual to identify multiple explanatory 'subsistent' categories as long as they do not logically or empirically contradict each other; put differently, the same basic particulars of 'existence,' in this case individual handaxes, may simply participate in more than a single form.

[407] This is a technique of 'numerical taxonomy' and its rationale is to organise *similarity* among artefacts and their traits on different levels: "[w]e have seen that behind this group of techniques lies the idea that objects can be similar to one another at different levels, so that the results can be represented in the form of a dendrogram: a tree representing the relationships between individuals and groups." (Shennan 1997 [1988]: 235)
[408] See Lycett (2009c) for an example of the phylogenetic study of technological ancestry deploying 'time' as its 'subsistent' category.

Archer et al.'s biogeographic approach to Still Bay point morphology

Archer et al. (2016) investigate geometric patterns in bifacial point technology of the South African 'Still Bay' – a long recognised techno-tradition of the African Middle Stone Age (MSA) featuring prominently in narratives about modern human behavioural evolution and demography. The authors' focus is the 'assessment of the homogenous nature of the Still Bay' and its broader implications for questions of human adaptation and behaviour during the MSA (*ibid.*: 59). They ask whether the shape and size variability documented in Still Bay points is continuous across different regions or whether diverging "design imperatives" were guiding the production of these points at different places (*idem*). *What is Still Bay? Human biogeography and bifacial point variability* uses a '3D geometric morphometrics' (3DGM) approach coupled with an 'Elliptical Fourier Analysis' (EFA) to address this issue (*ibid.*: 61).[409] The point of departure is the 'null hypothesis' – derived from the conclusions of previous work on the Still Bay phenomenon – according to which heightened sociocultural interaction in this period should have produced a relative homogeneity of point shapes across different regions. This hypothesis is tested with the high-resolution 3DGM shape-data gathered from the studied sample of Still Bay points. The basic reasoning is that interregional connectivity should be reflected in overall point shape similarities, while regionalisation should produce a more structured pattern of shape variability.

This construal of the research problem and its possible solutions already carries a formistic signature. Examined is the relationship between the general sociocultural organisation of the Still Bay and the shape variability of its bifacial points. A change in the structural constitution of one of the two dimensions is thought to have structural repercussions for the other. The underlying logic of reasoning stresses the general *correspondence* between the two dimensions without referring to any specifics of causality or determination. This presumed *structural* co-variation between the realm of lithic technology and the realm of sociocultural life leads to the establishment of two pairs of *analogies* – 'homogeneity' and 'continuous variability' on the one hand, and 'heterogeneity' and 'structured variability' on the other. The 'predictions' of the authors only make sense if this reconstruction is accepted.[410] It can then confidently be stated that the general structure of lithic variability at least broadly reflects back on the structural organisation of the sociocultural entities having produced this variability. The potential co-variation between lithic technology and a differentiated landscape is thereby reinforced by invoking aspects of 'design theory' and the tenets of general ecological reasoning (Archer et al. 2016: 60; cf. Torrence 1989c; Bousman 1993; Bleed 1997). The purpose of this body of theory is to bolster the general rationale of the study and to call attention to the range of factors that might have contributed to the total shape variability of the studied lithic objects. This last point also shows that 'variability' is understood as a compositional variable which can 'analytically' be deconstructed into its constitutive components:

> "Variation in point design, and variation underpinned by the extent of point manufacture, resharpening and recycling activities provide information about different spheres of technological adaptation. It is, therefore, important to attempt to isolate these components of point variation from one another." (Archer et al. 2016: 60)

The authors' approach to bifacial shape variability is designed to isolate and remove those parts of the overall variability tied to contingent situational factors, such as reduction stage and raw material variability (Archer et al. 2016: 59, 63f.). Only the 'residual' variability, if any, may inform us, as they say, about the structure of Still Bay society. The guiding idea here is that different aspects of shape variability are the product of different underlying processes. Arguably, these processes represent the relevant 'subsistent' categories of the investigation. The fact that they need to be separated and, if possible, eliminated as potential explanatory candidates simply mirrors the formistic conception that the 'particulars' of 'concrete' existence – i.e., individual Still Bay points – often participate in different 'norms,' 'laws' or regularities. In order to examine particular 'patterns of participation,' one must

[409] See Archer et al. (2015) for a detailed presentation of the methodology and broader rationale of this approach.

[410] Although the authors explicitly use the term 'prediction,' their trajectory of inference is not based on 'predictive reasoning' in the strict sense. What they mean with prediction is simply 'correlation' insofar as some compartments of reality can be said to regularly co-vary. This understanding of prediction exploits the discrete structure of reality and the patterned correlation among its parts. It calls upon the regulatory relationship between the realms of 'existence' and 'subsistence.' Their notion of prediction is therefore significantly different from the concept's significance in 'mechanism,' where it plays a key role in *explanation*. The only exception is when the authors take the allometry of bifacial tools into account, that is, the predictable relationship between morphology and size (Archer et al. 2016: SOM esp. SOM Fig. 1; cf. McPherron 1994, 1999, 2003, 2006).

therefore also address the *interference* of 'norms,' 'laws,' and regularities (cf. Pepper 1942: 178f.). According to formism, these interferences tend to 'distort' the discreteness of experienced reality. As a consequence, the view for what is *normal* and results from the natural order of things becomes clouded (cf. *idem*).[411] Therefore, explanation and insight are only possible if one isolates the potentially interfering categories for they are all correlated with their own patterns in 'existence.' The attempt to correct for such distorting categories hence reveals the status of these factors as 'subsistent' and shows that the applied logic of research is largely formistic.

After having removed the distorting components of variability using various statistical techniques, Archer et al. (2016: 65f.) show that their 3DGM shape data of bifacial points is strongly structured along spatial coordinates. This result is based on 218 Still Bay point specimens from well-controlled archaeological contexts, each delivering 518 distinct shape coordinates (landmarks and semi-landmarks). The authors compare this pattern of point variability with the three main South African precipitation zones taken to proxy varying ecological conditions and the general distribution of sites during the Still Bay. While the ecological context of the points appears to structure the data only weakly at best (*ibid.*: Fig. 6), the archaeological site distribution seems to broadly reproduce the structure of point variability (*ibid.*: Fig. 7). Archer et al. (2016: 65f., Table 3) conduct a 'principal component analysis' (PCA) to demonstrate that the configuration of residual shape characters varies significantly between a North-Eastern and a North-Western site cluster (**Fig. 13**). Because this correlation concerns the 'pure' shape variability (raw material and allometric reduction effects have already been subtracted), they interpret these findings as evidence for the presence of different 'design imperatives' in the two groups, suggesting that regionalisation played a much more important role in the Still Bay than often argued. A closer examination of the internal data-structure of the two groupings leads to the additional conclusion that not just the shape patterns differ but also which variables interact (*ibid.*: Figs. 8, 11). The multivariate inspection of these structural differences suggests that point production in the two regions is governed by different reduction trajectories resulting in different life-history patterns (cf. *ibid.*: 68). The authors in fact argue that bifacial production starts off rather similar in the two site clusters – by producing bifacial rough-outs – and then diverges as reduction continues and points are worked out in more detail.

Two observations are important. The first is that patterns are thought to indicate a 'norm.' This 'norm,' conversely, is regarded to regulate the observed patterns. The reliance on various statistical methods to extract mean differences and other trends in the shape data illustrate this point. The differences between the identified reduction trajectories, for example, are differences in the *ideal* trajectories. The identification of such differences presupposes the recognition of order in terms of *normality* and the existence of non-observable forces being responsible for the 'normality of pattern.' All of this is certainly formistic and attests to 'subsistent' categories at work. These are to a certain extent *eternal*, that is, they delineate unchangeable truths; they are, in other words, *universals* which may be exemplified under different historical conditions in different ways. An example is the 'subsistent' category 'reduction' which corresponds to a certain correlated structure of evidence that, in principle, never changes. The same reduction effects play a role in different technologies and can be identified by using broadly similar approaches. The second observation concerns the significance of 'classes.' It should be sufficient to note that the segregation of two groups of bifacial points in conjunction with two "pockets of sites" (Archer et al. 2016: 68) relies on a correlative classification. The subsequently conducted statistical comparison between the two classes of entities simply conforms to assessment of class overlap, anchored in 'set theory.'

[411] Cf. "What, then, about a mass that is restrained from following its law, such as the lead ball held in the hand before it is dropped? As far as the formist is concerned, this law is still acting and shows itself as weight or pressure downward, but it is being interfered with another law in which this particular lead ball also participates. [...] These interferences of laws with one another as a result of the participation of basic particulars in characters with themselves participate in laws, which frequently conflict, constitute such a marked feature of formism that they deserve further illustration. [...] There is evidence, we saw, for the norm of an oak tree. A botanist or horticulturalist could tell us in great detail what is the *normal* growth and appearance of any particular variety of oak. Give the oak suitable soil, water, sun, fertilization, and freedom from other vegetation, from insects, and the like, and the normal oak will be exemplified. The law of the oak will exhibit itself in concrete existence just as the law of gravitating mass exhibited itself in the dropped ball. But plant the oak in poor soil or on a windswept hill, or in a thick forest, and it will be distorted from its normal growth just as the planet was from the normal gravitational path. This distortion will be a resultant of the forces of other laws in which the characters of the oak participate in conjunction with normal law of growth of the oak." (Pepper 1942: 178f.)

In general, the formistic orientation of *What is Still Bay?* is also reflected in Archer et al.'s (2016) emphasis on artefact *form*. The authors effectively argue that shape variability is able to conserve an intelligible combination of utilitarian and cultural information. They indicate that the identified reduction trajectories are likely associated with divergent mobility-environment systems. The differences in 'pure' shape can therefore be interpreted as a cultural signature. They further invoke the results of a number of use wear studies to show that functional explanations are insufficient to account for the documented variability of point shapes. These enunciations make clear that all of these factors are regarded as potential *form*-givers and that *form* is conceptualised as a highly *plastic* category. *Form* is 'shaped matter' and many different factors may contribute to the process of 'shaping.' Differences and similarities in artefact form are therefore the central axes of lithic inquiry. In the case of the Still Bay, stark differences in the form-aspects of bifacial technology are taken to signal the relative cultural isolation of Still Bay populations. This, in turn, is taken to suggest that technological *convergence* and *independent innovation* are responsible for the particular recurrence of form we recognise today as the Still Bay point (*ibid.*: 70). *Form* is really conceptualised as a 'historical document' that records the totality of processes which brought it into existence:

> "Stone artefacts widely considered diagnostic in the identification of some of these [MSA] traditions are the products of dynamic sets of interactions between ecological contexts, technological capacities and cultural tendencies." (Archer et al. 2016: 70).

All things considered, Archer et al.'s (2016) approach seems to be a clear example of formistic reasoning. The authors' emphasis of the complexity of past reality is also a homage to the 'dispersivity' of fact and the related difficulty of coming to grips with a world in which many determinative forces participate in the forms we observe. Within this complexity of pattern, Archer et al. (*idem*) maintain that 'culture' forms an important 'subsistent' category – a 'subsistent' that is often not taken seriously enough. It is notable that 'culture' is thereby *spatialised*. Cultural differences among populations are primarily expressed in terms of geographic differences between lithic assemblages. Again, this simply attests to the fact that time and space are typically seen as the 'standard' categories of 'subsistence' which, because of their elementary status, must play a certain role in any explanation. Pepper (1942: 174) has seen this quite lucidly and noted:

> "[…] it would seem probable that all concrete existences participate in the laws of physical time and space, whatever other forms they may also participate in."

What is Still Bay? puts forth the cognate argument that all lithic particulars can be shown to participate in the basic spatial norms of culture, independently of other forms they may participate in.

4.1.4 ***Handaxe symmetry, hominin cognition, and abstract thought***

The fourth and last glimpse into Anglophone lithic formism is granted by the discourse on the status and significance of Lower Palaeolithic handaxes (or bifaces), a subset of the so-called 'Large Cutting Tools' (LCTs) (e.g., McNabb et al. 2004; Petraglia and Shipton 2008; Shea 2013a 55-64). The longstanding question of the purported place of these certainly enigmatic stone tools in human evolution continues to ignite many lively discussions in the field of lithic studies (e.g., Wynn 1979; Clark 2001; Lycett and Gowlett 2008; Gowlett 2015; Wynn and Gowlett 2018). Traditionally, the issue of *imposed form*, especially *symmetry*, has occupied a prominent position within these debates (Hodgson 2010, 2015; White and Foulds 2018; cf. Abramiku 2012: 188-192). On closer inspection, one might in fact speak of an entire 'symmetry discourse' centred on broader questions of hominin cognitive and social evolution, where researchers attempt to establish the precise sociocognitive implications of the material handaxe record, if any (e.g., Mithen 2003; Hodgson 2009, 2011; McNabb et al. 2018). This discussion has engendered two opposing groups of scholars – the first group argues in favour of symmetry-patterns and their evolutionary significance, whereas the second rejects the reality of the pattern, its significance, or both (cf. e.g., (Gowlett 1984, 2006; Leakey and Roe 1994; Ashton and McNabb 1994; McPherron 1994, 2000; Wynn 1995, 2000; Kohn and Mithen 1998; Kohn 1999; Nowell 2000; Mithen 2003; McNabb et al. 2004; Machin and Mithen 2004: 668f.; Machin et al. 2005; Lycett 2008; Machin 2009; Hodgson 2009; Iovita and McPherron 2011; Spikins 2012; Gamble et al. 2014: 119-123; Cole

2015; McNabb 2013, 2017; McNabb and Cole 2015; Iovita et al. 2017).[412] The logic of this debate is illuminating and it is worth unpacking some of its details.

Mithen (1996), for example, points out that

> "[t]he most characteristic artifact produced by Early Humans was the handaxe. Even a brief look at handaxes indicates a number of significant differences from those artifacts produced within the Oldowan tradition. They often display high degrees of symmetry, sometimes simultaneously in three dimensions, and indicate that the knapper was imposing form on the artifact, rather than just creating sharp edges as with an Oldowan chopper. […] To achieve such symmetry in form, longer knapping sequences were required. […] Planning ahead is essential if symmetry is to be achieved, and maintained as the piece is developed. […] Consequently to produce standardized forms, the knapper needs to exploit and adapt his or her toolmaking knowledge, rather than just follow a fixes set of rules in a rote fashion." (*ibid.*: 132f.)

Abramiuk (2012), reviewing the whole discussion, similarly asserts:

> "The Acheulean handaxe was essentially a large, teardrop-shaped tool, the rounded end of which could be held in the hand and swung in a chopping motion with the beveled end directed at the target (Bordes 1968: 64-76). […] From a cursory inspection of Acheulean tools, it is evident that their makers had a definite sense of aesthetics; […] What this suggests is that it was not only important for *Homo erectus* to have a point or an edge with which to work; it was also important to have a tool with a definite shape, as well as a tool that might be useful for unforeseen tasks in the future." (*ibid.*: 185)

Coolidge and Wynn (2009) add:

> "Archeologists often overlook a fact about bifaces that is really quite important. They were the first tools that probably existed in the minds of their makers as tools. In non-human and Mode 1 tool use the target was task completion – cracking open a nut or butchering a carcass – and the tools were components of those procedures. They did not exist as things apart from those contexts. But bifaces did. Hominins made bifaces, carried them around, and used them again and again as tools and as sources of flakes. The role of tools had changed. Instead of being elements in a procedure, tools themselves had acquired the status of permanent objects in hominin daily life, even when not in use." […]Bifaces remain a perennial puzzle for archeologists. On the one hand their "toolness," and imposed shape, were very different from what apes do and suggest that *Homo erectus* had a very different relationship with tools. On the other hand, the complete absence of innovation, and the dogged conservatism of the form (for well over 1 million years!), indicate that the relationship was also very different from the one modern humans have with tools. In this sense, at least, *Homo erectus* was neither ape nor human." (*ibid.*: 112f.)

These enunciations all posit that the *form* of a handaxe – a specific configuration of shaped matter – can be said to stand for some more *abstract concept* or *idea*. The material recurrence of the handaxe as a stable and recognisable form, in other words, can only be explained by new, but similarly stable non-material conditions. The latter 'resist' complete materialisation – they are discrete, non-material entities – yet must be recognised as the *sine qua non* of the 'existence' of handaxes. The handaxe is thus nothing else than the historical *exemplification* of a more general category of existence. It is no great leap to suggest that this more fundamental 'level of existence' must be a pure, quasi-universal category, especially since the handaxe phenomenon persists over thousands and perhaps millions of years in the archaeological record. In the above-quoted cases, these categories are 'planning depth,' 'standardisation,' 'aesthethic sensibility,' and 'tool concept.' They relate features of handaxe form to the realm of hominin cognition and posit that the two represent *correlated realities*. The emergence of the handaxe form in the archaeological record can therefore be said to signal the emergence of a new type of cognition. This construal clearly implies that various cognitive categories, or simply 'cognition' itself, are mobilised as 'subsistent' categories, and that the material configuration of a handaxe is viewed to point to a horizon *beyond* materiality (cf. Pope et al. 2006). Put differently, the handaxe embodies a 'norm,' and this norm informs about the essence of being a handaxe-producer. The formistic logic of this line of reasoning is undeniable.

The controversy on the recognition of patterned 'symmetry' – whether defined as 'plan view,' 'partial,' 'edge-on,' or 'basal' symmetry – in the handaxe record and its potential meaning further clari-

[412] It is notable, although I cannot go into the details here, that much of these discursive dynamics appear to be a product of the historical alliance between British *Cognitive Archaeology* and strands of *Evolutionary Psychology* (see esp. Mithen 1996; Gamble et al. 2014).

fies this formistic figure of inference. After taking stock of a critical argument by McNabb et al. (2004) that early South African handaxes do not seem to be particularly symmetric at all, Abramiuk (2012), for example, emblematically states:

> "This could mean two things. First, early Acheulean tools were not intended to be symmetrical; that is, early *Homo erectus* lacked a concept of symmetry. Second, early *Homo erectus* did maintain a concept of symmetry but was unable to express the concept behaviorally. Third, early Acheulean tools, although asymmetrical to us, may have appeared symmetrical to *Homo erectus*." (*ibid*.: 188f.)

This statement unambiguously showcases that a shared artefact form – the handaxe – is thought to indicate a shared 'mind frame.' What this 'mind frame' exactly is, of course, remains a matter of debate. Even McNabb et al. (2004) who have so poignantly criticised the notion of an empirically recurrent pattern of early handaxe symmetry, maintain that while hominins at this time apparently lacked a concept of symmetry, they clearly shared the 'mind frame' of an LCT – a phenomenon they refer to as 'conceptual standardisation.' Furthermore, one of the authors has subsequently suggested that the lack of the ability to express the concept of symmetry might have been due to certain underdeveloped brain functions (Hodgson and McNabb 2005). This suggests that even those who criticise the 'symmetry' as a cognitive 'subsistent,' adhere to the same general logic of explanation.

Abramiuk's (2012: 188-191) recap of the symmetry debate is also revealing for another reason: he explicitly refers to the possibility that the respective hominins 'maintained a concept of symmetry but did not express it at this moment in time.'[413] He (*idem*) thereby explicitly grants that certain mind frames might have been present, but were not actuated, manifested, or exemplified. Not only is this terminology doubtlessly formistic – it clearly evokes the 'principle of exemplification' – it also draws attention to the categorical distinction between *capacities* and *expressions*. This distinction is such a marked characteristic of formistic thought that it deserves closer consideration. Perhaps most importantly, the polarity between 'capacity' and 'expression' suggests that even though 'existence' and 'subsistence' are correlated, they are *not identical*. This secures the 'discreteness' of reality and the separate existence of the realm of non-empirical, 'ideal' entities. In addition, differentiating between 'capacities' and 'expressions' drives home the formistic insistence on the fact that some principles, laws, regularities, and norms are of such a nature that they cannot fully be particularised, let alone at all times and in all places. The polarity between 'capacity' and 'expression,' in other words, legitimises the formistic belief in 'subsistence.' Moreover, it expounds the possible *aspectual dimensions* of exemplification in formism. This figure of thought further reinforces the 'subsistence'-'existence' boundary since it asserts that only 'subsistent' categories can stand for *universals* –entities that appear to be 'eternal' in a certain sense. The question is therefore always *how* these categories are exemplified and it is far from clear whether they do always 'show themselves' in a similar way. The unit and mode of exemplification may accordingly vary across time and space; different aspects of the same form may refer back to different 'subsistent' categories. Abramiuk's (*ibid*.: 191) consideration, following Wynn (2002), that 'broken or partial symmetries rather than whole symmetries concerning the entire tool may have been important to some hominins' reflects this *problem of exemplification*. This difficulty seamlessly flows into the problem of *multiple realisability*.[414] The idea of 'multiple realisability' picks up the formistic presumption that there are 'levels of existence' and that these broadly co-vary; yet, more fundamental levels – those which are exemplified by their 'derived' levels of existence – may be expressed in a multitude of different ways. This delivers the formistic interpretation of *equifinality*. According to the formist, 'equifinality' of form is therefore a problem of 'subsistence.'

The general strategy to infer cognition from artefact form complies with Abramiuk's (2012: 146-152) *conditional approach for inferring cognitive capabilities*. This approach is primarily concerned with explaining how form, which itself stands for certain behaviours, has resulted from particular capacities. The relationship between 'capacity' and 'expression' is then formulated as a conditional

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[413] For essentially the same situational-functional argument *contra* McNabb et al. (2004), see Machin and Mithen (2004: 668f.).
[414] The concept of 'multiple realisability' (MR) is widely used in the philosophy of mind to address the problematic relationship between 'mental states' and physical 'brain states' (e.g., Fodor 1974; Sober1999). The contribution of MR to this debate is that it allows us to make sense of the correlated nature of the two phenomena and to accept the 'existence' of both of them ('levels of existence'). In addition, the same 'mental state' may be implemented by varying 'brain states.' MR arguments are arguments against reductionism. 'Formism' guards itself against 'mechanism' here.

statement.[415] The conditional approach consequently relies on *formal* reasoning, taking advantage of the patterned character of reality on which formistic inquiry is based. A classic conditional clause, following Abramiuk (*ibid*.: 147) would be 'if p, then q' where 'p' represents the *antecedent* and 'q' the *consequent*. Neither 'antecedent' nor 'consequent' are identified as variables, they both function as conditions. In the given example, more precisely, 'p' constitutes a *sufficient condition* for inferring 'q.' Yet, it is similarly valid to state that 'q' is a *necessary* condition for 'p.' Thus, the conditional approach reiterates the formistic logic of 'necessary and sufficient conditions' introduced earlier in this part of the chapter. The conditional approach is intuitively appealing, typically cherishes simplicity of reasoning, and represents a 'substrate independent approach' (*ibid*.: 151). It can be employed to study the behaviour or cognition of any organism and is therefore especially suitable to be used in comparative research programmes.

Gowlett's (2006) account of the significance of bifaces, for instance, can be viewed as an exemplification of this general logic of inquiry. He declares that his research

> "[…] considers "what" bifaces are at a deep level, arguing that they inform us richly about the nature of abstraction and its origins, and that they inform us too about the difficult relation between human knowledge "in theory" and knowledge "in practice", and about the interface between function and style." (*ibid*.: 203)

and adds that

> "[t]he idea of form is crucial – almost every archaeologist will start from the intuitive position that they know what a biface is – even if they then proceed to argue that bifaces are not products of an intended design. Here, however, we encounter a problem, reflected in archaeology in a traditional dichotomy of form studies and function studies. Some emphasize the form and its abstract concepts. Others can see no need for such form to be intended by early humans, and emphasize the role of function, arguing its ability to generate form as a side-effect or epiphenomenon." (*idem*)

This brings us to the problematic distinction between 'form' and 'function.' Quite often, this distinction is simply indicative of clashing 'mechanistic' and formistic perspectives on the lithic record. While the latter consider *form* as primary and look for correlations between 'form' and 'function' – 'function,' then, becomes just another possible 'subsistent' category – 'mechanists' regard lithic objects as machines and are interested mainly in their efficacy, that is, their function within hominin behaviour. The 'mechanist' is sceptical about artefact form and tends to delegate it to the realm of mere 'appearances.' The relationship between 'form' and 'function' thus always needs to be *substantiated*. In formism, to the contrary, 'function' is a relevant 'subsistent' category from the beginning, one that potentially *interferes* with other 'subsistents.' Functional explanations, therefore, are rarely actively pursued, but functionality instead becomes a focus of inquiry when scholars seek to debunk such explanations. Multiple strategies have been adopted to establish the 'more-than-functional' significance of handaxe geometry in formistic lithic research. Typically, the goal of these approaches is to reinforce the idea that the morphological class 'handaxe' is truly a 'natural kind'; that is, represents a *form* in the proper sense of the concept – i.e., a strictly *imposed form*. To show that handaxe form appears to be 'over-determined' or 'over-designed' – i.e., cannot fully be explained by the functional or adaptive dimensions of handaxe use – is a classic manoeuvre to present hominins as the relevant 'imposers.' In the case of the symmetry issue, it may for instance be demonstrated that a symmetry of form does not increase the functional performance of the objects in questions (e.g., Machin et al. 2007) and also unlikely to emerge as a by-product of handaxe manufacture and maintenance (e.g., Wynn 1995: 14).[416] Inquiries such as these motivate the conclusion that the significance of handaxes must lies beyond the utilitarian realm.

[415] In the context of the Levantine Mousterian, Kerry and Henry (2000: 242) for example explain: "[u]ltimately, if we are to evaluate the contextual model or other cognitive models, we need to identify nonambiguous linkages between specific conceptual domains (e.g., symmetry, horizontality, conservation, numbers of elements in structure mapping) and certain artifact attributes. The attributes need to be quantifiable as to the degree to which the domain is achieved, and the attributes need to be ones that cut across specific lithic technologies." This structural equalisation between 'capacity' and 'expression' is typical for 'formism' and directly derives from its theory of cognitive criticism centred on 'correspondence.'

[416] Symmetry as a by-product is problematic for the 'formistic' argument because, as Abramiuk (2012: 192) readily maintains, a by-product contradicts the hypothesis of symmetric handaxes being "manifested ideals." This reference to the notion of 'ideal' is not coincidental but gives voice to the 'formistic' category of *abstract ideas* which are not fully particularisable.

It is no coincidence here that in the face of many competing 'subsistent' categories and the resulting need to narrow down the space of explanation, the favoured 'subsistent' categories are regularly secured by 'abductive' reasoning – i.e., *inference to the best explanation* (Harman 1965; cf. Poston and McCain 2017).[417] 'Abduction' thereby simply ensures that the respective 'subsistent' categories reflect the 'best' explanation currently available for the observed patterns of form in 'concrete' existence. Thus, 'abductive' reasoning in formism entails the argument that an encountered form is more likely to exemplify the 'subsistent' category in question than other competing 'subsistents.' Yet, because formists have no problem accepting that similar forms may participate in a number of different 'laws,' 'norms,' or 'regularities' (cf. Pepper 1942: 178-180), *form* may easily be conceptualised as a *kaleidoscope* – as reflecting back on many interfering 'subsistent' categories at the same time. 'Interference' interpreted in this way of course becomes an enabling factor of inquiry since central tendencies in artefact form can be regarded to capture the cardinal dimensions of societal wholes. A notable example of this cognitive strategy is Machin's *The role of the individual agent in Acheulean biface variability. A multi-factorial model* (2009). In prototypical formistic style, Machin argues that handaxes must ultimately be regarded as microcosms of hominin society. She offers a poignant account of handaxe form that stresses the latter's *partial superposition* on *most* of the potentially relevant categories of 'subsistence' (i.e., aesthetics, style, sociality, cognition) (**Fig. 14**).[418] In this way, the complexity of handaxe design can be grasped as a *structural convergence* between artefact form and hominin society, again evoking the formistic principles of 'similarity' and 'correspondence.'

Arguably, much of the discursive space of explaining Lower Palaeolithic handaxes can be understood as a 'give and take' between proponents of different categories of 'subsistence.' The dynamics of discourse can hence be described as a *struggle of subsistent categories*. Scholars have for example proposed the 'subsistent' categories of 'tradition' (e.g., McNabb et al. 2004; Lycett and Gowlett 2008), 'signal/symbol' (e.g., Kohn and Mithen 2009; cf. McNabb 2012b), 'sociality' (e.g., Spikins 2012; Gamble et al. 2014: 123-126), and, more recently, 'hominin biology' (Corbey et al. 2016 and replies by McNabb 2017; Hosfield et al. 2018; and Wynn and Gowlett 2018) or 'latent solution' (Tennie et al. 2017). All of these approaches consciously or unconsciously embrace the ancient Greek tenet of 'hylomorphism' – the idea that matter takes particular forms because of reasoning not related to matter itself. This view often entails the assumption, as we have seen, that *matter* and *form* are the two main substances of which the realm of 'concrete' existence is made. All other entities, including concepts, ideas, and more abstract features of reality such as society, tradition, or culture are situated in the realm of 'subsistence'; they are the potential reasons for why matter takes particular forms. The resulting mode of inquiry is thoroughly formistic.

Two prominent 'mechanistic' angles of critique are worth mentioning here because they directly refer to this general formistic pattern of reasoning. The first is the so-called 'fallacy of the finished form' or 'fallacy of the desired end product' (cf. Davidson and Noble 1993: 372; Dibble et al. 2017: 816-821). Critique of the idea of a 'mental template' falls into the same category (cf. Ashton and White 2003; Marks et al. 2001; Chase 2008, 2016). In contrast to formists, lithic 'mechanists' are highly suspicious of artefact *forms* which they categorise as mere 'appearances.' Such appearances, according to 'mechanists' cannot be taken at face value. Without any principle of determination linking form, mechanism, and case, form-centred explanations remain 'empty' and 'ineffective' they argue. The link between 'subsistence' and 'existence' that formism seeks to establish, is too unspecific and generic for die-hard 'mechanists.' It is thus not a big stretch to suppose that some of the major division lines within the handaxe discourse can probably be reconstructed as a product of the lasting tension between 'formism' and 'mechanism' in lithic studies.

[417] The classic example for 'abduction' is the problem of explaining wet grass. If grass is wet, it probably rained. However, other explanations are possible depending on the context. For instance, the proposed explanation might be the best one for England where it regularly rains, while it might be not the best explanation for Arizona where automatic sprinkler systems are used to keep the grass wet during the dry season. 'Abductive' reasoning therefore typically requires elimination of competing 'best' explanations and a specification of contextual variables – yet, one does not necessarily need to specify any causal mechanisms.
[418] See e.g. Ruebens (2012) for a similar explanatory strategy in more mundane lithic research.

4.2 **Tropes of mechanism in Anglophone practice**

4.2.1 ***Henry's dimensional approach to lithic reduction***

Henry's *Correlations between Reduction Strategies and Settlement Patterns* (1989b) provides a first illustration of 'mechanistic' reasoning in Anglophone lithic studies. The paper may be counted as an early elaboration of the 'Reduction Thesis,' but also seeks to position the study of lithic reduction sequences within a broader ecological framework. Above all, *Correlations* delivered an important methodological impulse by demonstrating the interpretive merits of a 'dimensional approach' to the dynamics of lithic reduction (cf. Tostevin 2012: 144-147). Henry (*ibid*.: 140) opposes this new approach to conventional 'morphological approaches' and regards the former as a crucial complement for the latter (*ibid*.: 153):

> "The reconstruction of a reduction sequence relies upon the elemental observation that throughout the developmental life of a stone tool, from raw material acquis[i]tion through fabrication and use, the morphological changes that occur are subtractive in nature. However, conventional analytical procedures have focused on morphological, as opposed to dimensional, attributes for reconstructing reduction sequences (Collins 1975; Bradley 1975). [...] Conventional means of analysis allow for a general reconstruction of reduction strategies, but they ignore an important source of information, i.e., the trend of diminution during the course of an item's fabrication and use-life." (*idem*)

The 'dimensional approach' shifts the attention from the retouched elements of lithic assemblages (tools) to their un-retouched counterparts (the plain *débitage*). According to Henry (1989b), reduction sequences are best understood by first examining the dimensional relationships between cores and their associated blanks; only in a second step may the results of this analysis be compared to the metric and non-metric data of lithic tools. Based on some general *theoretical considerations*, the author outlines a basic *mechanical process* which underpins any reduction sequence and is first and foremost 'reductive,' i.e., directed and irreversible. This recognition is central to Henry's account since the effects of lithic reduction, then, cannot simply be 'unmade' or 'overwritten,' especially when plain *débitage* is concerned. Henry (*ibid*.: 140f.) asserts that each reduction sequence thus *by necessity* authors a general trend of raw material "diminution" resulting in a decrease in core size and associated blank size (**Fig. 15**). Because general theory about technological organisation and hunter-gatherer mobility indicates that the 'reduction stream' is often spatially segregated, this fundamental principle can be analytically exploited. Within any given lithic assemblage, one can compare the dimensionality of the preserved core facets, blanks, and tools in order to gain a "more precise understanding of the reduction stream within each of the broader segments (or stages), as defined conventionally" (*ibid*.: 140). The crux of the equation is the change in perspective from individual artefacts to 'populations of artefacts.'[419] These populations of artefacts are agglomerative entities – i.e., non-structured artefact totalities. By means of population thinking, it becomes possible to assess the general trends in the dimensionality of these different artefact categories. Since lithic reduction is –as the term implies – *reductive* and there is a causal correspondence between the blanks and their original core facets, one would expect that lithic reduction *in situ* would produce similar mean values of core facet and blank dimensionality. Similarly, dimensional differences between core facets, blanks, and tools may tell us whether tools have been manufactured prior to *in situ*-reduction or whether it is possible that tool production instead occurred on-site. Consequently, the comparison of the dimensionality of core facets, blanks, and tools provides a *relative measure* for the degree of core exhaustion and the possible mobility of tools (*ibid*.: 141). Since one can compare these measures to other conventional measures for core reduction, for example the relative ratio of cortex-bearing blanks or the dimensionality of primary elements, core reduction intensities can be estimated with high accuracy.

This pattern of reasoning shows that Henry's (1989b) 'dimensional approach' is firmly rooted in a mechanistic understanding of lithic reduction sequences. Lithic reduction is considered a relative-

[419] This approach is sometimes also labelled 'aggregate analysis' or 'mass analysis' (cf. Andrefsky 2001: 3-6). As an instance of 'population thinking' in lithic research, it primarily represents a *methodological* manoeuvre. The goal is to isolate assemblage-level trends and regularities that sometimes give lie to individual artefact differences. In other words, not every artefact needs to embody the respective trends and regularities (cf. Porter 1986). Nonetheless, this position is not at all 'synthetic' since it still accepts the doctrine that these assemblage-level characteristics can be repatriated to the configuration of all aggregated artefact-properties. As Ariew (2008) puts it, population thinking adopts a 'bottom-up' approach to population-level phenomena.

ly closed, mechanical core-blank system – a lithic machinery – operating by the interlocking of various successive knapping events. Each event has unequivocal and largely inevitable consequences on future core states which, in turn, precondition the results of future knapping events. The sequence of reduction is recast as a *chain of causal adjustment*. The basic regularity of reduction is the *co-diminution* of cores and blanks during the knapping process. In the language of Pepper's mechanism, this regularity can be identified as the 'primary law' of lithic reduction. The 'law' specifies the configuration of 'primary qualities' in the lithic machinery, typically expressed in exact quantitative terms.[420] 'Primary qualities' are the elementary observable features of lithic parts – i.e., individual artefacts – which are attributable to these parts alone and are relevant for the kind of action – i.e., mineral detachment – powering the core-blank machinery. In *Correlations*, the key 'primary quality' of lithic artefacts is their dimensionality since the outlined 'primary law' of lithic reduction *predicts* directed change especially in this domain of variables; cortex is also defined as a 'primary quality' since it similarly indicates the position of reduction and helps identifying what Henry calls "primary elements."[421] This conceptualisation of the relationship between the lithic machinery and its 'primary qualities' presupposes a 'field of locations.' The 'field of locations' defines the precise position of each lithic part in the spatiotemporal field inaugurated by a reduction sequence. The 'field of locations' therefore determines what can be 'cause' and what is 'effect' and thereby fixes the 'function' of each part in the machine. Henry's Figure 1 (cf. **Fig. 15**) provides nothing else than a graphical representation of the general workings of the lithic machine and the nature of its associated 'field of location' – the figure may be classified as *theoretical imagery*.[422] The whole point of the 'field of locations' is that each spot in the field can only be occupied *once* and by a single lithic part. Consequently, the 'field of locations' opens up a Newtonian space in which 'distances' can be measured in *absolute* fashion. If one knows the 'primary laws' of the machine that inaugurates the field, in other words, one can unambiguously infer the field-position of the attendant parts by analysing their 'primary qualities.' Henry's use of artefact dimensionality and cortex value are authorised by this general understanding of lithic reduction. With Pepper (1942), one may additionally point out:

> "To this absolute space of externally related locations was gradually added an absolute time similarly conceived as an infinite one-dimensional manifold of externally related dates. The dimension of time was not even at first amalgamated with the three dimensions of space. Space was rather conceived as traveling intact like a freight car along the track of time. Thus one could have the identical space location at different times. Space, in other words, was external. It was changeless though it did move bodily from date to date." (*ibid*.: 199)

This conceptualisation of the reduction process has an important epistemological consequence. The only discrete element that is left in the reduction sequence are the lithic parts themselves. Since each part occupies an exact and unique position in the 'field of locations' and since parts are causally enchained, this view greatly promotes a *continuous* understanding of reduction. The variables that define the parts making up the chain of reduction gradually merge into one another. The mechanistic interpretation of 'field' underlines this understanding. A field structure is the 'integrated' unobservable cause for the observable workings of the machine; the field unifies the machine as a whole and removes any remaining discreteness by means of 'integration.' This view opposes what Henry (1989b: 140) terms the conventional approach to lithic reduction, discriminating between four broader reduction stages. This is precisely where radical mechanists disagree with the exponents of almost all other world theories.

Henry's (1989b) critique on the residual discreteness of lithic reduction is conveyed by his notion of the 'reduction stream.' This metaphor of the *stream* is certainly instructive. A 'stream' represents a flowing entity whose constitutive elements grade into each other, so that they are hardly individualisable anymore. The 'stream' implies a steady transition of character states and a continuous movement of matter. It presupposes clear-cut directionality and profuse structural integratedness. A 'stream' can hardly be said to proceed in stages. It is this notion of the 'stream' that the author harnesses in order to characterise the process of lithic reduction. The key idea here is 'nominalistic,' posit-

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[420] See Chapter 2: esp. **Box 7**.
[421] Primary elements comprise plain *débitage* with more than 50% cortex, whereas blank elements are defined as plain *débitage* with less than 50% cortex (cf. Tostevin 2012: 144).
[422] See Chapter 3 for a general discussion of the role of theoretical or conceptual imagery in specifying test conditions and in laying out the workings of the world within Anglophone lithic research.

ing that *only particulars* can be said to 'exist' (cf. Pepper 1942: 198). Reduction 'stages,' by contrast, amount to 'ideal' entities and mechanists are generally sceptical about the existence of such entities. Henry's 'aggregate analytical' approach outlined before entails 'population thinking' (*sensu* Mayr 1959, 1991; Sober 2006) insofar as strong 'essentialism' is rejected and only individual-based variation granted.[423] The basic research orientation articulated by *Correlations* is therefore clearly mechanistic.

Representing lithic reduction as a machinery governed by 'primary laws' allows Henry (1989b) to formulate precise *test expectation*. The reason is of course that the specific articulation of 'primary qualities' in the 'field of locations' causes the 'primary qualities' to change in a directed and thus largely *predictable* manner. 'Predictability' – in accordance with the adopted methodological approach – is interpreted as a population-level phenomenon. This 'predictability' of patterns in artefact dimensionality is rooted in the mechanistic insistence on the 'specifity of response,' the fact that each knapping event, as a function of its position in the 'field of locations,' has highly specific consequences for both its products and future knapping events. The functioning of the lithic machine is *strongly determined*. Henry's core expectation is that there is an *equivalency* between cause and effect and hence a co-diminution of artefact dimensionality when technologically relevant groups of artefacts are compared.[424] Any observed *deviation* from this 'equilibrium condition' can be interpreted in terms of reduction intensity, mobility, and the potential of spatial segregation within knapping activities (*ibid.*: 141). The author provides two examples of possible patterns of deviations that would indicate that the assemblages in question do not represent the whole reduction sequence.

These two *theoretical situations* describe opposing ends on the spectrum of lithic reduction (Henry 1989b: 141, Figure 2; **Fig. 16**). Each of the two situations is characterised by specific relationships between the three technologically relevant artefact sub-populations and concerns the configuration of their 'primary qualities.' Figure 2A (cf. **Fig. 16A**) shows a close overlap of the dimensionalities of blanks, primary elements, and core facets, with the blank population hosting the smallest and the population of primary elements the largest artefact dimensions. This situation suggests that the present cores are not fully exhausted yet and that some cores might even be missing, for example because they were transported to another location. Figure 2B (cf. **Fig. 16B**), by contrast, shows a much more partitioned picture. Here, the size of blanks and core facets overlap, but occupy the lower part of the figure, with core facets being often smaller than blanks. Primary elements in this scenario only overlap with the largest blanks and generally tend to be larger than both blanks and core facets. This configuration points to high degrees of core exhaustion and a nearly complete reduction sequence. Building on these theoretical insights, Henry's proposition is that statistical differences in the relative overlap between blank, primary element, and core facet dimensionalities should be informative about differences in reduction activity and potential import-export dynamics. He (*ibid.*: 140, 144) suggests that these assemblage-level differences can be used to track nomadic mobility systems and human ecological adaptations.[425] Henry's example of Epipalaeolithic land-use in Southern Jordan will suffice here as an illustration (*ibid.*: 141-150).

Henry (1989b: 141) analyses nine Epipalaeolithic sites from near the Jordanian Plateau comprising fourteen individual assemblages. His main argument is that these sites, which occupy different elevation zones across the southern edge of Jordanian Plateau and the neighbouring lowland regions, were once integrated into a larger 'transhumant' settlement system (*ibid.*: Figure 3; cf. Henry 1986, 1987, 1989a, 1995).[426] The goal, drawing on Binford's (1979) concepts of 'personal' and 'situational' gear, is to elucidate that the composition of lithic assemblages changes relative to specific activity profiles on the seasonal mobility cycle. The analysis of plain *débitage* dimensionality is therefore complemented by an examination of tool dimensionality and the structure of toolkits (Henry 1989b: 144-146).

[423] Cf. Ariew (2008).
[424] Pepper (1942: 190) notes: "[…] since we found that we could substitute kilogram bricks for the tree stump and so increase the precision of our description of the machine [i.e., a lever] for that end of the bar, it follows that we can do the same for the pressure of the arm at the end of the bar. […] This is the fact of balance. It is important because it exhibits the equivalence of push and pull. The kilogram bricks for the tree stump and the arm are now seen to be just equal and just alike. We might have thought of the stump as a passive pull and of the arm as an active push. We now see that push and pull can be substituted for each other."
[425] For the purpose of assemblage-level analysis, Henry (1989b: e.g. Table 3) regularly collapses the overall variability of dimensional artefact values into statistical parameters of entire assemblages. This facilitates the direct comparison between different assemblages and helps isolating the main trends of reduction for each individual assemblage.
[426] Broadly understood, 'transhumance' describes a mode of mobility in which nomadic groups alternate between relatively fixed summer and winter pastures. These pastures are often defined relative to elevational and topographic gradients.

In the first step of the analysis, the author distinguishes between Epipalaeolithic sites of differing elevation belts (i.e., lowland, highland) and intensity of occupation determined by factors such as thickness of cultural layer, site orientation, and artefact density. Henry (1989b: 149) reveals that there is a correlation between elevation-type and the character of site occupation: higher elevations tend to harbour smaller, dispersed sites near flint outcrops, intermediate altitudes tend to be associated with small and shallow occupations, and low elevations seem to host primarily large and deeply stratified sites that are often situated close to water bodies (cf. *ibid.*: Figure 3, Table 1). He further shows that on a general level, the structure of the accompanying toolkits and production ratios (i.e., blanks per core, tools per core, tool proportions to all blanks) also differ between these three groups of sites (*ibid.*: 144, Figure 4, Table 2):

> "The differences in the variability between assemblages are consistent with the proposed differences in site types. The more ephemeral occupations of the piedmont sites are likely to have been associated with fewer and more site specific tasks than those conducted in the longer term occupations of the lowland shelters. Therefore, greater variability between the tool-kits of the piedmont sites should be expected." (Henry 1989b: 144, 146)

This dichotomy between lowland and highland sites is also found to be correlated with major differences in lithic *production efficiencies* (Henry 1989b: 146). Whereas higher elevations are characterised by generally fewer blade and bladelet *débitage* per core than the lower elevations, lower elevation sites are more varied in blank productivity and seem to disintegrate into two groups of sites: the first resembling the higher elevation sites in blank productivity, and the second being almost three times more productive (*idem*). Henry suggests that this pattern, in contrast to common intuition, cannot be explained in terms of raw material economising behaviour (*ibid.*: 147). Rather, these differences must be explained by the nature of the reduction sequences inferred by the 'dimensional approach.'

In the second step of the analysis, Henry (1989b) compares the results of his conventional analysis with the dimensional lithic data in an effort to explain the observed variability and to effectively link it to human ecology during the Jordanian Epipalaeolithic. Again, the author identifies a different pattern of core reduction when the lowland and highland sites are juxtaposed. He demonstrates that the lowland sites exhibit shorter primary elements and core facets than the highland sites (*ibid.*: 147). In fact, the primary elements are even shorter than the average bladelet (*idem*). Henry consequently concludes:

> "These data suggest longer productive lives for the lowland cores, but their facet lengths, being only about 2mm shorter, on the average, than the lengths of associated bladelets, indicate that the lowland cores were still far from exhaustion." (*ibid.*: 147f.)

The highland sites, by contrast, yield very similar dimensional values for blank size, core facet size, and the size of primary elements (Henry 1989b: 148). In the words of the author (*idem*), the relationship between the dimensionality of these artefact groups "trace an unbroken reduction stream from primary element, to core facet, to bladelet." Henry argues that this reduction signature indicates that human occupation in the highlands was of a different character (cf. *ibid.*: Figure 7). He interprets the data as suggesting that occupation was brief and linked to a set of activities exploiting the full breadth of the reduction sequence (*ibid.*: 148). Since the metric mean distance between the length of the three relevant artefact groups is extremely small, he infers *short* but *complete* reduction sequences:

> "Thus both the pattern of reduction and the dimensions of the piedmont assemblages are consistent with what one would expect in the context of ephemeral camps, where cores were used briefly in the production of a few bladelets for the expedient manufacture of tools." (*idem*)

According to Henry (1989b: 149), the only way to account for the puzzling discrepancy between the high productivity of blanks and the low degree of core exhaustion in the lowland sites is by postulating the import of laminar blanks from the highlands.[427]

[427] This is an instance of mechanistic 'abductive' reasoning. The postulation of blank-import is the *best* explanation because the problem of lithic site-signatures is framed as a problem of a *unified* settlement system. With Pepper (1942), we can say that this settlement system represents a higher-level machine regulating the nature of site occurrences in geographic space. The 'primary law' of this system is 'transhumance,' i.e., the necessary transition of populations from the lowlands to the highlands and other way around in specific seasons of the years. Each site, then, comes into view as a somewhat fixed position in the system's 'field of locations.' As a consequence, if the internal reduction structure of an assemblage is contradictory, as in the case of lowland sites, this must be interpreted as the effect of another node in the system. Because the system is constructed around the duality be-

Correlations ultimately proposes that this overall organisational pattern of lithic technology can best be understood by a shift in procurement strategy that must have paralleled the transition from the lowland to the highland occupations, and *vice versa* (Henry 1989b: 149f.). The author proposes that the differences between lowland and highland occupations can be explained by a general change in *mobility strategy*. While the total character of occupation in the highlands suggests a more 'residential' mode of settlement (*sensu* Binford 1980) where human presence was essentially "mapped onto resources" (*ibid*: 150), the nature of human settlement in the lowlands instead points to a 'logistical' strategy placing more emphasis on the portability of lithic materials and hence favouring the import of laminar blanks from the highlands. Henry thus closes the 'transhumant' settlement system by illustrating the functional complementarity of highland and lowland occupations and the flow of lithic material between them.

The author takes his results as an opportunity to criticise overly simplistic 'distance-decay models' of raw material economisation. He argues that such models, by predicting a close link between the size of artefacts and the distance to potent raw material sources, fail to take into account that human groups sometimes impose strong metric constraints onto certain tools (cf. Henry 1989b: 153) – constraints that are probably more 'cultural' than 'situational.' In such a situation for which he regards his Epipalaeolithic case study as an example (*ibid.*: 149; cf. Henry 1973; Marks 1976; Bar-Yosef 1981), alternative means for economisation must be employed. The case of the highland sites is taken to indicate that such an alternative strategy may consist in "advancing the reduction stream or manufacturing process closer to the finished implement when near raw material sources" (Henry 1989b: 153). This shows that reduction behaviour can be *economic* even if it does not follow a 'distance-decay' pattern – 'economisation' is often achieved by spatially segregating lithic reduction which, as a consequence, provides general information about the organisation of the adopted settlement system(s).

Overall, *Correlations* treats lithic technology as a 'derived' phenomenon. It is seen as a product of human ecology.[428] As such, lithic technology primarily affords a means to cope with particular environments, in particular the uneven and often patchy distribution of resources therein. This results in a well-defined *chain of determination* guiding argumentation and explanation. The base of the chain is built by the physical environment and its resource potential.[429] Henry (1989a) effectively uses topography, i.e., elevation belts, as a proxy for changing ecological conditions and resource availability. Human groups have to adjust their behaviour relative to this basal environmental structure if they wish to survive. Mobility provides a flexible strategic means of doing so. Thus, settlement systems can be viewed as a systematisation of implemented mobility solutions. Lithic technology, then, has to support these specific mobility strategies and variation in these strategies, conversely, bring forth different requirements for lithic technology. Just as Darwin (1859: 90) proclaimed an 'economy of nature' to understand the evolution of life, lithic technology is identified as a locus of 'human economy' to understand human ecology. This is why technological signatures can be used to infer the working principles of particular settlement systems. Varying lithic reduction signatures are interpreted as the outcome of the specific intersection of human mobility and human ecology (cf. e.g., Henry 1987, 1995; Kelly 1988; Nelson 1991; Kuhn 1995; Kuhn et al. 2016; Cicero 2017).[430] The reconstruction illustrates that reality is compartmentalised and the different compartments are regarded to constraint each other in a largely predefined manner. The physical environment is always more foundational than human mobility, and

tween 'lowland' and 'highland,' this node, understood as a *cause*, must be a highland site. The best explanation of the discrepancy is thus that there is a flow of objects between different elevations. [See also Henry (1989b: 149) for an additional metric argument why import is the most parsimonious explanation]

[428] See esp. Henry (1995: 1-6); cf. Henry (1982, 1986, 1987).

[429] Cf. Henry et al. (2017) for a more recent expression of the same research configuration.

[430] This is a general theme in Anglophone lithic research. Patterns of lithic technology are often interpreted from the perspective of mobility – a preoccupation that Kuhn et al. (2016: 86f.) have termed the 'human movement ecology paradigm'. This paradigm can be traced back to Binford's (1978, 1980) influential ethnoarchaeological work with the *Nunamiut* of Northwestern Alaska and the related recognition that hominin mobility needs to be studied beyond 'sedentism' and 'nomadism' (Kelly 1992; cf. Kuhn et al. 2016: 92). Binford's (1980) distinction between 'residential' and 'logistic' modes of mobility was an attempt to address this issue (cf. Ambrose and Lorentz 1990; Grove 2008, 2010). Inspired by the foundational work of Kelly (1983, 1995) and others, mobility became quickly the socket of studying human *strategic behaviour* in general. Research within this paradigm can be decomposed into three different strands of lithic inquiry: (a) *Technological Organization* (cf. Shott 1986; Bamforth 1991; Neslon 1991; Carr and Bradbury 2011; McCall 2015); (b) *Human Behavioural Ecology* (HBE) (cf. McCall 2007; Shea 2011b, 2017a; Kelly 2013); and (c) *Optimal Foraging Theory* (cf. Winterhalder 1981; Bleed 1986; Bousman 1993; Winterhalder and Smith 2000). All three approaches show considerable conceptual overlap and explicitly examine lithic technology in its wider ecological framing.

human mobility is always more basal than lithic technology. The 'chain of determination' therefore authors a clear-cut *direction of determination*, so that the more basic rungs of reality constitute the more derived levels. With Pepper (1942), we can say: the more basic the compartment, the more 'effective' its categories. The underlying logic of reasoning is mechanistic. Not only entails the structure of reality *causal hierarchies*, the world is generally viewed as a *strongly determined place*. Henry's (1989b) approach is clearly based on 'hard ecology'[431] and takes up a theme that has traditionally experienced considerable attention in Anglophone Palaeolithic archaeology: human-environment adjustments (e.g., Butzer 1964 [1971], 1982, 1986; Butzer and Isaac 1975; Binford 2001; Braun et al. 2008a; Petraglia et al. 2009b; Barker 2017). Even though we will return to this issue in more detail at the end of this chapter, it is already clear from Henry's (1989b) account that reasoning on the role and status of lithic technology is guided and corroborated by a theory of *causal adjustment*. Technological signatures are considered 'specific responses made by an organism on the stimulus of specific environmental configurations' (Pepper 1942: 226).

The advanced explanation reflects the *principle of heteronomy*,[432] i.e., the mechanistic certainty that each phenomenon must be explained in terms of another phenomenon, preferably a 'less derived' one. Explanation, in other words, is firmly grounded in the *specificity of external relatedness*. These externally related phenomena are seen as the parts of a worldly whole; they can be graded somewhere between the 'primary' and 'secondary' categories of reality. However, in contrast to the role of correlation in the 'formistic' endeavour of explanation, correlations in mechanism are never explanatory *ipso facto*, but are typically used to identify potential pairs of 'effective' and 'ineffective' categories. The detection of correlations thus facilitates the identification of *causally coupled* sections of reality. The twist is that these correlations, if they tell us something meaningful about reality, must be *predictable* in an unequivocal and highly detailed manner, and not merely in terms of structural similarities. From a mechanistic point of view, to explain a given domain of reality – in Henry's case lithic technology – means to show that its observable features follow by necessity from the constitution of the relevant interfacing domains of reality.[433]

These expositions should be sufficient to demonstrate that *Correlations* furnishes a mechanistic perspective on the lithic record. The analysis has revealed that two mechanistic systems of lithic technological organisation can be distinguished. The first is the reduction system itself, with its 'stream' of raw material diminution; the scale of this working system is the individual assemblage. The second system is the settlement system in which multiple localised reduction systems take parts; here, the scale of observation is a structured landscape. Both of these system, as we have seen, bring forth their own 'field of locations' – local reduction systems may in fact be recognised as the discrete locations of their larger settlement system – and each is characterised by specific 'primary laws.' With Bunge (2013), these systems can be understood as 'concrete' and structured composite entities. Each of them has one or more mechanisms or characteristic processes which determine their observable character. A 'concrete' systems in Bunge's sense can be defined by the ordered quadruple *composition-environment-structure-mechanism* (*ibid.*: 590). Clearly, this conception is consistent with Henry's (1989b) account and tightly situates *Correlations* in the realm of mechanistic approaches.

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431 Ecological thought has traditionally supported two species of approaches: 'hard' and 'soft' ecology. The division is well-documented in a number of scientific disciplines but has received some notable attention especially in environmental ethics (cf. Shrader-Frechette 1995). 'Soft ecology' approaches emphasise relational thinking and tend to be qualitative and general. The corresponding scientific attitude is 'interpretive' and 'understanding-based' (cf. Chapter 3). 'Hard ecology,' by contrast, seeks to be precise and predictive and stresses the importance of quantitative reasoning. It generally attempts to unearth second- or higher-order principles of ecological functioning, its science is 'explanatory,' and its explanations tend to be *subsumptive*, i.e., subsume the particular under the general. An example of a prototypical hard ecology approach anchored in 'hypothetico-deductive' reasoning is provided by Peters (1991). In general, soft ecology often relies on qualitative concepts such as 'ecosystem' which hard ecologists find difficult to operationalise. As Shrader-Frechette (1995: 126) puts it, soft ecology perspectives tend to *underestimate certainty* and may thus often demand too little from ecology, whereas hard ecology probably *overestimates certainty* and may thus frequently demand too much from ecology. This difference resonates with diverging conceptions of the structure of reality which place different emphasis on determinateness and the strength thereof (cf. Chapter 2).

432 Heteronomy is the dogma that the existence and development of phenomena is *fully dependent on factors external to these phenomena*. In 'mechanism,' this seeded character of reality is interpreted in terms of external causal constitution. The resulting causal structure presupposes a *hierarchy* of observable qualities of reality.

433 Cf. "Integrating technological studies into archaeology's mission within paleoanthropology, namely to document and explain evolutionary change in human behavior, inevitably leads beyond the confines of technology itself. In order to bring technological data to bear on major changes in human adaptations, it is essential to explore how toolmaking was related to hominin subsistence and foraging ecology." (Kuhn 2014 [1995]: 16)

4.2.2 ***Dibble's scraper reduction model***

The second window into mechanistic approaches within Anglophone lithic research is opened by the study of general 'reduction effects,' the investigation of artefact 'biographies' and 'transformational histories,' as well as various themes of 'reduction economy.' These inquiries pursue two interrelated goals: on the one hand, they seek to better understand the *physical-mechanical ramifications* of lithic reduction; on the other hand, they hope to shed new light on the significance of classic concepts such as 'form' and 'typology,' often in the context of ecology- and mobility-oriented studies or the broader endeavour to chart strategic behaviour in human evolution. The first objective is often linked to the ambition of reconfiguring the interpretive space of lithic analysis and to offer more 'basic' or 'foundational' explanations of the evidence than typically provided (McPherron 1994: 29; cf. Jelinek 1976). The second aim encapsulates a similarly mechanistic attitude; the ambition is to demonstrate that categories of 'form' and 'type,' although doubtlessly being detectable in the empirical world, must be treated with great caution:

> "In large part the debate over reduction strategies, reduction intensity and typological variability revolve around the reality of types. If one's perspective on the types is that they represent real or natural divisions in artifact variability, then it is natural to view lithic reduction strategies as geared towards the production of these various types. If, on the other hand, one's perspective on the types is that they represent arbitrarily imposed subdivisions in continuous variability, then it is natural to view them as stages of a single reduction strategy. [...] Neither Bordes, Roe or anyone else has ever established that the Acheulian biface types are anything other than arbitrary divisions of continuous variability [...]." (McPherron 1994: 38)

'Form' or 'type' categories are considered to trace 'appearances' and to be indicative of 'reality' only if the elementary processes that bring them into being have been identified and described.[434] The key issue here is the problem of *equifinality*, i.e., the circumstance that different processes may produce similar or even the same forms and types.[435] Both ambitions register the fundamental mechanistic trouble of policing the problem of *Appearance and Reality* (cf. Chapter 2). The status of the 'phenomenal' realm – i.e., what is observationally given – is deeply ambivalent for a mechanist: although the observational paves the only conceivable and reliable way to knowledge about what actually is, observable patterns may easily seduce the analyst and draw her/his attention away from the 'true' structure of reality.

Technologies of reduction have traditionally been of interest to lithic scholars examining the interface between economy and mobility (e.g., Kelly 1988; Kuhn 1992, 1995). A central reason is that aspects such as an object's 'use life,' 'reduction intensity,' and 'trajectory of reduction' promise to inform directly about object-mobility and economising behaviours of the object-users. Binford's (1979) distinction between 'expedient' and 'curated' technologies, later refined by Nelson (1991: 63-65), was intended to answer similar questions. 'Curated' objects, that is, highly reduced, re-sharpened, and/or re-cycled lithic elements, are generally thought to reflect 'mobile' items that have the potential to be carried around over considerable timespans and geographic distances (cf. Marks 1988); 'curated' technologies help to conserve raw material and thus deflect problems of raw material supply and predictability which may arise in settings of high group mobility (cf. Bamforth 1986; Kuhn 1992). 'Expedient' objects, by contrast, indicate situational on-spot solutions, lower degrees of mobility, reduced planning, and may entail *ad hoc* strategies of tool-utilisation (Nelson 1991: 64-66). As Nelson (1991: 65) correctly notes, however, 'opportunistic' and 'unanticipated' behaviours must strictly be distinguished from 'expedient' behaviour since the latter is often a regular and integral element of the overall set of strategies employed to meet particular situations and conditions. Although the dichotomisation between 'expedient' and 'curated' has been criticised as too simplistic (e.g., Nahler 1991) and it is clear now that one needs to take into account the entire gradient of more or less curated and more or less

[434] Again, this is where 'mechanism' and 'formism' tend to disagree strongly, for 'formism' takes the *form* in 'concrete existence' as its point of departure. Within American Palaeolithic archaeology, this coordinate of conflict is for example illustrated by the heated discussion between Angela Close (1991a, 1991b) and Harold Dibble (1991c) on the interpretive significance of lithic types.
[435] 'Equifinality' is usually referred to as the principle that 'a given end state can be reached by many potential means' (Mayhew 2015). In geomorphology, for example, the concept indicates that similar landforms may have been brought into existence by different sets of processes. In a notable study of geomorphic equifinality, Cruslock et al. (2010) have demonstrated that two different erosional processes – wave action and ice scour – result in highly similar erosional products and meso-scale landforms in structurally comparable lithological settings. Landforms alone, therefore, are not unequivocal proxies of the causal factors involved in their geomorphic genesis.

expedient technologies (Shott 1986; Nelson 1991), qua *theoretical distinction* it remains a valuable distinction and enables the formulation of precise predictions and test implications to guide future research (cf. Dibble et al. 2016: 827).

Generally speaking, the study of reduction intensities and economies – that is, to answer the question: how much material is missing? (e.g., Barton 1988; Kuhn 1990; Eren et al. 2005; Shott 2005b; Marwick 2008b; Iovita 2008) – is viewed to elucidate the functioning of a mobility system in a particular environmental setting. Object transformation and reduction are the inevitable consequence of task-specificity, the working principles of the attendant settlement system, and the present natural environmental conditions including raw material quality and availability (e.g., Kuhn 1994). Thus, knowledge on lithic technology is gained and secured by *causally adjusting* the reduction patterns to these ecological parameters (cf. Jochim 1976; Binford 1980; Kelly 1988; Rolland and Dibble 1990; Kuhn 1993; 2014 [1995]). This explanatory strategy is not only 'integrative' because factors of raw material consumption take over a privileged position in reconstructing hominin behaviour, but also because the structure of ecological constraints yields a specific mechanism of explanation:[436]

> Put another way, since systems of adaptation are energy-capturing systems, the strategies that they employ must bear some relationship to the energy or, more important, the entrophy structure of the environments in which they seek energy. We may expect some redundancy in the technology or means, as well as the organization (labor organization), of production to arise as a result of "natural selection." That is the historical movement toward an "optima" for the setting. Put another way, technology, in both its "tools" sense as well as the "labor" sense, is invented and reorganized by men to solve certain problems presented by the energy-entrophy structure of the environment in which they seek to gain a livelihood." (Binford 1980: 13)

What Binford describes in this short passage is nothing else than an ecological *equilibrium system* in which the respective elements, including reduction economies, are structurally adjusted to one another. The mechanistic orientation of this type of reasoning should be obvious.

Can this mechanistic signature be retraced in more specific instances of Anglophone lithic inquiry? Without any doubt, the best-known model of lithic reduction and artefact 'use histories' has been proposed in a series of influential papers by Harold Dibble (1984, 1987, 1988, 1995b). His 'scraper reduction model' was introduced to explain typological patterns in the French Mousterian and delivered an important argument in the aftermath of the 'Binford-Bordes debate.' The model has variously been identified with the 'reduction argument' (Kuhn (2014 [1995]: 15f.). The reduction argument holds that artefact *form* – i.e., shape- and morphology-based characteristics – change in the course of raw material attrition. It draws from older ideas (Cooper 1954; Frison 1968), especially on what is now widely known as the 'Frison effect' (after Jelinek 1976) and applies them to the variability of scraper types in the French Mousterian arguing that these types embody *transformational phases*, rather than 'functional' or 'cultural' markers. Already on a general level, Dibble's approach thus testifies to a mechanistic critique of purportedly 'static,' 'fixed' and overly 'eternalised' categories of concrete reality.[437] Even though its central argument of course challenges Binford and Binford's (1966; cf. Freeman 1966) take on typological variability, it shares the 'Binfordian' conviction that the essentially 'static record' of the past needs to be explained by the 'dynamic processes' that created it. The static record itself, therefore, is the gateway to proper knowledge, yet cannot be taken at face value (cf. Binford 1972, 1977, 1981b: 25).[438] Binford (1981b: 26) himself explicitly noted that the gulf between 'static' evidence and 'dynamic' explanation may best be bridged by invoking *causal relationships* and *general principles of necessity*. The categorical distinction between 'static-ness' and 'dynamic-ness' thereby justifies the

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[436] A general goal here is to achieve high-resolution, target-sensitive explanations and to disentangle the various causes underlying the formation of a given lithic assemblage: "[i]solating evidence diverse economic roles in lithic assemblages is not just a matter of measuring variation, of recognizing that some artifacts were completely used up while others had very short lives, or that some tools were moved long distances and others produced on site. We expect a certain degree of variability within any assemblage created by mobile toolmakers, especially when that assemblage accumulated over a long period of time, under varying conditions. What is more significant is the partitioning of variation, the degree of independence among artifact life history trajectories. Convincing evidence that artifacts reflected differing social or economic roles would come only from consistent associations between artifact forms, resharpening/maintenance, and perhaps raw material selection." (Kuhn 2011: 103)

[437] Cf. esp. Dibble et al. (2017: 817-825).

[438] Kelly (2016: 17) similarly notes in his chapter *How Archaeologists Think*: "[i]n a textbook, we might write a chapter describing "what happened" during Basketmaker times, a description of the people's subsistence and their social and political organization as we interpret it from material remains. Another chapter would use the material remains of Pueblo I sites to relate how subsistence and social and political life changed from Basketmaker times. This is not easy, yet breathing life into material remains is what archaeology is all about – going from the static remains of the past to the dynamic behavior that produced them."

conceptual separation between 'theory' and 'data' (cf. Chapter 3) and identifies the problem of *Appearance and Reality* (cf. Pepper 1942: 145; see *supra*) as a key venue in the epistemology of Palaeolithic archaeology. As McPherron (2006: 268) puts it, one may then "explicitly use typology to reconstruct process." Evidently, this research orientation draws heavily on mechanism:

> "In the long run, the most significant contribution of the "reduction argument" has been to focus attention on the "life histories" of tools. Viewing artifacts as the end product of a long dynamic process of manufacture, use, and renewal – rather than as fossilized conceptual blueprints – has helped to divert research in a very productive direction, one which is much more in keeping with other developments in Paleolithic studies." (Kuhn 2014 [1995]: 16)

The initial reduction argument of the 1980s has gradually evolved into a full-fledged 'Reduction Thesis' (e.g., Potts 1991; McPherron 1994; Dibble 1995b; Chase et al. 2009; Braun et al. 2009; Dibble et al. 2017: 827). This thesis provocatively asserts that patterned categories of lithic 'form' are likely to reflect arbitrary stages, steps or grades on a continuum of reduction whose causal-determinative coercion has to be identified in each individual case (cf. Marwick 2008a: 108, 112f.):

> "[…] It is important to note here that the use of the word "stage" in the context of the reduction strategy does not imply that these stages were somehow recognized by the makers of these artifacts. The word stage is substituted for the word type only to emphasize the connection between them and the idea of a single process. Still, the stages, like the types, are completely arbitrary constructs, and there is absolutely no intention to argue that these stages correspond to actual stages that may have been recognized by the makers of the artifacts (cf. Newcomer 1971). They are simply a heuristic device and no more." (McPherron 1994: 38)

The 'Reduction Thesis' has since been applied to a number of case studies in the Palaeolithic and Epipalaeolithic of the Old World. Examples are the Oldowan (Potts 1991; Braun et al. 2009), Acheulean handaxes (McPherron 1994, 1999, 2000; Iovita and McPherron 2011), the Middle Palaeolithic (Barton 1990; Holdaway et al. 1996; Iovita 2008); the African Aterian (Iovita 2011); the Western European Aurignacian (Blades 2003), and the Near Eastern Epipalaeolithic (Olszewski 1993, 2016; Neeley and Barton 1990). All of these studies challenge the overall stability of lithic reduction sequences. They promote a view of lithic reduction that highlights the *fluidity*, *continuity*, and *flexibility* of both the knapping process and the management and use of different knapping products (cf. Dibble et al. 2017: 827f.). A curious epistemological ramification of this conception seems to be the status of lithic reduction somewhere between natural (*n-transformation*) and cultural (*c-transformation*) processes of transformation.[439] The research programme supplied by the 'Reduction Thesis' specifically interrogates whether lithic reduction trajectories can be explained by non-human or system-internal factors alone, or whether at least some cultural input needs to be assumed even if some details of the reduction sequence are comprehensible in natural terms (cf. Baumler and Speth 1993). The 'Reduction Thesis' thus puts a counterweight on what it perceives as the dominant 'idiographic' view of lithic technology, at least balancing the tides between 'idiographic' and 'nomothetic' explanations in lithic analysis.[440] In line with their insistence on 'low-level' explanations (see *supra*), proponents of the 'Reduction Thesis' want to demonstrate that basic principles of the reductive process are sufficient to account for much of the encountered intra- and inter-assemblage variability. These processes are as 'natural' as they are 'anthropogenic.'

Dibble's 'scraper reduction model' (1984, 1987, 1988, 1995b) posits that the main recognisable scraper types of the French Mousterian represent *metastable states* of a dynamic, yet generally continuous and unified reduction system. The scraper 'types' are argued to reflect recurrently instantiated *stations* on a well-defined trajectory of reduction (cf. Dibble 1995b: 318f.). While this overall trajectory

[439] For the distinction between *n-transformation* and *c-transformation* within general 'formation theory,' see Schiffer (1976: 1-3; cf. Bernbeck 1997: 67-81).

[440] The duality between 'idiographic' and 'nomothetic' science was introduced by New-Kantian philosopher Wilhelm Windelband (cf. Thomae 1999). In his *Geschichte und Naturwissenschaft* (1904 [1894]), Windelband defined 'nomothetic' as the tendency to generalise in and to derive laws in an effort to explain types or other 'objective' categories of reality. A 'nomothetic' approach, according to him, is more common in the natural sciences [*Naturwissenschaften*]. 'Idiographic,' by contrast, was defined as the tendency to specify and to seek understanding of meaning and contingency which often results in an emphasis of uniqueness and the subjectivity of phenomena. Windelband attributes this research orientation primarily to the humanities [*Geisteswissenschaften*]. More recently, the term 'nomothetic' is sometimes also used to designate approaches that focus on *inter-individual* variation (i.e., variation between parts), whereas 'idiographic' serves to describe approaches that concentrate on *intra-individual* variation (i.e., variation within wholes) (cf. Beltz et al. 2016). In archaeology, 'nomothetic' approaches are often associated with processual archaeologies insofar as they employ Hempelian hypothetico-deductive schemes of reasoning (cf. Bernbeck 1997: 68; Chapter 2, 3).

may tell us something about the behaviour and culture of its Neanderthal authors, the types themselves are explicable in terms the 'primary laws' and regularities of sustained raw material attrition. Mechanical processes of lithic ablation and attrition, in other words, are regarded to have specific *typological consequences*. Typology, therefore, is not – as usually in 'formism' – the input variable but is rather identified as the *inevitable output* of not directly observable reduction processes. Typology becomes a category that captures the 'specifity of response' of the processual constitution of lithic reality. As a result, typology can only be convincingly explained if its patterns can be unequivocally linked to different process-specific effects. Dibble's (1987: Figure 4) reconstruction of the specific sequence of scraper attrition, illustrated as a sequence of typological scraper states, reflects this mechanistic logic (**Fig. 17**). Dibble (*ibid*.: 116) specifically contents that the different scraper types illustrate different phases of the potential use-life of scrapers. He argues that 'single scrapers' constitute the natural point of departure and thus the first 'stage' of scraper attrition; they are gradually transformed into various variants – in 'formistic' terminology 'sub-types' – of 'double scrapers' or, alternatively, may result directly in different types of 'transverse' or '*déjeté* scrapers'; 'double scrapers,' however, may further wear down into various kinds of 'convergent scrapers.' On a more general plane, Dibble (1995b: 319) distinguishes between two theoretically independent sequences of scraper reduction: the single-double-convergent and the single-transverse (*déjeté*) sequence. Which pathway of scraper transformation is taken primarily depends on whether or not additional edges are retouched in the course of a scraper's use-life.

Three features of Dibble's argumentation are important to highlight here. The first is that specific interdependencies between scraper morphologies and the location and intensity of edge modifications or attritions are outlined (cf. Dibble 1987: Figure 2, 1995b: Fig. 9; **Fig. 18**). These interdependencies can be described and modelled in mathematical language (Dibble 1995b: 319f., Fig. 10). This means that the various effects of scraper attrition become predictable. Specific actions and processes are linked to a specific morphological outcome by means of a principle of determination – a *cause* in the broader sense of the term is introduced. Thus, in order to corroborate the relevant interdependencies, one simply needs to *causally adjust* the relevant parameters. The second point is that these relationships are valid independently of hominin intervention, but they provide us with valuable clues as to *when* hominin interference is most likely to occur and *how* it can be evidenced. While the processes of raw material attrition themselves are purely *mechanical*, hominins of course need to 'allow' further attrition to occur and are 'in command' of certain aspects of reduction. They for example have to *decide* whether or not they wish to add a second working edge by incipient modification or use. The 'scraper reduction model' thus helps separating between different sources of typological scraper variability. Based on these considerations, one may even suggest that the single-double-convergent trajectory involves more hominin agency than the single-transversal sequence of scraper reduction. At any rate, the model elucidates that only a relatively low degree of hominin interference seems necessary to explain the observable variability of Mousterian scraper tools. The third feature that requires some attention is the precise nature of the scraper 'types' themselves. In this context, it is notable that Dibble (1995b: 318) aggregates various typologically distinct kinds of scrapers into broader categories – i.e., 'single scrapers' which are only retouched along one edge, 'double scrapers' with two laterally retouched edges, 'convergent scrapers' with two laterally retouched edges converging at one end, and 'transversal scrapers' with a single broad edge located at the distal end of the blank. Minor scraper classes are discarded from the analysis because they are considered to represent background noise or non-stable points on the reduction continuum, for example as products of idiosyncratic behaviour, random sources of variation, or non-sustained tool-utilisation (cf. Dibble 1995b: 332f.). This fact alone bespeaks of an 'integrative' attitude of explanation. More important, however, is the circumstance that the aggregated main scraper types are strongly *theory-informed*; they are deliberately 'theory-laden,' one might say. The reason, of course, is that mechanism can only accept form-based categories of reality if they turn out to be *instrumental* for the advanced mechanistic explanation. The scraper types, in other words, serve the adopted higher-level theory of reduction and attest the *causal adjustment* between the categories of 'appearance' (i.e., types, classes) and the categories of 'reality' (i.e., processes, causes, laws). By being 'effective' categories in this sense, the reality of these types is exposed and they can be treated as the active parts of the reduction machinery and its specific 'field of locations.' Importantly, the types can therefore be identified as the 'effective' categories of mechanism.[441]

The reduction process underlying the formation of the four main scraper types of the French Mousterian can now be understood in complete mechanistic terms. That Dibble (1995b: 318f.) calls attention to the four types as points on a continuum of reduction simply expresses the fact that they occupy different 'positions' in their 'field of locations' – a field which is propelled by a least one 'primary law' of reduction. This law comprises the subtractive effects of ongoing lithic reduction (e.g., modification, attrition, re-sharpening) and the specific mechanical relationships that were identified between the four groups of scrapers.[442] These relationships also specify the effective 'primary qualities' that power the reduction machine and lead to the predictable outcomes. The types are thus nothing else than idealised *events* which, by virtue of their 'location' in the field structure of reduction (cf. Pepper 1942: 191f.), are *causally enchained* in a specific order. The reality of the types and their significance is confirmed by the fact that they occupy this well-defined and *necessary* place in the total reduction machinery. The circumstance that the scraper types are effectively interpreted as *metastable states* – as 'foci of instantiation' if you will (see *supra*) – further indicates that the reductive machinery is conceptualised here as a fully integrated 'field structure' in which almost no residual discreteness is left.[443] The types simply denote the locations of the field where the *potentialities of material instantiation* are highest. This view is supported by the particular fashion in which noise and minor scraper classes are explained away (see *supra*). It also explains the still problematic nature of 'types' and their lurking status as *epiphenomena.*[444] With Pepper (1942: 212-220), we can conclude that, overall, Dibble's 'scraper reduction model' provides a prototypical example of a 'consolidated' variant of mechanism: the empirical lithic world is apprehended by the non-observable *singularity* of a structured and causally-imbued field. An implication is that the behaviour of lithic reduction systems is defined by analogy to the behaviour of already known field structures (e.g., electromagnetic field, quantum field). From this perspective, reduction systems come into view as spatiotemporal wholes with a unified reduction *geometry*.[445]

The preferred mode of visualising such a fully determined reduction system is the *flowchart* or even more basic *digraphs* (cf. Harary et al. 1965). These graph types enable the *formal* representation of constitutive relationships within a spatiotemporal matrix. They draw to varying degrees on 'graph theory' (e.g., Bondy and Murty 1976) and are therefore well-suited to depict dependent and independent causality and directed cascades of causation. In theory, they should also allow the representation of metastable states and subordinate conditions – in short, to capture the potential hierarchies within a mechanistic reduction system. Because digraphs may be constructed with the help of mathematical equations, graph conjectures may even be directly tested against the available data (cf. Bang-Jensen and Gutin 2007). A 'digraph' or *directed graph* is a simplification of a causal system but retains its cardinal characteristics. In the case of lithic analysis, reduction systems can be visualised as pure 'fields of locations.' Each node or junction of the graph stands for an 'event' or quasi-stable state, each

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[441] See Chapter 2: esp. **Box 7**.

[442] It is no coincidence that the 'Frison effect' (Jelinek 1976; Frison 1968) is regularly invoked here as fundamental principle of lithic reduction. Arguably therefore, the 'Frison effect' can be interpreted as a 'primary law' of lithic reduction (cf. esp. Dibble 1981: 7f., 1984: 435, 1995b: 299-306, 355; McPherron 1994: 175; Dibble et al. 2017: 819).

[443] 'Metastability' is a property of a dynamic system that seeks to explain the emergence of what can be called pseudo-discreteness on an entirely unified substrate. Typically, phenomena of metastability refer to the existence of two or more timescales on which the system under consideration exhibits very different behaviours (cf. Bovier 2009: 178). The concept therefore helps to understand the issue of *transition* between timescales and system-behaviours. On shorter timescales, dynamic systems tend to quickly reach some sort of equilibrium state and the kind of equilibrium will depend on the initial conditions. On longer timescales, however, one occasionally observes transitions between multiple of equilibrium states; each timescale, if you will, has its proper equilibrium state. These equilibria are only stable at the metalevel and a set of new system-internal stimuli may cause another transition. The point is that metastable states essentially describe *statistical realities*. The analogy of the 'metastable state' allows one to understand why some states are recurrently instantiated while others are not – the latter seem to delineate non-stable, transitional states. It therefore provides a means to grasp how non-discrete processes can produce 'pseudo-discrete' outcomes.

[444] In other words, the possibility to explain the occurrence of certain lithic types by calling upon the heterogeneous potentiality of a unified field-structure solves the problem of types being both 'real' and 'unreal' at the same time. Types are real because they explain how the reduction machine is powered, yet they are unreal because they represent a derived category of existence – one simply cannot deny their status as 'appearances.' By invoking specific field structures and their causal-determinative principles, it becomes possible to elucidate the specific empirical qualities of types 'bottom-up' without fully explaining them away. This cognitive strategy to overcome the problem of *Appearance and Reality* is characteristic for 'consolidate' versions of 'mechanism.'

[445] Cf. Pepper (1942: 212f.) for a detailed explanation of the notion of 'geometry' in the context of 'consolidated mechanisms.'

of which is connected to at least one other element of the graph by some determinative principle. Such graphs can thus coevally capture the precise 'location' of the 'working' parts of the reduction machine, the overall configuration of the 'field structure,' and the principles of causal integration. It is no surprise, then, that Dibble (1987: Figure 4) also conveys his application of the 'Reduction Thesis' to Mousterian scraper technology as a compact 'digraph' (cf. **Fig. 17**). Other well-known applications of the 'Reduction Thesis' have followed his lead and employ similar imagery. For example, Neeley and Barton (1994: Figure 6, 8; **Fig. 19, 20**) use simple digraphs to illustrate the reduction pathways of Epipalaeolithic microliths. Potts' (1991: Figure 1; **Fig. 20**) reconstruction of the Oldowan reduction continuum also makes use of this type of imagery. It is important to note that all of these images theorise non-equivocal relationships between different reduction nodes; these links, represented by two or more directed arrows impinging on a single node, specify the *equifinality* of systemic functioning (cf. Kuhn 2014 [1995]: Figure 4.9, 4.11). This point is important since only mechanism interprets 'equifinality' in this particular manner, as the problem of different processes producing broadly the same results. The issue of 'equifinality' can therefore only be solved if the relevant system-states are mapped onto their 'field of locations' and the associated 'primary' and 'secondary laws' that hold this field together are outlined. 'Digraphs' and flowcharts in Anglophone lithic research serve this function. They are therefore *explanatory* devices in their own right, but according to the specific mechanistic understanding of this concept.[446]

The general mechanistic orientation of approaches that deploy the reduction argument is not least reflected in Dibble's (1995b) summary of his broader survey of reduction dynamics in different Lower and Middle Palaeolithic contexts:

> "But these convergences [in artefact form during the Middle Palaeolithic] have broader implications than just the fact that we are able to classify the tools into the same typological framework. First, it is surprising that such similarities occur throughout the range of Lower and Middle Paleolithic industries. Second, not only do the same types occur, but they exhibit the same sorts of relationships between them. These facts point to a very fundamental explanation of tool variability. Processes like those proposed for scraper reduction have already been witnessed ethnographically, and they have been proposed for virtually all periods of human prehistory. Thus, they are real and represent the kind of low level explanation that can crosscut both stylistic and functional considerations. Given that the patterns of Middle Paleolithic tools are so consistent with the predictions of these models, it would seem that a reduction argument is the simpl[e]st explanation that can account for the data presently available." (*ibid.*: 357f.)

How can one be sure, in general, that these interdependencies between pattern and process hold true in general? In other words, how can we know their *universality*? A possible mechanistic answer would be: by means of controlled experimentation. The 'Philadelphia school' of lithic research would plausibly provide a very similar answer. Not only are the descendants of this school responsible for establishing seminal experimental research programmes all over the Anglophone research sphere, controlled experimentation has already played a key role in the formulation of the 'Reduction Thesis' itself. In general, lithic experiments are designed to bridge 'theory' and 'data,' as well as to assist in the construction of general reduction models and to verify them through direct observation (cf. Shott et al. 2000; Dibble and Rezek 2009; Lin et al. 2017).[447] They have a two-fold purpose: on the one hand, they help to isolate potential causal factors, determinative principles, and 'laws of reduction' which might have given shape to varying reduction phenomena; on the other hand, they enable to investigate under laboratory conditions how these factors interact with one another and what the results of these interactions are. The subsequent comparison of experimentally attested regularities with empirical patterns in real lithic assemblages is a classic mechanistic signature. Dibble's own doctoral dissertation *Technological Strategies of Stone Tool Production at Tabun Cave* (1981), for instance, has adopted this research strategy.

Experimental reasoning also constitutes the epistemological backbone of the 'scraper reduction model.' The model rests on a number of key experimental studies that established a constitutive relationship between limited numbers of independent lithic variables. It is only through this experi-

[446] As the examination of lithic imagery in Chapter 3 shows, these images therefore form a somewhat original category of scientific visualisation. Their explanatory role, however, can only be understood if the 'mechanistic' categories are unpacked; they simply serve to satisfy the epistemological needs of 'mechanism,' especially if it seeks to reconstruct *causal systems*.
[447] See e.g. Speth (1981), Pelcin (1997), Davis and Shea (1998), Dibble et al. (2005), Eren et al. (2005, 2008), Rezek et al. (2011), Lin et al. (2013), Iovita et al. (2014) and Magnani et al. (2014) for a sample of ongoing work in the domain of controlled experimental lithic research.

mentally attested status of two or more variables being 'causally adjusted' to one another that they may assume a place as *key variables* of mechanistic reasoning. The reason is of course that mechanism is committed to an 'integrative' approach in which epistemic *relevance* and *irrelevance* delineate areas of inquiry themselves. A not unimportant aspect of mechanistic explanations, in other words, is to explain away part of the available evidence (cf. Chapter 2). Experimental research to a large degree consists of the analysis of *flake formation*, that is, how a flake is made (cf. Rezek et al. 2016).[448] It typically quantifies the mechanical aspects of this process (e.g., Speth 1972) and uses mechanised and automated equipment (e.g., hydraulically powered knapping robots) to achieve this goal (**Fig. 21**). Interestingly, this research design represents a direct *imitation* or, perhaps better, *implementation* of the mechanistic root metaphor – the causally operating 'machine.' It also testifies to the already noted proclivity of mechanism to place the foundations of lithic inquiry on maximally 'objective' grounds whereby 'objectivity' is opposed to human interference and subjectivity (cf. Chapter 3).[449] As Lin et al. (2017: [8]) readily admit, this type of experimental research thus requires 'uniformitarian' assumptions. Having said this, such experiments for example established a strong interdependency between length and width when artefacts are continuously reduced and thereby paved the way for the 'scraper reduction model' (Dibble 1988, 1991a). Equally important was the discovery that surface and platform area of lithic artefacts appear to be systematically correlated and that the respective ratio can be understood as a relative measure for original blank size (Dibble and Whittaker 1981; Dibble and Pelcin 1995). This knowledge about original blank size is invaluable and enables the precise determination of reduction intensity since the 'missing' material can easily be calculated by subtracting the encountered blank size from the original blank size. Other cardinal experimental findings, for instance the patterned covariation between surface area and thickness (Holdaway 1991) or the significance of exterior platform angle configurations for producing certain flake types (Dibble and Pelcin 1995), delivered crucial supportive arguments to feed the reduction argument.

Many of these basic findings serve to establish and refine the *test implications* of the argument (cf. Dibble 1984: 110; 1995b: 324-332). Experimental findings, in other words, enable scholars to *predict* certain regularities among the lithic variables and to assess whether these regularities support the available hypotheses. All three elementary relationships on which the original 'scraper reduction model' is based – i.e., (i) that retouch intensity is related to different scraper types; (ii) that retouch intensity corresponds to length-reduction; and (iii) that the more derived scraper types (convergent, transverse) have small surface areas but comparatively large platforms (cf. McPherron 1994: 175) – were established in an experimental setting.

The role of experimentation in this research context is thus complementary to the status of 'theory' in 'analytic' science (Lin et al. 2017: Fig. 1; cf. Chapter 3). We are now in a position to appreciate why. As shown by Dibble's approach and the role of controlled experiments in the construction of the 'scraper reduction model,' the employment of *experimental reasoning* is essentially an attempt to 'objectify' the 'context of discovery' which is typically discredited for its 'psychologised' and 'subjective' nature. By means of experimentally adjusting lithic variables and exploring the general space of variable interaction, correlations and relevant 'primary qualities' can be identified and discovered *before* primary data-analysis begins. Experimentation can thus fill the conceptual void between 'subjective' theory-creation and the 'objective' assessment of theory-derived test implications (cf. Chapter 3). Arguably, 'experimental reasoning' have already supplanted purely 'theoretical reasoning' in many branches of Anglophone lithic research because of this reason.

This 'experimental mode of inquiry' – an approach to experimental testing modelled on physics and other key experimental sciences – has its origin in the 'scientific turn' of the 1960s.[450] From

[448] It is possible to argue that experimental research in this tradition is an attempt to build a specialised 'formation theory' – a theory that is dedicated to explaining the fossilisation of lithic artefact properties under varying conditions (cf. Schick and Toth 1993, 2001; Shea and Klenck 1993; Barton and Riel-Salvatore 2014; McPherron et al. 2014; Kuhn and Clark 2015; Dibble et al. 2017: Fig. 4, 830-837).

[449] As already argued in some detail in Chapter 3, this 'objectivist' understanding of experimentation based on 'causality' and 'predictability' is not shared by French experimental research which relies more strongly on *personal insight* and an 'understanding-based' recognition of processes and technical relations. We can now appreciate the reason for this discrepancy: the Anglophone notion of experiment is modelled upon the *experimental sciences*, especially physics, and therefore tends to interpret the very concept of 'experiment' mechanistically.

[450] Eren et al. (2016) refer to this type of archaeology as 'hypothesis-driven' and regard the *replication* of lithic artefacts as a key feature of such an 'objective' and 'scientific' archaeology. 'Replication' is here considered to be synonymous with *prediction*. It engenders a mode of *explanation* proper to 'mechanism.'

early on, controlled experiments were seen as an indispensible ingredient of a truly 'scientific' approach to the Palaeolithic past. Unsurprisingly, experimental research thus quickly became an integral element of the multidisciplinary research architecture of Clark Howell and Desmond Clark's *Paleoanthropology* (1966) or Glynn Isaac's *Human Origins* (1989). This 'Berkeley era' was a significant historical moment not only because it marks the synergetic fusion of research traditions from the U.S. and the U.K. and hence the proper birthplace of a joint Anglophone research endeavour in Palaeolithic archaeology, but also because it cemented the status of experimental research as a basic pillar of inquiry in the study of human beginnings (cf. Isaac 1967; Schick and Toth 2001). The work of Kathy Schick (1986, 1987, 1997) and Nicolas Toth (1982, 1985, 1991, 1997) on lithic assemblage formation and the dynamics of tool-making are outstanding examples of this research trajectory (cf. Toth and Schick 1983; Reti 2016). Again, the central aspiration of these investigations was to illuminate the 'dynamic processes that are responsible for the observable patterns of an essentially static record' (*sensu* Binford 1972).

This guiding principle of the 'static' record and the 'dynamic' past, adopted by Binford and many others, is co-extensive with the classic mechanistic distinction between 'pattern' and 'process.'[451] As Binford (1981b: 25, 1983b) himself has made clear on several occasions, the corresponding figure of speech is more than just a "matter of talking," it entails an *epistemological thesis* – namely that the archaeological record has to be understood as a *contemporaneous phenomenon*.[452] This recognition cannot be overemphasised for its epistemological ramifications are tremendous. The first and perhaps most important consequence is that because the record is 'static' and its patterns only *observable* in the 'present,' we need to develop knowledge about general relationships between 'pattern' and 'process' in this present *before* we can competently advance to the 'dynamic' aspects of the Palaeolithic past. The major reason for this inferential detour is the particular mechanistic understanding of *equifinality* (see *supra*). Since similar patterns might be driven by vastly different processes, one cannot simply infer process from pattern. The implication is clear: 'abductive' reasoning has to be banished and 'inductive' inference becomes problematic. The only prospective answer to the problem is offered by an axiomatic reconfiguration of the discipline around the principles of 'actualism'/'presentism' (cf. Toth 1991; Rossignol 1992: 4; Schick and Toth 1993; Pobiner and Braun 2005; Toth and Schick 2001, 2009a; Pickering et al. 2009) and 'uniformitarianism' (cf. Cameron 1993: 43-54; Shea 2011c)[453]:

> "Among Binford's principal original contributions was his insistence that the correlations used to infer human behavior from archaeological data had to be based on the demonstration of a constant articulation of specific variables in a system. He argued that all analogies were inconclusive, whether they were based on worldwide evidence or were homologies drawn from the same cultural tradition as the archaeological data being interpreted. Instead, all behavioral explanations of archaeological material had to be based on a lawful demonstration that in the living (actual) world there was a constant correlation between a particular form of human behavior and a specific type of material culture." (Trigger 2007: 399f.)

Thus, the constitutive relationships that hold specific patterns and specific processes together under particular conditions must be assumed to convey *constants of reality* – otherwise there is no hope of ever gaining 'objective' knowledge about the past (e.g., Binford 1983b: 18). The target *universally* valid interdependencies, however, are not interpreted as abstract concepts or 'subsistent' categories, but rather as properties – 'regularities,' 'laws,' or 'principles of determination' – of the causally integrated spatiotemporal field we call planet earth. The presence and the past are connected by their participation in the same mechanistic machinery and this machinery, following Bunge (2013: 590), can be

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[451] Cf. Chapter 2.

[452] Cf. "[...] It seems to me we must begin with certain fundamental statements of "being as such." *The archaeological record is a static contemporary phenomenon*." (Binford 1981b: 25; original emphasis)

[453] Following Cameron (1993: 43), I acknowledge that the notion of 'uniformitarianism' can be broken down into at least three variants, each of which may serve different epistemological purposes: *substantive uniformitarianism*, *methodological uniformitarianism*, and *associative uniformitarianism*. The 'substantive' variant argues that similar observations about the past and present can be correlated and explained by a constant rate or variable (e.g., the amount of C^{14} in the atmosphere); 'methodological' variants seek to derive general principles from the present correlations to guide inquiry into the past (*ibid.*: 42); and 'associative' uniformitarianism asserts that certain regularities in the association artefacts in the past must tell us something about the unobservable (and perhaps unique) behavioural and social processes of the past (*ibid.*: 43). With Pepper (1942), we can see that the first two variants serve the epistemological goals and principles of 'mechanism,' whereas *associative utilitarianism* tends to be summoned in 'formistic' approaches (see previous part of the chapter).

modelled as an ordered quadruple of *composition-environment-structure-mechanism*. Binford (1972: 106), for example, explicit called attention to the "interface between a living system and its field."

The central problem is always how one ought to deal with the disconnect between *Appearance and Reality*, a disconnect that is severely aggravated in the deep time context of Palaeolithic archaeology where not even the protagonists are invariable. At any rate, the entire suite of 'Middle Range Theory' (MRT) brought to bear by Binford and others, partly as a consequence of the interpretive impasse of the 'Binford-Bordes debate' (cf. Trigger 2007: 405-407), and its *ethnoarchaeological* research mandate can be understood as an attempt to deal with the difficult relationships between 'pattern' and 'process.' [454] The development of a generalised archaeological 'formation theory'[455] by eminent figures such as Brain (1967, 1981), Ascher (1968), Binford (1978, 1979, 1981a), Schiffer (1983, 1988), as well as Isaac (1976, 1981, 1989) and his students (e.g., Bunn et al. 1980; Bunn 1982, 2007; Kroll and Isaac 1984; Potts 1982, 1988; Blumenshine 1987; Pobiner and Blumenshine 1993; Kroll 1994) was motivated by the same problem (cf. Speth 2011: 134; Lucas 2012: 93-104).[456]

The question that was prompted by this research was of course what the most productive uniformity assumptions are and whether they may differ in varying contexts of application. Potts (1988), for instance, maintained that while early hominins clearly left patterns of 'butchering' debris in the archaeological record, the actual composition of the debris is often not even broadly analogous to butchering sites of present day hunter-gatherer groups; and that it may in fact well be that 'hunting' chimpanzees provide the better frame of reference in this case (cf. Cameron 1993: 44f.). Problems like this, however, only recalibrated the discourse and underlined that the search for the appropriate *frames of references* to reconstruct coupled systems of 'pattern' and 'process' was as important as doing 'actualistic' research (cf. Gowlett 1997, 2002, 2009; Binford 2001; Lycett et al. 2007; Toth and Schick 2009b; Shea 2017a, 2017b). The emergence of a 'primatological' branch of experimentation and field observation (e.g., Toth et al. 1993, 2006; Pickering and Wallis 1997; Plummer and Stanford 2000; White and Toth 2007; Pobiner et al. 2007) is a noteworthy example of the increasing expansion of this mechanistic mode of inquiry.[457] The guiding question, however, is always how one can bridge archaeological patterns and the putative processes that may have shaped them. Since the quest for such dependencies is essentially the attempt to grasp the working principles of particular causally integrated systems governed by 'primary' and 'secondary laws,' this entire species of research leans heavily towards mechanistic world theories.

4.2.3 *Adaptive interfaces, first-movers, and the environmental question*

The third and final example of persistent mechanistic tropes in Anglophone Palaeolithic research takes up the general character of the wider lithic discourse centred on hominin-environment interactions. There is no doubt that the 'environmental question' – i.e., whether and, if so, to what effect human

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[454] It has to be said, however, that research relying on 'Middle Range Theory' (MRT) is not automatically committed to a 'mechanistic' worldview. What makes a key difference is usually whether MRT is based on clear-cut uniformitarian principles – i.e., laws and other universal causal processes – or whether it is propelled by (statistical) analogies – i.e., ethnographically attested regularities. While the former tends to support 'mechanistic' modes of inquiry, the latter may easily sustain 'formistic' reasoning. The reason is of course that MRT-analogies often identify 'participation in patterns' as a precondition for secure knowledge formation (for the underlying difference between 'uniformitarianism' and 'analogical reasoning,' see Cameron 1993). In general, MRT has thus the capacity to unify the 'analytic' approaches to the past.

[455] 'Formation theory' is defined here in rather broad terms, as a collection of various approaches that address *site* and *assemblage formation processes*. My definition follows Lucas' (2012: 74) use of the term.

[456] As Bleed (2001: 109) correctly notes, the concept of the 'reduction sequence,' in contrast to the French *chaîne opératoire*, has been developed in close interaction with 'formation theory.' One may in fact argue that the reconstruction of reduction sequences often amounts to applying formation theory (cf. Dibble et al. 2006; Egeland 2008; Braun et al. 2008b). Richter (2018: 47) is therefore right in saying that the term reduction sequence most of the time simply accounts for a 'transformational analysis' of stony raw materials in order to understand the involved *site formation processes* (SFP) [in the sense of *Transformationsanalyse* (see e.g., Uthmeier 2004)]. Depending on the research interests of individual scholars and their scientific background, differential emphasis is thereby placed on the elucidation of 'n-transformations' and 'c-transformations' (*sensu* Schiffer 1976).

[457] As Van Reybrouck (2012: 321-323, Figure 22) has shown, the Anglophone use of primatology-derived information to render the Palaeolithic past intelligible has engendered a constant move back-and-forth between *similarity-based holistic projection* and *causality-based attribute transfer*. In essence, these two alternate strategies of bringing primatological information to bear on the interpretation of the past help further solidifying the thesis that Anglophone *Human Origins* research, maximally broadly and inclusively defined, is characterised by the general discursive tension between 'formistic' and 'mechanistic' tendencies. What Van Reybrouck terms 'similarity-based holistic projection' may well reflect the type of correlative-associative thinking promoted by 'formism,' while 'causality-based attribute transfer' sounds suspiciously 'mechanistic' insofar as it insinuates domain-independent causalities governing organismic behaviour in general.

evolution is propelled by eco-climatic forces – continues to galvanise both individual scholarship and collective research programmes (e.g., Clark 1984; Potts 1996b, 2013; Petraglia and Korisettar 1998; Van Andel and Davies 2003; Shea 2003; O'Connell 2006; Petraglia 2006; Stringer 2006; Marean 2007; Petraglia and Allchin 2007; Jones 2007, 2010; Barker et al. 2007; Petraglia et al. 2007, 2009a, 2009b, 2012; Riel-Salvatore et al. 2008; Wragg Sykes 2009; Boivin 2010; Potts and Sloan 2010; Petraglia and Rose 2010; Riel-Salvatore 2010; Lycett and Norton 2010; Pettitt and White 2012; Barker 2013, 2017; Foley et al. 2013; Dennell 2013; Kuhn 2014 [1995]: 166; Johnson 2014; Petraglia and Boivin 2014; Popescu 2015; Davies et al. 2015; Roberts et al. 2015; Groucutt et al. 2015; Barker and Farr 2016; Clark and Baron 2017; Boivin et al. 2017; Roberts 2017; Robinson and Sellet 2018);[458] the study of lithic technology is also increasingly seen as branch of 'behavioural-strategic' research (Kuhn 1993: 25-27; Shea 2013a: 13f., 2015),[459] in which environmental constraints are a prominent target of investigation and often play key roles in explanatory endeavours. Generally speaking, this pivotal status of the environment in Anglophone lithic research is hardly surprising from a Pepperian point of view. As leading experts of the 'strategic' or 'ecological' approach would readily admit (e.g., Torrence 1983, 1989a; Bamforth 1988; Nelson 1991; Kuhn 1995; Henry 1995; McCall 2007, 2015; Surovell 2009; Shea 2011b; Carr and Bradburry 2011; Bettinger et al. 2015), their central objective is to elucidate *systems of behaviour*, rather than simply describing and explaining distinct assemblages or artefact occurrences (cf. e.g., Isaac 1980, 1981; Butzer 1986; Blumenshine et al. 2012). In mechanistic terms, these 'systems' must be recognised as operating in a specific 'environment,' providing some of the relevant external *stimuli* to which hominins, just like any other organism, must respond (cf. Pepper 1942: 226f., 228). Since mechanism predicates the 'specifity of response,' both the 'structure' and the 'configuration' of past behavioural expressions must somehow be linked to the environmental conditions in which they occur. Usually, this requires the introduction of a general *mechanism* connecting environment and behaviour and rendering the observed patterns of behaviour *consequential*, that is, they are shown to be unsurprising. In this way, systems of behaviour can come into view as causally integrated wholes. They encapsulate a 'behavioural machinery' with a specific 'field of locations' and distinct regulatory 'principles' and 'laws.'[460] This basic research configuration clearly resonates with Torrence's (1989b: vii) directive "to look at the general causes lying behind the variability in stone tool form and production," and reproduces the ordered quadruple *composition-environment-structure-mechanism* which Bunge (2013: 590) has identified as the conceptual bedrock of mechanistic world-making. Shea (2013a), in a similar vein, characterises the resulting rationale of 'behavioural-strategic' inquiry in the following manner:

> "[Behavioral-strategic] approaches place more emphasis on reconstructing particular aspects of prehistoric behavior and less on formal taxonomic divisions among lithic assemblages. [...] These studies focus on technological variation among cores, flakes, and retouched tools, related to "strategic" variation in raw material economy, mobility patterns, artifact designs, and tool curation. Most practitioners of technological organization approaches are less concerned with evaluation the relative significance of different behavioral factors, such as residential versus logistical mobility, and their correlated technological strategies in the formation of particular archaeological assemblages." (*ibid.*: 13f.)

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[458] A number of influential idea and theories revolve almost exclusively around the environmental theme: Potts' *environmental variability hypothesis* (1996a, 1996b, 1998, 2007, 2012a, 2012b, 2013), according to which human evolutionary history parallels the earth's environmental history (cf. Behrensmeyer et al. 1992; Potts and Sloan 2010); Finlayson's *water optimisation hypothesis* (2013, 2014) and his *glacial refugia hypothesis* (2004, 2008, 2009; cf. Finlayson et al. 2000, 2012; Finlayson and Carrión 2007); Mellars' *'Garden of Eden' hypothesis* (2002, 2006, 2009); Marean's *'Aquatic Paradise' hypothesis* (2007, 2010, 2011); and Ambrose's *volcanic bottleneck hypothesis* (1998, 2003; cf. Hoffecker 2009; Jones 2012).

[459] Shea (2015) has recently noted that the 'strategic' approach to hominin behaviour owes a great debt to the provocative connection between John Tooby, anthropologist and co-founder of the "hard" *Evolutionary Psychology* programme (cf. Cosmides and Tooby 1987, 2009), and Irven DeVore, student of famed primatologist Sherwood Washburn and co-editor of the seminal *Man the Hunter* volume (Lee and DeVore 1968). He re-casts their joint paper *The reconstruction of hominid behavioral evolution through strategic modelling* (Tooby and DeVore 1987) as a founding document of the strategic approach. An important aspect of this approach, then, is that it crosscuts the human-animal boundary or any other species-level differences for that matter – it is "substrate-neutral." Although Shea's argument concerning the specifics of intellectual inheritance will surely be contested by others, it assures us of the general epistemological affinity between socioecological reasoning, *Evolutionary Psychology*, and strategic research endeavours in Palaeolithic archaeology. Interestingly, Lee and DeVore's 1987 paper in fact addresses an until this day largely unresolved issue, namely the conceptual and methodological integration of *Behavioural Ecology* and *Evolutionary Psychology* (see Shea 2011c for a number of archaeological problems related to this issue). The strategic approach, in other words, holds his share in the scientific effort to render the study of behaviour a unified and universal enterprise. The call for a general theory of behaviour (O'Connell 1995) is a distant call of the same 'foundationalist' ambition (cf. Van Reybrouck 2012: 227).

[460] Cf. Chapter 2: esp. **Box 7**.

Isaac's (1978, 1980, 1981, 1989) landscape-ecological reconfiguration of Lower Palaeolithic archaeology in Africa – epitomised by his memorable desideratum of 'casting the net wide' (cf. Sept and Pilbeam 2012) – may count as an early attempt to adopt a 'behavioural-strategic' research perspective. His 'palaeogeographic' approach (cf. Behrensmeyer 2012) shifted the attention away from well-stratified, high-quality sites to the organisation of hominin activity on a landscape scale.[461] The perhaps central departure from conventional approaches to the lithic record concerned this notion of the *site* itself (cf. esp. Dunnell 1992).[462] Isaac emphasised the enormous informational value of doing 'off-site archaeology' or even 'non-site archaeology' (cf. Foley 1981; Ebert 1992) and of systematically surveying and mapping mini- and nano-sites, low-density scatters, and other artefactual occurrences indicating hominin activities 'between the main artefact patches' (Isaac and Harris 1980; cf. Isaac et al. 1981). The whole point of this new research strategy was to conceive of lithic technology as an active participant in geographically-framed systems of artefact production, transport, utilisation, and eventual discard (cf. e.g., Blumenshine and Masao 1991; Blumenshine et al. 2003, 2008, 2009, 2012; Plummer 2004; Braun 2006, 2013; Braun et al. 2008a, 2009):[463]

> "The landscape paleoanthropological approach was adopted to broaden the site-scale focus of Leakey's excavations to the whole lateral extent of Oldowan-aged deposits, including those with less conspicuous or no apparent archaeological occurrences (Isaac et al., 1981). Similar approaches described collectively as landscape archaeology (e.g., Wandsnider, 1992) include "off-site archaeology" (Foley, 1981), "non-site archaeology" (Thomas, 1975), "siteless survey" (Dunnell and Dancey, 1983), "scatters-between-the-patches" (Isaac and Harris, 1978), and "distributional archaeology" (Ebert, 1992). None of these approaches assume that high-density artifact occurrences, such as many of those excavated previously at Olduvai, are representative of hominin activities involving material discard. Rather, individual artifact/bone occurrences in the landscape array are material traces of different phases of a subsistence continuum (cf. Binford,1982), which had been demonstrated for Olduvai's Oldowan to include the acquisition, processing, transport, and use of stone and carcass resources (Stiles et al., 1974; Bunn, 1981; Schick, 1987; Toth, 1987)." (Blumenshine et al. 2012: 248)

Isaac (1986: esp. Fig. 15.6; **Fig. 22**) explicitly contends that one has to abandon the notion of lithic items or toolkits as 'fixed' or 'static' entities and instead regard them as ""fallout" of more complex systems of artefact extraction and management." Geographic space, in other words, is viewed as a medium in which a network of activities with more or less delineated artefact patches becomes apparent. This conception not only takes up the productive tension between 'static' and 'dynamic' (see previous section), but also considers the question of where a site begins and where it ends as meaningless; the distinction between 'sites' and 'empty space' between them becomes practically arbitrary. Hominin behaviour is regarded to act as an 'irrigating' force that potentially covers up the entire landscape and produces a "veil of stones" of varying density and composition (*idem*).[464] The recognition that, realistically, this 'stone curtain' must be conceptualised as a *continuous* entity is extremely crucial. Isaac's model of hominin land-use pictures geographic patterns in the lithic data as the result of an 'integrated spatiotemporal system of behaviour' in which any residual discreteness is resolved. The system itself,

[461] For an early example of this lasting re-orientation of Palaeolithic research in Africa, see Harris and Isaac (1976).

[462] In prototypical mechanistic fashion, Dunnell (1992) problematises the 'reality' or 'relevance' of a *site* as a unit of observation and analysis. He (*ibid*.: 21f.) argues that the concept is defective and hampers the recognition and appropriate interpretation of the continuous distribution of artefacts on the scale of a landscape and underestimates the contemporaneity of much of the observable patterns (cf. Dunnell and Dancy 1983). Instead of a site-centred approach to the past, Dunnell (1992: 33-36) proposes a 'siteless' approach in which individual artefacts constitute the smallest units of observation. As we will see below, this represents a classic 'mechanistic' position.

[463] This distinct approach to landscape-scale hominin behaviour is consistent with what Rossignol (1992: 4f.) has outlined as the *landscape approach* contrasting with interpretive landscape archaeology in the wake of Tilley, Hodder, Bender, Thomas, and Roberts: "[w]e define *landscape approach* as the archaeological investigation of past land use by means of a landscape perspective, combined with the conscious incorporation of regional geomorphology, actualistic studies (taphonomy, formation processes, ethnoarchaeology), and marked by ongoing reevaluation and innovation of concepts, methods, and theory. This landscape approach not only provides a common theater for a variety of archaeologists to interact, but, more importantly, it provides a directed, but flexible, orientation for theory building. In other words, our landscape approach addresses regional-level problems in archaeology by capitalizing on the interaction among regional-level geological, ecological, and actualistic studies. This framework takes inspiration from Butzer's contextual approach (Butzer 1982; see also Hassan 1979) and Foley's regional taphonomic and off-site approach (Foley 1981a, b). Our landscape approach differs substantially from landscape archaeology. Because of their explicitly historical emphasis, method and interpretation of landscape archaeologists do not incorporate ecological and geological system variables. Both British and American practitioners of landscape archaeology assert an historical and (Hodderian) contextual focus for the discipline (Roberts 1987; Deetz 1990; Crumley and Marquardt 1990)." (original emphasis)

[464] Note that this realisation prompted a number of important methodological changes in how one would "sample" a palaeoanthropological landscape by systematic and semi-random test-trenches on a lager geographic scale (cf. Blumenshine et al. 2012: 248).

therefore, ultimately comes into view as a unified field structure. Hominin behavioural systems thus become intelligible as 'fields of locations,' as differentially configured activity fields with continuous breakpoints. The various 'locations' are connected by hominin movement, and the transport and discard of lithic items – sometimes in a randomised fashion, sometimes planned (cf. **Fig. 22**). In an important sense, sites and other pseudo-discrete aggregates of lithic artefacts therefore describe *metastable states* – locally materialised potentiality of the integrated system.[465]

The 'fallout metaphor,' employed by Isaac (1986) himself, provides indirect support of this interpretation. A 'fallout,' generally speaking, is the product of radioactive decay or the entropy of a system and always affects a larger geographic area; it typically becomes manifest as a constant rain of atomised matter. The point is that in the case of hominin behaviour, the fallout metaphor suggests that varying configurations of artefacts are *realisations of field properties*, i.e., a consequence of the basic 'geometry' of the underlying causally-integrated field (*sensu* Pepper 1942: 215).[466] Alternatively, we may understand the use of the fallout metaphor as a convenient means to indicate that lithics represent 'derived' categories of reality whose 'primary structure' is laid out by the respective behavioural system and its regulatory mechanisms. The 'veil of stones' conveys the particular 'appearances' that are correlated with this 'primary structure.' In mechanism, the concept of 'emergence' is usually mustered to describe this specific relationship between the 'primary' and 'secondary' categories of existence (cf. *ibid*.: 217).[467] In any case, this conceptual exposition makes clear that Isaac's landscape-ecological approach tackles hominin behaviour as an expression of a broader spatiotemporal machinery whose 'composition,' 'environment,' 'structure,' and 'mechanism' need to be disclosed (*sensu* Bunge 2013). The explanation of lithic reality is therefore *subsumptive* (*ibid*.: 591) – individual artefact occurrences and characteristics are explained by organisation and functionality of the behavioural system in question. The approach thus clearly carries the sparks of a 'consolidated' mechanism (cf. Pepper 1942: 212-221).

As Blumenshine et al. (2012: 248) have remarked, one of the main challenges of the landscape-ecological approach is to actually advance from the landscape evidence to critical aspects of 'hominin ecology'. The problem is that the evidence for hominin behaviour on a geographic scale – in part also because of the immense methodological and practical issues that such an approach has to overcome – is typically "too fragmentary and incomplete" to serve as the sole baseline for reconstructing hominin ecology (*idem*). Symptomatically, Blumenshine et al. (*idem*) therefore suggest to rather view the landscape-ecological approach as an instrument to test and refine *substantial theoretical models* of hominin ecology; this explicitly model-based procedure, in their view, would pave the way toward a more fruitful engagement with past behaviour and ecology. Based on earlier work on interface between landscape ecostructure of the Olduvai basin, including the distribution of key resources, and hominin site composition and distribution therein (cf. Peters and Blumenshine 1995, 1996), Blumenshine and Peters (1998) offer a predictive model of Lower Palaeolithic hominin ecology in the area to accommodate this demand. This model is intended to derive testable predictions about the interlinkages between "particular landscapes, particular hominids, and their associated technologies in a particular time and space" (*ibid*.: 568). Blumenshine and Peters (1998) explicitly note:

> "In order to use the archaeological record to test hominid land use models, hominid behaviors must be linked predictively to their material traces by causal ecological mechanisms related to the ecostructure of specified landscape facets [...]." (*ibid*.: 571)

In a first step, Blumenshine and Peters (1998: 569, 571) reconstruct the abundance and variety of 'affordances' (*sensu* Gibson 1977) tied to varying 'landscape facets.' This landscape facet represents a relatively homogeneous local landscape-segment which broadly corresponds to a general habitat type

[465] See the previous section for an explanation of the concept of 'metastability' and its relevance for 'mechanism' in conceptualising lithic reduction processes.

[466] Cf. "It is even possible to conceive of atoms popping in and out of existence all over the field, so long as their popping should conform to the structure of the field. That would, after all, be the fully discrete treatment of atoms in the field. The fact that we instinctively reject the idea indicates that a fully discrete mechanism has never been seriously contemplated." (Pepper 1942: 203)

[467] 'Emergence' is therefore typically defined as 'weak' insofar as an intimate connection to the respective 'primary structure' of reality is maintained (see e.g. Greve and Schnabel 2011 for a discussion of 'weak' versus 'strong' emergence). This not only ensures that 'mechanism' can sustain its 'bottom-up' research agenda, but also shows that the role of the concept is to explain the directed transition between 'reality' and 'appearance,' rather than to theorise the reality of system-level properties that are more than the sum of their parts. In mechanism, 'weak' emergence simply signals the correlatedness and structural quasi-identity" of the 'primary' and 'secondary' categories of reality.

(*ibid*.: 569). The 'affordances' of this landscape facet are defined as the sum of the possibilities for interaction that result from the combination of its properties, substances, and surfaces (*idem*); the associated potential for 'hazards,' i.e., the structure of risk tied to certain interactions, is also included. Blumenshine and Peters (*ibid*.: 571) argue that the character of these facet 'affordances' ultimately *determine* the nature of the encountered artefactual traces. In a second step, different landscape facets and their material lithic and non-lithic correlates are compared in order to isolate inter-landform differences in hominin-affordance interactions (*idem*). In a third and final step, then, these patterns of eco-behavioural co-variation are shown to be the inevitable consequence of particular *ultimate* and *proximate* mechanisms (*ibid*.: 571f.).[468] As proximate mechanisms, the authors discuss several breakage patterns of bone and stone linked to particular extraction and knapping behaviours (idem), whereas ultimate causes are identified as various "ecological mechanisms" (*ibid*.: 572-580, Figure 1). These mechanisms define a *causally and functionally integrated system of hominin-landscape interaction* with distinct and largely unambiguous empirical correlates. Blumenshine and Peters (*ibid*.: 572-578) for example list varying scavenging opportunities ('scavenging affordances') and changing levels of inter-carnivore competition for carcass-access as primary ecological mechanisms. They further maintain that the function and transport-patterns of lithic artefacts reflect the technological organisation of hominin activities and that the two can directly be linked to the ecological mechanisms in terms of the density and composition of archaeological occurrences – distance to the nearest raw material sources ('flow model') and activity-relative safety play key roles here (*ibid*.: 578). We do not need to go into the details of their certainly impressive account in order to recognise that their reasoning is thoroughly mechanistic. The behavioural system[469] they wish to reconstruct is re-cast as a *causally determined structure* in which the relevant constitutive relationships are singled-out, described, and linked to each another;[470] truth is secured and knowledge corroborated by means of *causally adjusting* the specified factors of reality. Prediction amounts to a key operation (cf. *ibid*.: 595-599) and, insofar as the predictions can be successfully tested, is *co-extensive* with explanation.[471] Again, lithic technology comes primarily into view as a 'derived' phenomenon – as a 'problem-solving' device that responds to the more basic stimuli of its operating environment (*sensu* Pepper 1942: 226-228).

Braun et al.'s paper *Landscape-scale variation in hominin tool use: evidence from the Developed Oldowan* (2008a) subscribes to a similar approach.[472] The authors use techniques of digital-image analysis to accurately measure lithic core reduction intensities, which they proxy by the ratio between single platform core mass and the relative platform area of the core. They then map the aggregated values of calculated 'reduction intensity' onto the palaeogeographic setting in which the respective cores have been discarded (*ibid*.: Fig. 5; **Fig. 23**). Although the pattern does not conform to the 'flow model' or 'distance-decay' scenario of raw material use,[473] which would predict an intensifica-

[468] The distinction between 'ultimate' and 'proximate' mechanisms in evolution has been popularised by Tinbergen (1963, 1965). Tinbergen proposed to place the study of behaviour on his famous *Four Whys*: (i) causation, (ii) adaptation, (iii) phylogeny, and (iv) ontogeny. While Tinbergen's ethology was essentially conceived as a 'mechanistic' science, he maintained that multi-causal explanation is often superior to mono-causal accounts. He stressed, however, this condition requires the analyst to neatly discriminate between different kinds of causes. The distinction between 'ultimate' and 'proximate' causation also served this larger purpose. 'Ultimate' mechanism are the 'first causes' and most elementary explanations for a given phenomenon. An ultimate explanation for a phenotype would be its genotype or its shape-giving selective pressures. 'Proximate' mechanisms, by contrast, are 'secondary causes' [*Wirkursachen*], that is, the more immediate reasons that lead to certain behaviours. Such reasons are often directly tied to the physiology or ecology of the organism in question.
[469] For an explicit usage of the term 'behavioural system,' see e.g. Tyron and Potts (2011: 376, 383).
[470] Cf. "The direct and indirect causal pathways involved in deducing archaeological patterning from the ecostructure of landscapes are complex (Figure 1). Nonetheless, our predictions about trace fossils of hominid landscape interactions rest upon two simple principles." (Blumenshine and Peters 1998: 600)
[471] Cf. "Our ability to identify the source(s) of potential flaws in the models, and therefore to revise them in ways that reflect this improved understanding of prehistoric hominid ecology, is enhanced by the systematic and explicit manner in which the predictions are generated. Even if the precise source of the flaws eludes us, the structure of the land use model (Figure 1 and Tables 1 through 3) serves the valuable function of systematically organizing thought on a subject matter that traditionally has been treated inductively with respect to the archaeological record, and that has generated no independent and incisive test implications." (Blumenshine and Peters 1998: 600)
[472] Cf. "[…] Variability also appears as a major feature of the Oldowan archaeological record. This may be the result of the numerous hominin species that existed throughout the Oldowan period (Delagnes and Roche 2005). Yet a more testable explanation is that Oldowan behavior is very sensitive to its ecological context (Plummer 2004). If this is the case, paleoecological analyses conducted in concert with Oldowan archaeological projects is crucial. If Oldowan archaeologists can understand behavioral patterns relative to varied environmental contexts, it may be possible to really understand the ecology of early Pleistocene hominins." (Braun 2013: 342)
[473] For discussions and applications of the 'distance-decay model' (Renfrew 1969; Clark 1979), see e.g. Dibble (1995c), Roth and Dibble (1998), Brantingham (2003), and Blumenschine et al. (2008: 78).

tion of lithic reduction as the distance to the nearest raw material source increases, the authors are able to show that palaeogeographic discard patterns exist and that there is a trend towards increasing reduction intensity as one moves away from water bodies. Braun et al. (2008a: 1061) add that the respective transport decisions also show that the assessment of the potential use-life of the objects probably played a significant role. They (*idem*) conclude that this behaviour reflects a strategy of 'mitigating the risks associated with a subsistence pattern that requires sharp-edged tools.' This study not only showcases 'causal-adjustment reasoning' and the use of standard-predictions (*ibid.*: Fig. 6) to facilitate interpretation, it is also decisively 'integrative.' The distribution of lithic assemblages in the wider landscape is effectively explained by a *single measure* – a measure that is argued to causally bridge hominin activity and ecology.

Jochims' (1991, 1998) model of the relationship between hominin settlement pattern and environmental structure provides another illustration of the mechanistic reconstruction of causally-integrated behavioural systems. The author (1991: Figure 1) theorises the basic causal-determinative linkages that define the temporal and spatial axes of such an integrated system (**Fig. 24**). The model entails specific predictions designed to guide the examination of particular empirical cases. It pays particular attention to the relative strength of particular linkages and their relative symmetry under different conditions. The main regulating factor in the model is the nature of *environmental variability*. Jochim (*ibid.*: 311) simply recognises that some nomadic groups face temporally variable but spatially relatively stable environments, or the other way around. Alternatively, the hosting environments may be coevally variable or stable on both temporal and spatial coordinates. In general, he asserts that the temporal and spatial structure of the environment affects the abundance and distribution and thus the locational and temporal predictability of key resources (*ibid.*: 311-313). This, in turn, will shape the patterned association between the location of campsites, seasonality, and the activities carried out there. The result is the identification of five ideal-typical archaeological "signatures" (*ibid.*: 313, Figure 1: A-E; cf. **Fig. 24**). It is easy to see that this systemic articulation of environmental structure, resource availability and predictability, and human settlement pattern describes the mechanistic quadruple *composition-environment-structure-mechanism* (*sensu* Bunge 2013).[474] It is also clear that the various domains of reality are connected by directed 'causal chains' and that there is a simple 'hierarchy' among these chains: the environment constraints the resource potential, and the resource potential constraints human settlement:

> "If the various typologies of hunter-gatherers are taken as a guide, [...] [behavioral] variability is not necessarily characteristic of all groups, nor is it randomly distributed among them. Rather, it is directly related to characteristics of their natural environments: variability of behavior is directly related to variability in the environment. An examination of different sorts of environmental variability leads to some conclusions about the structure of behavioral variation." (Jochim 1991: 311)

Thus, the further up this chain a phenomenon is situated, the more 'derived' it appears. It must consequently be explained in terms of the qualities of the next lower stage of the chain. These seemingly derived qualities, then, are interpreted as 'secondary qualities,' while the *causing* qualities are identified as the 'primary qualities.'[475] The designation of 'primary' and 'secondary qualities' may of course change as one moves up and down the ladder. Yet, the important point is that conceptions like this rely on the 'hierarchy of response model' of ecological functioning (*sensu* Miracle 1995: 3; cf. Nelson 1991: Figure 2.1; Hoffecker 2002: Fig. 1.6; Steenhuyse 2007: 11-24; McCall 2015: Figure 2.4; **Fig. 25**). This notion is not only the hallmark of 'hard ecology' approaches, but reflects the mechanistic perception of the world as a 'layered cake' [*Schichttortenmodell*] (cf. Hahn 2013: 34; **Appendix II.3: Fig. II.1**),

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[474] Cf. "By recognizing and concentrating on the *variability* in settlement pattern and structural data, both within and among hunter-gatherer systems, it becomes possible to propose that patterns of organization relate to conditions external to the examined systems and to begin to do pattern recognition studies in these domains. [Julian] Steward, of course, was a pioneer in the investigation of the ecological relationships that hunter-gatherers maintained with their environment, and it may be that all of his work, his research in this domain constitutes our most important inheritance." (Binford 2001: 30; original italics)

[475] Talking about 'mediating' or 'intermediate' layers of reality – for example mobility – regulating environmental adaptation does not change this situation. These constructions simply spell out what it means to invoke a causal chain. In the case of mobility for example, lithic technology is typically construed as an adaptation to mobility requirements, that is, to the specific mobility system in place, but the mobility system is itself regarded to be an adaptation, namely to particular eco-environmental conditions (cf. Straus 1996: 95-96; Thacker 1996: 120-121; Bettinger 1998: vi; Riel-Salvatore and Barton 2004; Hopkinson 2004; Ambrose 2008). These constructions effectively increase the *focus* and *precision* to the analysis – two highly valued virtues in any 'integrative-mechanistic' framework of inquiry.

emphasising the 'bottom up' assembly of distinct compartments of reality.[476] Depending on the strength of the respective ontological claims, such approaches tend to adopt a more or less 'discrete' version of mechanism (cf. Pepper 1942: 195-212). This mechanism allows for residual 'discreteness' among its elements – in fact, discreteness turns out to be a crucial precondition of *externally relating* these elements.[477] The prototypical case of 'causal adjustment' – and thus of demonstrating 'cause-and-effect' relationships – consequently tends to support 'discrete' interpretations of mechanism,[478] rather than its 'consolidated' variant; in 'discrete' incarnations of mechanism, *heteronomic strategies* of explanation can more easily be maintained. The fact that Jochim (1991) frames his general model and its application to the South German record of the Magdalenian-Holocene transition as "long-term ethnography" finally illustrates that Pepper's world theories crosscut conventional academic divisions and that mechanistic reasoning is not just a matter of 'behavioural-strategic' or strictly 'ecological' approaches.

Mellars' (2001, 2006: x-xi, 2009) reconstruction of the dramatic demographic and social changes during Oxygen Isotope Stage 3 (ca. 50-30 kya), for instance, amply illustrates the kind of causal-inferential chain which is typically summoned by mechanists:

> "To cut a long story short, I argued that the rapid climatic and ecological changes of OIS 3 would inevitably have promoted major shifts in both the distribution and overall densities of human populations in different areas of Europe, which in turn would have led to a sharp increase in the frequency of population interaction, and direct competition, between the adjacent groups for both space and resources. All of these competitive social pressures, combined with the scale of the environmental changes themselves, would have had equally inevitable impacts on the subsistence activities and associated technologies of the human groups, leading to inevitable, if not entirely predictable, patterns of technological change. A number of social adaptations (such as the formation of larger residential units, or perhaps increased separation of individual economic and social roles within the individual groups) could be seen as equally plausible adaptations to the combined environmental and demographic pressures." (Mellars 2006: x-xi)

The highly influential 'Cambridge school' of *palaeoeconomics* established by Eric Higgs and his followers (cf. Coles and Higgs 1969; Vita-Finzi and Higgs 1970; Higgs 1972, 1975; Dennell 1983; Bailey and Parkington 1988) similarly stresses the derived nature of lithic technology and considered patterns of technological organisation as a specific response to the needs and characteristics of its correlated 'subsistence economy.' Higgs himself (1972, 1975) at times even came close to regarding lithic technology as a mere *epiphenomenon*. In the introduction to *Palaeoeconomy*, Higgs and Jarman (1975: 3f.) explicitly note that

> "[…] the primary human adaptation to the environment is the economy […]"

and

> "[p]alaeoeconomic studies lay their main stress on a basic aspect of human behaviour which can be shown to conform to predictable laws over long time periods."

The core business of the 'palaeoeconomic approach,' namely to reconstruct subsistence economies, was, in other words, thought to be in principle independent of what was regarded to constitute 'cultural data,' including stone tools (cf. Barker and Dennell 1976; Bailey 1999: 552-557). Although this view certainly represents an extreme voice in the wider Anglophone scene, it spotlights the potential ramifications of an extreme version of mechanism in lithic studies. By embracing a radical conception of a layered reality-assembly, Higgs was obliged to also adopt a radically 'integrative' stance. According to this position, only the economic conditions can count as 'real' since only they serve the immediate purpose of survival and livelihood. All other phenomena must consequently be thrown into the 'unreal.' Being 'unreal' in this sense does not necessarily imply that the phenomena in question do not exist, it simply points to the fact that they cannot claim to possess 'independent existence.' They can thus

[476] Within 'consolidated mechanisms,' the 'hierarchy of response model' is interpreted to suggest that there must be a 'first mover' – a *causal singularity*. This singularity ultimately confirms that only a single particular 'truly exists' (cf. Pepper 1942: 214). This single particular, in a perfect mechanistic world, is of course the fully integrated field structure itself.

[477] This is precisely the point where 'mechanism' is threatened to collapse into a refined version of 'formism' emphasising discreteness and similarity (see **Appendix II.2** for a detailed discussion).

[478] See for example Basell (2008) who employs an explicit 'push and pull' logic to explain the distribution of archaeological sites during the East African Middle Stone Age (MSA).

fully be reduced to their constitutive factors. In the conceptual language of mechanism, the respective phenomena amount to the 'ineffective' categories of reality; they describe merely the 'secondary qualities' of the more basic and hence 'effective' categories of reality. This epiphenomenalisation of lithic technology is just another symptom of the mechanistic exigency of negotiating the *Appearance and Reality* gap (see the previous section and *supra*).

What seems to guide most of these approaches, independently of their specific intellectual background, is the notion of a *functional-systemic equilibrium*. The objective of Anglophone mechanistic lithic research is often to find the precise conditions under which the functionally related components of a behavioural system – e.g., lithic technology, mobility, and the natural environment – can be said to be 'in balance.' The total system effectively inaugurates a principle of 'checks and balances' from which no component has reason to break out. The *equilibrium* describes a state in which the components are causally-related in such a way that changing one component would most likely change the whole system. Pepper's (1942: 227-230) principle of 'causal adjustment' is simply the specification of an *equilibrium* state in which the components causally enforce each other – 'causal adjustment' consist in the *causal coordination* of the 'effective' parts of reality. We can speak of *equilibrium* because the mechanistic logic implies a *symmetry* between 'push' and 'pull' or 'cause' and 'effect' (cf. Pepper 1942: 190). Within the framework of the 'behavioural-strategic' paradigm, equilibrium conditions are typically modelled as 'best' responses. In the extreme, the match or mismatch between *strategic equilibria* and actually realised responses may be taken as a measure for 'adaptive performance' (cf. Krebs and Davis 1978; Winterhalder 1981, 2001; Winterhalder and Smith 2000; Bird and O'Connell 2006).[479] Implicitly or explicitly, equilibrium reasoning is inspired by economic 'game theory' (e.g., von Neumann and Morgenstern 1944; Nash 1950), especially its evolutionary branch (e.g., Taylor and Jonker 1978; Maynard Smith 1982; Skyrms 2001, 2004), and typically feeds into 'Deductive Equilibrium Methodologies' that provide the cognitive resources to detect and analyse 'rational expectations' and phenomena such as 'Bayesian Nash Equilibria' (cf. Van Huyck et al. 1990).

Some of these economic ramifications of mechanistic thought will be taken up in the following sub-sections. I will first address the underpinnings of *Human Behavioural Ecology* (HBE) and of what is known as *Technological Organization* (TO) before discussing two specific economic approaches to reconstruct the "coming together" of stone tool technology and hominin behaviour.[480] These examples will help to further lay bare the epistemological stakes of mechanistic reasoning in Anglophone lithic studies.

'Human Behavioural Ecology,' 'Technological Organisation,' and the currency of causally-integrated systems of behaviour

The 'behavioural-strategic' (e.g., Hoffecker 2001, 2002; Odell 2001; Adler 2002; Elston and Brantingham 2002; Wallace and Shea 2006; Adler and Tushabramishvili 2004; Surovell 2009; Shea 2011b, 2013a: 13f., 2017a; Kelly 2013: Chapter 5, 2014; Churchill 2014) and the 'organisational approach' (e.g., Binford 1973, 1979; Torrence 1983, 1989c; Bleed 1986; Kelly 1988; Bamforth 1991; Nelson 1991; Bousman 1993; Kuhn 1995; Bamforth and Bleed 1997; Carr and Bradburry 2001, 2011; McCall 2007, 2015: 61f., 79-90), while representing the two main mechanistic lithic research frameworks, are built on broadly similar methodological and epistemological maxims and often overlap in practice. This is not to say that there are no important divergences and conceptual tensions between the two, but these are relatively minor and can be neglected for the present purpose. We have already seen that both approaches make productive use of the assumption that lithic technology is one of many factors contributing to an integrated spatiotemporal system of behaviour (cf. Tyron and Potts 2011).[481] Yet, technology is not just any factor; it represents the primary means with which hominins access their social and

[479] The study of 'maladaptation' is logically implied here. 'Non-adaptive' behaviour can then be defined as behaviour that deviates from the derived optimality expectations (cf. Jochim 1983).
[480] The latter two examples have been sampled from the recent volume *Lithic Materials and Paleolithic Societies* edited by Adams and Brooks (2009).
[481] For a specific emphasis on the aspiration of processual archaeologies to scientifically reconstruct 'behavioural and formational systems underlying the organisation of the archaeological record' (Rossignol 1992: 5), see also Willey and Sabloff (1980: 195) and Dunnell (1986: 38). Even 'adaptation' is understood as a systemic variable – as the 'congruence' or external relatedness of systemic components (i.e., cultural organisms and their environment) (Binford 1978: 3; cf. Rossignol 1992: 5, footnote 1).

natural environments, extract energy, and potentially change these environments. Technology, therefore, occupies a key position at the interface of compartments and domains of reality (e.g., Isaac 1977a, 1977b; Butzer 1977; Jochim 1981; Kuhn 2011; Kelly 2016: Chapter 3, esp. 28, 32).[482] It is this interfacing status that renders lithic technology fundamentally 'mouldable.' While the 'discrete' mechanist would argue that this technological 'plasticity' is a necessary result of the 'causal adjustment' of the different parts of reality and the tendency of wholes to find seek out *stable equilibria*, 'consolidated' mechanists would simply maintain that since there is no place for discreteness in reality, technology automatically merges with its underlying field-structure, leaving almost no inherent 'sturdiness' behind.[483] Shott et al. (2011) give a voice to this 'received view' of *technological customisability* when they note:

> "[...] The systematic production of usable flakes is often presented by lithic technologists as a rigid set of strategies or procedures to be followed in a step-by-step fashion. The quintessential example is the *chaîne opératoire*, developed by the French in the 1980s and widely applied today. An alternate view is that lithic reduction is a fluid behavioral set conditioned by an intimate familiarity with techniques and materials and tempered by environmental and situational circumstances." (Shott et al. 2011: 320; original emphasis)

This recognition of lithic technology as a fluid behavioural set tempered and conditioned by environmental and situational factors remains central to both 'behavioural-strategic' and 'organisational' approaches. As Torrence (2001: 73) correctly points out, this conception allows one to engage with the 'Big Picture' of how lithic variability is shaped and structured. To conceive of lithic technology as a 'plastic' entity enables the focused investigation of the relative strength and significance of the various *causal factors* that might have contributed to the formation of particular lithic assemblages and technological signatures. 'Discrete' mechanism would thereby concentrate on individuated causal variables, whereas 'consolidated' mechanism usually focuses on 'constraints' (cf. Goldratt 1996). This talk about 'constraints' signals that technology is analysed in terms of its *relative position* within the integrated behavioural system. A 'constraint' is a factor or element that restricts another entity, that is, it prevents that entity from achieving its potential alternative goals; constraints create bottlenecks and thereby regulate the expression of the constrained phenomena.[484] At least two points are important here. The first is that the character of technological expression depends on its 'location' in the larger machinery of which it is a part (*sensu* Pepper 1942: 191, 197). Each part of the behavioural system, in other words, is constrained by its position in the 'field of locations' and thus by all other 'locations' connected to it. This brings us to the second point, namely that speaking about constraints in this manner means speaking about the *properties of the mechanistic field-structure*. The relevant constraints are only understandable if the entire quadruple *composition-environment-structure-mechanism* is taken into account. 'Constraints,' understood in this way, do not stand for discrete processes anymore but describe *field forces* and *field potentials* that can precisely be quantified.

In Anglophone lithic inquiry, scholars typically convey this research orientation by conjuring the study of technological 'costs and benefits,' and the relative trade-offs between different economic factors and design decisions (cf. Torrence 1989c: 2; Ambrose and Lorenz 1990; Kuhn 1993, 1995; Bousman 1993; Carr and Bradburry 2011: 308, 310; Shea 2011a, 2013a: 39).[485] Researchers have mustered an entire array of potential 'currencies' to measure the strength and significance of the active 'field forces' that give shape to a particular behavioural system. The most popular currencies are 'energy,' 'calories,' 'time,' 'uncertainty,' 'security,' and especially 'risk' (e.g., Torrence 1989c: 3, 2001: 73-78; Blumenshine and Peters 1998; Bright et al. 2002; Ugan et al. 2003; Bettinger et al. 2006). Other more object-centred currencies are for instance the 'portability' and 'curational potential' of lithic artefacts (e.g., Binford 1979; Cole 2009; Kuhn and Miller 2015), but also the design-properties of lithic implements or complex projectile delivery systems, i.e., their 'functional efficiency,' 'versatility,' as well as

[482] Churchill (2014: 53-59), for instance, speaks explicitly about 'lithic technology as an adaptive interface.' This notion, *grosso modo*, of course resonates with Binford's (1962: 218) influential proclamation of "culture as an extra-somatic means of adaptation"

[483] Borgerhoff Mulder (2005), for instance, underscores the 'extreme phenotypical plasticity' which HBE approaches typically predicate.

[484] See Cox and Goldratt (1986) and Goldratt (1990) for a general 'theory of constraints.'

[485] Shea (2011b: 14), for example, argues that the link between lithic patterns and hominin behaviour should be studied in "strategic terms, to seek the cost-benefit structure of the incentives underlying particular behaviors, and to document variation in the contexts in which particular behavioral strategies are deployed (or not)."

their 'reliability' and 'maintainability' (cf. Bleed 1986, 1997; Nelson 1991; Bamforth and Bleed 1997; Hopkinson 2004; McCall 2015: 80). The regulative idea is that some or all of these currencies have to be *optimised*, yet under general conditions of constraint. Bruce Winterhalder (2001: 31-33) has referred to this core feature as the 'assumption of constrained optimisation.' Optimisation is simply described as some kind of 'utility' that is maximised under conditions of scarcity and systemic constraint. The utility function that can be extracted by analysing and comparing the role of some or all of the relevant currencies within the behavioural system helps understanding why lithic technology takes particular forms and what the systemic role of particular lithic 'locations' is. To isolate, theorise, and investigate variable currencies and their role in structuring 'systems' and 'locations' facilitates the recognition of the *causally-integrated whole* that mechanists wish to illuminate. These currencies are nothing else than causal variables that are evaluated in terms of their relevance and explanatory power. The *adjustment* of these currencies in changing temporal and spatial contexts provides lithic experts with the means to come up with hypotheses about the "working" principles of the behavioural machinery seek to decipher:[486]

> "Stone artifacts come to us as static entities, but they are products of dynamic behavioral processes. Linking static lithics to dynamic behavior requires one to correlate patterns in variation in the lithic record to variability in behavioral strategies. Strategies are solutions to a specific set of problems determined by the interaction of costs, benefits, and risks on evolutionary actors (Krebs and Davies 1991, Pianka 1988). Modeling strategic variation involves hypotheses about the changing relationship between cost and benefit overt time. The three most fundamental of these relationships are optimization (maximizing benefits per unit of cost), satisficing (obtaining minimally necessary benefits per unit of cost), and intensification (increasing costs in return for unchanging or declining benefits). [...] The precise currencies of costs and benefits involved in various dimensions of lithic variability and how to measure them are much debated. Time, energy, and risk are obvious variables (Torrence 1989, 2001), as they are for nearly all behavior, but other factors specific to stone tool technology involve utility (potential for continued use), versatility (potential for multiple uses), and portability (costs associated with transporting lithic artifacts)." (Shea 2013a: 39)

Torrence's (2001: 78-80) discussion of the role of the 'severity of risk' and its associated 'failure costs' in explaining general latitudinal differences in the technological make-up of ethnographically documented nomadic groups similarly showcases the determinative role of the respective factors and highlights the 'chain of causality' in which they participate:

> "Failure costs, and therefore the level of risk, increase toward the poles because the availability of food decreases with longer winters and there are fewer alternative resources because species diversity has an inverse relationship with latitude. Latitude is therefore a useful proxy measure for severity of risk with higher latitudes having higher risks. [...] The type of tool used to procure animals also responds to increasing failure costs as monitored by latitude. Near the Equator small mammals are mainly hunted with instruments and weapons, but in the far north untended facilities such as traps are more common (Torrence 1983: Table 3.4). Similarly, tended facilities are used in the hunting of large terrestrial mammals to a greater degree in the riskier northern environments than among low-latitude groups." (*ibid.*: 27)

The necessity of *risk management* provides the general 'mechanism' required to link the 'composition' and 'structure' of technology to a specific 'environment' (cf. Read 2008; Hoffecker and Elias 2003, 2007; Hoffecker 2005). Risk, in other words, emerges as the 'lubricating' stuff that keeps the behavioural machinery running. It is not coincidental here that 'risk' is a somewhat curious entity; it is neither material, nor an abstract idea. Rather, it must be understood as a field property which, although being unobservable, delineates a 'primary' and 'effective' category of reality – it is therefore 'real' insofar as it causally conditions the observable.

Nettle et al.'s (2013) praise of HBE research as the study of human behaviour from an adaptive perspective and in terms of how behaviour varies with ecological context – as providing 'clear predictions' and heightened 'methodological rigor' – arguably resonates with the ambition and self-recognition of 'behavioural-strategic' and 'organisational' approaches to lithic technology in Anglophone Palaeolithic archaeology. Nettle et al. (2013) especially highlight the aspiration of HBE to disentangle *ultimate* and *proximate* mechanisms (*sensu* Tinbergen 1963; Mayr 1988; cf. Krebs and Davies

[486] The guiding metaphor here is a complex clockwork with many adjustable screws. The task of the analyst is to adjust them in such a way that the clockwork 'runs' smoothly. This obviously requires finding the correct or effective mechanical links between the various screws and understanding the general 'working' principle(s) of the clockwork.

1978) – they admit, however, that for practical reasons it is usually more profitable to focus on the *proximate* causes – and to integrate the study of 'behavioural variability' with the study of 'behavioural optimality.' Shea's (2011b: 11, 15) insistence on determining the sources of lithic variability is an echo of the same research mandate. Some would certainly argue that this undertaking requires an integration of ecological and Neo-Darwinian evolutionary theory, including relevant subfields such as evolutionary ecology and evolutionary economics (cf. Kuhn 2004a; Bettinger et al. 2015; Goodale and Andrefsky 2015). In general accordance with Torrence (1989c: 4f.), Kuhn (1993), and many others, Borgerhoff Mulder (2005) also stresses the importance of adopting a 'problem-solving approach' in order to examine 'adaptive strategies' and 'how humans have been selected to respond flexibly to environmental conditions in ways that enhance their fitness.' The evocation of classic Darwinian mechanisms such as 'adaptation,' 'selection,' and 'inheritance with modification' in the study of hominin behavioural variability[487] thereby unequivocally earmarks these approaches as mechanistic.[488]

Cole's examination of economic efficiency at the Middle-to-Upper Palaeolithic transition

In *Technological Efficiency as an Adaptive Behavior Among Paleolithic Hunter-Gatherers*, Cole (2009) examines patterns of lithic economic change across the Middle-to-Upper Palaeolithic transition, comparing in particular Châtelperronian and Aurignacian assemblages from three sites of the Périgord region of Southwest France – La-Côte, Caminade Est, and Le Flageolet I. The article is primarily concerned with issues of raw material 'economisation' and sets out to identify the specific behavioural strategies adopted in varying contexts to respond to these problems. Cole (*ibid.*: 128-131) departs from a general body of evolutionary and ecological theory to highlight the 'adaptive significance' of varying strategies of lithic raw material acquisition and conservation, as well as their differential 'efficiency.'[489] From these general considerations, he derives three hypotheses linking particular economic concerns to particular observable consequences (**Fig. 26**). These enunciations are purely theoretical and the goal is to pinpoint correlated economic and lithic variables to predict assemblage-level patterns that can be tested against empirical data. The basic rationale of this approach is to use the predicted patterns as a baseline to back-infer the correlated economic strategies. The author (*ibid.*: 131-133) discriminates between the 'blank portability hypothesis,' the 'distance attrition hypothesis,' and the 'mixed strategy hypothesis'; each of the three represents a different generic solution to the problem of raw material economisation in high-mobility settings, i.e., the fact that lithic raw material is finite and potentially has to be carried around in different formats. Cole (*ibid.*: 133f.) uses dimensional data and diversity estimations[490] to assess the overall size difference between artefacts made from local and nonlocal raw materials, the difference between tool and blank size in these two groups, and the difference in diversity between the two. All three hypotheses project distinct combinations of signature values for these three respective lithic variables.

The first hypothesis, the 'blank portability hypothesis,' describes a tactic of lithic raw material acquisition and conservation revolving around the planned transportation of high-quality raw materials (Cole 2009: 131). This tactic consequently entails the intense reduction of selected raw materials and a heightened anticipation of raw material needs. Therefore, (i[1]) non-local raw materials are expected to be smaller sized, (ii[1]) there should be no significant difference in blank size when local and non-local raw materials are compared, and (iii[1]) non-local raw materials should be generally less diverse.

The second hypothesis, the 'distance attrition hypothesis,' represents a raw material management tactic grounded in the principle of tool curation (Cole 2009: 132). This tactic implies the differen-

[487] It is noteworthy that there is a long tradition of thinking about stone tool technology as *extended phenotype* (*sensu* Dawkins 1982) – as the effective extension of the hominin body ((Washburn 1959: 30, 1960; Leakey 1971; Foley 1987; Schick and Toth 1993; Foley and Lahr 2003; Kelly 2016: 29; Shea 2017b: 39-42). This conceptualisation – the 'prosthetic view' of technology – not only abets the direct selection of technology-hominin couplets, but naturally evokes the idea of 'phenotypic plasticity' in the context of lithic technology. Toth and Schick (2009a: 299), for example, explicitly speak of lithic tools as "synthetic organs" and refer to the nature of technological evolution as "techno-organic."
[488] Bunge (2013: 590) explicitly lists Darwinian evolution as an example of mechanistic explanatory system relying on "nonmechanical" mechanism.
[489] See also Steenhuyse (2007: 11-24).
[490] Additional lithic data include lithic weight data and estimations of reduction intensity (e.g., ratio of retouched versus unretouched blanks per raw material unit).

tial treatment and transportation of retouched and unretouched lithic artefacts. As a result, (i^2) there should be no overall size differences between local and non-local raw materials, (ii^2) the size difference between tools and blanks is expected to be less pronounced in non-local raw materials, but (iii^2) local and non-local raw materials should be similarly diverse.

The third hypothesis, a mixed strategy that combines elements of the previous two tactics, specifies an approach to raw material economisation in which both differential raw material transportation and tool curation plays a role (Cole 2009: 132f.). The strategy therefore implies both the selected treatment of certain raw materials and a focus on the raw material potential of tools. In this scenario, one can expect that (i^3) lithic artefacts made from non-local raw material are generally smaller, (ii^3) the difference between tool and blank size is higher in local raw materials, and (iii^3) non-local raw materials should be less diverse (*ibid*.: Table 9.1).

Based on the juxtaposition of these test implications with the dimensional data and the diversity measures derived from La-Côte (level III), Caminade Est (level G), and Le Flageolet I (levels XI and IX), Cole (2009: 134-139, 140) argues that the encountered lithic patterns provide evidence for a general increase in technological efficiency in the timeframe between 38 and 32 kya in the Périgord region. This conclusion is based on the recognition that different economic strategies appear to be reflected in different lithic assemblages. Whereas La-Côte level III does not conform to any of the test projections and therefore appears to indicate a 'neutral' strategy or, alternatively, socioeconomic conditions under which economisation proved unnecessary, Caminade Est level G reveals a strategy in which blank portability was a major concern but the differential modification and reduction of blanks was apparently not important (cf. Cole 2002). The lithic signature of Le Flageolet I level XI, by contrast, suggests raw material economisation in terms of portability and distance attrition (Cole 2009: 140). The chronological sequence of these economic strategies signals that raw material economisation became an increasing concern across the Middle-to-Upper Palaeolithic interval. There is both a trend of strategic 'formalisation' and 'diversification.' Although Cole (*ibid*.: 128), in classic mechanistic fashion, proclaims that he

> "[...] is aware of no scientific theory that would predict an increase in the efficiency of [sic!] hunting and gathering throughout the Pleistocene without reference to any causal factor,"

he is ultimately hesitant to announce a 'law of progression' or a general 'evolutionary principle' of increasing economic efficiency. The circumstance that he sympathises with this idea, however, shows the felt necessity of linking 'pattern' to 'process' and to specify a general *mechanism* to account for the lithic observations (Cole 2009: 128f.).

There is another mechanism, however, which the author tacitly entertains, and without which his analysis would fail. This principle is a generalised version of *rational choice*. For his theoretical projections of the three generic tactics of raw material economisation with special attention on optimising technological 'efficiency' to be valid, it is required that the respective hominin players can be conceptualised as rational players. In fact, their economic rationality must be comparable to the rationality of the community of analysts since otherwise the projection of economic rationality is seriously hampered. Having said this, Cole's (2002, 2009) hypotheses about strategic behaviour and lithic raw material economy clearly entail rational conjectures on how one would manage lithic artefacts given particular strategies. The kind of economic rationality that he presumes, moreover, is technology-neutral, that is, independent of the respective technological systems adopted by hominins at the time.[491] Only then is it viable to assess issues of 'economisation' based on a fixed set of variables. Whether the author believes that *economic behaviour* and *technological behaviour* are to be separated since the former represents a more 'basic' category of reality, whereas the latter delineates a 'derived' category regulated by the first category must remain open, yet would at least be consistent with the pursued line of reasoning. The key point is that 'rational choice theory' (cf. Robbins 1932; Becker 1976; Cashdan 1990; Binmore 2009; Chibnik 2011: 2-5), even though not explicitly elaborated on, provides the set of fundamental mechanisms needed to study economic behaviour in the Upper Palaeolithic by

[491] As we will see in the subsequent chapter, this conceptualisation is heavily disputed by French technologists who regard economic organisation as critically *dependent* on the infrastructure of technology (see esp. the first part of Chapter 5). Beyond the larger world theory differences, we may also understand this divergence as local resurfacing of the 'substantivist-formalist debate' in economic anthropology (cf. Eriksen and Nielsen 2001: 83-85; see *infra*).

similar means as one would study such behaviour in the present.[492] Cole's *Technological Efficiency* is the study of *homo economicus* in the deep past. As Kliemt (2013), for instance, points out, *homo economicus* furnishes a 'model' of economic behaviour emphasising 'opportunity-taking rational action' and revolving around future directedness, insofar as individuals need to distinguish between what is and what is not a causal consequence of each of their actions and decisions taken separately, case-by-case motivation, and subjectivism, i.e., methodological individualism; it is the 'consistency assumption' underpinning this model (*idem*) that provides the kind of generalised mechanism required to place *Technological Efficiency* on firmly mechanistic grounds.[493] This invariable rationality principle is the precondition for the type of predictive reasoning adopted by the author.

Blades' approach to Aurignacian technoeconomics at La Ferrassie

Blades' paper *Aurignacian Core Reduction and Landscape Utilization at La Ferrassie, France* (2009) argues that the lithic economy evidenced in the Aurignacian layers of La Ferrassie in the Dordogne region can be explained as a response to changing ecological conditions in the vicinity of the site (esp. *ibid*.: 194; cf. Blades 1997 [2001], 1999). The ecological backdrop of the site is defined as the co-variation of climate regime and animal ecology which, in tandem, are regarded to have affected the structure of neighbouring animal communities and therefore the availability of potential prey species. Blades' approach is rooted in the *heteronomic assessment* of lithic patterns with respect to the local ecological circumstances into which they are 'inscribed.' The lithic patterns retrieved from the diachronic Aurignacian record of La Ferrassie are *externally related* to the available ecological data in order to isolate significant correlations. The author's general strategy is to derive reliable proxies for each of the two domains – lithic economy and human ecology – and to juxtapose them.

As a proxy for lithic economy he uses 'core reduction intensity' which he measures in terms of relative core-length(s) (Blades 2003, 2009: 191). Human ecology, by contrast, is approximated by the diversity and composition of the faunal assemblages documented in the Aurignacian layers (K6-l1) of the site. Since varying climatic conditions are expected to support differentially packed animal and mineral resources in the immediate surroundings, the structure of the local animal community can be taken as a rough proxy for the general ecology of the site.

The author then simply evaluates the two proxy measures in terms of patterned co-variation (Blades 2009: Figure 13.1, 13.3). He finds that core-length values appear to vary as a function of colder versus warmer climate regimes (*ibid*.: 191). The determination of colder climates in the earlier phases is based on the association with reindeer-dominated faunal assemblages, whereas the later Aurignacian phases are characterised by a more diverse (bison, horse, deer) faunal composition (*ibid*.: 191). Cores are on average shorter in the earlier phases of the Aurignacian (K6-K4) which the author inter-

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[492] Cole's (2009) approach therefore resonates with the often-cited assertion by economist Becker (1976: 14) that "[…] all human behavior can be viewed as involving participants who maximize their utility from a stable set of preferences and accumulate an optimal amount of information and other inputs in a variety of markets." The emphasis here lies on *all*; economic theory is thought to provide a universal set of regulatory principles to study human behaviour across time and space, independently of its context or history. The principles that guide economic action and decision-making are considered *invariable* – they have the status of mechanistic 'principles' or 'laws' (cf. Chapter 2: **Box 7**).

[493] Arguably, Cole's (2009) approach, as most other approaches that can be grouped under the labels 'behavioural-strategic' and 'organisational' (see *supra*), is firmly rooted in the 'formalist' tradition of economic anthropology. 'Formalists' are usually opposed to 'substantivists' since the so-called 'formalist-substantivist debate' is a major date in modern anthropological discourse (cf. Eriksen and Nielsen 2001: 83-85). This debate was about the nature of economy and whether it can be studied as self-sufficient domain of human life, propelled by economic principles and law-like regularities. 'Formalists' have tended to adopt this view and argued that economy can therefore be studied by the same means and guided by the same assumptions in any context, past or present. 'Formalism' in economic anthropology has emphasised quantitative approaches and 'rational choice theory.' Inquiry in this tradition has typically focussed on *pragmatic strategies* and sought to demonstrate that *utility maximisation* plays a role in any human society (cf. Leclair and Schneider 1968): "[i]f we recognize that a difference of degree rather than of kind exists between most of our economic institutions and those of other peoples, the unity of the data concerned with the problem of economizing must be apparent" (Herskovits 1952: 42). Firth (1939, 1967), Schneider (1964, 1974), and Herskovits (1952), for example, were some of leading 'formalists' of their time. 'Substantivism,' by contrast, holds that economy cannot be studied as an independent phenomenon; it is always *embedded* in sociocultural practice and hence a product of human cultural life. As a result, not all human economies can be studied by the same means or in the same way, and there are serious epistemological preconditions of understanding them properly. 'Substantivists' have for example variously argued that modern economic concepts such as 'risk' and 'time-budgeting' are often not applicable to tribal or prehistoric societies, simply because these people do not necessary shared this concept. 'Substantivism' favours a qualitative and ultimately interpretive approach to economic organisation. Prominent 'substantivists' are for example Polanyi (2001 [1944]), Dalton (1961, 1969), and Bohannan (1955, 1959), but also scholars such as Sahlins (1972) and Godelier (1999). The 'substantivist-formalist debate' has lost much of its former heat in recent years but remains largely unresolved.

prets as evidence for an overall more intense lithic reduction (*ibid.*: 191, 194, Figure 13.1; cf. Blades 2003). Thus, the cores of the later and slightly warmer Aurignacian phases (K2, J, l3-l2) are on average longer. Complementarily, these are interpreted as less reduced (Blades 2009: 194). Blades (*ibid.*: 188-190) adds that the treatment of cores in terms of scar directionalities and platform configurations remains complex and mixed throughout the entire sequence and that there is thus no reason to believe that core technology *sensu stricto* is an important developmental factor; he (*ibid.*: 190) explicitly stresses the 'importance of a reduction continuum' in this regard.

Based on general considerations from evolutionary ecology, Blades (2009: 191, 193) establishes a theoretical link between 'reduction intensity' and mobility strategy, that is, foraging radius. Since core reduction intensities can be taken to reflect relative raw material consumption and therefore represent a measure for the 'economisation' of stone, they can be related to the frequency and character of hominin movement(s). The author (*ibid.*: 191) asserts that this, in turn, seems to suggest that

> "[...] the longer cores during the later Aurignacian occupations may mean that groups travelled shorter distances from quarries, had more regular access to quarry locations, and/or moved more frequently from the shelter to other locations without transporting the cores."

The exact inverse relationships can then be projected for the group of shorter cores, which appears to indicate longer travel distances from raw material sources, less regular access to these sources, and/or more frequent moves from campsites to other localities without necessary transporting the cores.[494]

Blades (2009: 192, 194) concludes that Aurignacian lithic technology at La Ferrassie reflects changing economic strategies tied to differential mobility and prey exploitation patterns. These strategies seem to have been structured by the prevailing climatic regimes. Core length is seen to record 'economising' behaviours related to 'adaptive' requirements. These conclusions are consistent with the author's earlier work, which essentially finds the same relationships based on a number of additional lithic variables such as tool retouch intensity and blank weight (cf. Blades 1997, 1999). Altogether, the adopted cognitive strategy is clearly mechanistic. Not only is knowledge established and corroborated by causally adjusting selected technological variables and ecological parameters, the reconstruction also reveals a clear-cut 'chain of inference' predicating the environment-subsistence-mobility link as the basal layer of determination. Again, behaviour is understood as a systemic phenomenon with its unique 'field of locations,' so that the individual lithic assemblages from La Ferrassie can be recognised as relative parts constrained by the other working parts of the total machinery. Basic economic principles are ultimately responsible for rendering the machine a *viable* one. Blade's (2009) study is also notably 'integrative' insofar as it mobilises only a handful of variables to determine the overall character of the adaptive system. This not only underlines that these factors are identified as causally relevant but also shows that *ordered causation* – in the sense of a 'directed chain' – and its 'specifity of response' are taken for granted.

[494] Note that the inference of travel distances relies on a general *distance-decay* model assuming that raw materials diminish with increasing distance from the point of origin (see *supra*). This model, as we have seen, is inherently 'mechanistic' (see the first part of this larger section).