Aesthetic Activity and Human Evolution:

An Interdisciplinary Approach

Xuanqi Zhu

PhD

University of York

Philosophy

February 2022

Abstract

The interdisciplinary study of human aesthetics and evolution is an active field of research. With advances in evolutionary biology, evolutionary psychology, and neurosciences (especially cognitive neuroscience and neuropsychology), research topics that bridge these sciences and human (broadly conceived) aesthetic ideas have received much of our attention. This can be seen in studies of evolutionary aesthetics and neuroaesthetics, both of which have provided valuable insights into the relationship between aesthetic activities and our evolutionary past and the neural substrates of cognition. This thesis, however, aims to provide an interdisciplinary approach that sees the aesthetic as an organismic phenomenon which can only be fully appreciated through a better understanding of the structure of the continuous dynamics between organisms' behaviours and their ecosphere. More specifically, this thesis develops a contextualist framework for aesthetic activities which is based on an extended conception of evolution. Furthermore, based on a case study of the Acheulean handaxe industry, this framework provides us a better understanding of the emergence of the earliest aesthetic culture of the human lineage. To do this, this thesis will draw on various sources of other disciplines—evolutionary psychology, evolutionary biology, niche construction, and Palaeolithic archaeology—to articulate an integrative evolutionary mechanism that is behind the aesthetic world.

Though this thesis cannot provide a fully satisfactory answer for how human aesthetics as a whole works, it may help in directing us towards this answer.

Table of Contents

List of Illustrations

Figures:

Tables:

Acknowledgements

Above all, I am very grateful to my supervisors, Greg Currie and Penny Spikins. They are exceptional. I am indebted for their expertise, kindness, and patience over the past years. During this Covid-19 pandemic, I know I could not have made it without their invaluable guidance.

I also owe thanks to all those other who have supported me throughout the course of this research:

To all my wonderful friends in the Department of Philosophy and the PalaeoHub of the Department of Archaeology, for all the intriguing discussions, for making this long road much more joyful.

To my family for supporting me both emotionally and financially.

Finally, I want to thank my wife, Jiwen, for her unfailing love and care, over the last six years.

Author's Declaration

Some of the material discussed within this thesis has previously been published in this following paper:

Currie, Greg, and Xuanqi Zhu. "Aesthetic sense and social cognition: a story from the Early Stone Age." *Synthese* 198.7 (2021): 6553-6572.

Except this, I declare that this thesis is a presentation of original work, and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged.

Introduction

Aesthetic activities are a ubiquitous phenomenon of modern humans (*Homo sapiens*). For populations living in industrialized societies (like ours), it seems clear that one’s aesthetic life is tightly interwoven with one’s daily life. Aesthetic elements permeate human choices and actions, making them aesthetic activities too. Our aesthetic interests permeate almost everything we encounter—from natural things such as human body, animals, plants, or landscapes; to artefacts which can be as unimpressive as the patterns printed on a toilet roll, or which can be as emotionally and culturally rich as the *Guernica* by Pablo Picasso; from some handicraft that a child could make, to the production of a movie which requires a long chain of proper cooperation among various human industries and technologies. In this thesis, it will be argued that our aesthetic activities are highly embedded in their contexts. Meanwhile, those activities and their contexts are in a constant co-evolving relationship, each being the cause of novel changes in the other. These contexts include both cultural and biological elements; together, as I will suggest, they form a human aesthetic niche—in which the expression of aesthetic activities (including the ideas, preferences, and judgements connected with them), is affected by and is affecting selective pressures in an evolutionarily holistic way, leading to differential rates of propagation and sedimentation of patterns of such activities, forming aesthetic traditions in populations.

An acknowledgement and a comprehension of such a complexity is important for the quest for a better understanding of human aesthetic activities. This will, more specifically, be based on developing several ideas in our current theoretical repertoire (e.g., evolutionary psychology, evolutionary aesthetics, the modern synthesis, natural selection, sexual selection, and the idea of evolution itself) and introducing several other ideas that are key to our quest (e.g., organismic niche construction, multiple inheritance, the extended evolutionary synthesis). At the same time, this interdisciplinary approach to human aesthetic activity will be applied to a case study of the Acheulean[1] technological tradition of handaxe[2] making. By sorting out available evidence from the Palaeolithic[3], it is suggested that the Acheulean handaxe is best understood and appreciated as an aesthetic object in relation to this stone toolmaking tradition which appeared ~ 1.8 million years ago and gradually developed into what might be the first aesthetic tradition of the human lineage.

The structural synopsis of the thesis is as follows:

In Chapter I, I will first focus on the relevant ideas of aesthetics (e.g., aesthetic preference, aesthetic judgement, and aesthetic supervenience), suggesting a contextualist stance in terms of understanding these relevant ideas. Beside this, in the following part, the formalist view of aesthetics is argued to be wrong, and theorisers of contextualism (e.g., those by Walton, Levison, and Currie) will be discussed. In short, it will be proposed that aesthetic preferences and judgements

[1] See no.1., Glossary.
[2] See no.8., Glossary.
[3] See no.13., Glossary.

depend heavily on how much relevant information is in the context that has been accessed by the subject, and how such a context is in part evolutionary. Therefore, in the third part of the chapter, theories of aesthetics which point to the relevance of an evolutionary context (e.g., theories by Dutton, Dissanayaki, and Carroll) will be briefly discussed. In the last part of the chapter, I will suggest that the theories based on evolutionary psychology are limited in their power, and an evolutionarily contextualistic approach to aesthetics may provide us with a better understanding of human aesthetic activities. This is a view that requires a broadening of the current theorization of aesthetics and human evolution (as that of evolutionary aesthetics), and the inclusion of an extended evolutionary framework.

To do this, in Chapter II, I argue that we will need a rethink on the concept of evolution itself. So firstly, it will be explained how evolution is formulated in a constrained way in the traditional evolutionary framework which is based on the mechanisms of natural selection and sexual selection and genetic inheritance. Then, the focus on these two mechanisms' roles in human aesthetic activities will be suggested as being gene-centric, and a way to rethink the concept of evolution will be provided. On this basis, I will develop a model (based on Waddington's Landscape, 1957) for how this extended evolutionary context could work in helping us understand aesthetic traditions and aesthetic responses to those traditions. In the following section, necessarily, it will be explicated why such an extended evolutionary context is needed. Finally, a short discussion on niche construction theory will be given, and it is suggested that this extended contextualist view of aesthetics can be better brought out and supported through the perspective (phenomenon) of organism niche construction.

Chapter III, therefore, will concentrate on the idea of an organism's niche and the theory of niche construction. Most importantly, the point to be made is that the human aesthetic dimension is one indispensable aspect of the human niche and is better understood through the idea of an aesthetic niche (and accordingly, aesthetic niche construction). In the first part, the concept of niche construction will be evaluated through the discussion of related notions—i.e., those of niche, construction, and selective pressure, and instances of niche construction will be provided. After this, the relationship between niche construction theory and the broader biological background (in which the modern synthesis, inheritance systems, and related theories such as the Baldwin effect, extended phenotype theory, and developmental systems theory will be discussed) will be given. Based on these different niches, especially the cultural niche of humans, will be explored in section 3. The identification of the human aesthetic niche and its relationship with the cultural niche will be explained in section 4.

Chapters IV and V will be dedicated to the case study of Acheulean handaxes which is intended to explain the aesthetic niche and the proposed extended contextualist view of aesthetics. By seeing this tradition of handaxe making as a practice of human niche construction, and by examining how the mechanisms of niche construction could have worked in Acheulean societies, it will be suggested that the development of this stone tool technology had laid the ground for an aesthetic culture in the Lower Palaeolithic. More specifically, in Chapter IV, a general archaeological picture of the Acheulean industry will be provided (including the stone tool technologies before and after the Acheulean and aesthetic activities afterwards) in the first place. Secondly, an overview of the Acheulean is needed, and it will also be explained why we should treat those finely made handaxes as aesthetic objects. In Chapter V, by drawing upon mechanisms of niche construction theory, I will present a speculative framework for the emergence of the aesthetic Acheulean culture in the first half. I will suggest that it was the need (selective pressure) for maintaining an advanced technology in the population which provided the opportunity for an aesthetic culture. It will be argued that a developed social learning system must had been in place to buffer such selective pressure by its crucial role in terms of lowering the cost for skill acquisition or propagation and enabling high fidelity preservation of skills and related knowledge over generations. As a result, the selective dynamics would have an effect on the aesthetic activities and sensibilities of Acheulean individuals—possibly, there were individuals who advertised their skills through their displays of handaxe making; and in turn, there were also others who made judgements about the quality of handaxes and the skills of the maker that went into the process of making. In the second half of Chapter V, I will provide evidence which supports this scenario. This includes discussions of: the symmetry in handaxes as an intended goal, the technological transition from the Oldowan to the Acheulean, and social learning in Palaeolithic societies.

Chapter I: A contextualist concern

As already made clear in the introductory section, the majority of the discussions in this thesis are presented in an interdisciplinary way. Therefore, it is crucial to have in mind a general picture of various concepts and ideas and how they are connected based on the context in which they are used. For aesthetically related concepts especially, the explanation of why certain aesthetic concepts are relevant to this interdisciplinary research and how they can be meaningfully linked together in such a context will be important. At the same time, this chapter proposes a contextual view of the aesthetic; therefore, in the first section, I will focus on the basic notions that are related to this research while suggesting how they are grounded in context. In section 2, I will suggest that formalism as an aesthetic doctrine is questionable and theories from the alternative, contextualist viewpoint will be discussed. As for section 3, I shall give brief summaries of some of the debates and theories in evolutionary psychology and aesthetics, which aim to explore the connections between human evolution and aesthetics and what the nature of the aesthetic is. Section 4 will then explore the implications that we might draw from an evolutionarily extended contextualist approach. And it is suggested, being a development to the ideas presented in section 2 and 3, the extended evolutionary approach to aesthetic issues is viable.

1.1. The aesthetic notions/theories that are involved in this research topic

I shall begin with the question: what are the things that would count as aesthetic in this thesis? The term 'aesthetics', firstly appeared in Baumgarten's thesis in 1735, originally referring to a scientific study of perception. Now aesthetics is generally regarded as the study of beauty in the human and natural world. So, there are a broad range of things that can be regarded as aesthetic; not just art, but also objects in daily life such as the design of cars, phones, toys, clothes, commercials, films, and for those from the natural world, objects such as insects, animals, flowers, landscapes, etc. should be included. These things enter an aesthetic context when we give aesthetic preferences to them. Beside this, the term of 'beauty' should be understood in a broad sense as well, to include other psychological tendencies where attention is positively attracted towards some stimulus.

With the terms 'the aesthetic', 'aesthetic phenomena' or 'the aesthetic world', I intend them to be a broad notion that includes the followings: aesthetic behaviours (e.g., practices with aesthetic concerns such as the creation of art, the design of the appearance of normal artefacts), aesthetic outcomes (the intended objects of aesthetic behaviours), and the aesthetic mind. Furthermore, the notion of the aesthetic mind is relevant to these two elements:

a. Aesthetic preference: the psychological preferences for certain perceived stimuli which have an aesthetic aspect.

b. Aesthetic judgement: the judgement that something is aesthetically good or bad or that something has aesthetic properties of such and such.

An aesthetic mind is one with either or both of these capacities.

First of all, I am not claiming that collectively these elements exhaust the concept of the aesthetic mind. Rather, there seems yet to be no easy answer as to how many elements could collectively exhaust the aesthetic mind (since perhaps non-aesthetic psychological mechanisms may well have a role to play). Here, I concentrate on these particular elements because of the immediate relevance, with regard to the theme of the thesis, they carry. To put it briefly, as what will be made clear with our investigation on the processes of organism–environment interaction and on the idea of evolution itself (Chapters II and III) through our evolutionary past of the Acheulean industry (Chapters IV and V) that existed 1.8 million years ago, an aesthetic mind would then have been in place and contributed to the evolution of the human lineage. This aesthetic mind, though in a less sophisticated form compared with ours, was capable enough to exert selective power through aesthetic preferences and judgements. I will argue that to a significant extent, an intense pressure of the selective environment, that Acheulean populations were facing (i.e., the selection for a system that maintains the major practice of subsistence) was buffered, and this was due to the joint force of exercising one’s aesthetic preference for and making aesthetic judgements about certain morphological traits of stone tools. Before this scenario can be fully unfolded, it is important to give some scrutiny to these two notions to see the relationship between them.

1.1.1. Aesthetic preferences and aesthetic judgements

A point to which some extra clarification will be given is the relationship between aesthetic judgement and aesthetic preference. To begin with, clearly, aesthetic preference and aesthetic judgement are two distinct things. They refer to different things: an aesthetic preference is a preference, a psychological tendency or inclination that we (and our ancestors) all have. It is (i.e., having preferences), based on what we know from biology, likely to be an evolutionary adaptation due to the long process of natural selection; an aesthetic judgement is a judgement that requires the subject's cognitive power exerted consciously over the qualities of the object being judged. So, even though we might agree that some animals do have aesthetic preferences, it seems less likely to suggest that a female bowerbird is making aesthetic judgements when she sees (not appreciates) the bowers made by the males. And one suggestion of this thesis, as we will see in Chapter V, is that: our hominin[4] ancestors living in the Acheulean period should be regarded as subjects capable of making aesthetic judgements about objects in the handaxe making practice; in other words, an aesthetic culture was present as early as in Acheulean times.

1.1.1.1. The aesthetic preference in context

Being used in the above-mentioned way, the term 'aesthetic preference' may nevertheless stir up some confusion; therefore, some clarification devoted to it might be useful before the discussion of aesthetic judgement comes in. The first

[4] See no.10., Glossary.

thing to say is that, even though we normally use the term ‘preference’ (or its equivalents) in typical contexts of aesthetic conversation to denote a comparison of concrete objects, a preference is multi-layered. In such typical contexts (e.g., the statement ‘I prefer this painting over that one.’), a decision or an action is entailed, i.e., I choose to see this painting rather than that painting. However, this decisional preference somehow blurs the perceptual or psychological process which is at a more basic level, that is, the process of how I get to the conclusion that ‘I prefer this painting’. To give this process a simplified explanation, I suggest that it is usually the case that people express their ‘overall’ aesthetic preference for one object over another. This is achieved through aesthetic assessments concerning many aspects of the object. Usually, an object will have many aesthetic features, each of which can be preferred or not. As an outcome of this, we somehow produce an overall preference for one thing over the other, but very often, it does not mean that we prefer all its features to all the features of the other one.

The point worth mentioning here is that those aesthetic features which underly the overall preference are context sensitive. They are invoked based on the contextual clues detected by the individual and are assigned accordingly with different weight. As a result of a synthesis of those contextually gauged basic features (those perceived contextual clues will indicate which one(s) of the painting’s constituents is(are) of the most importance), one could then obtain an overall preference at a higher level. Thus, the details about what (or how) certain aesthetic features will be preferred and the overall preference are context dependent. With a change in contextual conditions, there can be a change in how certain features are weighted and possibly a change in the overall preference will follow—a person may prefer the thing that they previously did not prefer. Of course, in situations where there is a simplification or deprivation of contexts, such complexity considering aesthetic preferences may disappear.

This context dependence has been somewhat indicated in Cutting's (2005) study of the mere exposure effect (i.e., MEE)[5]—though Meskin et al.'s (2013) later findings suggest that this effect does not hold in every case; the frequency of one's encountering experience does have an influence on one's aesthetic preference. Also, in Irvin's (2014) discussion, the context's intervention is present in people's aesthetic experience, e.g., the spatial position of how an object is presented to the viewer, the handedness of a person, and the different ways in which participants were ask about their attitudes toward a stimulus might affect participants' aesthetic preferences or judgements.[6] Moreover, it has received some experimental treatment in Palmer et al.'s (2012) investigation on aesthetic preferences related to colours and spatial compositions. For colour preferences, the authors argue that people's colour

[5] I.e., the effect that people tend to prefer (or evaluate/rate positively) the stimuli to which they were exposed more frequently. Though Cutting's experiment is focused on preferences among Impressionist paintings, the mere exposure effect can be driven by a general mechanism for information processing, the perceptual fluency (Huang and Hsieh, 2013). A further discussion on perceptual fluency will be given in section 2, Chapter V.

[6] To explain briefly: in the first case, participants were told to rate the quality of four pairs of stockings (which were in fact identical) presented in a store; 70 per cent of them chose to prefer (with judgements about quality provided) the ones on the right side; in the second case, researchers have found that right-handed (left-handed) subjects tend to think of paintings on the right (left) side as being more aesthetically pleasing; in the third case, it was found that when subjects were asked to verbalize their reasons for 'liking' the paintings, they were more likely to prefer representational paintings over abstract ones; however, interestingly, if the subjects were asked to give reasons for 'disliking' the paintings, they were more likely to prefer abstract paintings over representational ones. In these cases, those factors that affect one's aesthetic preference are irrelevant to the objects' themselves. Details in: Irvin, Sherri. "Is Aesthetic Experience Possible?" in Greg Currie Nj, Matthew Kieran, Aaron Meskin & Jon Robson (eds.), Aesthetics and the Sciences of Mind, Oxford University Press. pp. 37-56. 2014.

preference is influenced by their affective/emotional valence toward the things[7] they have encountered which show correlating colour associations. So, if a person is highly emotionally attached (or averse) to a social institution, there will be a positive correlation between their emotions to this institution and their liking/disliking of the associated colours. Evidence from university students' preferences for their university's colours has been provided to support this prediction (Ibid, p. 201). As for spatial compositions, similarly, experiments (in which images of an object presented in different positions of the picture frame are rated in terms of participants' aesthetic preferences) have indicated that with the appearance being the same, the real-world interactive history between people and the object can affect their compositional preferences. As one experiment shows, people prefer the image of a bowl showing a downward looking perspective and lower in-frame position, which might be due to the facts about how bowls are normally presented (and used) in our daily experience (Ibid, pp. 206-210). Furthermore, other experiments have implied that contextual clues can be influential to aesthetic preferences—e.g., in one experiment, subjects were asked to rate preferences for images of the same racing horse with manipulated differences in its relative horizontal positions in frame; meanwhile, contextual clues were given through titles of the images. The results show a positive correlation between the given title and the image that rated as most preferred—e.g., when the title was 'Front Runner', the images in which the racehorse was located on the sides and were facing out of the frame were preferred (Ibid, pp. 214-215).

[7] According to the authors, these things can include cultural units or institutions such as 'athletic team, gang, religious order, university, or even holiday' (Palmer et al., 2012, p. 201).

The above cases point to the fact that there are facts in the socio-cultural context (including those accessed consciously by people and those accessed unconsciously) that have been appealed to when people express their preferences. As Palmer et al. have claimed, our aesthetic responses can be 'strongly influenced by implicit statistical knowledge of the observer's ecological niche'.[8] This is a view that allows for the interplay between preferences and the context of the subject's environments, alluding to a potential role of the niche. In effect, a perspective that appeals to the concept of an organism's niche construction and its selective landscape will provide an explanatory framework of the dynamics of human aesthetic preferences (including their formation, propagation, contradiction, or extinction). I shall leave this issue aside for the moment as further discussions will follow in later chapters (see Chapters II and III). However, allow me to repeat myself: this multi-layer nature of aesthetic preference and its dependence on context is emphasized here only to highlight what is really behind the phenomenon of our preferring one thing over another.

1.1.1.2. The aesthetic judgement in context

Intuitively, there can be two opposite modes when we talk about the relationship of two things, that is, either they are unrelated things in any circumstances, or they can be related in certain conditions. For aesthetic preference and aesthetic judgement, they obviously belong to the second mode. Although there can be cases

[8] Palmer, Stephen E., Karen B. Schloss, and Jonathan Sammartino. 'Hidden Knowledge in Aesthetic Judgments: Preferences for Color and Spatial Composition'. In Aesthetic Science: Connecting Minds, Brains, and Experience, 189–222. New York, NY, US: Oxford University Press, 2012, p. 190.

where an aesthetic preference that is purely based on basic preferences, when put in the context of our (humans') real life, they are often related to each other, with the selective landscape providing conditions that guarantee this relation. Again, many creatures have preferences (some of them are aesthetic preferences), but probably do not make judgements of quality. When a female bowerbird manifests its preference for bower A rather than bower B, its act of preferring is probably based solely on its basic preferences, and it is not cognitively judging the quality of them.

Even though our aesthetic preferences (both overall and basic preferences) and judgements often work together (i.e., we often prefer those things that we judge to be better), it is important to note that they can be in a conflicting state. One simple way to show this contrast between preference(s) and a judgement is to think of the fact that a person could prefer A over B while judging that B is in effect better than A in terms of its merits. For instance, I can reasonably judge that *Guernica*[9] is better than photos on the *National Geographic* website, but this does not mean I will prefer *Guernica* in any context. As I will argue with the case study on Acheulean handaxes in Chapter IV and V, this way of mental processing was well exemplified by Acheulean agents. That is, agents of the Acheulean were able to mediate their preferences with judgements of quality. Let us imagine a learner (who knows the basics to tell a good maker from a poorly skilled one) who lived in the late Acheulean at the site[10] of Boxgrove[11]. When they preferred one handaxe over another what was happening in their mind might include: first, the basic preferences for symmetry

[9] Guernica by Pablo Picasso, 1937, is regarded as one of his most famous works and an icon of anti-war paintings. https://www.museoreinasofia.es/en/collection/artwork/guernica
[10] See no.14., Glossary.
[11] An important Acheulean site in West Sussex, England. See Appendix II, 1 and 5.

and probably other perceptual traits (e.g., colour and textile) was satisfied; second, a cognitive judgement was justified by what the subject had observed—e.g., a good tranchet final finish (a style of handaxe making that is found mostly in the site[12] of Boxgrove). Here, in the context of Boxgrove, a judgement and the preferences were working together. The act of preferring some particular handaxe was determined by basic preferences (which gained the subject's attention in the first place) and a judgement of quality.

Now if we accept the account for the structure of our aesthetic preference that is presented above, we can see that aesthetic judgements are also contextually grounded. An overall aesthetic judgement (analogous to preferences, judgements can be about the parts and about the whole) would weigh those different basic preferences and produce the result that you prefer, say, A overall to B because shape is more important (here the context plays an irreplaceable role in guiding the subject to deem the 'shape' of a thing as of more importance). Therefore, one might have a basic preference for some perceptual trait of object A over that of object B; however, one's cognitive judgements that are rooted in context can affect the eventual act of preferring (i.e., to choose A or B).

It is sometimes said that aesthetic judgements are not based on reasons but simply on one's feelings. However, many have argued that we can often provide reasons that justify those feelings—our aesthetic preferences. We do so by pointing to aspects of the work which support our judgement ('look at the elegance of that line, the emotion on the face of the subject'). In fact, we generally defer to aesthetic

[12] See no.4., Glossary.

experts whose judgements we think are to be trusted in matters of film reviews, music reviews etc. And we do not simply want to hear what they prefer—we are interested in the aspects of the work which they pick out as supporting their preferences, thinking that we can learn from this. Such facts have pointed to something worth noting, that aesthetic judgement can affect aesthetic preference. Let us set the context to be our contemporary human world, someone might start off by preferring listening to some average pop song over a musical (say, *Phantom of the Opera*); however, the judgements of others may cause them to start to ponder over the qualities of the musical. In doing so, some qualities of the musical, that were hidden before, become apparent to them. As a result, they find themself preferring the musical now. This might be also true in the Acheulean period, so learners in handaxe making cultures might prefer handaxes with other morphological traits alongside symmetry. The three postulated region-specific styles in handaxe morphology[13] (see section 1, Chapter V) seems to be evidence for this assumption.

1.2. The aesthetic supervenience extended

As to what has already been mentioned in section 1.1., the concept of 'context' is a key notion that concerns my discussions of aesthetic preference and judgement. Here, 'aesthetic supervenience' will thus be another important concept to explore. Just to give a short explanation of the state of 'supervenience', we say that a class of

[13] During Acheulean times, there seemed to have been different styles (i.e., the Boxgrove style, the Kilombe style, and the twisted style) regarding manufacturing the shape of handaxes; these traditions are suggested to be localized aesthetic norms of style preference that involved in the course of making.

facts A supervenes a class of facts B when there can be no difference between two situations with respect to the facts of A unless there is also a difference with respect to the facts of B.

As with aesthetic supervenience, it has been widely agreed that aesthetic properties of features are ‘dependent’ or ‘supervenient’; that is, they depend on other, non-aesthetic features. In other words, generally, the supervenience theory of the aesthetic is mainly about the idea that for any aesthetic property to be designated, there necessarily must be some external base to be designated. For instance, one prominent source of this external base is physical properties (though in literature, much aesthetic appreciation concerns the meanings of words, which are not about physical facts). It is clear that there is a physical base for many aesthetic properties, and our descriptions of such bases includes the physical properties we ascribe to them, such as colour, shape, sound, texture, and the connections between these properties, such as the combination of sounds, the relative spatial positions of elements of an object (sometimes elements of something are not differentiable to the same degree based on different situations or for different subjects). These descriptions, of physical facts of things, constitute the basis of our ascription of any aesthetic property. Though there are many different versions, the core difference between different conceptions of aesthetic supervenience is much about the difference of what people think aesthetic properties supervene on. By ‘basis of our ascription of any aesthetic property’, through one reading of it, it can be a strict view which suggests a set of physical-to-aesthetic rules, others would say that it does not have to be a simple determinism of aesthetic properties by the physical. This is where these different readings or treatment of 'supervenience' should be briefly discussed.

1.2.1. The viewpoint of formalism

Firstly, at one end of the spectrum, there is a version we call formalism which is a purely a formal conception of the aesthetic. That is, this view would hold that all aesthetic properties an object has supervene on the formal components (e.g., the shades and colours of a painting or a set of specifically structured notes on a music score) of that object. Though such a line of thought is suggested to have a theoretical connection with the ideas of aesthetic disinterestedness and immediacy, there is still a debate (e.g., Shelley, 2017); thus for current purposes, I focus only on giving a very short explanation of the kind of aesthetic formalism that I will argue against. From such a formalist perspective, aesthetic properties that an object rightfully has are grasped directly and fully through its perceptual features. For example, a formalist will say that the sum of the aesthetic properties of a painting supervene on (and only on) its visual appearance—e.g., the specific pattern of colours and shapes on its surface, and our aesthetic judgements about it are warranted as well by our perceiving and experiencing of the visual content (i.e., its formal properties) of this painting. This entails either of the following: 1. two paintings which look exactly the same must be aesthetically the same; 2. if there is not a difference in the way the paintings look, there is no aesthetic difference between them.

The limitation of formalism has been made clear in art appreciation (e.g., Walton, 1970). If we take artistic formalism to be true, then we are bound to accept that two things which are perceptually identical must be treated as identical in terms of their aesthetic value. There is a problem with this view: it is conceivable that there can be an object that cannot be discriminated perceptually from an artwork and people do treat them differently on aesthetic grounds. This is the case when we think of perfect copies of paintings (most of us will agree that a forgery of Van Gogh's *Sunflowers* may look just the same as the original, but we tend not to think they possess the same aesthetic value) or ready-made artworks (here, relatedly, Danto's discussion on the *Brillo Boxes* by Andy Warhol). Music is a somewhat different case with regard to how we understand the notion of a 'copy' in a musical work—first, it is always the composition (whether it is a composition by Beethoven) and the performance (whether the conductor of a symphony or the singer of a musical has delivered the work in an apposite way) that are both to be valued in any work of music. Second, there seems to be no material uniqueness to products of music in the sense that we compare it with paintings (or we may say that though there is a material uniqueness to products of music, but it simply falls outside of our interest). As long as the point on formalism in artistic appreciation has been made, I shall leave aside the special case of music (perhaps literature too, think of Cervantes' and Menard's Don Quixote[14]) for the moment.

The limitation of formalism exists in non-art aesthetic object as well. Something ordinary or mass produced (e.g., a mug, a teddy bear, even a supermarket shopping bag, etc.) can bear aesthetic properties, which cannot be fully explained by formal

[14] Menard's Don Quixote: i.e., '*Pierre Menard, Author of the Quixote*', is a short story by Jorge Borges, 1939. In the story, Pierre Menard, a fictional French writer from the 20th century, who tries to actually 'recreate' (rather than merely 'transcribe' or 'copy') the *Don Quixote* in a word for word manner, by trying to experience everything that Miguel de Cervantes had experienced.

features, for its owner. This can be seen in cases where ordinary objects obtain a contextual specialness to the subject. That is, the idiosyncratic life experience of a person with a particular object could produce an effect (it can be either positive or negative, long-term, or short-term) on one's aesthetic response to certain features of an object (for instance, someone might strongly loath some colour due to the early experience of being bullied, in which the bully was wearing that colour); and this effect would present when the subject come across such features (this person might develop a general dislike for objects in that colour). At a more general scale, something like the relationship between an original painting and its copy could be employed for ordinary objects as well. In other words, people would probably have different aesthetic judgements about, say, an original teddy bear toy of some well-established brand and its perfect copy to some other brand even though the knockoff looks and feels the same.

In view of its limitation, the formalist account alone is not enough to explain these aesthetic values we put into things. So, for something aesthetic and a replica of it, it seems right to say that if the replica were to be valued as aesthetically equal, then it has to not just have the same appearance but is also the same in some other ways.

1.2.2. Aesthetic supervenience in context

Many have suggested a broader view in terms of aesthetic supervenience. That is the idea: to specify the 'some other way' that determines the aesthetic discrepancy between an original and a copy is that other contextual properties must be included. For instance, Kendal Walton (Categories of Art, 1970) has indicated the importance of contextualisation in artistic appreciation. Walton has rightfully pointed out that the 'categorisation'—i.e., the psychological process of classifying something into some category—is crucial in terms of how we evaluate a work of art. Recall his example of Picasso's *Guernica (*Walton, 1970, p. 347*)*: imagine a society which habitually produces guernicas that are similar but not the same (guernicas have the property of being three-dimensional) as *Guernica*. In this society, *Guernica* would probably be included in the category and seen as a 'guernica'. However, it would thus be perceived no longer as it is in our society—belonging to the category of paintings. Being counted as a member of the category guernica, *Guernica*, due to its flatness, may strike individuals from that society as peaceful, lifeless, or uninteresting, contrary to being violent or disturbing as what we may perceive. Further, Walton has provided four criteria (the minimal contra-standard requirement, the experiential requirement, the intentional requirement and the institutional requirement) that something can be correctly categorised (for details, see ibid., p. 357). These requirements, in effect, point to the fact that a work's historical background is playing a role in terms of making the right categorisation of works of art. In Walton's own words, 'no examination of the work itself, however thorough, will by itself reveal those properties', and 'relevant historical facts are not merely useful aids to aesthetic judgement […] rather they help to *determine* what aesthetic properties a work has; they, together with the work's nonaesthetic features, *make* it coherent, serene, or whatever' (Ibid, p. 363-364).

In '*What a Musical Work Is*' (1980) Levinson has put forward an ontological treatment for the aesthetic type of music. One core of the treatment is a contextual dependence which relates to the individuation of art works. Based on such dependence, Levison argues that it is not merely the sound structures that are going to be caught by the subject's mind, but rather, it is the sound structure with the performance means *plus* a set of relevant contextual resources in which the composing action happens that are to be perceived and understood as a musical work. Therefore, aesthetic properties of two pieces of music works even with identical sound structures—but with different 'musico-historical' contexts—would vary, since they invariably constitute distinct works. Think of John Cage's *4'33''*[15], as which is in some sense a simplified illustration for Levinson's arguments. It would not be so plausible to suggest that if John Cage did not compose the 4'33'', and there were a piece of work which coincides with the *4'33'* we know (i.e., with the score being made up only of rests, and with each of the movement being the same length as Cage indicated, and a total length of four minutes and thirty-three seconds), that was composed and performed sometime after 1952, it is going to be perceived as having exactly the same aesthetic properties. As Levinson puts it, 'the aesthetic and artistic attributes of a piece of music are partly a function of, and must be gauged with reference to, the total musico-historical context in which the composer is situated while composing his piece' (Levinson, 1970, p.10).

Later, in 'An Ontology of Art' (1989), Currie had extended Walton's idea of contextual dependence through the notion of achievement. This idea claims that it is also part of our aesthetic judgements to assess what the artist has achieved in terms

[15] A work of composition by John Cage, an experimental composer, in 1952. The musical score contains only rests, and three movements (each lasts 33'', 2'40'' and 1'20''). Its premiere was given by pianist David Tudor in 1952. Images of Cage's original score at: the Museum of Modern Art, New York, https://www.moma.org/collection/works/163616?artist_id=912&page=1&sov_referrer=artist

of the prevailing skills in the artistic creation of his/her society. A process of acknowledging what has been achieved by the maker is part of what people are really appreciating, caring about, and enjoying. However, to adequately understand something's achievement, one must have a knowledge of the history of how it is made. Therefore, this would include, e.g., what the technical limitations were for the artist, the conventions he/she chose to go with or against, and factors of which even the maker was not aware (Currie, 1989, section 2.8 & 3.12). More recently, Currie and Zhu (2019) revisited the issue of supervenience, however, from a more evolutionary perspective. In that paper they put forward a story for the Acheulean handaxe industry (a tradition of making large cutting tools from stone) and suggested that the social evolution at a general scale which centred on stone tool technology could have led to possibly the earliest human aesthetic societies. One relevant idea to draw from the story is through the notion they term '*manifestation'*—i.e., 'how an artefact is seen as aesthetically delightful and/or valuable is affected by the skills and other qualities it manifests' (Currie & Zhu, 2019, p. 3). In other words, for the case of Acheulean handaxe making, the handaxe (as the object of aesthetic valuing) must have been evaluated based not only on the finished form, but also with some knowledge about the context—an understanding of the tradition, the techniques, or skills (the preparation, the knapping, the adaptations tailored for unexpected changes) which fulfils this process. This example of how a Palaeolithic practice of technology could develop an aesthetic relevance by social/cultural evolution has indicated something intrinsic about the aesthetic which is also reflected in the aesthetic evaluation of today's art and aesthetic objects. That is, people's aesthetic interests in objects are not separable from an interest in how well the object was made—a contextual fact which is not extractable from the mere appearance of an object.

In later parts of the thesis (Chapters IV and V), I will provide a case study on the practice of Acheulean handaxe manufacture as well. By including archaeological evidence for the environment of and life in the Acheulean, and the technology of making handaxes, I will then present a model which claims that Acheulean society, through its aesthetic concern with finely made handaxes, marked the earliest aesthetic culture in the human lineage. The emergence of this culture shows that the nature of our hominin predecessors' (and of our own) aesthetic attribution and appreciation, in a large part, was integrated with an evolutionary context in which those valuable skills and qualities grow—a social learning system evolved for stone tool technology.

In terms of explaining how specific aesthetic sensibilities could have formed in relation to a techno-cultural practice within Lower Palaeolithic hominin populations, I take up a similar evolutionary perspective, but one which points to an even more general idea of the constant process of organism–environment interaction by drawing upon the theory of niche construction (Laland, Odling-Smee, and Feldman, 2003). To put the model in a few sentences: first, selective pressures are the major force that drives cultural and biological evolution; second, the Acheulean industry, as a techno-complex that evolved from the Oldowan industry, imposed novel selective pressures (costliness) on the display of skills (and other aspects of the practice), and thus provided opportunities for aesthetic elaboration; third, a developed social learning system was then in place to buffer those selective pressures, meeting the need of high fidelity transmission of skills and knowledge. In this system, there are individuals whose skills and knowledge were advertised to others who wanted to learn through the displays of handaxe making. Meanwhile, the exposure to such a system affected people's capacity to make judgements and to form preferences regarding the skills that were put into the making process. The idea of niche construction and the relevant evolutionary mechanisms will be discussed throughout Chapter III. The interpretations from the proposed model (as will be presented in section 1, Chapter V) will minimally make these two points about the aesthetic attribution of humans.

First, aesthetic sensibilities (perhaps of a special kind) and the phenotypic arrangements of these sensibilities (which affect what aesthetic properties people think an object has) have their origin in our ancient niche-constructing behaviours of tool use. Second, in this very general sense, aesthetic supervenience can be described as a supervenience on a more general and varied set of properties which includes those of the selective landscape. A fuller explanation of these points will come in section three, but before this, we should have a look at what has been said concerning aesthetics and evolution.

With this being said, let us turn to those evolutionary theories which have also provided speculations about human aesthetics with an evolutionary consideration.

1.3. The theoretical constructions for aesthetic preferences and judgements that bring together evolution and aesthetics

Though there are various topics in studies concentrating on human aesthetic psychology and brain biology (e.g., the neural basis for certain aesthetic experiences, the neural-cognitive overlapping between aesthetic experience and other cognitive tasks, the influence of aesthetic training on cognitive development, etc.), evolutionary psychology is a general approach which focuses on a causal connection between deep human evolutionary history and the existence and persistence of human aesthetic phenomena.

Many of our theories of aesthetic appreciation and art criticism, those which are sitting close to the cultural dimension of the human world, have the implication that the historical and cultural background of an aesthetic object obtains the complete set of materials we need in terms of apprehending its aesthetic values. Therefore, to answer why something is aesthetically appreciated, one would need to turn to the cultural elements in the background (e.g., social norms and conventions) However, as our discussion moves on, we shall see that an evolutionary perspective (though an extended one) can help with picking out elements which play a role in aesthetic valuing, though they are overlooked sometimes.

For that purpose, let me first present a short overview of the research field of evolutionary psychology which, by extending the Darwinian principles to the functioning of the human mind, aims at an understanding of our modern psychological life from the point of view of the genetic inheritance of humans.

1.3.1. An overview of evolutionary psychology

From the most general view, evolutionary psychology is the study, based on Darwinian principles of adaptation,[16] of the mechanisms by which the psychology of modern humans has evolved into the way it is today. And it is accepted by many that, as a result of natural selection, evolutionary psychology inevitably implies a 'massive modularity' conception of the human mind. The basic idea of it is that the human mind has evolved into a number of sub-systems (modules) which deal more or less independently with different aspects of life. In this view, for example, there is a 'mind reading' module that is activated in situations involving mind reading (and similarly, there can be a cheater detection module, a risk evasion module, a hormone seeking module, etc.). These modules are task-specific and are manifested through behavioural traits. The approach of evolutionary psychology suggests that: 1. the mental characteristics contributing to the survival of the individual that has them or to the individual's success in reproduction are modularised neural adaptations; 2. those other aspects of our psychology, which do not serve such ends, are by-products or 'spandrels'.

Evolutionary psychologists who hold an adaptationist stance for human aesthetic sensibilities therefore draw upon these two principles for an explanatory framework: aesthetic sensibilities as adaptive psychological responses that help with survival or

[16] According to the general principles of the selective framework pertaining to the persistence of any behavioural traits in any given environment, the expression of modes of behavioural traits must either solve pressing adaptive challenges or contribute to the relative success of reproduction for their carrier—i.e., the principle of natural selection and that of sexual selection (a further discussion on these principles will be given in Chapter II).

with reproduction. Implications about human aesthetic evaluations have been drawn from various studies on evaluations for natural objects, and human bodily and cognitive traits. Based on empirical evidence—for instance, the more preferred natural elements in human designs, the pattern between human preference variation and changes in physiological conditions—there seems to be an inherited correlation between evolution and aesthetic sensibility that can be identified (for more on these studies, see section 2.2.1., Chapter II; Miller, 2001; Fink, 2002, 2006; Rhodes, 2006; Buss, 2008; Dutton, 2009; Miller and Maner, 2010; Rusch and Voland, 2013). Geoffrey Miller, compared with other evolutionary psychologists, provides more explicit claims on the topic of human art. He takes the approach of sexual selection and proposes the view that the arts are, in essence, diverse forms of sexual display (Miller, 2001). Artworks are made to attract potential mates (i.e., to enhance the relative success of reproduction.). This is a biologically reductionist view of human artistic practices according to which works of art are costly signals (of 'good genes') analogous to the tails of peacocks, the courtship dance by the birds of paradise and the decorated bowers of the bowerbirds. In contrast with this line of thought, Steven Pinker is famous for the by-product view, according to which the whole territory of human art should be understood as a side effect of humans' evolved biological structure. And the consumption of art, such as enjoying a piece of music, are cases of humans exploiting the neural circuits that generate pleasurable feelings in the brain. In this sense, the arts are cheesecake for the mind, and we enjoy them simply because they happen to activate our other adaptations.

The impact of evolutionary psychology is therefore reasonably extended out into the field of aesthetics to which I will now turn.

1.3.2. What is the nature of aesthetic evaluation? Some relevant theories from evolutionary aesthetics.

Just like the evolutionary psychologists who are interested in the aesthetics of the creation of art, there are philosophers who are interested in seeing our aesthetic activities as the outcome of our evolutionary past. Sitting at the centre of this field is the issue whether, evolutionarily speaking, our aesthetic psychological tendencies, especially those for the creation of art, are an adaptation, a by-product, or something else. Since, traditionally, the by-product view gives an impression of evolutionary irrelevance (though I will argue that this is not the case),[17] many theories adopt the adaptationist view, though some choose to stay sceptical.

1.3.2.1. The adaptationist view for human aesthetic practice: several theories

Going against Pinker's by-product theory, Denis Dutton holds the view that human art in general plays an adaptive function in human evolution, and it is shaped by sexual selection. In *The Art Instinct* (Dutton, 2009), he first suggested that humans are born with innate aesthetic preferences of certain kinds, and gave evidence of the universality of those preferences from the case of landscape appreciation. The example of the *People's Choice* (Dutton, 2009, p. 19) project has shown shared

[17] In Chapters II and III, I will argue that, within an extended evolutionary framework, by-products are not at all evolutionarily trivial, but can have a significant role to play in affecting human evolution.

predispositions in the aesthetic preferences of people living in very different countries (China, Iceland, Kenya, the United States, etc.) in terms of their preferred genre of painting and their preferred content within paintings. The result indicates that in general, despite one's geographical and cultural situation, natural environments are more appealing. Many aesthetically related preferences are also closely connected with other psychological universals such as a dislike of spiders or snakes. These universal psychological inclinations, being the outcome of natural selection, are cognitive adaptations. He then dedicates a chapter to evolution and fiction, arguing that our major aesthetic interests in storytelling are products of the evolved human mind. Those concerns about reproduction and survival can all be 'translated into the eternal themes of love and death for tragedy, and marriage for comedy',[18] along with the setting of character types and structures. Later, Dutton turns to the topic of art. Here he accepts Miller's theory and explains how the evolutionary mechanism of sexual selection has 'selected' for a human 'art instinct'. In other words, it is a match between the maker who carries/produces the costly signals (like the peacock's tail which is believed to indicate its owner's fitness) and the observer (who is continuously refining their discernment of better genes) who live in certain selective environments. In short, as Dutton claims, 'art may seem largely cultural, but the art instinct that conditions it is not.' He suggests that Darwinian evolutionary theories extend our way of thinking about the origin and persistence of art. Such a conceptual tool puts art under the natural domain where

[18] Dutton, Denis. The art instinct: Beauty, pleasure, & human evolution. Oxford University Press, USA, 2009, p. 132.

human culture is created by 'a mind whose underlying interest, preferences, and capacities are products of human prehistory.'[19]

We may regard Dutton's theories as an admirable effort to establish an evolutionary psychological explanation for aesthetics. By assimilating the findings in evolutionary psychology, Dutton makes the fair point that many of our aesthetic tendencies have their deep roots in the evolutionary past of our species and the relationship between the specifics of our present-day aesthetic phenomena and this evolutionary past is much closer than how we thought before. However, just as what we can expect concerning evolutionary psychology, Dutton's evolutionary aesthetic standpoint is a partial one. It may reasonably help answering questions such as why people would feel an aesthetic way in certain contexts or why we tend to pay more attention to certain elements in a painting as being aesthetically appealing. At the same time, as he has noted,[20] the adaptations related to aesthetic appreciation are just a part of the things that humans can enjoy; this view leaves other concerns (such as the enjoyment of what Dutton called the 'intellectual' and 'contemplative' elements)[21] open.

Holding a similar adaptationist view, Ellen Dissanayake is well-known for her idea that art is about a process of 'making special'. According to Dissanayake, it is a universal human proclivity, an adaptation, to make things special and to recognise

---

[19] Ibid, p. 203.

[20] As Dutton had put it, by the example of Rembrandt's portrait of his mother reading the Bible, our aesthetic response to arts 'layer rich meanings and values that may be difficult to disentangle. In the case of Rembrandt, respect for an aged woman, admiration of her devotion to her religion, and astonishment at the artist's technique—all have evolutionary ramifications. Even if it is never able to offer a complete satisfactory general theory of art, evolutionary psychology has the potential to contribute significantly to a philosophical understanding of art and its effects.' (Dutton, Denis. "Aesthetics and evolutionary psychology." The Oxford handbook for aesthetics (2003): 693-705, p. 705)

[21] Ibid, p. 703.

such specialness. And art ‘is an instance of this broader human faculty’. She uses the terms ‘artify’ and ‘artification’ instead of ‘making special’ since her 2001 paper where she posits the view that music is an evolved adaptation which was ‘artified’ by ancestral humans as a cultural practice. As she explains, the origin of ‘artification’ has roots in the mother-infant interaction and goes back to Palaeolithic times. Such interaction is an adaptation because of the evolutionary benefits it provides to both infants and mothers. In Dissanayake’s own terms, this innate and adaptive mode of behaving is where the ‘germs of human art’ sits. That is, this prehistoric natural bond entails the basic imperatives for artistic behaviours. As in her definition, there are five basic ‘proto-aesthetic operations’ and they are all present in this mother-infant bond: a. simplification or formalization; b. repetition; c. exaggeration; d. elaboration; e. manipulation of expectation (i.e., there are anticipations and subsequent fulfilments of anticipations). She proposes that ‘artification’ itself is a targeted adaptation with evolutionary functions that contribute to the reproductive success and the survival of individuals and groups. ‘Artification draws attention to vital matters, provides something to do to address uncertainty, relieves individual anxiety, establishes trust and confidence among participants, and coordinates and bonds individuals in a group.’[22] Apart from this, she also argues that traditional evolutionary aesthetic theories (like those held by Miller) as well as neuroaesthetic studies (e.g., Zeki, 1999; Zaidel, 2009, 2013) overlook people’s proximate motivations and emotions in aesthetic activities while the theory of artification embraces these causes.

[22] Dissanayake, Ellen. "Genesis and development of «Making Special»: Is the concept relevant to aesthetic philosophy?" Rivista di estetica 54 (2013): 83-98, p. 91.

One potential issue with 'artification' is that it seems too general. Even if we agree that 'making special' is a gene-based predisposition and art-making behaviours can be included into this broad category since they exhibit the key features of making special, but so can other behaviours. It seems that she has not provided explicit reasons why the operations to 'artify' or 'make special' are unique to the arts.

Focused specifically on the study of literature (though he also allows for the theoretical extension of his theory), Joseph Carroll (2012, 2013) is another supporter for the adaptationist approach who suggests that an evolutionary perspective would give us a better understanding of the production of human literature. To Carroll, literary creation is an aspect of human psychological functions, and this is where its value lies. The adaptive functions of literature include, in Carroll's sense, both the practical (e.g., providing useful information; offering game plans for future/latent challenges) and those not immediately practical ones (e.g., providing a medium for shared social identity; fine tuning mental organization). By proposing the theory of an 'imaginative virtual world', Carroll tries to move forward from the explicit reductionist view to a more inclusive view that accommodates the dynamic cultural facet of the arts. As he suggests, human individuals all live in their own imaginative worlds, which contain virtual versions of the things in the real world, e.g., forms of cultural norms, image of other humans, personal identities and so on. The literature would then feed into our imagined worlds, influencing the operation of our imagined plans, and consequently guiding our real actions in an adaptive way. Thus, he argues that, unlike the theories related to sexual selection or naturally grounded adaptation, relying on such an imagined structure, human behaviours are partially detached from our biological instincts. Works of literature affect the organization of emotion, cognition, and motivation, and therefore direct human behaviour. In a more general sense, Carroll holds the view that the whole 'imaginative world', which extends far beyond the field of literature (including religions, myths, legends, images, sculptures, songs, dramas, films), should be understood as being subject to the basic structure of human evolution in which forms of aesthetic practices are selected adaptations.

1.3.2.2. What should we say about the nature of human aesthetic phenomena and art, or should we stay sceptical?

Unlike the abovementioned evolutionary theories that suggest an adaptationist view, Stephen Davies provides scrutiny on many of the options on the market. By evaluating some of the key hypotheses of evolutionary aesthetic theories (e.g., adaptation, by-products, and technology) about the nature and the postulated roles of art, Davies suggests that many of the theories are insufficient to provide a satisfying evolutionary explanation for art.

Firstly, Davies accepts evolutionary accounts for humans' aesthetic preferences for certain landscapes, animals, and human bodily traits. He agrees that such preferences signal conditions (e.g., a source of water, meat, shelter, etc.) that increase the chance of survival, and therefore would be favoured by natural selection. Similarly, for human bodily traits, he acknowledges the mechanism of sexual selection, according to which some preferred aesthetic traits serve as honest signals for individual fitness. Also, he rejects the biologically reductionist tendency of aesthetic evaluation and rightfully introduces the socio-cultural level into the discussion. As he puts it, ‘the judgement of and attraction to human beauty rarely is narrowly sexual, nor does it come into play only where mate selection is at issue.’ Not only physical appearances, but also one’s personality, and one’s habits that are manifested during inter-personal communication, and the many traits that concern the realm of social self-presentation and self-definition are all put into consideration before an aesthetic judgement is given.

As with art, Davies critically evaluates the questions of whether art is an adaptation, a by-product, or a technology. He argues that the arguments of the adaptationist view are questionable; for example, a putative evolutionary origin based on sexual selection does not seem to be the only cause of the ubiquity of the art that we are experiencing today. As for what we can observe: children may exhibit artistic skills/behaviours; females as well exhibit the same capacities and interests in art-making practices as males; no evidence has proved that artists, as a profession, are more successful in terms of reproduction. Davies is also sceptical about the by-product hypothesis, arguing that art-related behaviours could at some point become adaptive even though they are not biological adaptations in nature. Furthermore, he also rejects the technology theory of art, claiming that not all forms of art are purely cultural innovations. For instance, music is a kind of art which is closely connected to human biological evolution. Therefore, he questions the analogy between music and fire making: a. unlike the technology of making a fire, the art of music is not just an ends-driven activity, rather it is intrinsically appealing; b. behaviours associated with music making seem to have a much tighter relationship with human genetics;

humans display a music making tendency at an early age (often involving dancing or singing).

Like Dissanayake and Carroll, Davies argues that a social aspect is inevitable and should take on a major explanatory role in terms of explaining human arts. This is right because it is not just the physical/natural (which refers to qualities of health or fecundity) aspect of a human body which is regarded as aesthetically relevant; as he emphasises, the complex network of the interactions between individuals and groups should be considered as well. However, there are some points in Davies' arguments which are not made explicit. For instance, he acknowledges some arts, though not adaptations in origin, do have the potential to become adaptive 'in due course' (2012) because they may serve as honest signals for fitness. But the mechanism of this social signalling system which sustains the various costly art practices seems not fully explained. Secondly, he sometimes claims that the by-product theory makes the connection between art and evolution trivial. This familiar 'feeling' is widely shared by many (e.g., Dutton, Dissanayake); however, this need not be the case in effect. Especially for humans, strong forms of by-products could have significant evolutionary consequences. One best-known example is the increased frequency of human alleles that provide resistance to malaria. According to studies on human niche construction (e.g., Laland, 2008; O'Brien and Laland, 2012), human activities/practices (such as agriculture and tyre manufacturing) have produced by-products (such as an increased amount of standing water) which cause the spread of mosquitoes, and eventually contribute to the prevalence of malaria.

These by-products, in turn, pose a selective pressure that favours the increase in the alleles which confer protection against malaria.[23]

To put it briefly, Davies holds a sceptical view in terms of the theories about the nature of the aesthetic and art, and he suggests that genes and culture are co-evolving. In respect to the arts, he claims that 'there may be no clear answer to the question […] whether they are primarily biological or cultural'.[24]

1.4. Summary: an evolutionarily contextualist approach to human aesthetics

To wrap up the theories mentioned above, and for the purposes of our current concern on human aesthetic preferences and judgements, I suggest the following: 1. the hypothesis of inherited modularity does not fully account for the whole of human mental activities, at least not for the aesthetic part of it which is culturally mediated. 2. Though this socio-cultural aspect has been touched upon in some of these theories, they have not provided a general framework which accommodates such an aspect, and other ones (i.e., the possibilities for the adaptationist view and the by-product view) from an evolutionary standpoint of our species. 3. Just as Davies has very briefly suggested (Davies, 2017), the usefulness of distinguishing between adaptations, by-products, and technologies is called into question by thinking of ourselves as 'a niche-constructing species' (ibid, p. 368). There are recent works in aesthetics which propose an intimate relation between aesthetics and niche

[23] As a result, for human populations involving such practices, researchers have found an increased expression of such alleles (e.g., the HbS allele). Further discussions on by-products and niche construction are provided in Chapters II and III.

[24] Davies, Stephen. "Evolution, aesthetics, and art: An overview." The Routledge Handbook of Evolution and Philosophy (2017): 359-371.

construction. For example, in works by Menary (2014), Portera (2016) and Bartalesi (2019), human aesthetic activities are suggested to be a mode of niche construction. Making a similar point to Davies, and at the same time giving a more detailed argument for the relevance of the idea of niche construction,[25] I will suggest that such a distinction does not produce a better understanding of human aesthetic practices and the preferences and judgements attached to them.

Through the following chapters, from a very general point of view, the answer that is provided by this thesis to the big question about the nature of the aesthetic (i.e., whether our aesthetic mind, which is embodied in our behaviours such as making aesthetic objects, creating art, and giving aesthetic ascription, is in essence cultural or biological) will be that human aesthetics seems most plausibly to be a human phenomenon which is both cultural and biological. But more specifically, as suggested above in section 1.2., a better contextualist way to understand human aesthetic preferences and judgements is to put them with an extended evolutionary background. To see how such an extension is feasible, we will need some preparation.

An evolutionary framework that accommodates the complexity of human socio-cultural life (as mentioned in 1.3.2)[26] is required. In this regard, the theory of niche

[25] The evolutionary psychological view can produce a tension here: the issue of 'trivialisation' (as implied by the by-product hypothesis) and that of over-internalisation (by the adaptationist view). This tension seemingly leaves two alternatives: either a mode of aesthetic behaviour is a selected adaptation which is genetically inherited or it is a by-product to which there is no room for an evolutionary story.

[26] E.g., Carroll has argued that art regulates human behaviour by bringing about cognitive modifications (e.g., through the connotations and contents embedded in the arts) which 'can influence child-rearing, mating, social interactions […] it can lead some people to choose lives of celibacy […] drive others to kill themselves or others, prompt people to affirm universal humanity or to glorify their own sect or tribe at the expense of others.' (Carroll, Joseph. *Dutton, Davies, and Imaginative Virtual Worlds: The Current State of Evolutionary Aesthetics* in *Aisthesis. Pratiche,*

construction provides a valuable perspective. Many of the shortcomings that are involved in evolutionary aesthetic theories might have resulted from shortcomings in understanding cultural evolution as it really is. Based on the idea of organism niche construction and the selective mechanisms it entails (e.g., the reciprocal causation of evolution, multiple inheritance systems), we would have an evolutionary framework which encompasses such socio-cultural aspects of human aesthetic practices. Within this framework, each of our aesthetic activities is regarded as an instance of niche construction and therefore is capable of producing ecological consequences to affect the transmission of human phenotypic traits (this will be elaborated on in Chapter III).

Meanwhile, this contextualist view will be applied to the investigation of the case study of Acheulean handaxes—through which it seems evident that Acheulean handaxes were not appreciated simply based on their appearance but also on the broad context of their making process and the tradition of making which stabilised the Acheulean culture (see Chapters IV and V). The assumption of this case study is that the aesthetic sensibilities related to Acheulean handaxes were neither a fully innate module nor a spandrel but were adaptive phenotypic traits in a close connection (which might be best described as a co-evolving process, possibly

linguaggi e saperi dell'estetico 6, no. 2, 2013, p89.) Elsewhere, he says that 'the disposition for producing and consuming the arts would have served as a selective force on the population.' (Carroll, Joseph. The Adaptive Function of the Arts: Alternative Evolutionary Hypotheses, 2012, p5.) Similarly, Hannes and Voland propose that we should not limit the effect of art to the individual level; artworks are 'an integral element of social rituals, the function of which is to bind societies and to align them to common values or tasks and to emotionally synchronize their members.' (Rusch, Hannes and Eckart Voland. Evolutionary Aesthetics: An Introduction to Key Concepts and Current Issues in Aisthesis. Pratiche, linguaggi e saperi dell'estetico 6, no. 2, 2013, p122.) As will be explained through Chapters II and III, an extended evolutionary perspective can incorporate this socio-cultural role of the arts.

involving a level of Baldwinisation)[27] with changing selective pressures for the technological tradition of Acheulean handaxe making.

At this stage, however, to see what an extended evolutionary background is like, we need to turn to the basic level—the concept of evolution. This will be the focus of the next chapter.

[27] I.e., a process in which derived phenotypic traits (e.g., as a response to a novel selective pressure) become less dependent on the learning environment and become more innate. This co-evolving process is better understood with the discussion on the Baldwin effect and the niche construction theory (see section 3.2.3., Chapter III).

Chapter II: Putting aesthetics into an extended evolutionary context

As suggested in Chapter I, human aesthetic preferences and judgements, contrasting with the standpoint of formalism, depend heavily on the information in the extended evolutionary context—i.e., which includes the knowledge about the socio-cultural background and that of the evolutionary background; for instance, a knowledge of the institutional history of some activity, the use of specific skills or techniques in the making process of an object, and clues of potential honest signals (see sections 1.1.1., 1.2.2., and 1.3.2., Chapter I)—that one accesses. Meanwhile, it is also suggested in the previous chapter, that this type of context-dependent view differs from the evolutionary psychological perspective of aesthetics (see section 1.3., Chapter I) which implies that aesthetic evaluation is in essence fully grounded in the evolutionary context.

In this chapter, I will further develop the contextualist view proposed in Chapter I. In the first section, I will point to the fact that a cultural background is involved in human aesthetic preferences and judgements. Following this, section two will go over the basic principles/mechanisms (those of natural selection, sexual selection, and by-products) on which the evolutionary psychological approach to the aesthetic relies; and it will argue that the evolutionary psychological stance is a gene-centred view which overlooks the cultural background. However, it is right to say that human aesthetic evaluation is to some extent biologically mediated because humans have biologically inherited aesthetic sensibilities. Section three then suggests that the context (more precisely, the relevant context for an aesthetic practice/object) in which an aesthetic practice is conducted is tightly connected to both the biological and the cultural backgrounds of an individual. And to accommodate these contrasting natures of the aesthetic, this contextualist view needs an extended conception of evolution, i.e., to focus on the expression of phenotypic traits rather than on genes. Section four explains how human aesthetic practices and objects can be therefore better understood in this extended evolutionary background.

Finally, in section five, I will give an overview of niche construction theory (which will be discussed in Chapter III), suggesting that this ecological framework provides the evolutionary mechanisms that bring out these contextualist ideas of aesthetics, and that through recognizing an aesthetic niche human aesthetics and evolution are integrated.

2. 1. The cultural background behind human aesthetic responses

> *'A smear of soup on a man's beard looks disgusting, though there is of course nothing disgusting in the soup itself. I presume that this follows from the strong association in our minds between the sight of food, however circumstanced, and the idea of eating it.'—C. Darwin, The expression of the emotions in man and animals, 1890* [28]

Above are words from Darwin where he talked about the expressions of human emotions. Though aesthetics is not the target in his original context, this quotation does have some interesting implications.

[28] Darwin, C. R. 1890. The expression of the emotions in man and animals. 2nd edition. Edited by Francis Darwin. London: John Murray, p. 269.

According to the major claims of the evolutionary psychology of aesthetics (the mechanism of which will be discussed later in this chapter) that were mentioned in the previous chapter (section 1.2., Chapter I), humans are born with innate aesthetic sensibilities of certain kinds. These encoded programs are said to have been affecting our aesthetic behaviours. We are just tuned to liking or disliking certain arrangements of signals because of the lengthy evolutionary history of the human species in selective environments, for instance, the scene of a sunrise or a sunset on an expanded savannah, blossoms with a sweet fragrance, or contrarily, maggots on a rotting carcass, or simply the sight of crawling spiders or snakes, etc. And there are aesthetic theories for the making of human art and appreciation based on those inherited predispositions (see also: section 1.2.2., Chapter I). However, it is unclear how far we can extend these sorts of evolutionary explanations. While an evo-psychological story like this about certain aesthetic responses can be reasonably defended in terms of signals that truly bear a relevant evolutionary history, it is highly contestable that this same story would give much credibility when put under any circumstances where there is little room for biological/genetic internalization. Therefore, as is implicated in what Darwin said above, the evocation of disgust is not because the soup or the beard is in their essence disgusting; rather, something in the *cultural context* might have contributed to the invocation of the disgust here. Though, to some degree, this case might be explicable in evolutionary psychological terms,[29] considering Darwin's earlier descriptions of his experience at Tierra del

[29] That is, there seems to be a link between the scene and a risk of health: i.e., the arrangement of such stimuli—a person and a smear of soup on this person's beard—indicates a lack of hygiene on the part of this person. Therefore, there could be an explanation from evolutionary psychology: i.e., having this feeling of disgust helps people to lower their chance of catching diseases.

Fuego[30], the cultural context seems to be the cause for the different disgusts held by Darwin and the Indigenous people—the 'strong association in mind', as Darwin puts it, is formed in effect through cultural means.

As from our daily experience, culture usually plays an active role in guiding the evocation of people's emotions. For example, it is obvious for many cultures of the present day, that customs of table manners are widespread, and the feeling of disgust can easily be triggered among people from different cultures without the need of a bearded man. Certain behaviours (including not only the kind that involves a set of executed bodily movements, but also verbal expressions) or the consequences of those behaviours would be deemed as inappropriate or even offensive and could induce a strong emotional response, although they bear a much weaker link with hygiene or other similar topics in which selectively related fitness is affected by natural selection. For example, behavioural traditions relate to dress code, the order of seating, the layout of tableware, the manner of talking, etc, all have little to do with improving hygiene or avoiding harmful food from the traditional perspective of natural selection; however, they do matter from a perspective of cultural selection.

This implies that many of our emotional responses that are involved in aesthetic contexts are also culturally mediated, although they usually appear so naturally and can be activated so readily. This claim becomes more obvious if we consider situations which are more aesthetically and culturally demanding. For example, say,

[30] 'A native touched with his finger some cold preserved meat which I was eating at our bivouac, and plainly showed utter disgust at its softness; whilst I felt utter disgust at my food being touched by a naked savage, though his hands did not appear dirty.' (Darwin, 1890, p. 269)

someone is pondering over *The Last Judgements* by Hieronymus Bosch; the emotion, whether it is anxiety, fear, or awe, is largely mediated by the culture of the 15th century which was deeply imbued with a religious narrative. Clearly, this is equally evident in contemporary art production, e.g., installation arts and conceptual arts, for which culturally aligned responses are usually at the core (e.g., the emotionally and politically provoking *Sunflower Seeds*[31] by Ai Weiwei, or the *Brillo Soap Pads Box* by Andy Warhol). In the same vein, but more broadly, there are numerous occasions in people's daily life in which we find that our aesthetic responses (no matter whether positive or negative) are tightly twisted with the cultural life we have lived: e.g., when we talk about the designs that are put into the artefacts we made, or when we enjoy literature, music, or YouTube videos.

What we can infer from the above is that, although the traditional view of evolutionary psychology is valuable in pointing out that the evolutionarily distant context is influential to many things in our aesthetic world (which will be referred to as 'the human aesthetic niche' and will be discussed in Chapter III), it is nevertheless incomplete in terms of giving comprehensive explanations for human aesthetic value or appreciation. The preferences we hold and the judgements we make during the process of valuing and appreciating are culturally biased. Through the examples above, I highlight (when thinking of highly culturally specific cases) that a correlation between aesthetic preferences and judgements and related stimuli can be formed in the socio-cultural dimension through human social learning. Human culture, relying

[31] This installation is intended in a way that not only the raw material of the artwork, the process of the making, but also the manner of how it is presented all carry symbolic meaning that is grounded in Chinese culture. More details about the artwork: Ai Wiewei: Sunflower Seeds, Tate Modern, 2010-2011 (https://www.tate.org.uk/whats-on/tate-modern/exhibition/unilever-series/unilever-series-ai-weiwei-sunflower-seeds)

on sophisticated social learning systems that enable high-fidelity dissemination and fixation of cultural norms, is a force mediating the expression of aesthetic responses (preferences and judgements) from members of society, therefore generating culturally specific aesthetic behaviours and practices. What is important is that the expression (in a cultural manner) of these aesthetic traits (practices, behaviours, judgements, and preferences), at the populational level, can be as stable and inheritable as that of other aesthetic traits which are biologically expressed. Therefore, as suggested at the end of Chapter I, what we need is a contextualist perspective that accommodates these two aspects of the aesthetic: the phenotypic traits that are innate and those that are derived. To construct such a perspective, we need to rethink and extend the concept of evolution.

With this being said, let us first have a look at how 'evolution' is understood in the traditional evolutionary approach to aesthetics by a discussion of the two basic mechanisms on which this approach relies.

2.2. The evolutionary psychological mechanism for human aesthetic sensibilities and its limitations

As stated previously, the theorization about the relationship between aesthetics and our evolutionary context focuses on the identification of adaptations or by-products, and as argued by evolutionary psychologists and philosophers, this relationship can be translated or employed in many forms of human aesthetic activities—from the aesthetic preferences we show among ordinary objects to artistic creation (see section 1.2, Chapter I). Here, from a more basic level, I will give a brief overview of the evolutionary processes underlying such aesthetic theorization; that is, the principles of natural selection and sexual selection. Nevertheless, for the sake of a more focused discussion, I simply take the view that genetic drift is not a major source of modern humans' evolutionary changes (and I would assume this to be true for species based on large populations such as humans); thus, the effect of genetic drift is not to be elaborated on in this section.

The processes of natural selection and sexual selection can be understood as a biological description of two mechanisms that result in the differential reproduction of individuals of a species and thus lead to differential frequency of genotypes in a population. To be more specific, the process of natural selection occurs when: first, there is a population within which the individuals manifest a level of phenotypic diversity under a collection of selective conditions; second, during the life of coping with those environmental pressures, some of the individuals might react more efficiently than others due to their phenotypic novelty which is determined by underlying genotypes; third, in possible circumstances, those who have performed in a more effective way are more likely to survive, i.e., to be 'selected' by the selective surroundings. They then therefore have a better chance of producing more offspring than their competitors; finally, if such selective conditions stay stable for several generations, since the number of the offspring of those individuals who behave better keeps growing larger than that of others, the genes encoding those 'better' phenotypic traits are likely to prevail among the population. In this sense, we may say that a process of natural selection for certain genes based on certain selective environments of this species is fulfilled. Namely, natural selection explains the changes in a population of some organism's behavioural patterns in terms of the interactions between the properties/characteristics of genes and their selective environments. And the notion of 'adaptiveness' or 'fitness' is a factor to measure whether the interactions are sustainable or not. Therefore, based on Robert Brandon (2014), the definition of natural selection can be put as follows: a reliable causal relation, within a common selective environment, between the cause, differential fitness/adaptiveness, and the consequence, corresponding differential reproduction.

As for sexual selection, the first thing I want to suggest is there seems to be two versions of sexual selection. The traditional one, which is employed by evolutionary psychology and evolutionary aesthetics, is the view that for species relying on sexual reproduction, both sexes have evolved using the abilities to 'detect' and 'select' individuals carrying genes of high adaptive value as potential mates. As a result, those genes and behavioural traits shaped by those genes become ubiquitous over many generations. This selection is achieved by a process of detecting honest signals of 'good genes'. Sexual selection is proposed to explain those situations where organisms show characteristics that seem to have nothing to do with survival, and some of them might even be disadvantageous to the carrier's survival, for example, the plumage of birds (such as peacocks' long tails and the superb colours and shapes of many sub-species of the birds-of-paradise) and the tail of the Goodeinae fish (Irestedt, et al., 2009; Currie, 2011; Hosken and House, 2011). Sexual selection can only be sustainable when the evolutionary rewards outweigh the signalling cost. The colourful feathers and long tails are not only metabolically costly, but they also put their owners in danger by making them visually conspicuous to predators or making them slow in terms of mobility. However, individuals who can afford such costs (i.e., who display such traits) would usually be those with better abilities—e.g., an ample intake of resources that leads to fully developed plume colour and length, well-developed mobility and a stronger body—which all indicate better genes (Buss, 2008). In addition to the direct way of extra-sexual selection (i.e., individuals of the opposite sex are to be 'examined' based on certain species-specific standards, which filter for the 'good genes' before a partnership could take place), sexual selection should also include the effect of intra-sexual competition (i.e., individuals of the same sex usually compete with each other for potential mates). Hence sexual selection could have two consequences: first, the spread of genes that underlie honest signals (with both extra- and intra-sexual selection being its source); second, the spread of genes that benefit one's success in competing with same-sex rivals (with intra-sexual selection being its source). The other version of sexual selection is the view that regards sexual selection as a form of cultural selection which affects people's mate choice. That is, sexual selection in this sense refers to the culturally informed interaction between individuals from both sexes where their culturally expressed traits (e.g., behavioural patterns, norms, or ideas, beliefs, etc.) influence their potential mating opportunities (the mechanism of cultural selection will be discussed in Chapter III).

For evolutionary aesthetics and evolutionary psychological theories with an aesthetic interest, natural selection and sexual selection are the two fundamental forces which account for the process of an organism's evolution. Thus, when talking about ‘adaptiveness’ or ‘fitness’ of certain phenotypic traits—here, traits belonging to the human aesthetic realm—of a species, explanatory theorizations depending on these two principles focus on adaptations of two corresponding kinds. That is, as stated by Buss (2008), there are ‘two classes of adaptations: those that evolved because of the survival advantage they gave organisms’ and ‘those that evolved because of the mating advantage they gave organisms.’

2.2.1 The limitation: the adaptationist view and the by-product view—a standpoint that is centred on the genes

Originating from these two mechanisms of selection, the observed phenomena of stable transmission and persistence of behavioural traits across generations are seen fundamentally as manifestations of genetic transmission and persistence. Accordingly, at the descriptive level, even though the content or forms of human aesthetic traits vary a lot, the causes/impetus are suggested to be captured wholly in the past lives of our ancestors (Cosmides and Tooby, 1997; Pinker, 1997; Buss, 2008; Rusch and Voland, 2013), i.e., those traits must have played a role in making some of our ancestors survive better and have more offspring which, in turn, led to the high expression frequency of the underlying genes (thus, those traits) in future generations. Such a reading of human evolution is subtly reflected in the famous phrase of evolutionary psychology—‘our modern skulls house a Stone Age mind’[32].

As has been partly discussed in Chapter I, those expressed instances on this wide spectrum of aesthetic traits are usually defined according to these two mechanisms

[32] Cosmides, Leda, and John Tooby. *Evolutionary psychology: A primer*., 1997, p. 10.

of selection, as adaptations or by-products. Here I focus more on showing how the concept of evolution appears (the adaptationist view on the aesthetic theorization is discussed in section 1.2, Chapter I) in this view. Broadly speaking, the evidence for an adaptationist view of human aesthetic traits mainly comes from studies of human aesthetic preferences/judgements related to, generally, three typical categories (based on participants from industrialized societies): 1. human (physical) bodily traits,[33] 2. personal characteristics,[34] and 3. natural objects.[35] Moreover, there is other research in which a much more dynamic correlation between human physiological status and aesthetic rating of human attractiveness has been found, e.g., the ratings of females for male faces showing stronger masculinity are higher when they are in their fecund phase of their menstrual cycle; female body odour is perceived by male participants as most 'pleasant' when females are around their ovulation (Buss, 2008; Miller and Maner, 2010).

As indicated by such findings, people usually show sensibilities, preferences, or judgements that, according to evolutionary psychology, are determined by our remote contexts/environments which exerted selective pressures on adaptively

[33] There is a large body of literature on the topic of facial and body beauty: modern humans tend to find a face which manifests symmetry, averageness, and hormone markers (i.e., feminine, or masculine relevant features) that are aesthetically attractive (e.g., Fink, 2002; Rhodes, 2006; Buss, 2008); also, the masculine shape of male torso, a ~0.8 waist-to-hip ratio in females, and skin quality are rated as more aesthetically appealing (Fink et al., 2006, Buss, 2008).
[34] This includes traits that are more abstract: e.g., a good sense of humour, a predisposition to creative activities such as music composing, painting, and literary writing, etc. (Miller, 2001; Dutton 2003).
[35] Apart from the well-known example of savanna-like landscapes, other studies have indicated a universal preference for some subtle balance between nature and humanities: in a study where participants were asked to rate photos of different scenes, though purely natural scenes were consistently judged as more aesthetically appealing than purely man-made environments, man-made environments containing high proportions of vegetation were overwhelmingly preferred when compared together; another study investigated the preferred contents of painting among participants from different countries. The result showed that paintings having contents of not just a landscape, but also the presence of water, people, and animals were mostly preferred (Buss, 2008; Dutton, 2009).

valuable mental configurations that produce aesthetic responses on the appearance of specific cues—e.g., a balanced (not perfectly symmetrical) face or torso indicates healthy development in organs and a functioning immune system that prevents parasites and pathogens; a ~ 0.8 waist-to-hip ratio indicates not only healthy development but also a fertile reproductive status; also, the abilities for creative activities can be an indicator of general intelligence[36] (Buss, 2008; Dutton 2009). In short, the adaptationist claim is that: many of our aesthetic sensibilities and preferences are innate and universal human psychological adaptations that get passed from generation to generation by the process of genetic inheritance.

The other line of thinking which often responds to this adaptationist view of the aesthetic is the by-product view. For supporters of this view, they focus on the adaptive function of aesthetic tendencies in the making of art. Unlike many other traits of humans, such as a large brain or dexterous hands, they argue that many of our aesthetic preferences (especially those expressed through art production and appreciation) do not have an adaptive role in human evolution. Cosmides and Tooby (1997) have suggested that the existence of artworks may just be an evolutionary by-product. Similarly, Steven Pinker (1997) also argues that human art, music, humour, etc. are not real adaptations, but side-effects of other evolved abilities. In this regard, aesthetic preferences for these objects are suggested to be regarded as being the same as other psychological tendencies such as the desire for cheesecake and sweets or alcohol which is not itself adaptive. The irresistible desire for cheesecake is not the thing that contributes to the survival of its owner, it is the underlying

[36] Many aesthetic and artistic activities are cognitively demanding, e.g., requiring linguistic competence (such as a large vocabulary, creative organization of structures), a good learning ability, fine motor control, etc. (Dutton, 2003).

biochemical mechanisms which drive individuals to gain calories that make a contribution to survival. According to proponents of the by-product theory, the reason for the expression of such phenotypic traits in the population is that they stimulate those otherwise evolutionarily adaptive characteristics. So, when it comes to the aesthetic, our aesthetic sensibilities involved in art consumption and art making practices are suggested to be evolutionary spandrels that are activated because of inherited adaptations. Therefore, in the by-product framework, human aesthetic practices and sensibilities are evolutionarily inessential; they are side-effects which exert no influence on the course of human evolution.

However, these two stances share the same constrained conception of evolution—one that is based on genetic inheritance which is vertical and unidirectional. That is, no matter whether some trait is an adaptation or an accompanying side-effect of an adaptation, it is biologically encoded and fixed. Therefore, as we have discussed in Chapter I (section 1.2.) and above (section 2.1.), many of the aesthetic theorizations based on evolutionary psychology are limited in the sense of not allowing for an aspect of cultural inheritance and has somehow set up an opposition in which there are aesthetic traits that are naturally encoded and that are culturally rooted. Though such theories have presented arguments to show that many human aesthetic traits—including both the processes of appreciating, preferring, or enjoying certain objects or stimuli and the practices that produce those objects and stimuli—have a genetic ground, and that our distant evolutionary contexts have been playing a role in mediating the expression of those traits, this perspective overlooks an aspect of the evolution of organism which is of the same degree of importance: the propagation of phenotypic traits through non-genetically transmitted resources.

That said, a better framework of explanation is needed in response to the concern that the roles respectively played by cultural intervention and evolutionary psychology in terms of explaining that features in the human aesthetic world are in essence incompatible. The dichotomy of nature versus nurture is a longstanding one. A framework would need to be a unified one which allows for both cultural mediation and genetic innateness in the formation and expression of human aesthetic traits. To do this, I suggest that we need to broaden our toolkit by firstly introducing a re-evaluation to the concept of evolution. In other words, the evolutionary psychology-based view of human aesthetics is so limited in its explanatory power because it fails to capture the evolution of organisms in a realistic way.

2.3. A re-evaluation of the concept of evolution: an extended evolutionary context

To capture the full reality of our aesthetic activities would require an extension to the concept of evolution itself to make the cultural evolutionary.

One thing that must be said here is that by going against the traditional evo-psychological viewpoint on aesthetics and suggesting a prominent role of cultural mediation, I am not subscribing to an aesthetic relativism. The fact that aesthetic responses are closely implicated with cultural resources does not imply that those responses are individualized and discrete between cultures and there are no shared patterns to be found among people's aesthetic experiences. It is clear that while different cultures have different traditions, people can appreciate cultural products cross-culturally. People from Western cultures can appreciate artworks of Eastern cultures and vice versa. With a proper understanding of relevant aesthetic contexts, people from other cultures can have a proper appreciation of aesthetic objects produced in such context. Just like language learning in humans, there are no cognitive barriers that prevent people from learning a second language. Analogously, there is a cognitive substrate which allows cross-cultural aesthetic appreciation, and this cognitive substrate is employed universally in modern humans. In short, putting aside diverse personal and cultural values, there is some fundamental universality in human perception, as Lamarque suggests, that although the aesthetic is mediated by the specifics of culture, it is a cross-cultural phenomenon, something that is shared by modern humans (Lamarque, 2005). Just as we could reasonably offer an aesthetic defence for the cows of the Dinka people[37] (and thus the practice of the breeding of their cattle, see Currie, 2012), as we know more about the lifeways of the indigenous population, in the same way, we gain understanding of aesthetic objects in our own culture—from commodities like designer handbags to Banksy's mural *Portrait of Basquiat Being Welcomed by the Metropolitan Police* on the wall of the Barbican Centre—based on what our take on the symbolic meaning of luxuries is and on how much we know about the affairs and politics in the society. The point worth noting here is that while access to the cultural make-up of an object is crucial in terms of

[37] An ethnic group that is native of South Sudan. They raise cattle in special ways (e.g., cutting the horns to encourage regrowth; manipulating the hump to increase its size; castrating bulls for bigger body size and glossier coat; cutting the tail hair for tassels) which lead to intentionally guided/biased development of the animals, resulting in expression of phenotypic traits in the cows which are deemed and appreciated as aesthetically desirable (Currie, 2012, pp. 107-108).

obtaining a fuller and better aesthetic response in the viewer to aesthetic objects, such access is certainly open to us—a species with a purpose-general adaptation of learning.[38]

Further, if we try to ask how exactly (in what manner) some object (and the activity of making it) will be aesthetically perceived and digested by members of a population/society, then this will largely depend on the relevant parts of the general cultural context which legitimate its aesthetic relevance. As Currie points out, for something to be treated as aesthetic, importantly, there will need to be 'a social context[39] that recognizes the practice of aesthetic production, thereby making a tradition of that practice.'[40] The forms that such recognition takes can be various—e.g., religion, magical and symbolic practices, a system of terminology, etc. (Ibid, p. 123), what they have in common, however, is that each of them is playing a role which demarcates its distinct realm of aesthetic recognition.[41] And the scope of this realm is made possible through the specific interplay among factors involved in aesthetic practice and many other practices. Let us take the Dinka's cows as an example. It is very likely that a cow raised in Dinka society would be treated as a recognized aesthetic object, and it would be appreciated in some serious way

[38] The mechanism of learning (both social learning and individual learning) is vital for a suggested extended evolutionary background in terms of affecting the configuration of this cultural make-up. The significant role of learning in humans will be emphasized through discussions in later parts of this chapter and in Chapters III (on cultural niche construction) and V (on social learning in the Acheulean industry).

[39] I have used the terms 'cultural context' or 'socio-cultural context', in parallel to 'social context' to denote the same background that acts as the foundation for such recognition. As what will be proposed (in Chapter III), they can be included and considered under the general concept of 'cultural niche'.

[40] Currie, Gregory. "Art and the anthropologists." Aesthetic science: Connecting minds, brains, and experience (2012): 107-128, p. 123.

[41] As a matter of fact, the 'distinct' is used only in a relative sense. There are borderline cases of aesthetics for which it is hard to decide whether something should be evaluated as belonging to realm (tradition) A or an adjacent realm (tradition) B.

(similar to the way of art critics) specified by a set of criteria (e.g., the size of the body, the texture of the coat, the shape of the horns, etc., see footnote 10). On the contrary, for a cow that is raised in our society, even if it was raised in the same way so that the cow exhibits traits that meet the Dinka criteria of cow breeding, it is unlikely that the cow would be regarded as having equivalent aesthetic value. The same is true for a myriad of other traditionalized aesthetic practices that are differentially (and many are exclusively) expressed in different cultures.

Therefore, if we regard the potential for an action or simply a behavioural pattern—which is within the capability of human behavioural flexibility (i.e., allowing for cultural intervention, e.g., through ways of learning) and is recognizable by the existing traditions in some culture—as in the essential medium of human phenotypic traits that are subject to the arrangements of cultural factors in the relevant context, then this provides us a picture of cultural dynamics which, to a large extent, resembles the gene-based dynamics of evolution adopted by the evolutionary aesthetic theories mentioned above. And it is in this line of thinking I suggest only through an extended approach to the concept of evolution we can locate the bedrock upon which a contextualist framework (which accommodates both the cultural and the natural contexts) for human aesthetics can be obtained.

That said, this extended conception of evolution enables us to focus on the contextualized expression of human phenotypic traits,[42] rather than solely on the

[42] Which include a large part of those aesthetic traits that are not compatible with the abovementioned gene-centred theories and all other traits that are either culturally or biologically grounded.

encoded expression of genotypic traits. This shift of focus is important and useful in three aspects.

First, it is important to see that the evolutionary story of the human species (especially) is to a significant degree a story of human culture. It reflects the history of how individuals as organisms manage to respond appropriately to the context in which they live. With the help of culture, individuals can respond adaptively and flexibly to the context, and by bringing about trans-generational accumulations of cultural resources (in which humans excel), this effect of culture has been augmented likely since the Lower Palaeolithic (this will be elaborated in Chapters IV and V, based on the case study of Acheulean handaxe technology). Therefore, the information that goes into the chain of DNA is responsible only for a portion of the complete story of the human–context interplay, since adaptive patterns of behaving can be copied population-wide through social learning (rather than reproduction). [43]

Second, according to the first point, given a context which is highly culturalized like ours (i.e., the accumulated cultural resources are prevalent, making the expression of phenotypic traits substantially culturally attuned), a large part of the information that does go into the processes of biological internalization would be culturally

[43] Certainly, the human brain is naturally selected and modularized in many ways; however, it does not lead to the consequence that in any case when any of the encoded aesthetic sensibilities participate in an expression of human aesthetic traits (e.g., performing an aesthetic practice or holding an aesthetic belief), the expression will be rendered wholly automatic—although, as indicated above by the rules of natural selection and sexual selection, we have innate aesthetic sensibilities which are triggered automatically, they do not count as sufficient conditions for many of our aesthetic practices. In culturalized societies, those sensibilities work with other culturally mediated aesthetic sensibilities. This can be made clear through examples in which the expression of aesthetic traits goes against gene-centred principles—going after signals of biological fitness and reproductive value. Such examples include aesthetic preferences and (positive) judgements for: e.g., the foot binding tradition which existed in China until the early 20th century, and the practice of female genital mutilation in some African cultures.

filtered information.[44] In this regard, for certain phenotypic traits that exhibit an insensitivity to culture, appealing to a genetic explanation would lead to a misattribution of causes.[45]

Third, making such an extension is in no sense introducing any logical incongruence. Based on what we have discussed above concerning the selective role cultural factors (e.g., traditions) play in respect to how a practice is recognized, and the first and the second aspects here, we have a complex but unified picture of human evolution (however, an extended version) during which phenotypic traits are expressed in a highly synthesized manner—with the dynamics of differential fitness, of adapting, and of inheritance operating together, leaving selective traces across different levels (from the genetic, the epigenetic, and to the behavioural, or vice versa). In short, humans evolve in two ways, the biological way, and the cultural way, and these two ways affect each other simultaneously.

[44] This could be achieved through mechanisms such as epigenetic coding. Recent studies in this field have indicated that contextual information can be transcribed into the DNA sequence of the offspring through the biochemical process of (DNA/RNA or histone) methylation, thus producing expressions of context-specific phenotypic traits. Experiments on rats and fruit flies have identified epigenetically induced transgenerational aversion to smells, predispositions to diseases affected by parental diet, and psychological traits related to aggressiveness and nervousness (Carey, 2012; Dias and Ressler, 2014; Guida et al., 2019). For humans, it is also suggested that the nutritional status of the parents (e.g., exposure to unhealthy diet, famine, etc.) affects offspring's preference for a high calorie diet leading to susceptibility for higher BMI and obesity (Cao-Lei et al., 2014). Other than this, it is argued that parent's DNA methylations, due to exposure to extreme stress or trauma, can be passed down to next generation, though how exactly that affects the phenotypic traits of the offspring is not clear yet (Kandel et al., 2012).

[45] For example, a person can show an over-expressed preference for and compulsive consumption of alcohol and can be diagnosed as having an alcohol dependence characteristic according to genetic tests. However, it might well be factors in the cultural context (e.g., long-term exposure to alcohol, alcohol use in early stages of development) that cause the dependence. It is suggested to be the case that there are cultural factors which are accountable for many addictive disorders. And this has stirred up debates on whether addictive disorders are brain diseases or not. (For details on this topic, see Leshner, 1997; Foddy and Savulescu, 2006; Levy, 2013; Pickard and Steve, 2013; Sinnott-Armstrong and Pickard, 2013; Cuthbert, 2014.)

Now, to illustrate this complex picture, if we focus on the behavioural level (at which phenotypic trats are expressed in the form of behavioural patterns, actions, or practices) we can imagine the possible evaluations of some given practice to be a process resembling a ball rolling down from many different rugged hills. Here, Conrad Waddinton's famous metaphor for cell development can be a helpful analogy (Fig. 2.1).[46] By adapting Waddinton's landscape, in our case, the uneven surface of a region of the hill represents an overall description of the sum of relevant selective dynamics (constructed by both cultural and biological factors)[47] that functions in some given society at a particular time (thus, different societies would produce a unique region which defines the ball's starting position). On this landscape (I use '=' in substitution of the term 'represent'): the ball = some given practice; the valleys[48] = types of traditions that recognise practices; the inclusiveness of a tradition = the width of a valley; the

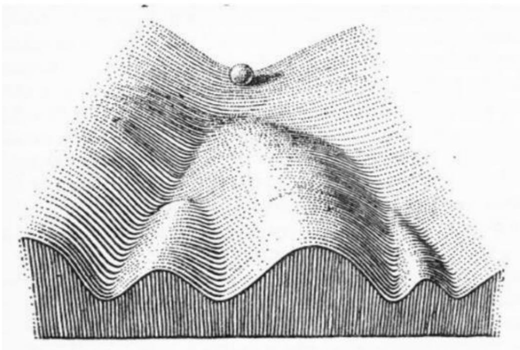


Fig. 2.1. The original illustration of Waddington's Landscape of cell development. Reproduced from Waddington, 1957, p. 29.

[46] Waddington used this metaphor of a ball rolling down a mountain as a model to indicate the process of cell differentiation throughout the stages of development. It used to be an accepted view that a cell develops towards its fate in a way that is unidirectional, i.e., from an immature (pluripotent) state to a mature (differentiated) and finished/fixed state, and this idea, as Waddington did, can be depicted as this rolling process from the top to a bottom of a valley. However, recent cell biology rejects this view based on studies of induced pluripotent stem cells (iPSCs) which suggest that a cell's fate is reversible (Ladewig et al., 2013; Takahashi and Yamanaka, 2016).

[47] The formation of this shape involves extensive participants from various domains, though sometimes the chronicle of a tradition could leave a misleading impression. For instance, in the practice of film making, it is affected by the development of a wide range of factors, e.g., the technologies in the production and post-production of films (lens optics, camera image sensors, visual effects algorithms), medium, costume, music, social norms, politics, etc.

[48] Certainly, a tradition can be subdivided, and as a result there would be valleys under a type-valley at the bottom of the hill. This might be represented by the length of the valley. In that case, the diversity of a tradition can be included in the landscape.

degree of specialization of a tradition = the mean value of prominence of a valley relative to its adjacent ridges; the strength of selection = the slope (gradient) of the hillside. If the denotatum of the ball is fixed, when it is put onto different landscapes, it tends to end up in different valley bottoms. Considering the example of wearing high heels, on the landscape of our society, the ball (the practice of wearing high heels) is very likely to roll towards the bottom of the 'aesthetic valley' due to the vast width of the valley and the strengthened slope of it.[49] When this same ball is put on the landscape of, say, a Papua New Guinean tribal society, the starting position of it can be so far away from the 'aesthetic valley' of this society, and it might end up at a bottom as some non-aesthetic practice or simply being something unrecognised (in this case, it never reaches the bottom). Hopefully, this tentative visualization makes this point clear: to fully recognise or appreciate a practice we need to understand the rise and fall of the landscape it belongs to.

The above points to a very general view about the nature of human aesthetics—it is a hybrid of nature and culture which is highly embedded in its context. In the next chapter, I will focus on the concept of niche construction from evolutionary biology, suggesting that niche construction theory (which emphasizes the mechanisms of niche modification, reciprocal causation, and multiple inheritance) is a theoretical structure that brings out this contextualist view of aesthetics.

[49] While cultural factors are clearly involved in facilitating this aesthetic practice and preferences for it, studies have also suggested that it is facilitated by encoded evolutionary aesthetic sensibilities (Lewis et al., 2017; Prokop and Švancárová, 2020).

2.4. Why do we need to know this extended evolutionary context to better understand human aesthetic responses?

With the discussion above serving as the general conceptual basis for a contextualist view of the aesthetic, we can take a closer look at how it might contribute to the process of aesthetic evaluation at the level of the individual.

As discussed in Chapter I (section 1.2.2.), contextual information, especially that implicated with the process of the making of an aesthetic object, is closely related to individuals' aesthetic preferences and judgement. These arguments fit into the general picture presented here in the above section (as visualized in Fig. 1.). To begin with, in recognizing a practice properly, we first need to know what an appropriate starting point might be to put the ball. That is, a misunderstanding of the practice would result in a mis-locating of the starting position and then lead to a misattribution of aesthetic properties. For example, when an installation is mistaken as a sculpture, or when a painting is mistaken as a collage, it would be very likely on the part of the viewer to have an aesthetic experience that is distorted and generate aesthetic judgements that are not appropriate. Therefore, this points to the importance of actions and behavioural patterns because they are the elements through which a practice is realized. So, we (as viewers) care about what acts are there and what manipulation has exactly been performed before we comprehend an instance of some practice.

Moreover, there are other factors accompanying the conducting of actions. As discussed in section 2.3., this contextualist framework (based on an extended conception of evolution) for aesthetics attends to the kinds of aesthetic practices that are expressed both culturally and biologically. In this regard, the aspects of encoded underpinnings and culturally mediated (through epigenetic effects) underpinnings are also parts of the relevant context. Apart from the case of high heels (footnote 22) and alcohol dependence[50] (footnote 18), many human aesthetic practices belong to this category, e.g., plastic surgery, clothes designs, body building, sports (this notion involves a wide range of practices, clearly many of them are relevant here, such as anthems, team-based competition, design of in-game tensions or risks), etc. Again, the human aesthetic is both cultural and biological.

In addition, the background (the shape of the surface in Fig. 1.) against which those actions, behaviours, and the underpinning factors are performed is also important. Let me clarify this by appealing to a question involved in making art. From the stance of aesthetics of the art, for instance paintings, the question can be reasonably asked: why do you need to know about the chemical properties of the paint for people to properly understand a painting? From the first-person perspective, it seems to be the case that we do not consciously reflect on such knowledge. A painter is not required to know the principles how different particles are organized, in different ways, to become different media for painting. And a gallery goer, as well, is often not bothered by not knowing details about the making of the paints. The media exhibits diverse physical characteristics, and it is to those perceivable properties that the artist and the viewer are always attending. However, people would at least have to rely on some of the basics of the paints without seeing

[50] Though it does not seem to be the case for us, it is possible, for some other culture, that practices related to such phenotypic traits could be regarded as an aesthetic tradition.

this as a piece of chemical knowledge. For instance, during the making of the fresco we now see on the ceiling of the Sistine Chapel, Michelangelo would have to rely on a version of the chemical knowledge of the paints, namely, the combination of calcium hydrate with carbon dioxide which produces calcium carbonate, $\{Ca9(OH)2 + CO2 \longrightarrow CaCO3 + H2O\}$. Nevertheless, this needs not to be consciously obtained; what would be enough for him making the fresco is that when painting on the surface of the final wet layer of plaster applied in a fresco painting, it allows pigments to penetrate the plaster and when it dries in the air, the plaster forms a stable solid body, and the colours would stick firmly and cannot be washed off. Therefore, this knowledge in a 16^{th} century artistic production context would be highly relevant in understanding and appreciating 'what Michelangelo had done on the ceiling of the Sistine Chapel'—i.e., the practice of making a fresco. The sum of many other pieces of such knowledge defines the potential interactive affordances available to the painter. And since such knowledge is accessible to other members of society, it is also employed by the viewer during their interactions with the artwork. Likely, the viewers would then try to reproduce the process of making, based on the knowledge they have. They may well be able to infer some of the options that the artists faced, and the choices they made, and the possible reasons they had for such choices. Back to the chemicals of fresco making, the knowledge of this kind would allow the maker to achieve the vivid and endurable content of the mural, which allows the viewer to 'see' what actions Michelangelo would have to perform to create real depth in the painting and to balance the painting process and the drying plaster. All of these are then involved in the process of having an aesthetic experience and making an aesthetic judgement about this piece of art. A viewer who literally knows nothing about the paint is more likely to end up with a limited appreciation.

Taking this notion of an extended evolutionary framework, we may have a holistic perspective for aesthetic evaluation that centres on the knowledge about the way an in-context practice is done. To put it in other words, this is in a sense a general explanation for what we mean by appealing to notions like skills, expertise, prowess, or virtuosity, etc., when we appreciate something aesthetically.

This contextualist perspective specifies the evolutionary network behind the use of these notions. These notions are concerned with aesthetic practices (usually objects/products of such practices) in light of the knowledge about the actions involved. The fact that we attribute these notions to objects is for the purpose of denoting, through such attribution, the truth (information) that underlies the performance of those actions and practices. Certainly, as implied above, there can be misattributions of skills to an object in question. In this regard, this contextualist view is helpful. By taking the actions, the underpinnings, and the bio-cultural background as a whole, it helps to reconstruct the 'floor plan' (Fig. 1.) that the maker of the object has when the making process is initiated (here, the use of the term 'floor plan' is tentatively analogous just for expediency). This floor plan shows the overall structural arrangement of the system's dynamics in a relevant context, constraining the making of some object at some particular time. This context stipulates the interactive affordances between the agents and their accessible aesthetic resources. Though obviously it gives an impression resembling the way that 'blueprint' has been used in genetics; as a matter of fact, there are no floor plans for the agents which stay unchanged. The floor plan is constantly changing because its relevant context is ever-changing. As discussed above (see footnote 20), aesthetic practices do not evolve in a vacuum; other practices have the potential to develop an aesthetic relevance at some time, adding novel contents to the picture. Likewise, the opposite is true; some factors involved in an aesthetic practice could become aesthetically irrelevant at some time, erasing contents from the picture. When a feasible 'floor plan' is obtained, it serves as an informative guide for our attributions of such notions.

Last but not least, in Chapters IV and V, the Acheulean practice of handaxe making will be investigated as a case study. Just as with the examples mentioned above about the aesthetic practices of ethnic groups, without a grasp of the context of where they grow, the products of this Acheulean practice are likely to be appreciated in some distorted way. However, once we attend to its original context, we would have a richer aesthetic experience about those finely made handaxes. Also, as will be suggested in Chapter V, through a niche construction-based model of the cultural evolution of handaxe technology and the social learning system, Acheulean individuals might well be capable of appreciating a piece of work in a similar way—possibly through their evaluation of the skills and techniques put into its making—as we do when we appreciate an aesthetic object, and like the appreciators of the cows and feather dress of the Dinka group and Papua New Guinean tribes.

What's more, being a tradition that began as early as 1.8 million years ago, Acheulean handaxes provide fundamental clues to the evolution of the aesthetic sensibilities of our lineage. Regarding this cultural practice as a mode of niche construction, and analysing archaeological evidence, I will argue that with a lifespan of over 1.5 million years, the Acheulean practice of handaxe making constitutes a tradition which is aesthetic. Furthermore, I will suggest that the advent of this tradition marks the foundation of the aesthetic sensibilities we see today in people's judgements of art and other artefacts from an aesthetic point of view.

2.5. The idea of organism niche construction and mechanisms: an overview

In the last two decades, the concept of evolution has been greatly debated in fields such as evolutionary biology, ecology, ethology and anthropology. At the centre of the debate stands the question: does our paradigmatic understanding of evolution leave out important components? The answer, according to some prominent figures in evolutionary biology (e.g., Kevin Laland, John Odling-Smee, Marcus Feldman, etc.) is yes. They then have focused on the phenomenon called niche construction which describes the interactions between organisms and their environments, and they have put forward a theory for it, known as niche construction theory (NCT).

As an elaboration on this topic will be included in the next chapter, I will give just an overview of the theory, showing why it is relevant. In a nutshell, I propose that the idea of organisms' niche construction is helpful because in essence it helps explain the nature of human aesthetic practice, and the NCT is the theory which integrates the contextualist view of aesthetics with evolutionary mechanisms underlying the way which describes how we exist as a species—i.e., by constantly changing and being changed by the human niche.

The major claims of NCT, very briefly, are: 1. Organisms are creatures that act, behave, and respond. By exerting such capabilities, organisms constantly bring about changes to the niche (an abstract space that is defined by selective pressures to which a species is exposed)[51] in which they live. 2. Organisms' actions have selective potential (in the sense that they modify the environments to fit their own lifeway); thus, stabilized niche constructing practices shape the environment in a way that favours phenotypic traits expressed in such practices. This usually leads to the prevalence (or over expression) of some practices. 3. When the environment is significantly modified as a result of point 2 above, the modifications are likely to be inherited by future generations through multiple inheritance systems.[52] 4. Such a fact would in turn affect the evolutionary trajectory[53] of future generations. In this regard, a species' evolution is to some extent shaped by its own practices of niche construction. Evidence of niche construction-induced evolution is widely confirmed in species (e.g., earthworms, beavers, and humans) whose inheritance systems tend to be stable across generations, i.e., the information of past advantageous behaviours is more reliably preserved (that is, through the processed soils by earthworms, the dams built by beavers, and the artefacts and cultural institutions of humans), thus leading to lower costs of obtaining those behaviours in subsequent generations. In this regard, as a contrast to the paradigmatic view of the 'modern

[51] The history and definitions of the notion 'niche' will be discussed in the next chapter (section 3.1.).
[52] Next chapter, section 3.2.2.
[53] Producing not only heightened phenotypic expression, but also increases in the frequency of genotypic traits through mechanisms such as the Baldwin effect—whereby a socially learned behaviour becomes less and less dependent on the learner's interplay with the learning environment (see next chapter, section 3.2.3.1., for an explanation of this effect. Also, as mentioned in note 17, epigenetic mechanisms could plausibly contribute to the Baldwin effect).

synthesis' (which is a gene-centred view of evolution),[54] this way of seeing evolution has shifted the mechanism of evolution from a one-way causation into a reciprocal causation where the organism and selective environments are mutually affecting each other.

Therefore, once we start to see human activities in light of niche construction, 'nature' and 'nurture' can be re-united in an evolutionary sense, since they are the two possible outcomes of niche construction. In this sense, the above-mentioned scenario for a contextualist view of the aesthetic is best understood by drawing on the idea of niche construction, a perspective which incorporates cultural dynamics (a process that is called 'cultural niche construction')—which our derived aesthetic activities are subject to—into evolutionary dynamics.

The idea of niche construction provides a solid ground for the idea of cultural evolution. The process of cultural evolution and the episodes of selection emerging and dying down within this process are confined in the context of a constructed human niche which is highly mediated by our own hands—the product of niche construction, i.e., the product of organism-environment interaction. In such a 'space', past actions and choices of human individuals are closely related and are preserved with high fidelity, becoming the resources and a constraint for future actions and choices. More specifically, the idea of niche construction draws our attention to the fact that, for all the phenotypic characteristics that define human evolution—those that are stably inherited and manifest across generations—they are not only a consequence of genetics, but also that of non-genetic cultural or epigenetic forces.

[54] See next chapter, section 3.2.1.

To focus on the cultural forces (considering the magnitude of our cultural niche construction), relying on human cognitive capacity and the cumulative cultural resources, changes (technologies, knowledge sharing systems, institutions, infrastructures, etc.) made to the human niche allow individuals to exhibit a marked level of developmental/behavioural plasticity. Such plasticity is tuned through a crucial external structure: social learning, enabling stable transmission of behavioural patterns, practices, and traditions. This is how the modified niche (i.e., the revised sum of selective pressures caused by practices of previous individuals) delivers its influence on the behaviours of its extant members. That is, with an effective social learning system, which we do have, human societies can achieve rapid and efficient reproduction of ideas and behaviours among the population. As a part of the niche, the modes of social learning can be affected by those ideas and behaviours. Practices usually produce non-random changes to the niche which facilitate further optimization to certain modes of social learning. As this feedback loop grows, biased social learning structures can occur, and thus, biased learning and exploration opportunities are what learning individuals are facing. Finally, this can lead to differential acquisition and propagation of behavioural traits. Therefore, there are behavioural patterns that seem to be 'fixed' in a population without necessarily being genetically grounded adaptations; they are adaptive non-adaptations.[55]

[55] A well-studied example, which demonstrates the process where creatures construct niches which alter selective pressures and are passed on to future generations, is the human milk consumption. It is believed that modern humans began to consume the milk of other animals at least several thousands (~ 8000) of years ago as they learnt to domesticate animals. Due to the benefits of domestication, this culturally derived practice largely buffered selective pressures for efficient and sustainable energy intake. Therefore, it gradually became a prevalent and stabilized tradition through social learning. At the same time, the prevalence of the lactose tolerance allele in certain populations today (e.g., those

It is also in this sense that the by-product rightfully deserves an evolutionary role as well. As long as it generates instances of niche constructing activities, it could affect the fitness of individuals, who interact with the realm of the niche which is modified by the by-product, through modified selective pressures and biased social learning. [56] In fact, human by-products are frequent. Think of the waste that we produce (e.g., the greenhouse gasses, the radioactive contamination, plastic waste, etc.). They are by-products of other (adaptive) human activities; however, they are having significant impacts on our life, stimulating development in environmentally related technologies and industries. Other things, such as many consumables, are by-products too. For example, the desire for cigarettes itself does not seem to bestow any adaptive value regarding survival or reproduction; it may be an instance of a by-product, just like Steven Pinker's cheesecake, which is preferred due to the activation of some otherwise adaptive neural pathway. Nevertheless, the tradition of cigarette production and consumption is still firmly intertwined with human populations—it too stimulates technologies, generates cultural forces, and affects human activities.

With this overview of niche construction theory, human aesthetic practices (considering their close relationship with culture, hybrid nature, and context dependence, as discussed in this chapter) fit into this framework based on the interaction between organism and selective pressures. Therefore, I suggest that the contextualist idea of human aesthetic practices is better integrated with human

---

in Europe) where dairy consumption is common practice is widely accepted as the evidence for the evolutionary consequence produced by this dairy mediated human niche (further discussions on this case will be given in the next chapter, section 3.3.2.).

[56] Think of the example of the interplay between human agriculture and the spread of malaria that has been discussed before (see section 1.3.2.2., footnote 18, Chapter I).

evolution through the idea of niche construction—i.e., through seeing our aesthetic world as an aesthetic niche, which has a significant ecological and evolutionary role.

2.6. Summary

In this chapter, I have proposed a contextualist view concerning human aesthetics by arguing that: first, aesthetic practices are intimately related to both human culture and human biology; second, an extended evolutionary background is important in terms of the appreciation of human aesthetic practices and objects. Further, I suggest that this contextualist view and an extended conception of evolution are instantiated and integrated through the mechanism of niche construction. In the following chapter, I will elaborate on the notion of niche construction and the evolutionary mechanisms involved.

Chapter III: The Concept of Niche Construction

Following the previous chapter where we gained an understanding of the general picture of how and why these important issues (i.e., the concern of contextualization in aesthetics, the need for an extended evolutionary perspective, the idea of putting aesthetics under a living human niche which is selective) can fit together, the concept of niche construction will be the focus of this chapter. As already indicated in Chapter II, ecological consequences—as a result of culturally mediated (non-random) interactions between the human species and its selective environments—of human practices are capable of affecting the human niche by bringing changes to the selective landscape. This gives us a reasonable inference that those consequences might have played a channelling role in the formation and configuration of our aesthetic mind. In this sense, the idea of niche construction and the evolutionary mechanisms involved are important; they initiate this process and underlie the suggested contextualized framework of understanding human aesthetics.

In this chapter, the first section will give a more detailed explanation of the theory of niche construction by going through notions of ‘niche’, ‘construction’ and ‘selective pressure’. Then section 2 focuses on how the idea of niche construction differs from and relates to the modern synthesis and other theories within current evolutionary biology. Section 3 will highlight the prominence of the human cultural niche and explain that activities constructing this niche are among the causes which gave birth to: 1. the aspect of the human aesthetic mind which is culturally motivated and 2. aesthetic niche construction based on cultural traditions (which then became one major method of human niche construction). Section 4 will then suggest that an aesthetic niche is also an important part of the human niche, and I will note that the aesthetic niche is not a subset of the cultural niche.

On such a basis, I hope this chapter will further elucidate my argument that a better way to integrate the ideas of aesthetics and evolutionary theories is through the notion of an aesthetic niche and that the aesthetic niche is not wholly cultural or wholly biological: it contains elements of both.

3.1. Niche construction: when the passive becomes the active

3.1.1. The definition of niche construction

The term 'niche construction' refers to the phenomena where organisms actively modify their own and others' niches (Day, Laland, Odling-Smee, 2003; Odling-Smee, Laland and Feldman, 2003; Scott-Phillips et al., 2014; Laland, Matthews, Feldman, 2016). However, when such modifications subsequently change the selective pressures in an evolutionary sense, one outcome seems possible: evolution by niche construction. Within the realm of evolution, the concept of niche construction provides a broader way of seeing the dynamic course of evolution—by altering the environment, organisms actively shape their own evolution. And such a theory, in which niche construction is regarded as one fundamental evolutionary process, is called 'niche construction theory' (i.e., NCT) by biologists and ecologists (Laland and Sterelny, 2006; Kendal, Tehrani, and Odling Smee, 2011; Laland and O'Brien, 2010, 2011; Odling-Smee et al., 2013; Laland, et al., 2014, 2015; Laland, Matthews, Feldman, 2016; Laland, Odling-Smee, and Endler, 2017).

Before going into examples of niche construction theory, it would be useful to give an explanation about how basic concepts such as ‘niche’ and ‘construction’, as well as ‘selective pressure’, should be understood.

3.1.2. Different uses of niche

To start with, the use of the term ‘niche’ in ecology has a history. This term has been variously used by ecologists (and non-ecologists) and can have different connotations with respect to different contexts in ecological studies (and non-ecological fields such as economics, cell biology, architecture, etc.); however, the notion of ‘niche’ in an ecological sense is widely thought to be formally introduced by Grinnell, who defined it as a correlation that is formed by a species and its local habitat that enables a species to persist. He published a study on the California thrasher in 1917; in his use of this term, a niche contains both physical settings and the accompanying phenotypic configurations. In his research, the niche of the California thrasher was defined by the natural conditions (the California fauna and flora, the Upper Sonoran life-zone, and the chaparral), and the traits of the bird itself (e.g., its strong legs which provide excellent running abilities, a long tail that gives good balance while running, brown feathers that helps with hiding and the shyness of its personality). Such facts, as Grinnell stated, ‘emphasise dependence upon cover, and adaptation in physical structure and temperament thereto, go to demonstrate the nature of the ultimate associational niche occupied by the California Thrasher.’[57]

[57] Joseph Grinnell, The Niche-Relationships of the California Thrasher, in Grinnell, The California Thrasher, 1917, p433.

The Grinellian niche, as I understand it, is the view that a niche can only be identified when there is a match between the external conditions and the phenotypic traits of a species. Therefore, the niche of a species refers to the sum of: 1. the abiotic conditions (physical specifics) of the habitat in which the species lives, and 2. The species' behavioural patterns and adaptations that are tuned to those conditions.

Later, ecologists Charles Elton (1927), who emphasized the effects a species may leave on environments, and George Hutchinson (1957), who firstly brought quantification into the concept of niche, both made major advances in the development of this notion.

Originally in his book *Animal Ecology*, Elton had situated the concept of niche under the broader idea of the ecosystem that was based on food chains and trophic webs. As he said, 'animals have all manners of external factors acting upon them—chemical, physical, and biotic—and the "niche" of an animal means its place in the biotic environment, its relations to food and enemies.'[58] In other words, a niche in this sense resembles a node/point that denotes a specific position in the local food chain and this position further explains the relation with adjacent nodes/points (i.e., other organisms) in sustaining the local ecosystem (e.g., what eats what and what is eaten by what). However, what is more relevant, from the point of this thesis, is that Elton also described how members in the food chain could interact with the environment—e.g., to survive, beavers change the local water system by cutting down trees and building dams, and this would be a relatively stable change to the biotic and abiotic conditions that other animals living in that area would face.

[58] Charles Elton, Animal Ecology, 1927, pp. 63-64.

Hutchinson's (1944, 1957) treatment of this term might have been the most influential one after Elton's. Perhaps due to the momentum in the empirical studies on population dynamics between two species that occupy a 'homogeneous environment' (Pocheville, 2015) back in his time, Hutchinson's idea of a niche emphasises how organisms' viability is dependent on environmental conditions and how different species can compete to exclude potential rivals, or manage to coexist, against given sets of such conditions. Hutchinson briefly formulated his use of niche in a footnote in his 1944 paper: 'the term niche […] is the sum of all the environmental factors acting on the organism; the niche thus defined is a region of an n-dimensional hyperspace.'[59] It is with this emphasis on environmental constraints that Hutchinson (1957) later developed this idea and presented a formal definition of niche: a niche is an abstract volume in a space which consists of all the relevant

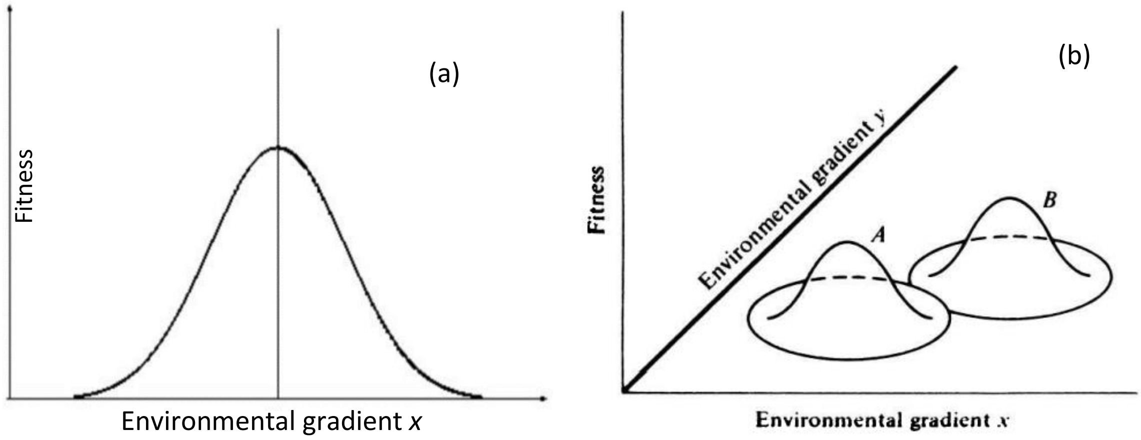


Fig 3.1.: (a) The illustration of the relation between the fitness of an organism and an environmental gradient x. Source: author's own illustration. (b) Extracted from Pianka (2011, Figure 13.2., p. 270): A three-dimensional plot of fitness of two organisms, A and B, against two environmental variables *x* and *y*.

[59] Hutchinson, 1944, p. 20, quoted from: Odling-Smee, F. J., Laland, Kevin N., and Marcus W. Feldman. Niche construction: The neglected process in evolution. Princeton University Press, 2003, p. 38.

variables in the environment which together enable the population in question to persist and replace itself (Pianka, 2011; Pocheville, 2015). To put it concisely, the basic idea is that: if we think of the changes in fitness of a species against only one environmental variable *x* (e.g., temperature, humidity, or availability of food) as a typical bell-shape curve (Fig 3.1., a.). Then when there is another variable *y* taken into consideration, a three-dimensional space which reflects the fitness as a function of these two variables is formed by *x*, *y* and the axis of fitness (Fig 3.1., b.). In this sense, to model the effect of more variables means to add another axis, introducing one other dimension, to the current picture. Therefore, conceptually, the n-dimensional hypervolume is an outcome of the adding process where 'n' equals the axis number, which equals the complete set of variables that affect a population's sustainability in the natural world.

As is shown in Fig. 3.1., b., and was emphasized in by Hutchinson himself in his distinction between 'fundamental niche' and 'realized niche'[60], this formalized conception of niche set a stage for what later became a prominent body of ecological studies to this day: between-species competition (for resource). During the 1960s, this idea of niche had been closely linked with the concept of resource utilization (even though it constitutes only a part of the original n-dimensional hypervolume) and operationalized by mapping it onto real populations in their habitats based on specific resource types. For example, a typical way of doing this is through

[60] Hutchinson described the n-dimensional hypervolume of a species as its 'fundamental niche'; it is an idealized description of the existence of a population. However, this is usually not the case, as in reality, for example, the presence of other species sharing same kind(s) of physical resources in the ecosystem (or, in the case of predation, the species in question becomes a physical resource) would compress the idealized geometry of the fundamental niche. Therefore, the actual n-dimensional niche of a species is usually just a portion of the fundamental niche, what Hutchinson termed the 'realized niche' (Pianka, 2011; Pocheville, 2015).

histograms that represent the observed frequency of utilization of classes of resources such as food type or space occupation. Based on resource use, this way of interpreting a niche is quantitatively tractable and has since then stimulated rich empirical studies on the phenomenon of competition and coexistence (Odling-Smee, Laland, and Feldman, 2003, pp. 38-39; Pocheville, 2015, p. 554).

However, compared with Grinnell and Elton, the emphasis on external variables to some extent overlooks the role of organismal behaviours, and this makes the Hutchinson's 'niche' closer to the concept of 'environment' (Pianka, 2011, p. 267). So, according to Pianka, the behavioural level should not be overlooked and 'the ecological niche is defined as the sum total of the adaptations of an organismic unit, or as all of the various ways in which a given organismic unit conforms to its particular environment.'[61]

Similarly, but also differently, the niche involved in NCT is intended to reflect the evolving nature of a niche, and to 'set the scene' for NCT with a 'simple, pragmatic, and minimalist' definition (Odling-Smee, Laland, and Feldman, 2003, p. 40). The niche is designated as 'the sum of all the natural selection pressures to which the population is exposed'.[62] As far as I am concerned, this definition is also broad and thus inclusive (Laland, 2016); it acknowledges all the situations in which the species at issue sustains its persistence and development by continuously interacting with the natural context. That is, the process of 'continuously interacting' indicates that the niche of a species should manifest its specific ways of communicating, which

[61] Pianka, Eric R. Evolutionary ecology. Eric R. Pianka, 2011, p. 268.
[62] Odling-Smee, F. J., Laland, Kevin N., and Marcus W. Feldman. Niche construction: The neglected process in evolution. Princeton University Press, 2003, p. 40.

includes various possible interactions between the species and its surroundings, with the material world. For instance, for a species '*x*', its niche incorporates how it copes with all kinds of challenges '*x*' encounters in order to survive (e.g., how each one of them competes with conspecifics, how to obtain enough food, how to access mating opportunities) and also the feedback '*x*' has on the environment (e.g., resources it consumes such as its prey, resources it produces such as its excrement) which later produces new challenges. To put it in a very brief sense, the concept of niche, when used at the species level (e.g., the human's niche, the beaver's niche, etc.), refers to the sum of interactive possibilities or potentials existing in the accessible ecosystem that could affect the species' fitness over time.

So, if we put the notions of environment and niche in front of us, the 'environment' of some creature refers to the external constraints by which its fitness is bound; while the 'niche' refers to the selective pressures that come from such constraints *plus* everything else which is produced during the interactions between this organism and those constraints. Just as with the 'environment', for which we can talk about the environment of the human species, of human populations in a certain region, or of a human individual, we can talk about the niche at different levels. Similarly, it can be divided according to the attribute of the underlying resources as well. Thus, when used in some specific sense (e.g., humans' cultural niche), it refers to a range of the whole niche of the species that is denoted/limited by such a specific sense (i.e., the class of human niche construction that is informed by cultural resources). Being of key importance, further elaboration of the idea of the human cultural niche will be given in section 3.

3.1.3. What is meant by ‘construction’

As for ‘construction’, this concept could take the meaning of shaping, manipulating, changing, or re-organising. It refers to the kind of phenomena in which changes are brought to the niche by the target species or other species (as mentioned above) in both purposeful and inadvertent ways. In other words, to say that some specific mode of behaviour of modern humans counts as an example of niche construction is to say that by conducting this behaviour (e.g., coal and metal ore mining), the modern human species has largely changed its niche both purposefully (e.g., obtaining resources for energy and industrial products) and inadvertently (e.g., resulting in severe environmental pollution and degeneration that poses challenges to the survival of a considerable part of its own population). This causal relation of ‘selective pressure —> corresponding niche construction —> reshaped selective pressures —> novel behavioural traits being included into the major mode of niche construction’ will be repeatedly discussed in this and the following chapters (through more recent examples of our cultural practices such as farming, and the case study concerning the prehistoric Acheulean handaxe industry). It is worth noting that niche construction can take place in a cross-species manner. For example, beavers’ dam-building, being itself a case of niche construction of the beavers, may well have been simultaneously constructing the niches of other species in the hydrographic network or species of the local flora. For the relevance to my purpose, I only focus on ‘self-induced’ niche construction throughout the thesis.

3.1.4. The notion of 'selective pressure'

In a few words, the notion of 'selective pressure' is a way of describing the changes brought about during the process of an organism's biological life by their possible impact on the species' evolutionary trajectory. All the changes matter in an evolutionary sense only because they regulate the force of selection and thus change the real-time interactive mode among organism-selection matches. Anyone who accepts the idea of 'evolution' in modern biology would, in a general sense at least, accept the role of the 'mechanism of selection'. During the dynamic course of organism-selection interactions, both sides are continuously and mutually affecting each other. When a specific selection occurs following interactions, one immediate outcome would be: it automatically forms a 'gradient of fitness' (Fig. 3.2.), where the width of the gradient is determined by the behavioural flexibility (i.e., the length of the x axis in Fig. 3.2.) of the organism at a given time. Set the ideal match as having a 1.0 coefficient of fitness,[63] and then the gradient is an arrangement of

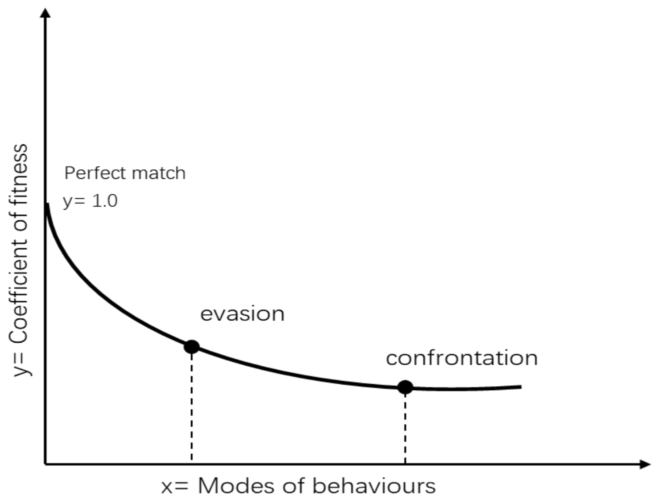


Fig. 3.2. A gradient of fitness of an individual organism A at time T. The x axis shows a portion of all possibilities in its behavioural flexibility, ordered in a decreasing manner starting from the theoretically perfect match to less perfect matches. Source: author's own illustration.

[63] That is, a perfect organism-selection match is used in an ideal sense, when the organism solves a selective task (or buffers specific selective pressures) with the logically most efficient way. Therefore, it bestows highest adaptive value to the organism. Very often, organisms do not behave in accord with the perfect solution. The illustration (Fig. 3.2.) is only applied here as a heuristic way to visualize

different modes of behaviour against this selection. From the perfect match to the perfect mismatch, the coefficient drops from 1.0 to 0. Organisms with different behavioural modes are facing different rates of reward based on the levels of fitness their behavioural modes possess. In the long run, individuals who have a higher-than-average proportion of behavioural modes which are on the distal end (i.e., away from the ideal match) of different selective gradients are likely to experience more challenges for survival. In such a sense, those ideal interactive modes always generate 'pressures' on other modes of interactions. Let's imagine that there is an organism A; its biggest challenge for survival in the environment at time T is the existence of predator B. And let's say that the perfect solution for A in situations where members of A meet members of B is by deception (e.g., by standing still and waiting). Thus, many other behavioural modes (phenotypic traits) represent situations in which those modes are selected against by the pressure (e.g., having a confrontation with the predator or immediately running away from it, as shown in Fig. 3.2.).

Other than the width of the gradient, the steepness of it might be a more important factor that influences the manifestation or presence of behavioural modes. A steeper gradient indicates a situation in which the divergence from an ideal match might incur a significant cost. Therefore, the more intense the pressure is, the 'harsher' the turn in some evolutionary trajectory (which is expressed through ratio of the phenotype in the population) it could lead to. This may explain why in certain

---

the possible relationship between different solutions (with different fitness rewards if performed) that are theoretically open to an organism.

cases where we observe a more salient diversity of phenotypic traits whereas in other cases there is a lack of diversity.

Though there seems to be no specific works devoted to the clarification, by Laland or others who proposed niche construction theory, on the how the 'niche' of this theory differs from that used in or implied by other ecological or biological literature, I hope the above discussion of 'niche', 'construction', and 'selective pressure' helps with clarifying these following points which I see as sitting in the centre of NCT:

a. Evolution is an outcome of a dynamic and mutual mechanism that acts upon the organisms and the environments (i.e., the fact in which a species is constantly constrained by external factors, and is constantly making modifications to its surroundings simultaneously as a response to those factors).

b. The constraining environmental conditions (as Hutchinson's model emphasises) and the organism's acts (as implied in Elton's niche) are the key roles that need to be considered.

c. Selective pressure is the agent through which these two parties form an evolving equilibrium (as implied in Grinnell's and Hutchinson's niche).

Therefore, being defined as the sum total of selective pressures, I suggest that this treatment of the 'niche' by NCT, though 'broad' and 'simple' (as Odling-Smee et al. put it), may be a more precise statement about the 'niche' from the perspective of NCT. In the following section, let us see some examples that manifest niche construction.

3.1.5. Examples of niche construction

Examples of niche construction are extensively present in the animal world, such as 'building nests, burrows, mounds, …the alteration of physical and chemical conditions, the creation of shade, influencing wind speed'.[64] Though not all of these phenomena could lead to a relevant evolutionary consequence for their constructors, there are still many cases which exemplify NCT. For instance, yeast can promote its propagation by way of changing the environment of the fruit that contains yeast (to attract Drosophila); hermit crabs can modify their shells to help their survival, and plants can adjust their germination time (Laland, 2017). One much studied example is the case of earthworms. Earthworms process soil. Such behaviour not only brings important consequences to the ecosystem as is known to all, but it also has significant impacts on the evolutionary trajectory of the species itself. By continuous niche construction (soil processing), earthworms have changed the environmental conditions they are exposed to in a stable way. One major threat terrestrial life puts on earthworms is dehydration. Since there are reactive ions such as sodium existing in the soil, the oxygen ion on the skin of earthworm will tend to bind with those active ions. Through the effect of hydrodynamics, the H_2O molecules will tend to move outward (increased water potential) and the body of an earthworm will soon become dehydrated. To buffer this selective pressure, earthworms must increase the level of water existing in the soil. The behaviour of manipulating the soil into being a more porous structure provides the solution to this problem. This explains why earthworms can live in terrestrial conditions; through niche construction, they successfully 'get around' a major selective force, thus keeping their way of living—

[64] Kelvin Laland et al., An introduction to niche construction theory. Evol Ecol (2016) 30, p192.

breathing through the skin. Other than this, the case of dam-building in beavers serves as another good example. Beavers build dams to block rivers, to flood valleys and create private lakes for themselves. Not only do such behaviours constitute niche construction, but they also bring about relevant evolution. The dam, in virtue of the building process, is itself a selective factor for the builder. Besides this, once a dam is built, the whole system (the dam and the lakes) exists in a relatively permanent way, which means such a modified environment becomes the natural environment of the offspring of the builder. Unlike those dam builders, the next generation are facing a dam-centred semi-aquatic living environment in which the 'selective script' is different (i.e., with novel selective pressures now put in the foreground and some others moved to the background; or, with the weight of certain pressures lifted and others mitigated). Here we can see a process of how niche construction that happened in one generation could modify the selective pressures for future generations and thus influence the evolution of a species. As Bateson states, 'the aquatic environment created by the beavers led them to evolve adaptations such as webbed feet that facilitated swimming. The hypothesis is plausible because none of the beaver's nearest relatives, the true gophers and kangaroo rats, have webbed feet.'[65] Accordingly, to identify such a process whereby the evolution of a certain species is influenced by its niche construction, many suggest that there are some conditions to be met (Laland, 2016):

'1. An organism must significantly modify environmental conditions; 2. Organism-mediated environmental modifications must influence selection pressures on a

[65] Patrick Bateson, Behaviour, Development and Evolution. Cambridge, UK: Open Book Publishers, 2017, p108.

recipient organism; 3. There must be an evolutionary response in at least one recipient population caused by the environmental modification.'[66]

There are obvious differences between NCT and traditional evolutionary theory (TET for short): first, the latter is based on the genotypic changes of a species within periods of time, while the former is not. Evolutionary theory depicts the phenomena where a species survives or develops due to the positive interactions between particular genetic traits of it and the environmental conditions it faces. In other words, from such a perspective, we can always identify certain genes, which bring about selective advantages to the host and which, at the same time, are responsible for the evolution of the species in different evolutionary periods. However, for NCT, such a genetic basis is not the focus. So long as some trait 'A' (phenotypic) is required and expressed in niche construction, it could possibly generate a selective pressure on trait 'A'. Second, according to the first point, TET accepts only genetic inheritance, while NCT encompasses an emphasis on the concept of 'ecological inheritance' (Laland, 2017) through which we better see how the whole process of niche construction can act as one fundamental factor that influences evolution. In other words, the focus on the genetic frequency of TET can somehow confine the conception of evolution: evolution does not always require the presence of a genotypic change as a necessary condition. What really is affecting the trajectory of evolution is the relationship between selective pressures and the fitness of a population under those pressures (to which genetic changes are contingent). Yet, as NCT has implied, there can be changes in the fitness of a population without there having to be a corresponding change in the distribution of genes at the populational

[66] Kelvin Laland et al., An introduction to niche construction theory. Evol Ecol (2016) 30, p193.

level at the same time. However, NCT and TET are not in contradiction. They are both situated under the grand dome of evolution, with each of them accounting for different facts (more on this point will be discussed in the following section).

From the discussion above, NCT has displayed an aspect of evolution which, as proponents of NCT claim, has been somewhat neglected, i.e., niche construction induced evolution. It is from this aspect we can see that organisms are playing a more active role than we used to think in their evolution by shaping their selective landscape through their choices and behaviours. For humans, considering our abilities in conducting niche constructing practices, it should not be an unreasonable assumption that the trajectory of human evolution can be significantly affected by niche construction (especially cultural niche construction) induced changes in selective pressures. Thus, this aspect provides us with a theoretical manner to see the pattern of changes in phenotypic traits (many of which are constituent of the aesthetic niche) of humans in a broader but pertinently contextualized way. Before the cultural and the aesthetic niche are brought into picture, it is necessary to have an overview of NCT in relation to the background of evolutionary biology.

3.2. Niche construction theory and the evolutionary biological background

This section explains the relationship between NCT, the modern synthesis and other related theories. The aim is to give a general outline of NCT’s position within evolutionary biology.

3.2.1. NCT and the modern synthesis: what we talk about when we talk about the evolution of organisms

After the publishing of The Origin of Species by Charles Darwin, evolution has been described as the phenomenon in which characteristics among members of certain species are either preserved or erased by natural selection. However, a profound shift in such evolutionary thinking happened with the advent of the concept of the 'modern synthesis' around the 1930s to the 1940s, which has 'united Darwin's concept of natural selection with the nascent field of genetics and, to a lesser extent, palaeontology and systematics.'[67] With the progress made by genetic research, the Darwinian idea of natural thus found solid support at the molecular level since evolutionary changes were able to be explained by the competition of different genes. By this account, the process of evolution is defined as the change in frequencies of DNA sequences within a population. The modern synthesis (MS), since then, has become the dominant conceptual framework in understanding the evolutionary process (Danchin, et al., 2011; Scott-Phillips, et al., 2013; Laland,2015), and the traits (biological patterns) that are found trans-generationally are treated as, in essence, genetic traits. To put it another way, if we regard evolution as the unfolding or the transmission of phenotypic variations within a spatial-temporal dimension during the development of diverse lineages of different species, then in the framework of the modern synthesis, genetic variations are always required as a premise for such transmission to be possible. Therefore, as many evolutionary biologists point out, when we talk about evolutionary theory in a modern context,

[67] Wray GA, Hoekstra HE, Futuyma DJ, et al. Does evolutionary theory need a rethink? No, all is well. Nature 514, 2014, p163.

we are still, to some extent, talking about a mainstream consensus on how evolution occurs which is gene-centric and a result of the combination of Darwinian natural selection and genetics (Laland, 2014).

However, many have claimed that such a view overlooks the importance of other processes that could also affect evolution. There are cases, like the behaviour of manufacture and use of tools among human-raised crows (Danchin, et al., 2011), the inborn fear towards artificial olfactory stimuli among rats (Dias and Ressler, 2014), the spread of lactose tolerance/absorption alleles in human populations (Laland, 2006, 2014; 2016; Menary, 2014; Papineau, 2005; Scott-Phillips, 2013), the transmission of human height (Danchin, et al., 2011), that have raised worries about the explanatory power of the MS. To be specific, phenomena such as epigenetic variation, niche construction, etc., could also be components of evolution that should not be ignored; therefore, it seems necessary to broaden the current framework in order to have a comprehensive understanding of evolution (Griffiths, 1994, forthcoming; Sterelny, 2004; Papineau, 2005; Danchin, et al., 2011; Scott-Phillips, et al., 2013; Laland, 2014, 2015, 2016). Recently, as evidence from adjacent fields grows, Laland (2014, 2015), has proposed such a broader framework which is termed the 'extended evolutionary synthesis' (EES).

3.2.2. Heritability, Ecological Inheritance, and NCT

With the background introduced above, we may better see the position of NCT within such a post-'modern synthesis' evolutionary framework. For the EES and the MS, the most prominent and important theoretical difference, which also sits at the core of evolutionary theories, is their assumptions about heritability. In other words, for NCT's general claim (i.e., an organism's niche construction introduces changes to the evolutionary process of itself) to be true, we must accept new ways of inheritance. As stated above, in the MS, biological information is transmitted across generations only through DNA sequences (i.e., genetic inheritance), whereas in EES, a broader conception of inheritance, which incorporates both genetic and non-genetic inheritance, is to be required. That is, if we take this extended view, mechanisms (e.g., epigenetic imprinting, social learning, etc.) which could not be reduced to the genetic level and whose significance is consistently being underestimated by the MS, are in fact indispensable ways of inheritance.

To understand this multi-faceted characteristic of inheritance and its relation to niche construction, it would be helpful to make a simple classification for these mechanisms. Based on the levels of observation, for instance, one classification consisting of four levels of inheritance has been proposed (Danchin et al., 2011)—epigenetic inheritance, inheritance affected by parental effects, cultural inheritance, and ecological inheritance. Each of them emphasizes one specific aspect of the inheritance system and is produced by specific causes (for example, epigenetic inheritance could be produced by epigenetic variables such as methylation and genomic imprinting, and cultural inheritance is usually produced by social learning). From such a classification (though, of course, we can have other classifications), it is clear that niche construction theory is compatible with these mechanisms of inheritance.

Concisely speaking, the phenomenon of niche construction is the process whereby ‘organisms modify environmental states in non-random ways, thereby imposing a systematic bias on the selection they generate, and allowing organisms to exert some influence over their own evolution.’[68] Namely, inheritance is a phenomenon in which those environmental modifications conducted by organisms (whether in an epigenetic way or a cultural way) could persist and substantially influence the selective pressures acting on them. Because such modifications to environments can last for a long enough time for them to be inherited by succeeding generations, they, therefore, can exert a significant force on the long-term evolutionary process of the constructors’ species. Therefore, niche construction can be regarded as one way through which the diverse manners of inheritance can be expressed.

For now, one point that has been made is that for the EES to work; we need to include not just the principles of genetic inheritance, but also other forms of non-genetic inheritance. Such an inclusive view of inheritance systems is of a great importance because non-genetic inheritance becomes an actual source of evolutionary changes. In the same vein, theoretically speaking, NCT highlights a reverse in the causal chain between selective environments and organisms. For the MS, the course of the evolution of a species plays out, mainly, as a passive selection process and is maintained through genetic inheritance. However, in the EES, the course of evolution has proven to have been affected by niche construction. That is, through niche construction, organisms’ positive responses to selective pressures account, at least partly, for their specific trajectory of evolution. As defined

[68] Kelvin Laland et al. An introduction to niche construction theory. Evol Ecol (2016) 30, p192.

previously in section 1, the niche (the total of the selective pressures a population is exposed to) is in effect a dynamic equilibrium, with individuals of a species constructing it (i.e., buffering those pressures while introducing novel pressures into the niche), and the traces or products of the construction can be preserved through various methods of inheritance, enabling stable improvements in fitness across generations. For example, in modern humans, behaviours which buffer selective pressures will likely be favoured and can persist for a relatively substantial time through cultural inheritance; thus, social learning could lead to the regulation of fitness at the population level. Like the bowers of bowerbirds or dams of beavers, another animal example that could help in illustrating this point is, again, the burrows of earthworms. Through the activities of burrowing, earthworms have substantially modified their selective environments (i.e., the structure of the soil) and thus improved their fitness (by mitigating the selective pressure of dehydration). Besides this, as this modification is relatively stable, the eased selective pressures would continuously affect the evolution of future generations of the lineage. In other words, earthworms' niche constructing alters the soil structure in a permanent way, and this change, which has been preserved across generations, 'makes it easier to absorb water and has allowed them (earthworms) to retain their ancestral freshwater kidneys, rather than evolve novel adaptations to a terrestrial environment.'[69]

At this point, we might have a better grasp of the position of NCT in an extended framework of evolutionary theory. Nevertheless, another thing that is worth

[69] Danchin E, Charmantier A, Champagne F A, et al. Beyond DNA: integrating inclusive inheritance into an extended theory of evolution[J]. Nature Reviews Genetics, 2011, 12(7), p478.

mentioning is that although mechanisms of epigenetic, cultural or other forms of inheritance differ from each other, when put into a real context, they can function in an overlapping way.[70] I turn to this issue now.

3.2.3. Other related theories

Within the research field of evolution, there are other theories that also play an explanatory role. Therefore, some clarifications on their relationships with NCT are also important. Some of them will be discussed here: the Baldwin effect, the extended phenotype theory, and the developmental systems theory.

3.2.3.1. The Baldwin effect

The notion of the Baldwin effect was first proposed in 1896 by James Baldwin and others. It refers to a process by which some initially learned behavioural traits becomes innate throughout the population (Sterelny, 2004; Papineau, 2005). Roughly, a Baldwin effect could happen in such way (or on such conditions) that:

a. There is a change in selective environments which makes a behavioural trait X adaptive.

b. This change does not happen in a radical way and exists long enough for a small portion of the population to acquire X through trial and error.

[70] For instance, the practice of human farming, though it is a method of cultural niche construction, what it produces is not only the culturally inherited behaviours involved in this practice, but it also produces genetically inherited changes in human alleles (this case will be discussed later in section 3).

c. Recognition of 'fitter' individuals promotes social learning of X, which stabilizes X as a species-specific mode of behaviour.

d. The stabilized trait of X stimulates/intensifies selective pressures on factors (both phenotypic and genotypic elements) which facilitate the acquisition of X, and eventually make X innate (to ensure step c and d, the changed environment must remain stable).

Think of the example of species A and predator B that we talked about in section 3.1.4. (also, refer to Fig. 3.2.). Once the best solution (some behaviour of deception) is discovered by members of A, other individuals who learn such behaviour more quickly are more likely to survive. After many generations, the efficiency for the future population of species A to learn this behaviour will grow (due to natural selection); finally, at some point, performing this behaviour whenever members of B are present will seem to be an instinct of members of A.

To some extent, there seems to be a trade-off between learning costs and benefits for encoding phenotypical traits. Once the benefit outweighs the cost, a transition may ensue. As Sterelny states, it is 'a transition from development contingent on rich and specific environmental signals to development which is insensitive to environmental variation.'[71]

When compared with the mechanism of organism niche construction, the theory of the Baldwin effect is more like an explanation for a special outcome of niche construction. That is, the Baldwin effect occurs when certain derived behaviours

[71] Sterelny, K. (2004), A review of Evolution and learning: the Baldwin effect reconsidered edited by Bruce Weber and David Depew. Evolution & Development, 6, p299.

producing positive fitness consequences to the organism become encoded, while niche construction is one major source of such behaviours. The Baldwin effect also relies on stable environmental inputs (i.e., persistent selective pressures) to allow 'target' traits to be encoded. However, for niche construction, since it usually results in modified pressures, it can produce and promote the retention of derived behaviours, but it does not always lead to total internalization. The process of niche construction can give rise to the Baldwin effect, but niche construction does not 'only operate in cases where a learned behaviour comes to be innate, but in a wider range of cases, many of which may involve neither learning nor behaviour.'[72]

3.2.3.2. The extended phenotype theory (EPT)

In line with the 'gene-centric' idea, Richard Dawkins introduced the concept of the 'extended phenotype' in 1982 (Dawkins 1982). The EPT holds the view that genes do not just encode the proteins and affect the biological development of an organism, they can also have extended effects on the environments in which organisms live. EPT focusses on genes that underlie those effects (including those that might be better understood through niche construction such as beaver dams). This view is intended to be a complement or 'a sequel to *The Selfish Gene*' as Dawkins puts it (Laland, 2004, p. 313). So, compared with NCT, EPT is a narrower theory in explaining phenotypic traits. Since EPT is gene-centric, a genetic basis, and only this basis, is always required. Therefore, the EPT sees those environmental states that are

[72] David Papineau, Social Learning and the Baldwin Effect, in Evolution, Rationality and Cognition, edited by Antonio Zilhao, Routledge, 2005, p42.

modified by organisms as 'no different from independent environmental states and treated as background condition' (Laland et al., 2015, p. 5), and niche-shaping activities are 'reduced to genetically controlled aspects of phenotypes, or adaptations' (ibid, p. 5).

However, this has missed a large portion of the significance of NCT as we discussed above: its inclusiveness and its recognition of a reciprocal causation. The effects of niche construction can result from not just acquired characters, but also as by-products of activities of other species. As the example of beavers and that of humans (in the following section 3) have shown, 'acquired characters are typically not extended phenotypes, yet they can generate selective feedback if they are expressed in niche construction.'[73] Therefore, when analysing the phenotypic trait of, e.g., beaver dam-building, for EPT, beaver dams are a product (a materially expressed form) of some naturally selected genes, and only those genes 'for' dam building (like those involved in facilitating beavers' motor coordination) are to be considered and regarded as fully accounting for this trait. However, there is more that needs to be told because in this case the selective environments leading to the selection of those genes are themselves a function of other non-genetic factors (e.g., individual learning, social learning). These factors could play a more salient role in populations of, say, 'higher' animals where complex behavioural traits can be found. For instance, in human populations, dairy farming is no doubt an acquired behavioural trait, and of course it is an expression of many human genes (e.g., genes for lactose tolerance). Some naturally selected genes can affect the learning of such behaviours (e.g., those

[73] Kelvin Laland et al. An introduction to niche construction theory. Evol Ecol (2016) 30, p194.

encoding the preference for high calorie food), but surely there is no gene 'for' farming or cheese-making. Rather, the whole developmental process of human individuals plays a more prominent role here. Meanwhile, as implied by the reciprocal causation allowed in the mechanism of niche construction, adaptive niche construction may elicit non-random selection for certain genes. As a result of such selection, those genes can feed back to modify future niche construction, which could then favour some other genes. It is in this sense, the assignment of certain genes as the 'causation' or 'reason for' the presence of niche constructing behaviours oversimplified the complexity involved.

3.2.3.3. Developmental systems theory (DST)

Unlike the Baldwin effect and the extended phenotype, DST approaches evolution from another theoretical angle. Not being dedicated to one specific biological process (e.g., social learning, epigenetics, niche construction or even inheritance), it is the idea of regarding the evolution of organisms as, in essence, varying replication processes of different developmental systems. The systems represent the whole of developmental processes or life cycles (Griffiths, 1994), and 'the individual, from a developmental systems perspective, is a process—the life cycle.'[74] Further, since individuals interact with the environment throughout their lives, according to DST, such interactions constitute developmental events. Besides this, all the information and materials required in developmental events are thus defined as developmental

[74] Griffiths P E, Gray R D. Developmental systems and evolutionary explanation[J]. The Journal of Philosophy, 1994, 91(6), p296.

resources. Therefore, as long as the state of developmental resources remains stable, the system remains stable, and evolution is 'best construed as differential replication of total developmental processes or life cycles.'[75] To compare DST with NCT, they both reject the gene-centric view and share/suggest a broader understanding of evolution. However, when put into DST, constructed niches, along with genes, epigenomes or socially learned information or even sunlight (Griffiths, 1994) are all developmental resources. Mechanisms such as genetic drift, genetic mutation, parental effects, or niche construction are all diverse ways of replicating those resources.

3.3. Niches of different kinds: the ecological niche and the cultural niche of humans

3.3.1. The differentiation of niches

As already mentioned in 3.1.2., we can classify niches into levels (from the sub-individual to the species), and this is what we usually do when we talk about niches.[76] Meanwhile, we can also talk about niches according to the attribute that was assigned to them (e.g., ecological niche, cultural niche, aesthetic niche, etc.). This method of classification is useful for studying organisms which manifest complex behavioural patterns, human species especially. Indeed, primates such as chimpanzees or macaques are proven to have quite sophisticated cultural methods of niche construction—e.g., the making of leaf-sponges for extracting water is widely

[75] Griffiths P E, Gray R D. Developmental systems and evolutionary explanation[J]. The Journal of Philosophy, 1994, 91(6), p278.

[76] Usually, when we have such conversations, we are referring to particular groups or populations of some species rather than to the whole species: e.g., the niche of modern hunter-gatherers, or that of urban stray dogs.

found in wild chimpanzee communities and is thought to be a 'cultural universal' (Whiten et al., 1999; Hobaiter et al., 2014; Lamon et al., 2018); also, the activity of food-washing in Japanese macaques is suggested to be another case of a behavioural tradition which is culturally transmitted over generations (Kawai, 1959, 1965; Sheurer and Thierry, 1985).[77] Even so, the human species still shows an incomparable reliance on its wealth of culture in shaping its niche.

In this section and the next section, I will turn to the evolutionary significance of the human cultural niche (i.e., the kind of human niche construction that is produced by cultural resources) and the human aesthetic niche (i.e., the kind of human niche construction that is performed with aesthetic resources), through which I suggest that the notion of an aesthetic niche is a theoretical approach that better integrates ideas in aesthetics and evolution (as indicated in the last chapter). I use the terms 'human niche' and 'ecological niche' interchangeably as referring to the entire niche of us (modern humans).

3.3.2. The cultural niche and cultural niche construction of humans

If we concisely describe niche construction as a reciprocal process in which species shape and are shaped by their niches, then once we consider the different ways in which this process is carried out, it seems obvious that modern humans are not just one of the species that modify their environments in a notably comprehensive scale but probably also the only species that rely so heavily on cultural practices in

[77] See note 5 in Chapter V for more on these two cases and a further discussion on behavioural traditions.

achieving these modifications (and therefore, a species heavily affected by such modifications). In coping with the selective pressure of food acquisition, our predecessors transformed forests, wild lands into farmlands, and they began to domesticate animals for meat and milk. They also began to change the earth's landscape by building solid shelters and houses long before historical times, and probably obtained the knowledge of medical treatment to protect themselves from illness. Nowadays, with the help of technology, modern humans can transform hills and waterways into constructive landscapes; modern cities are spreading around every corner of the world. The inventions of aeroplanes, high-speed trains, container ships, etc., have been accelerating the process of resource distribution worldwide. Similarly, the internet (along with the invention of many other devices such as cell phones and personal computers) intensifies the exchange of information among individuals, groups, communities, and nations. Moreover, we can expand our niche beyond the earth by sending satellites and research stations into space. Compared with other organisms, we can see how extraordinary human practices are and how they enable our niche construction to shape almost every aspect of our lives.

There are well studied cases demonstrating human-led cultural influences on human genetics. For instance, modern humans have domesticated various kinds of animals for dairy products and meat which has led to the spread of the lactose tolerance allele. Similarly, crop farming is believed to have contributed to the spread of the HbS allele (which protects humans from malaria) and the increased copies of salivary amylase gene (which helps the digestion of starchy foods by converting starch into sugar) in certain human populations based on their specific cultural circumstances (Perry, 2007; Rendell, 2011; Laland, 2012, 2016). Such facts have illustrated that cultural practices are influencing human evolution by responding to certain selective pressures (e.g., the need for dairy products or starchy crops as a source of food) and meanwhile bringing new ones (e.g., selective pressures on enhanced lactose tolerance or amylolytic processes when such practices become prevalent through cultural selection).

This is, however, only one (direct) side of the feedback effect of our cultural practices (i.e., from 'practice A' to a modified expression of 'practice A'). The other (indirect) side of this feedback effect has equal importance, i.e., from 'practice A' to a modified expression of 'practice(s) non-A(s)'. A culturally learned and transmitted behaviour can cause fitness changes in other cultural traits (e.g., affecting the transmission of those traits and the expression of related genes). Analogous to the evolutionary impact brought about by beavers' behaviour of dam-building[78], a set of human behavioural traits often exerts effects on some other set(s) of cultural traits that are not so immediately related to the practice. Culturally transmitted traits such as religious beliefs, customs of marriage, reliance on technology, preferences in food choice, etc., can lead to significant behavioural consequences at the populational level—e.g., large-scale conflicts, changes in fertility rate, sex ratio, health, etc.—which could have profound but indirect impacts on other behavioural patterns (and the genes they express).

[78] The behaviour of dam-building places the beaver into a dam-centred semi-aquatic environment, which not only (directly) modifies selective pressures on related genes (e.g., those expressed through the trait of 'webbed feet'), but also (indirectly) affects 'genes that are expressed in quite different traits, such as beaver teeth, tails, feeding behaviour, susceptibility to predation, diseases, and life history.' (Laland, 2004, p. 317)

Changes in sex ratio might be the case where this causal relation is more clearly shown. Studies have indicated that in certain regions of Asia, e.g., China, the cultural trait of preference for sons might be correlated with the existing sex ratio (Creanza et al., 2012; Li et al., 2000). According to Li et al., the sex ratio at birth in China was 1.14 in 1989, and 1.17 in 1990 (much higher than the normal level of ~ 1.05), while for Sweden, this ratio stayed between 1.05 and 1.06 from 1749 to 1988 (Li et al., 2000, pp. 92-93). However, recent official statistics (NBSC, 2019)[79] confirm that such a cultural trait continues to be expressed (Table. 3.1.), especially for children born between 2000 to 2010, where this imbalance came to near 1.20. Though the reasons for this preference can be intricate and have deep historical roots, the consequences are plain and significant—a very imbalanced sex ratio, a drop in total population fertility, deteriorated marriage prospects for males, and pressures on females of fertile ages, etc., all of which are

Age (years)	2010			2015		
	Sex composition (%)		Sex ratio (female=100)	Sex composition (%)		Sex ratio (female=100)
	Female	Male		Female	Male	
0	45.9	54.1	118.0	47.0	53.0	112.6
1	45.2	54.8	121.1	46.2	53.8	116.5
2	45.5	54.5	119.7	46.2	53.8	116.6
3	45.8	54.2	118.5	46.0	54.0	117.2
4	45.8	54.2	118.2	46.0	54.0	117.6
5	45.8	54.2	118.4	45.8	54.2	118.4
6	45.7	54.3	118.7	45.5	54.5	119.7
7	45.7	54.3	118.8	45.5	54.5	119.6
8	45.7	54.3	118.9	45.7	54.3	118.8
9	45.8	54.2	118.5	45.7	54.3	119.0
10	45.8	54.2	118.2	45.7	54.3	118.7
11	46.0	54.0	117.3	45.8	54.2	118.3
12	46.2	53.8	116.6	45.7	54.3	118.9
13	46.4	53.6	115.5	45.6	54.4	119.3
14	46.7	53.3	113.9	45.9	54.1	117.8
15	47.2	52.8	112.1	44.3	55.7	125.8
16	47.9	52.1	108.9	45.8	54.2	118.2
17	48.2	51.8	107.5	46.3	53.7	116.0
Total	**46.3**	**53.7**	**116.2**	**45.8**	**54.2**	**118.2**

Table. 3.1. Sex composition and sex ratio of the population aged 0-17, by age (extracted from: NBSC, 2019, p. 13).

[79] National Bureau of Statistics of China, Women and Men in China, Facts and Figures, 2019. https://data.stats.gov.cn/search.htm?s=%E4%BA%BA%E5%8F%A3

capable of affecting the expression of other cultural traits and behaviours (e.g., ethical concerns in birth giving, cultural activities related to such preferences—some of which can involve active sex-selective intervention such as abortion, abandonment, etc., on which I will not expand further here). For industrialized societies, one projected outcome is that, with the help of technology (e.g., the internet), this net of inter-trait influence will expand and become more complex—a behavioural pattern can reach more people and encounter more kinds of other traits (because the ideas, beliefs, or preferences can travel more easily in the population). The internet, along with technological advances in telecommunication (e.g., the '3G', '4G', and '5G' standards for broadband cellular networks) and in electronic products such as PCs and cell phones have already profoundly changed the way of human life and lowered the cost for a massive re-tuning of human behaviours. According to the same reports by NBSC, the average time spent by residents in China (both rural and urban residents, sample size = 48,580) on the internet is nearly 3 hours per day, and for about half of this time they are using cell phones or tablets (NBSC, 2019, p. 175). Apart from being massively tuned to the internet and electronics-dependent way of behaving (and thinking), recent studies have indicated a correlation (future study is needed to determine whether it is a causal one) between a behavioural pattern of prolonged screen time and the risks for depression, ADHD, and brain development of children (Madhav et al., 2017; Hutton et al., 2020). In a nutshell, through cultural practices, acquired characteristics of humans can easily take part in shaping the evolution of our species, promoting a fitness match between a population and correspondent selective pressures and simultaneously affecting the fitness of many other phenotypic (and genotypic) traits in this population.

In recent ecological studies, many have suggested that we should endow cultural practices with a special role as we approach the issue of human niche construction. For Laland (2011), being one of the three primary sources (i.e., genetic, ontogenetic and cultural processes) that underlie niche construction, cultural practices are of special importance since our niche constructing activities, on a large scale, are culturally guided and 'cultural processes provide a particularly powerful engine for human niche construction'.[80] And for Rendell et al. (2011), 'human niche construction is informed by a uniquely potent and cumulative cultural knowledge base'[81] and cultural practices may construct the human niche with even greater efficiency than gene-based practices. To put it in other words, culturally inherited and transmitted information and resources are highly integrated into the human niche so that changes that are brought into this cultural context (e.g., new methods for livestock farming or for crop farming) usually affect the frequency of certain human behaviours among populations, and further, could affect the frequency of human genes as well. Such a special position of cultural processes is widely accepted in studies of human niche construction. As will be suggested by the case study on Palaeolithic handaxes in Chapter IV and V, the potency of cultural resources in the ecological niche had already taken up a significant role even in homo species living in the Acheulean one million years ago. Such facts make it reasonable to say that the reliance on cultural resources is a core feature of humans' niche construction. And thus, it makes sense to point out that, at least for the human case, the 'cultural niche'

[80] Laland K N, O'Brien M J. *Cultural niche construction: An introduction*. Biological Theory, 2011, 6(3), p195.

[81] Rendell, Luke, Laurel Fogarty, and Kevin N. Laland. *Runaway cultural niche construction*. Philosophical Transactions of the Royal Society of London B: Biological Sciences 366.1566 (2011), p823.

should count as a significant part of the ecological niche and deserves special treatment/emphasis.

3.3.3. Cultural niche construction and cultural evolution

To briefly summarise what has been said above with an illustration (Fig. 3.3.), the cultural niche is the place where cultural evolution happens, and culturally grounded behaviours are continuously 'constructing' (by changing the selective pressures on themselves and on others), and therefore the cultural niche is the process that leads to cultural evolution. More broadly speaking, cultural niche construction produces two types of changes both of which can have a stable expression at the phenotypic level. One type are genetic changes, i.e., changes that are preserved through genetic inheritance. The other type are non-biological changes, i.e., changes that were preserved through cultural inheritance. Cultural evolution belongs to this second type. However, these two types of change are usually closely connected: when a

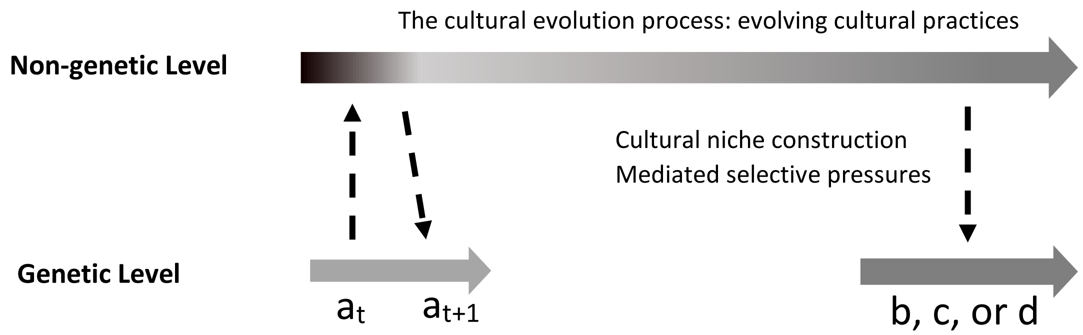


Fig. 3.3. The interaction between cultural evolution and genetic changes. a_t: a gene expressed through some cultural activity at time t. a_{t+1}: modified expression of the same gene at tine t+1. b, c, d: genes other than a. Source: author's own illustration.

cultural practice is stably expressed (or inhibited), certain genes (partially underlying the trait) (Fig. 3.3., a_t) can receive an enhanced (or reduced) expression (such as the amylase gene) (Fig. 3.3., a_{t+1}); meanwhile, the expression (or inhibition) of the same practice can influence the fitness and expression of other genes (Fig. 3.3., b, c, d). So long as the dynamic selective relationships among various cultural practices persist, they introduce dynamics among selective pressures on various genes as well. However, a stable change in cultural frequency does not always pair with a change in genetic frequency—human social learning (especially in industrialized societies) has been greatly facilitated with the help of technology; therefore, humans are able to acquire the skills to behave adaptively without needing to change genetically, leaving a narrower window for adaptations.

Seeing this central role of human culture, for human niche construction, the phrase ‘cultural niche construction’ or ‘cultural niche construction theory’ (i.e., CNC) is widely used to indicate the niche-constructing activities which are performed/conducted through or due to human cultural processes. And the ‘human cultural niche’ is a central subset of the entire ecological niche of humans that are classified based on their cultural relevance.

Now I will move on to the following section, in which I will suggest that: first, like our cultural niche to our total ecological niche, our aesthetic niche plays an important role in our cultural niche construction; second, our aesthetic niche is, however, not a subset of our total cultural niche.

3.4. The identification of the aesthetic niche (construction) and the relationship between the aesthetic niche and the cultural niche

Just as what ecologists have emphasized on the 'cultural niche' for it to be a key aspect of the human niche, I suggest we have enough reason to pay attention to another niche which is also a key aspect of the human niche, namely, the human aesthetic niche. In line with my general approach to the aesthetic (see Chapters I and II), the concept of human aesthetic niche construction is understood in a broad sense too. This broad approach allows us to include a much wider range of activities that are aesthetic as well, rather than only the fine arts. And this is a more apt way of seeing aesthetic practices as situated in a general context of our interactions with the selective pressure (i.e., the context of human niche construction).

3.4.1. The aesthetic niche and aesthetic niche construction

Although there are a few people in the field of aesthetics who have already proposed the need (to more or less of an extent) for an idea of an 'aesthetic niche' (Menary, 2014; Potera, 2016, 2018; Bartalesi, 2019), the broad biological and ecological context (as stated in 3.1 to 3.3) is somehow less discussed. For example, Menary has proposed a definition for the aesthetic niche 'as containing stable aesthetic artefacts, practices and practitioners.'[82] The issue here is that it fails to emphasise the evolutionary nature and the ecological role of the aesthetic niche, making it more like Hutchinson's definition of the niche. To make it evolutionary, similar to how the niche is defined, we may define the aesthetic niche instead as the

[82] Menary R. *The aesthetic niche*. British Journal of Aesthetics, 2014, 54(4), p473.

total of the selective pressures to which a population is exposed during their aesthetic niche construction.

Based on our discussion on CNC in section 3.3, it makes sense to suggest that the human aesthetic niche (construction) must hold the same importance. It should be rightfully regarded as an important avenue to the human niche (construction) as well. The reason for this is simple: on the one hand, most of our cultural practices are aesthetic practices, which means the evolutionary mechanism in CNC (see section 3.3. and Fig. 3.3.) can take place in aesthetic niche construction as well; on the other hand, the aesthetic niche might have been playing an indispensable role in the human lineage long before what might be the first major advance in technology[83] which largely accelerated cultural niche construction during the Lower Palaeolithic (I will explain this in part 3.4.2). Just like activities in CNC, our aesthetic practices clearly meet the requirements, as suggested by Laland (2016, p. 193), for something to be a mode of niche construction. That is, through aesthetic activities, 1. humans have significantly modified environmental conditions; 2. those aesthetic modifications have influenced selection pressures on some recipient population; 3. there are evolutionary responses in at least one recipient population caused by those modifications.

There seems no doubt that modern humans are born into a highly aesthetically modified niche that is filled with enormous aesthetic legacies/resources. Human

[83] Though basic practical physics knowledge of stone was needed for Oldowan technology (~ 3.3 to 1.8 mya), Acheulean biface production is technologically much more demanding. Meanwhile, the chronological development of Acheulean technocomplexes is a good example which reflects the dynamics of CNC (as simplified in Fig. 3.3.) by causing cultural evolution, shaping selective pressures on social learning, and finally, leading to the expression of a novel trait: to respond aesthetically (showing aesthetic sensibilities) to a cultural trait (of handaxe production). I will elaborate on this hypothesis in Chapters IV and V.

aesthetic niche construction is present in most human artefacts, for instance: bodily decorations (e.g., tattoos, hairstyles, clothes, etc.), objects for daily use (tools, gifts, ornaments, etc.), architecture (e.g., houses, galleries, stadiums, and other communal aggregation sites for religious or political needs, etc.), or more abstractly, publications (e.g., commercial ads, government propaganda, etc.), and fine arts. The aesthetic practices employed, and the resources accumulated in the aesthetic niche, can have a feedback effect (just as in CNC) on the selective fitness of themselves and other aesthetic traits, therefore affecting the frequency of those traits in the population. Looking beyond our own industrialized societies, the potency of aesthetic niche construction has led to the diversity of aesthetic traits that are expressed in different modern populations of our species: e.g., the '*Sing-Sing*' tradition and the '*Moka'* exchange in Papua New Guinea highlanders (Strathern, 1971; Feil, 1987; Stewart and Strathern, 2005; Holland 2007), the potlatch tradition in the Pacific Northwest of North America (Boas, 1897; Piddocke, 1965; Ringel, 1979; Harkin, 2011), and the Gerewol festival in Niger (Beckwith, 1983). In order not to repeat myself too much, I suggest only that for aesthetic traits which are also cultural, they too are subject to the mechanism for CNC as described in section 3.3. For populations both in industrialized and non-industrialized societies, the differential expression of their aesthetic traits is tuned to their context (i.e., their selective landscape). Meanwhile, changes in cultural (and aesthetic) practices can modify the selective pressures that act on a wide range of other aesthetic traits.[84] As Portera puts it, 'a significant part of what we experience as beautiful is the result of a

[84] For example, recently in Papua New Guinea, a set of aesthetic traits involved in self-decoration (e.g., the use of feathers, pigments, or leaves) for the 'Sing-Sing' festival, are over-expressed due to the tourism, which might have indirectly increased the frequency of the hunting of the blue bird-of-paradise (IUCN Red List of Threatened Species, 2016).

reciprocal, constructive relationship between us and our physical, biological, and cultural environments: an aesthetic niche construction process.'[85] More than that, it is through the idea of the human aesthetic niche, through understanding the dynamic mechanism and the selective pressures on an aesthetic trait (i.e., aesthetic behaviours, activities, and the ideas, preferences, and judgements behind it) that is expressed in the population, that we can begin to understand and appreciate an aesthetic trait that is from a distant culture or to better understand and appreciate an aesthetic trait of our own culture.

3.4.2. The relationship between the aesthetic niche and the cultural niche

It is a fact that our aesthetic niche overlaps largely with our cultural niche, and a considerable number of our aesthetic activities and preferences are culturally mediated; however, it is not the case that the human aesthetic niche is a subset of the human cultural niche.

As stated above, cultural niche construction (CNC) is a crucial aspect of the human niche, since 'much of human niche construction (NC) is guided by socially learned knowledge and cultural inheritance'[86] and especially for modern humans, we mostly modify environments through our cultural practices, and in many cases, aesthetic niche construction (ANC) is intertwined with CNC. So, when conceiving the relationship between NC, CNC and ANC, it gives such an impression that there is

[85] Portera, Mariagrazia. "Why do human perceptions of beauty change? The construction of the aesthetic niche." RCC Perspectives 5 (2016): 41-48, p. 42.
[86] Laland K N, O'Brien M J. Cultural niche construction: An introduction. Biological Theory, 2011, 6(3), p197.

seemingly a progressive chain: NC → CNC → ANC, in which the former constitutes a higher level and encompasses the latter. However, the aesthetic niche is in fact another sub-niche of the human niche that parallels and overlaps with the cultural niche (Fig. 3.4.). For example, if we recall the research of evolutionary psychology (see section 3, Chapter II) on human aesthetic sensibilities and preferences for certain basic characteristics in the natural world and in the human body—e.g., savanna-like landscapes, scenes with the presence of water, people, and animals; body height, waist to hip ratio, skin tone and texture, volume and texture of hair, the symmetry of faces, and even smells; Miller, 2001; Fink, 2002, 2006; Rhodes, 2006; Buss, 2008; Dutton, 2009; Miller and Maner, 2010; Rusch and Voland, 2013), it is plausible to say that there are aesthetic traits which contribute to the part of the aesthetic niche that is not overlapping with the cultural niche. Being biological adaptations or by-products, aesthetic traits belonging to this type construct the aesthetic niche in a way that is automatic and with no reference to the cultural niche. Looking back to our evolutionary past, some of these traits might well have played an indispensable role long before the Acheulean industry which accelerated the expansion of the cultural niche of Acheulean hominins (footnote 27).

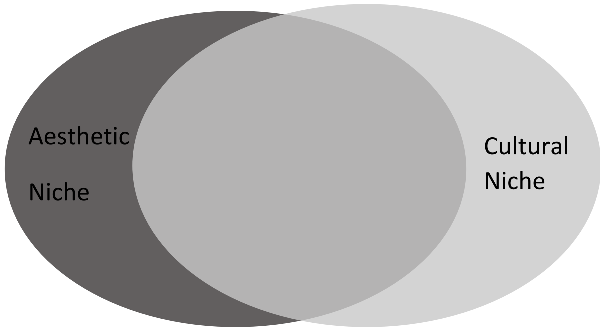


Fig. 3.4. The relationship between the aesthetic niche and the cultural niche. Source: author's own illustration.

Furthermore, if we are to generate an explanation for the relationship between these two niches, based on the dynamic mechanism of the CNC (see part 3.3.3.), it would be wrong to conceive that we can draw a hard line between the cultural niche and the aesthetic niche. We can rightfully hold a neutral feeling towards a wide range of objects we encounter in life. But this does not exclude the possibility that, at another time in the future, the practices producing such objects may step into the domain of aesthetic niche construction, and therefore we may attribute an aesthetic element to them (e.g., all the designs that went into the first generation of computers were probably designed for their functionality; however, for modern PC and laptop industries, a large part of the design put into the products are for aesthetic concerns). A cultural trait can be aesthetically neutral at the start and can take on an aesthetic aspect later, or under more radical conditions, this aesthetic aspect can become innate due to persistent and intense selective pressures induced by cultural (aesthetic) niche construction (see Fig. 3.3.). In this sense, the aesthetic niche should not be seen as a subset of the cultural niche.

3.5. Summary

Based on our discussions so far, I hope that I have described: a general explanation of the phenomenon of organism niche construction itself, the position of the theory of this phenomenon in relation to its theoretical background, the selective mechanisms and evolutionary forces entailed in human cultural and aesthetic niche constructions. Thus, through those discussions, I suggest that the idea of an aesthetic niche provides an explanatory framework that better integrates the aesthetic with the evolutionary theories.

Aesthetic practices of niche construction of our lineage share a deep history with our cultural practices. Archaeological evidence has identified the different traces of such practices, e.g., the making of pigment (~ 100 kya), engravings on ostrich eggshells (~109 kya to ~52 kya) and on ochre blocks (~ 75 kya), perforated shells (~ 75 kya), bodily ornaments, and in later times, cave paintings (probably ~ 60 kya), figurines (~ 40 kya) and musical instruments (~ 35kya).[87] In Chapters IV and V, I will provide a case study on the practice of Acheulean handaxe making, arguing that through the mechanism of niche construction, this form of cultural practice had led to the emergence of a culturally grounded aesthetic sensibility.

[87] See Chapter IV for more detailed discussion.

Chapter IV: The Expansion of the Aesthetic Mind

Based on what we have discussed about niche construction and the human aesthetic niche in Chapter V, the aesthetic niche of the human lineage could have emerged at an early stage of evolution (even long before the dawn of any cultural traditions of our hominin ancestors). This was due to the aesthetic practices that were driven by natural or sexual selection. As long as the mechanisms of natural and sexual selection were in place, an aesthetic mind could have been formed. Although there seems to be no clear answer to questions about the origin of this aesthetic mind, with the archaeological evidence at hand, I suggest that we have a plausible answer to the origin of a significant development of this aesthetic mind. It is since this development the aesthetic mind in the Palaeolithic began to manifest a key feature which is also found in our modern aesthetic mind. Therefore, we are in the right place to start with the questions, 'What is this development?' and 'How did this development take place?' In this and the following chapter I will provide an investigation of the Acheulean industry and I will propose a model which draws upon the idea of the organism's niche and its interaction with the world as my response to these questions.

This is, nevertheless, an endeavour that is based to some extent on speculations about a particular evolutionary mechanism (i.e., one that is about a particular kind of psychological experience—the kind we call aesthetic) which existed and functioned over a million years ago. Just like any research that involves archaeological interpretation, speculations are always open to questions as new evidence is expected to be found as our methodology is constantly being developed. The proposed model here should maintain such openness as well, yet the formulation of it should be rigidly based on the evidence available in the archaeological record (which I suggest we have) that might support such claims so as to make these speculations reasonable hypotheses rather than mere guesses.

Hopefully, the hypothesis that the sociocultural life in the Lower and Middle Palaeolithic, though highly constrained, in the sense of niche construction, would lend us some insights into the real dynamics of our hominin ancestors' societies. By 'constrained', I mean that, based on the evidence at hand, the production of stone tools was the only dominant form of technology that hominins were relying on (though there is a possibility that individuals in the Palaeolithic might have some wood technology and its absence in records may be due to the lack of preservation of wood). This allows us to construe the model in a rather focused manner, targeting how generations of making and refining of such technology could in the long-term lead to a profound change in the social learning system throughout the Acheulean which then gave birth to perhaps the earliest form of some culturally grounded aesthetic sensibilities in *Homo species*.

In this chapter, an overview of the Acheulean industry will be given in the first place. More specifically, from sections 1 to 2, a general picture of the Acheulean and the archaeological industries before (i.e., the Oldowan industry) and after (such as the Mousterian) it will be provided. Basic skills and techniques involved in Oldowan and Acheulean stone tool making will also be explained and compared. Also, a general picture of prehistoric aesthetic objects will be given. Section 3 will then explain why many of the Acheulean handaxes should be regarded as aesthetic objects. Section 4 will point to the social context and the chronological development of the Acheulean tradition, arguing that they are important to the formulation of the explanatory framework that will be presented in Chapter V.

4.1. A brief introduction to the Acheulean

One very salient feature of the Acheulean tradition is the emergence and prevalence of a novel form of stone tool, i.e., the Acheulean handaxes/bifaces. In contrast to the simple tools of Oldowan, the production of handaxes is achieved through a planned action chain of continuous hand-held percussion. During production, the maker needs a stone core as the raw material (e.g., quartzite, basalt, or flint) for the intended product (i.e., handaxe) and a stone hammer (usually, quartzite will be used for hard hammering technique, and softer materials like sandstone or limestone might also be used for soft hammering in Late Acheulean), then gradually modifies the shape of the stone core by a long series of blow-by-blow knapping which removes flakes[88] from the core. The flake scars on excavated handaxes indicate such a reduction process.

The name 'Acheulean' was given by archaeologist De Mortillet named after the site of Saint Acheul in France at which the excavation of stone tools of this type had brought about a significant shift to the existing understanding of human history (i.e., the dominant framework based on the Bible) in about 1859 (de la Torre, 2016). With

[88] The thin pieces of stone that were detached from a larger stone core by a hammer-stone, usually, for use as a tool. See no.6., Glossary.

a timespan of over one and a half million years, the Acheulean may be the most long-lasting technological tradition during the evolution of homo (de la Torre, 2016) and handaxe-bearing assemblages[89] are found across Africa, Europe, and Asia. These tools exhibit morphological traits that resemble a teardrop shape with such features e.g., a globular butt, forward extension, lateral extension around a major plane, and thinning adjustments. They were predominantly processed bifacially and made symmetrical in their plan view, though unifacially processed ones have also been discovered and dated to the early stage of Acheulean (Beyene, 2013). It is from the middle to the late Acheulean when the larger number of the most sophisticated handaxes, among which those characteristics of obvious aesthetic concern are found. More specifically, handaxes at this later stage were made thinner, highly symmetric, carrying more and well-arranged scars and with a finely processed edge line. Certain ones were even beautifully and deliberately manufactured with a seashell or a hole sitting at the middle (as shown later in section 4.2.3).

Since handaxes are so different in shape from stone cores and flakes, which were widely used in the Oldowan (Semaw, 2009), in terms of their shape, there are experiments focused on the comparison of their usefulness (e.g., Machin, 2007; Toth, 2009; Galan, 2014; Key and Lycett, 2017). However, the studies have implied that the morphological differences between handaxes and other simple stone tools do not confer to the former some distinctively greater utility. Such facts become more intriguing when considering the emergence of those Late Acheulean handaxes which display remarkable craftsmanship.

[89] See no.3., Glossary.

Therefore, one important question emerges: what was the drive behind the observed refinements in handaxe morphology and related knapping skills throughout this lengthy technological tradition when investments into handaxe shape provide little or even no direct or immediate functional reward to hominins living in the harsh Palaeolithic environments? To approach this question, let us first take a glance at the general picture of the prehistoric world in which the Acheulean developed. Two aspects of this general picture are deemed relevant here: different Palaeolithic stone tool traditions and the various prehistoric aesthetic practices.

4.2. Prehistoric stone technologies and aesthetic behaviours—an overview of the Acheulean on a larger picture

In the first half of this section, a background of the overall development of tool-making technology in the Lower Palaeolithic will be discussed. This will include a discussion of the Oldowan industry which preceded the Acheulean, and a brief comparison between Oldowan and Acheulean tools, as well as other stone technologies after the Acheulean. What is more relevant, in order to better spell out the main idea that the Acheulean represents the dawn of a special kind of human aesthetic sensibilities, is an overview of the aesthetic elements of the handaxe and other prehistoric aesthetic behaviours which will be provided in the second half of this section. These various forms of aesthetic expressions covered a long period from about 1.7 million years ago (the advent of the Acheulean) until about 44 thousand years ago (the Sulawesi cave paintings), from the earliest traces of aesthetic sensibilities for a tool making tradition found in handaxes to abstract drawings found on ochre blocks, and to bone flutes and fascinating cave paintings. This will give us a grasp of the bigger picture of the progression of the human aesthetic world in prehistory, how it flourished during the stone tool tradition, gradually evolved, and flourished in many other aspects of our ancestors' lives.

4.2.1. The tools used in the Oldowan:

From what we know, the genus *Australopithecus* have a history of stone tool making over more than 3 million years. The oldest evidence is certain forms of stone tools found in Kenya which are dated to around 3.3 mya, and although the question remains open, they were possibly made by some members of the Australopithecus (perhaps *Australopithecus garhi*), species thought to be the ancestor of the *Homo*. For the genus *Homo*, the oldest stone tool tradition is the Oldowan Industry. The excavation of a large number of these tools at many sites in Olduvai Gorge, Tanzania marked the discovery of this technological tradition, which is also the one that predated the Acheulean Industry. The Oldowan developed and persisted between ~2.6 mya (at Gona, Ethiopia) to ~1.4 mya. However, from about 1.76 mya to 1.4 mya, during this later stage of the Oldowan, some hominin groups began to make Acheulean handaxes (e.g., the site Kokiselei 4 in Kenya). The dominant tool forms of the Oldowan are called 'choppers' and 'flakes' and are believed to be made by *Homo habilis* throughout the Oldowan period. More specifically, the term 'Oldowan' was given by archaeologist Louis Leakey following his study at Olduvai Gorge, where stone choppers and flakes were found in the 1930s. In the following years, more comprehensive investigations were carried out by Mary Leakey and it was at this time when the Oldowan as a particular method/tradition of stone tool production was fully described: many assemblages bearing stone tools were identified, and those tools were primarily characterised by choppers[90], flakes and hammerstones[91], thus indicating a systematic production of some targeted tools, i.e., choppers and flakes. Mary Leakey's work had then led to 'unparalleled enthusiasm and attention' to the study of the Oldowan (Semaw et al., 2009). As more and more archaeological research flourished, more assemblages resembling the 'chopper and flake' tradition were found across Africa, e.g., in Ethiopia (where the oldest specimens were excavated), Kenya, Uganda, Tanzania, Algeria, and South Africa, which means the Oldowan tradition was prevalent and stabilised.

The establishment of this distinctive tradition of tool making was temporally accompanied by another noteworthy evolutionary event, i.e., the emergence of the earliest *Homo erectus (*~1.9 mya*)*. Even though members of both *Australopithecus* and *Homo* might both be responsible for producing Oldowan style tools, some potential in terms of cognitive and behavioural capabilities might be indicated by the development of average cranial volume (from ~400 cm^3 to ~650 cm^3, more than a 50% increase) over one million years of evolution. This is a significant point to note, since the anatomical evidence of such encephalization along with the reduction of the size of jaws and teeth in early *Homo* individuals may indicate a profound evolutionary change of the genus *Homo*, involving the systematic exploitation and

[90] A type of stone tools that were used for purpose of breaking or chopping, exhibiting a transverse cutting edge at one end.
[91] A hard stone used as a hammer during the knapping process of stone tool production to strike off lithic parts from a stone core. See no.7., Glossary.

construction of the technological niche (such anatomical changes were only possible if stone tools were widely used therefore buffered selective pressures for large jaws and teeth at a population level). To put it briefly, such evidence indicates that the species would have been relying on high energy food (such as meat and marrow) as a major source (of course not the only one) for survival for quite a long time. This reduced the relative selective pressure favouring larger and more herbivorous-like jaws and teeth. In the meantime, the sustainability of such high-energy food can only be maintained by the assistance of better tools. Even scavenging would require butchering tools (better tools for skinning, de-fleshing, dismembering, and bone-crushing expanded how much meat and marrow the scavengers could obtain and consume in a competitive environment full of uncertainties such as the arrival at a killing site of large predators). There is also planned game hunting, which, according to recent research can be identified as early as 1.8 mya (Layton et al., 2012; Galan and Dominguez-Rodrigo, 2014). Therefore, it makes sense that there would be selective pressures for a set of cognitive correlations such as these:

a. the ability to notice/discover changes on things, such as the scars on a stone core.

b. the ability to coordinate bodily movements based on visual information to perform correct actions during knapping.

c. the ability to be aware of abilities ‘a’ and ‘b’ via memories of past events of tool use to gain a level of ‘know-how’ in terms of making desired flake removals that would serve as a functioning edge (this might be supported by the enlarged brain of *Homo habilis).*

As Schick and Toth (2006) suggest, such evidence ‘points to a shift toward an adaptation based more and more upon technological means.’[92]

As for the techniques required for its manufacture, ‘simple knapping and flaking’ might reasonably describe the skills applied in Oldowan tools. Usually, with a few knapping actions, the hammerstone would create a chopping edge at one end of the stone core—the tip, and the other end of the core was left untouched for grasping. Flakes were also produced in a similar manner by striking at a stone core. In practical contexts, studies (e.g., on the morphology of excavated tools, microwear traces on the tools, cut-marks on animal bones found at Oldowan sites, and fracture patterns of those animal bones) have suggested that Oldowan individuals might have been using these tools in an already diverse range of activities for food acquisition and processing (Schick and Toth, 2006), such as digging, wood and plant cutting, de-fleshing, bone detaching, tuber crushing and marrow extracting.

Also, a closer look at the percussion techniques and material properties may imply certain ‘not so simple’ cognitive capacities in our ancestors at that time, according to Semaw, those ‘hominin toolmakers had a superb understanding of *conchoidal fracture* on stones, and they selected relatively high quality and fine-grained raw materials that were suitable for making sharp-edged implements.’[93] Other morphological studies (e.g., pitting or fracture marks on the hammerstones) have also suggested the existence of an accurate/reliable hand-held direct percussion technique in the Oldowan. Within a dated timespan of ~2.6 mya to ~1.7 mya, this

[92] Schick, Kathy, and Nicholas Toth. "An overview of the Oldowan industrial complex: the sites and the nature of their evidence." The Oldowan (2006): 3-42, p. 10.
[93] Semaw, Sileshi, Michael Rogers, and Dietrich Stout. "The Oldowan-Acheulian transition: is there a “Developed Oldowan” artifact tradition?" Sourcebook of Paleolithic transitions. Springer, New York, NY, 2009, p.177.

tradition stayed much the same as the dominant technological form until around 1.7 mya when it was gradually substituted by a much more complicated tradition—the Acheulean.

4.2.2. The tools used in the Acheulean

Below (Fig. 4.1.) is a visual comparison between a typical Oldowan chopper and a typical Acheulean handaxe:

a. An Oldowan stone chopper tool, ~ 2.6 to 1.7 mya, from Guelmim-Es Semara, Morocco. Source: Locutus Borg. Permission: Public Domain.

b. A well-made handaxe, ~1.7 mya, found in Tanzania. Source: F. Diez-Martin et al., 2015

Fig. 4.1. Pictures of an Oldowan chopper (a) and an Acheulean handaxe (b).

The morphological difference is conspicuous: for the majority of Oldowan choppers, there are only a few flake scars around the tip of the surface, while for most Acheulean handaxes, including the those made at the very beginning of Acheulean, the scar count is much higher (in order to make a continuous and surrounding edge. Handaxes were also usually bifacially knapped) and a more homogeneous tool form had appeared. Besides this, an intermediate stage, which is absent for Oldowan, is a prerequisite for handaxe making. Handaxe makers would firstly need to produce a suitable stone core from a larger blank, as the starting point to make the end tool, i.e., the handaxe. That is to say, to successfully make a handaxe, the maker would need not only the lithic knowledge required for Oldowan-style knapping, but also a much more complex organization of preparational and knapping actions, the cognitive ability to monitor and adjust the long sequence of actions according to some intended end-form. The need for certain functional cutting edges plus the proper execution of actions (e.g., to make centripetal blows on the edge; to keep the striking angle less than 90° to produce conchoidal fracture) seems likely to guarantee the production of an Oldowan chopper, but not so likely to guarantee a handaxe which carries a long continuous edge and is symmetrical. This is then summarised as the two main differences between the Oldowan and the Acheulean:

1. The inclusion of an extra interval stage during manufacturing (de la Torre, 2016).

2. The imposition of a 'mental template' on the product (de la Torre, 2016).

Accordingly, researchers have agreed that a better working memory, which is believed to be much weaker or non-existent in the Oldowan (de la Torre, 2016; Toth and Schick 2018), was also needed to achieve the handaxe-making process. A better working memory would enable tool makers to make real time judgements and adjustments since it enables better cognitive performances in information storing, tracking and perhaps more importantly, information correlating. The kind of cognition used in handaxe-making involves the integration of a set of elements such as action planning and performing, working memory and the processing of sensorial inputs. As some researchers suggest, this kind of more 'human-like' cognition only emerged during the Acheulean. Before then, the cognitive repertoire for the Oldowan was suggested to be 'more ape-like' and 'primarily involving the co-ordination of visual attention and motor control.'

In short, these facts indicate that there is a significant difference in terms of cognitive cost between these two technological traditions. And this is also consistent with other evidence: the emergence of *Homo erectus*, whose average brain size reaches about 1000 cm^3, more than a 50% increase compared with *Homo habilis*. In some sense, we may say that the Oldowan choppers were made *on* a stone core (where a manufacturing plan is more subject to random outcomes), yet the handaxes were usually made *from* a stone core (where a manufacturing plan is brought out or realized from a material base).

4.2.3. The stone technologies after the Acheulean

During the final stage of the Acheulean (which was about 0.3-0.15 mya), Middle and Upper Palaeolithic stone tool technologies continued to develop for at least 100 kyr[94] before the Mesolithic, constituting several other developmental 'industries', such as the Mousterian, which marked the appearance of the Levallois technique.

[94] There are two points worth noting here: first, the Acheulean as a tradition of tool production did not just disappear in the face of other technological alternatives, in effect it had persisted into the Middle Palaeolithic (for example, it is suggested that Acheulean sites in Sub-Saharan Africa ended ~170 kya; however, the earliest known Middle Palaeolithic sites in this same area are believed to be ~290 kya; so the Acheulean tradition might have continued for about 100 kyr); second, the '100 kyr' is used only in an expedient and conservative sense since from a global perspective, early Middle Palaeolithic sites that are older than 300 kyr have been found in Africa, Europe, Near East, and Asia and there are no precise answers as to when the Acheulean ended at those different regions of the world. See Alastair JM Key, Ivan Jarić, and David L. Roberts (2021) for a recent discussion on the end of the Acheulean and its overlapping with the Middle Palaeolithic.

Such advances had largely increased the efficiency of stone use and enabled the mass production of highly standardised stone tools. Later on, during the Upper Palaeolithic, the toolkit of our antecedents became more diverse, and the level of craftsmanship increased, a good example is the laurel-leaf points of Volgu (~16,000 years old) of the Solutrean industry. Stone tools made during the Mesolithic and Neolithic also display distinctive features: the Mesolithic used a microlithic technology while in the Neolithic, the behavioural novelty of the use of polishing stone tools has been widely identified. Briefly speaking, until the establishment of pottery technology during the Neolithic, stone tools have been used by our *Homo* predecessors for at least 3 million years before the first appearance of the copper tools around 4000 years BC. Since the specifics of these later industries are not the focus of this chapter, I will now turn to the aesthetic aspect of the Palaeolithic world.

4.2.4. The prehistoric aesthetic dimension—when the path became paved

4.2.4.1. What is aesthetic about Acheulean handaxes?

Now, before the fuller discussion of the case study of the Acheulean handaxe industry is given (see, section 2 here, and Chapter V), some explanation of our prehistoric aesthetic world is necessary. First, we should ask, what are the aesthetic elements in an Acheulean handaxe? As a case study focused on a particular object—the handaxe—and its relationship with early humans' aesthetic sensibilities, several features of handaxes could be regarded as displaying aesthetic sensibilities. The most distinctive is the symmetrical form that is imposed on handaxe morphology. This symmetry is found, to varying degrees, in handaxes from archaeological sites across Africa, Europe, and Asia. Also, on a temporal scale, symmetry is identified on both those early crudely or unifacially made specimens from Konso, Ethiopia as old as 1.7 myr and those Late Acheulean ones which were delicately made with a nearly perfect symmetrical index (see, the appendix at the end of the thesis) from England as recent as 300 kyr. Besides a preference for symmetry, potential aesthetic preference went into other aspects such as: a. the choice of special raw material due to the appealing colour or texture of the material, b. the exaggeration of size, or c. a special 'design' on the plan view of a handaxe.

Under category 'a' we have for example., the so-called 'Excalibur' (~350 kya) which was found in Spain and made of red quartzite and is thought to have been used as a funeral object (Fig. 4.2., a.), and a handaxe (~600 kya) found in South Africa, made of ironstone (Fig. 4.2., b.).

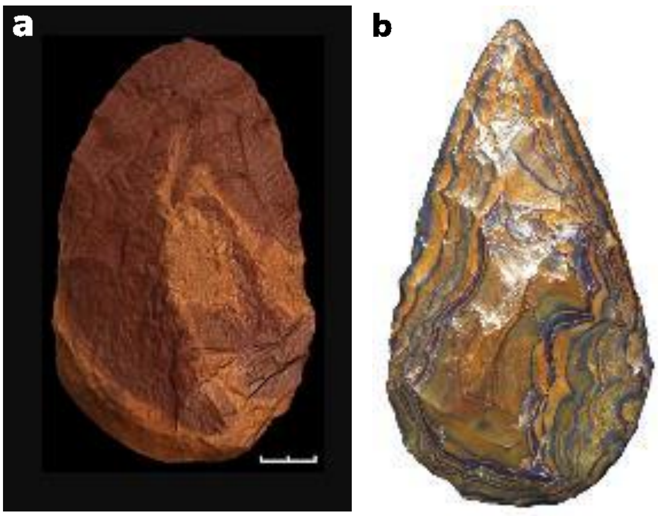


Fig. 4.2. **a.** the 'Excalibur', source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Excalibur_(1).jpg.

b. The 'great handaxe', source: Wingfield, Chris, John Giblin, and Rachel King, 2020.

Under category ‘b’: e.g., the giant ‘ficron’ (~300 kya) from Cuxton, England, which is 307mm long (Fig. 4.3., a.); the ‘great handaxe’ (~400 kya) from Furze Platt, England, which is 306mm long (Fig. 4.3., b.).

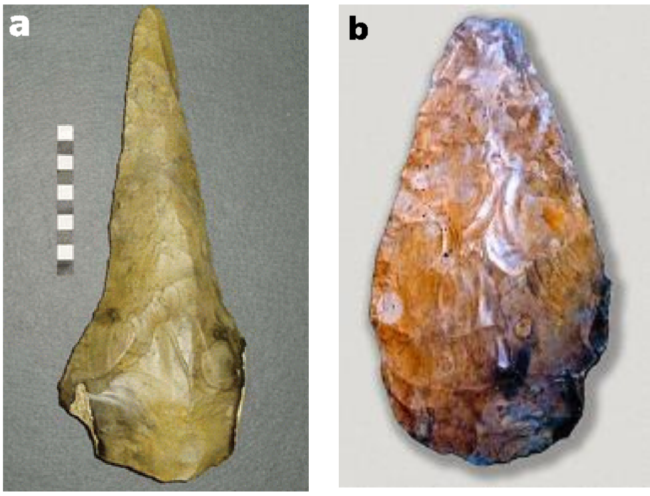


Fig. 4.3. **a.** The giant ‘ficron’, source: Wenban-Smith, 2004.

b. The ‘great handaxe’, source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Great_Handaxe_from_Furze_Platt-Berkshire.jpg

Under category ‘c’: there seems to be elements of ‘design’ in the literal sense here: some handaxes seem to show an intention by their makers to accentuate certain visual forms, which possibly were deemed as important or appealing to them. E.g., the handaxe knapped with a seashell symmetrically sitting in the middle (500-300 kya), Norfolk, England (Fig. 4.4., a.); the handaxe made with a hole in the middle (800-300 kya), Niger (Fig. 4.4., b.).

Fig. 4.4. **a.** The handaxe with a shell embedded, source: Wynn, 2018.

b. The handaxe with a hole, source: Wynn, 2018.

However, even though these features did occur sporadically through time, they did not occur in as systematic a manner as symmetry did. Besides this, perhaps because of the nature of these aesthetic features that makes them less accessible to the approach of archaeological experiments, such circumstances together provide little experimental data on these features.

By saying that these aesthetic features are ‘less accessible to an experimental approach’, I am not making the claim that features like colour (raw material) or design cannot be studied in a quantitative manner. However, their nature (i.e., being highly idiosyncratic) has made them a secondary focus for archaeologists’ experiments. A stone core may simply happen to have a hole or a seashell sitting in it and its relation to the subsequent manipulation carried out on this core may simply be accidental. It is also conceivable that the maker of the handaxe with a seashell in the middle made it for some practical reason which may be revealed through experimental comparison: one may say that a hole in a handaxe increases the grip, making it easier to clutch rather than to hold or that an ironstone handaxe cuts better than typical flint handaxes in some not yet known circumstances (though both seem not so plausible from a functional point of view). Unlike symmetry, it is hard to argue that a proposed match between certain special 'designs' and potential functional needs is more realistic than others. For this reason, symmetry, which is a regular feature of handaxe morphology, becomes the natural target of most of the studies. Other than this, there is indeed some evidence coming from experimental data (Key and Lycett, 2017) that supports the idea that handaxes from category 'b' exhibit an aesthetic preference for exaggeration in size. This is the experiment which led researchers to identify the 'threshold effect'. More specifically, during cutting experiments based on 500 handaxes varying in size, a size of ~100 mm long turns out to be the size of threshold efficiency (the authors assume that this effect might have played a role in affecting the size of Acheulean handaxes[95]). According to the data, there is a significant pattern in which handaxes of below-threshold size show marked inefficiency while there are no strong correlations between increasing handaxe size (above 100 mm) and cutting efficiency (this is possibly due to the maximum size in the experiment sample[96]). Therefore, considering these features, another point can be made: they are just obvious cases of aesthetic sensibilities. It just makes more sense to assume: 1. The special raw materials chosen were not going to provide any more utility (especially when we think of handaxes made up of

[95] This is, of course, based on the morphological study of physical traces on handaxes and anatomical evidence which led to the general idea that Acheulean agents were probably, at least, not using their hands in some dramatically different way as we do.
[96] The largest handaxe used in Key and Lycett's experiment is 205mm in length; however, if we think of the Furze Plat giant, which is over 300mm, it is not irrational to presume that the latter should be much more inefficient.

animal bones[97]); 2. The ones made in exaggerated sizes were not contributing to efficiency if used for cutting tasks; 3. The designs were possibly decreasing the physical homogeny of a piece of stone core, and thus the tools carrying them were flawed since their physical strength was compromised, making it unlikely that such handaxes were intended by their makers as tools for some (physically) practical task. Therefore, in the following sections, I will discuss them only briefly with symmetry being a special focus.

Fig. 4.5. is an illustration of the reference terms for handaxes. It defines what 'plan view' and 'profile view' refer to regarding a handaxe specimen. These terms are used in this way from now on.

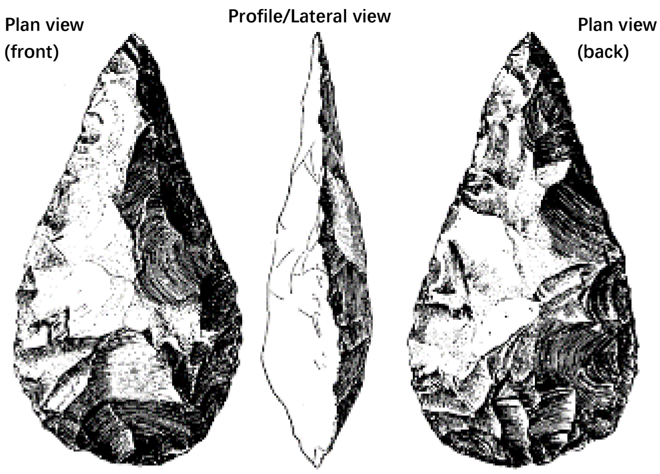


Fig. 4.5. Illustration of reference terms for handaxes Source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Bifaz_lanceolado-San_Isidro_(Madrid).png

[97] Compared with stone handaxes, bone handaxes are rare. According to Zutovski and Barkai (2015), nearly all the bone handaxes were made from elephant bones and the most of them were made no earlier than 1 mya. However, Sano, Beyene et al. (2020) recently have identified a bone handaxe dated to 1.4 mya. This is currently the oldest bone handaxe found, and it was made from a hippopotamus femur.

4.2.4.2. Other behavioural novelties with aesthetic concerns after the Acheulean:

I will now suggest that, when the mechanisms providing the opportunity for major development of the human aesthetic mind during the long period from ~1.7 mya to ~0,3 mya, such an aesthetic mind kept growing after the Acheulean. In an analogous sense, once a cognitive pathway is built between the mind and some external activity/practice (e.g., handaxe-making), it could expand into a network of similar pathways that link many other things to the mind. Once evolution endowed our ancestors with the cognitive imperatives to be attracted, guided, and affected, consciously or unconsciously, by certain sensorial inputs, this then opened up the potential for behavioural novelties. This would mean that those sensorial inputs became 'things' that hominins can attend to and therefore manipulate.

Starting with perhaps the oldest evidence of such manipulation, e.g., at around 100 kya, the technology of pigment production using ochre has been discovered (Henshilwood et al., 2011). Researchers have found what they call a 'painting kit' (Fig. 4.6.) consisting of several stone and bone tools (used to crush and mix the ochre) and shells of giant sea snails (used as containers) in the cave of Blombos, South Africa. The finding may indicate the existence of primitive painting behaviours (using pigments to represent/express mental contents), though we do not have the evidence for

Fig. 4.6. The Blombos 'painting kit'.
Source: Henshilwood et al., 2011

what was actually painted using these painting kits. According to Henshilwood, such evidence marks the first known instance of the production of a compound and use of container.

Within the similar period of 110-91 kya, another interesting behaviour is the collection of non-subsistence shells (Jerardino and Marean, 2010) (Fig. 4.7.). Research in this area has discovered two types of seashells, Glycymeris connllyi (dog cockle) and Phalium labiatum (helmet shell); the ones illustrated here were found in a cave in Pinnacle Point, South Africa. The authors have excluded the natural causes that might lead to the relocation of these shells in the site, because of: 1. The living environments (20-100m and 100-150m under the ocean, respectively) of these two shells, which require skilled diving, would make the option of direct access unlikely; 2. The distribution of these shells in the cave is not random but clustered. Thus, large waves or other nonhuman agents do not seem to be a good explanation. Furthermore, surface examination (concerning the trace of weathering by water

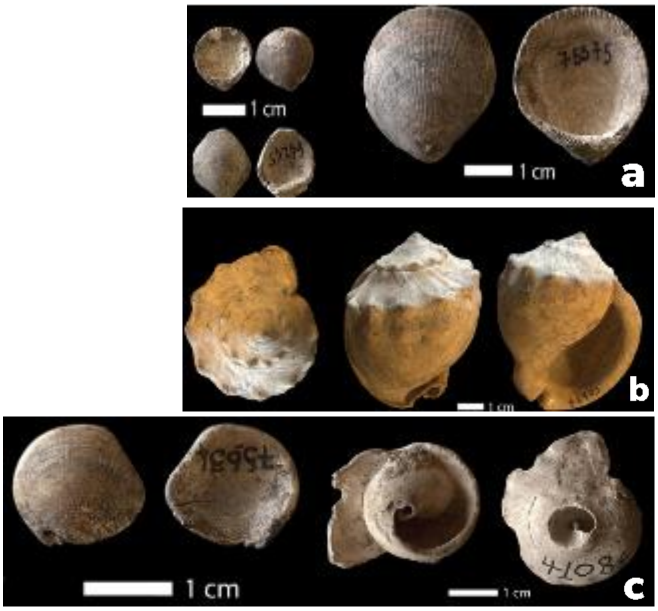


Fig. 4.7. a. Samples of dog cockles, b. A helmet shell, c. Water worn samples of a dog cockle and a helmet shell. Source: labiatum Jerardino and Marean, 2010

and sand) of the specimens suggests that these shellfish were already dead before they were brought to the cave[98]. Therefore, the collection of such shells was probably not based on a need for food. Also, there is no inclusion of other species of non-food shells in the cave (Ibid, p. 416 Table 2, p. 421). So, the authors further contend an aesthetic motivation for such behaviour.

More direct evidence of aesthetic interests comes from Blombos Cave with the discovery of ochre blocks (~75 kya) on which geometric motifs were repeatedly incised (Fig. 4.8., a.). Unlike most of the marks found on animal bones or stone tools, these motifs appeared in a more organized manner and apparently were not accidental outcomes of other behaviours such as butchery; the forms themselves were the intended outcome of the maker. According to Hodgson (2017), the occurrence of these engraved ochre blocks implies that the sensibilities and preferences for certain form, shape, and patterns became 'fully decoupled from tools' and were 'transferred to non-functional objects in a systematic way'. Similar geometric engravings were found on other objects and in large numbers in both earlier and later times in South Africa. For instance, engraved ostrich eggshells were continuously being made over a time span of ~109 to ~52 kya in Diepkloof, which suggests this practice to be highly stabilised (Texier et al., 2013) (Fig. 4.8., b.). Much later in time, more complex designs emerged on animal bones; therefore, in those

[98] Two cases here (Fig. c) might help illustrating the authors' statement of 'evidence for weathering resulting from water and sand abrasion thus suggesting that these mollusks were long dead before their shells were included in the cave's deposit' (Jerardino and Marean, 2010, p. 416): 1. a dog cockle whose edge is heavily worn; 2. a helmet shell which has damage to its apex and abrased whorl. Such morphological traits seem can be easily produced by an abrading process on a sandy beach—i.e., with the shell being continuously moved/rolled by the waves against the beach (in some study this process is termed 'rolling transportation' (Cadée, 2016)). Considering the living environments of the shells, the presence of such traits implies a beach weathering condition, which make sense of the claim that those shells were collected when they were dead.

cases, it is easy to tell that the marks were intentional design rather than random cut-marks. See, for example, the bone fragments from site Bacho Kiro, Bulgaria, dated to 47 kya (Fig. 4.8., c., and d.) (Marshack, 1976). According to Bahn and Lorblanchet (2017, p181), such findings serve as a proof of the 'graphic capacity' of the maker and they 'attest that some Neanderthals and *pre-sapiens* were close to the threshold that marks the appearance of the great art of the Upper Palaeolithic.'[99]

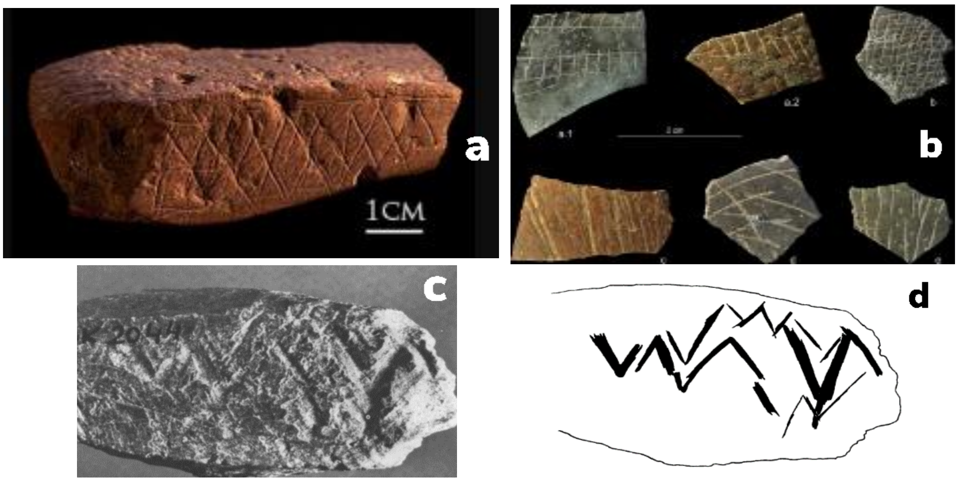


Fig. 4.8. a**.** An ochre block from Blombos Cave, source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Blombo.jpg b. Ostrich eggshells with engravings, source: Texier et al., 2013 c., d., The bone fragment with zigzag motifs from Bacho Kiro and a schematic reconstruction of the motifs, source: Marshack, 1976.

[99] Lorblanchet, Michel, and Paul G. Bahn. The First Artists: In Search of the World's Oldest Art. Thames & Hudson Limited, 2017, p.181.

Another mode of behavioural novelty with an aesthetic interest was the use of wearable decorations. Our ancestors began to use ‘jewellery’ as early as 130 kya with the discovery of the famous Neanderthal talons (Fig. 4.9., a.) from Krapina, Croatia. Based on recent surface analysis (Radovcic et al., 2020), researchers have identified traces of fibre (used for binding) and the use of yellow and red ochre for

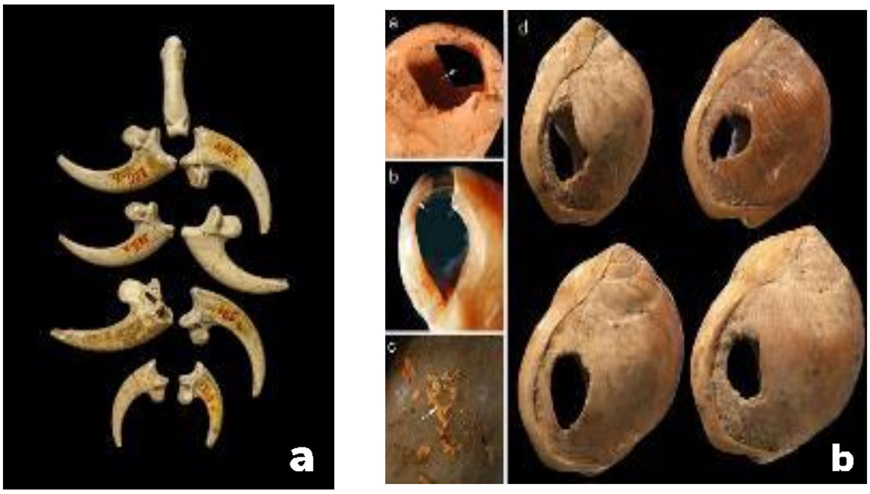


Fig. 4.9. **a.** The Neanderthal talons, source: Radovcic et al., 2020

b. Samples of shells that suggested to be parts of a necklace, source: Bahn and Lorblanchet, 2017

colouring. Again, in the cave of Blombos, more than forty Nassarius snail shells were found (Fig. 4.9, b.). Based on examination, these shells are believed to be perforated artificially and were worn as necklaces around 75 kya (Bahn and Lorblanchet, 2017).

Until about 40,000 years ago, aesthetic behaviours seemed to have reached a higher level of cognitive and behavioural complexity. It is at this stage that things we now regard as prehistoric art began to emerge. It took various forms, e.g.: 1. the 44,000-year-old large cave paintings found on Sulawesi Island, Indonesia (It is 4.5 m long, with one section of the painting showing a hunting scene with some therianthropic creatures hunting a local animal. This is by far the earliest evidence of narrative (Aubert et al., 2019) (Fig. 4.10., a.); 2. the earliest musical instrument: a flute made of bone, dated about 35,000 years old, was found in Geissenklösterle, Germany (Fig. 4.10., b.); 3. the many instances of 'Venus' sculptures (the earliest specimen, the Venus of Hohle Fels, was found in cave Hohle Fels, Germany and is dated to ~40-35 kya) (Fig. 4.10., c.).

Fig. 4.10. **a.** A part of the Sulawesi cave painting, source: Aubert et al., 2019

b. A bone flute from Geissenklösterle, source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Flauta_paleol%C3%ADtica.jpg

c. The Venus of Hohle Fel, source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:VenusHohlefels2.jpg

In short, these post-Acheulean cases indicate that, as long as the pathway (in a neurological sense) connecting aesthetic sensibilities with individual behaviour control, and with the higher inter-personal and group level was paved, this cognitive mechanism could then be deployed in many other practices. And it is during the Acheulean when this pathway is built. However, for the question 'why was there such an abrupt growth of complexity occurring around 40 kya?' There seems to be no clear answer yet. Haidle's (2014) 'mushrooms and fungi' analogy nevertheless can be a good point. 'The mushrooms are the most obvious expression, but only a part of the evolving organism.'[100] That is, the social and biological basis cannot be separated when we try to understand the emergence of those more complex forms of artistic creation; the existence of mushrooms requires a sound developmental process of the fungus. For example, even the zigzag lines engraved on eggshells did not occur arbitrarily. Though they seem simple to our eyes, their occurrence would require a complex synergy of the biological and the social dimensions: on one hand, e.g., individuals would need the neurological basis which allowed them to visualise, store, and decouple certain mental content from a practical context, and to carry out actions with enough precision; on the other hand, the group would need to reach a level of development to sustain such behaviours, which means that group might have: e.g., the technologies to help with survival, a reliable information transmission system, a large enough group size, and a symbolic system. Aesthetic behaviours, unlike the lactose tolerance mutation, cannot be selected as some single unit on the DNA chain. We cannot postulate, in an evolutionarily plausible way, a *Homo erectus* group which produces highly standardised, perfectly symmetrical handaxes while not showing any evidence of group hunting or having a system of social learning. This view is consistent with the niche construction based evolutionary picture presented in Chapter III, which sees aesthetic phenomena as both biological and social-cultural.

[100] Haidle, Miriam N. "Examining the evolution of artistic capacities: Searching for mushrooms." Art as behaviour. An ethological approach to visual and verbal art, music and architecture (2014): 237-251, p.246.

4.3. The Acheulean handaxe and the aesthetic—some general points

Speaking of behaviours and practices that are valued aesthetically. Before going into the specific patterns of the Acheulean industry which will be relevant to our questions at the beginning, there are some general concerns that worth mentioning. These are concerns about 'whether something should be regarded as aesthetic', though they come from different sources.

4.3.1. Features that are aesthetic?

As stated above, with regard to features like symmetry which, from a practical point of view, is excessive, and those belonging to the three categories listed in section one, I will suggest that they are genuinely aesthetic features. Then I also suggest that their presence was a systematic outcome of a well-developed social system that centred handaxe making as the traditionalized practice of niche construction. In such a system, selective pressures have brought about a competitive environment among the experts and the learners of handaxe making. Therefore, by saying that they are 'genuinely aesthetic features', I mean they are aesthetic in a strong sense: i.e., those features are not just appealing or pleasing to us when we (who live in modern societies) look at them, rather, I suggest there was a genuine aesthetic context which emerged at least by the late Acheulean which involved the intentional production of items with these features. This was a context analogous to ours (although maybe a structurally simpler one), in which both the maker and the appreciator were influenced by certain goals—to produce and to look for attractive products since they carry information about valuable qualities another individual may have (though for members of Acheulean communities, such goals might reasonably play their role unconsciously in guiding their behaviours). The model of this social system will be discussed in the next chapter; here this brief explanation is given to clarify the sense in which I use the term ‘aesthetic’ to describe these features. It is also in this sense that we can better understand why the systematic behaviours of making these features (through the medium of handaxes) indicates aesthetic sensibilities and an aesthetic practice.

However, one general concern will be ‘why should we think that these features are aesthetic features?’ Since there is no direct way of reading the minds of Acheulean handaxe makers, and any claims, based on the artefacts, about their motivations would be inferences about the minds of agents living a million years ago. In this regard, what makes it plausible to say that such features are aesthetic features, the handaxes carrying them are aesthetic objects, and the behaviour of constantly producing them aesthetic behaviours?

The possible response comes from three different angles. Firstly, it should be excluded that these features were unintended or accidental outcomes of the process of handaxe making. Secondly, it should also be excluded that these features were made to serve certain practical purposes. Thirdly, if we have managed to find evidence supporting the first two points, then it becomes plausible to suggest that such features are aesthetic ones—the makers of handaxes made the tools in this way because of they found those features pleasing, attractive, enjoyable, etc. I would argue (in the following parts and in the next chapter) that, based on archaeological evidence such as the existence of copying error throughout the handaxe making process and the absence of a positive relation between morphological refinements of handaxes and practical benefits, those features can neither be a by-product, nor were they made for some practical return, therefore, and were likely an intended outcome of an aesthetic motivation. In the next chapter, I propose a model based on the ideas of niche construction, strengthened social learning, and social competition to explain why such motivation was maintained during the Acheulean. Of course, there can be a potential objection to this view based on ideas from considerations of what is called theory of mind. That is, if agents in the Acheulean did not have the mental capacity to see others as intentional individuals who also take pleasure from aesthetic features and make inferences about others from their aesthetic experiences, then the continual making and refining of these aesthetic features as we observe in the archaeological record cannot be explained by the social learning and competition model. I do not see this objection as very plausible. Based on the evidence we know, e.g., the existence of cooperative hunting, the complexity involved in group level handaxe making, and other kinds of aesthetic behaviours emerged soon after Acheulean as mentioned above (e.g., the use of bodily adornments, the making of geometrical marks) it seems the case that the Acheulean individuals might well have a capacity for understanding their own mental states and those of others. Besides, there are studies that indicate chimpanzees might also have a level of theory of mind, e.g., they are able to pretend to be subordinate in face of strong competitor, and they can give deliberate deceptions to others about the food location, however, we do not need to expand these studies here.

4.3.2. Artefacts that are art?

Clearly at this stage, it might be an issue as to whether handaxes are works of art. Here, I will sidestep the unsettled issue of defining art, since not seeing these products of the Acheulean tradition as artistic object is not excluding them from being aesthetic objects. In explaining this, let us take a step back and have a quick look at the cluster account of art. The topic of what counts as art is surely an interesting yet unresolved issue. In the face of the difficulties that various definitions of art encounter, the cluster account of art has been proposed (e.g., Gaut, 2000, 2005 and Dutton, 2008). Very briefly, this account argues that 'art' is not definable in the sense of giving individually necessary and jointly sufficient conditions in assessing whether something is art. Rather, it suggests that the concept of art is a cluster concept with a set of criteria which are jointly sufficient and disjunctively necessary for the application of the concept of art. Denis Dutton and Berys Gaut have both proposed their own versions (based respectively on a 12-point criterion[101] and a 10-point criterion[102]) of a cluster account to art. Here I focus on the 10-criteria version of Gaut's. In demonstrating that 'definitionalism' and the resemblance-to-paradigm account are faulty, Gaut has provided concise and tenable critics on functional, institutional, and historical definitions as well as a critic of vacuity and incompleteness for the resemblance-to-paradigm view. And the cluster account is superior for being able to work around these criticisms and explain 'the range of disagreements' (Gaut, section IV) among different definitions concerning what is art. According to Gaut, this account provides a promising characterization of art based

[101] Dutton, Denis. The art instinct: Beauty, pleasure, & human evolution. Oxford University Press, USA, 2009, p.51-59.

[102] Gaut, Berys. " Art" as a cluster concept, in Carroll, Noël (ed), "Theories of art today", 2000, p.25-44.

on a set of relevant criteria/properties. These criteria include: 1. Possessing positive aesthetic qualities; 2. Being expressive of emotion; 3. Being intellectually challenging; 4. Being formally complex and coherent; 5. Having a capacity to convey complex meanings; 6. Exhibiting an individual point of view; 7. Being an exercise of creative imagination; 8. Being an artefact or performance that is the product of a high degree of skill; 9. Belonging to an established artistic form; 10. Being the product of an intention to make a work of art. If we assess the category of 'finely made handaxes' against the criteria, we may agree that these handaxes: possess positive aesthetic qualities and are artefacts of a high degree of skill. In this regard, these handaxes do seem to be non-art. However, when we focus instead on certain handaxes, those made to an exceptional level, e.g., the handaxe 'Excalibur' (which is thought to have been produced as a ritual or funeral object) and those mentioned in section 4.2.4.1., we might be inclined to say that these particular handaxes constitute borderline cases. Because, while satisfying criteria 1 and 8, they seem also capable of: being expressive of emotion, having a capacity to convey complex meanings[103], and being an exercise of creative imagination. In this sense, unlike definitionalism, the aesthetic relevance of handaxes is preserved.

Therefore, by putting the issue of art and non-art aside, I suggest that it seems to make more sense, for the purpose of my arguments in this thesis, to see art as sitting on a spectrum of aesthetic experience, with artwork located on one end of the spectrum, inducing, and providing the richest feelings and experiences, and the

[103] For instance, the giant 'Ficron'—through its exaggerated size, the 'Excalibur'—by its blood-red colour, and the handaxe with a shell embedded, they might be involved with symbolic practices of hominin groups. Therefore, their unique morphological traits could carry valuable meanings. However, future evidence is still needed to support such hypothesis.

diverse kinds of everyday objects lying on the rest of the spectrum, and many of them could reasonably be treated as borderline cases.

Following this line of thought, I reject another potential idea that the appreciation of daily objects is too simple to be included in a serious aesthetic discourse. This idea may have its roots in the general tension between ordinary objects that are deemed to be aesthetic and works of art that having aesthetic aspects. In such sense, the ones who have such concern is in effect questioning whether the appreciation of features like the symmetry of handaxes could qualify as an aesthetic appreciation. The argument of this idea goes beyond the case of handaxes of course. The structure of it looks like this: firstly, it is commonly accepted that to appreciate a piece of art, to see the beauty in it, we would have to acquire a range of sophisticated knowledge. Secondly, it usually requires special training before we can apply such knowledge correctly as we encounter potential works of art. Thirdly, since the appreciation of features of ordinary objects appears to be intuitive, isolated, and has a lack of a connection with the cultural background, thus cannot be counted as aesthetic. For this narrow view of aesthetic relevance, I should say that our appreciation of ordinary objects, like our appreciation of art, could also involve a complex process of learning and training. To 'properly' appreciate the design of a phone, the decoration of a room, or the material of a chair, one needs to live in a society which provides enough exposure to the knowledge of those things (usually many other things as well) such as the history of them, ideas behind certain features. Members of the society are, in a sense, trained or cultivated through their frequent interactions with those objects. Our enjoyment, pleasure, comfort etc., drawn from various features of ordinary objects, though different from the sublimity or marvelousness of works of art, are not in essence purely intuitive, isolated, or context insensitive, therefore preserving a ground for aesthetic discussion. In short, I argue that handaxes are better understood as aesthetic objects, and the practice of handaxe making, especially in the late Acheulean, is an aesthetic tradition. Not being a kind of art does not entail its being trivialized in the aesthetic discourse.

For the purposes of fully appreciating the handaxe making as an aesthetic practice, I should now turn to the next section which provides a special focus on the specifics about this stone tool tradition.

4.4. The complex social practice of stone knapping and its development in the Lower Palaeolithic

Before a suggested answer to the above questions is given in the next chapter, I should first provide some facts about this major practice that was widely employed by Acheulean hominin populations. These facts are important in terms of understanding the Palaeolithic context in which hominins were living (i.e., the Acheulean ecological niche), and of making sense of the proposed framework (see section 5.1, Chapter V) which draws on niche construction and selective mechanisms.

4.4.1. The innate costliness of handaxe making

Being itself a stone processing technology, the systematic production of handaxes is a practice of high cost. It is so in three aspects:

At the Individual level: When compared with other stone tools, handaxes are visually more complex. However, the 'more' should not include only those immediate physiological capabilities, of some potential maker, which guarantee the outcome. While a more complex way organising a series of knapping actions is crucial, to consistently produce technologically more complex handaxes, the level of indirect knowledge required to support the practice becomes much higher. The knapper needs direct knowledge of the practical physics of stone, which determines the choice of the raw material and the hammerstone, the right force and angle applied to each hitting action, the prediction of the end form, etc. Besides this, while carrying out the (pre)organised knapping plan, the maker would also need to be flexible to any unpredicted outcomes throughout the whole procedure. Studies suggest that hominins in the early Acheulean might have had an already sophisticated understanding in terms of lithic processing as different materials were treated differently (Hiscock, 2014; Diez-Martín, et al., 2018; Currie and Zhu, 2019). Handaxes made from raw materials of higher quality were processed more carefully and more intensely.

Recent research has also claimed that learning to knap is cognitively demanding. In one experiment carried out on participants from the university students and local communities, researchers found that their 'results corroborate previous experimental evidence that Paleolithic stone tool-making is a demanding technical skill that can require years to master, even given substantial social support and explicit instruction.'[104] Another experiment by Lycett (2015) has highlighted the dynamics between the 'inherent instability' of handaxe-making practice, i.e., the phenomenon of copying error and the stabilizing factor, i.e., imitative learning. In the experiment of a transmission chain (Fig. 4.11.), the effect of copying error is observed at each copy. As we can see, within 15 steps, a clear tendency of increasing the copying error (compared with the 'model') had already produced a significant divergence from the starting point.

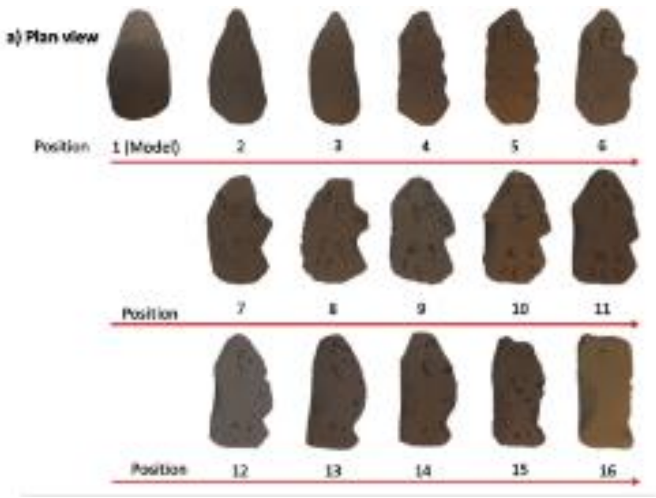


Fig. 4.11. An illustration of the presence of copying errors on a transmission chain Source: Lycett, 2015

At the group level: To keep the persistence of such a practice, hominin groups had to overcome other various forms of costs involved in stone tool making. To list some based on Hiscock's (2014) study: a. The hominin groups would need geological mapping of many kinds of natural resources (rocks, water, fauna, flora, etc.), b.

---

[104] Pargeter, Justin, Nada Khreisheh, and Dietrich Stout. "Understanding stone tool-making skill acquisition: Experimental methods and evolutionary implications." *Journal of human evolution* 133 (2019): 146-166, p 162.

Groups might encounter challenging situations while searching for lithic resources (e.g., the heightened possibility of confronting unpredicted predators in unfamiliar surroundings), c. The transportation of rocks, and d. The physical risks individuals would take during the knapping (finger/eye injuries which could lead to blindness or lethal infection), which affect the sustainability of the group.

At the manufacturing level: The technique of knapping itself, including raw material selection, step-by-step flaking, etc., is time consuming. And making a fine product is costly also because it is in its nature an unforgiving practice. The physics of stone, especially near the finishing stage, leave no room for mistakes. That is, once a failure has happened during the process, it usually destroys the whole piece or even breaks the whole blank. In short, it is never an easy achievement, neither for an individual to produce a good handaxe, nor for the society to maintain such a habitual activity in the distant past of the Lower-to-Middle Palaeolithic.

4.4.2. The chronological morphological refinements in handaxes

In short, the overall process of hominin stone tool development exhibited a gradual increase in sophistication. Throughout the lengthy time of tool-making (which started around 3.3 mya), the hominin lithic industry has shown a notable growth in the degree of manufacturing difficulty (pre-Oldowan, Oldowan, Acheulean), which means the skill level required to make a stone tool had risen throughout this period.

As for the changes in handaxes, according to a study based on samples excavated from the Konso assemblages in southern Ethiopia, there was a trend of higher refinement in bifacial processing of handaxe forms (Beyene, 2013). As suggested by the author, for different pairs of handaxes from four chronologically arranged Konso (KGA) localities (KGA6-A1, ~1.75 mya; KGA4-A2, ~1.6 mya; KGA12-A1, ~1.25 mya; and KGA20, ~0.85 mya), a pattern was shown: from near-unifacial finishing to more extensively bifacial finishing, and well worked bifacial finishing (Beyene, 2013, p. 1587).

In the same study, the number of flake scars was counted, which can be seen as another measurement of the skill level. The result shows a significant increase in the scar number for handaxes along the timeline, which may reasonably indicate a prolonged knapping procedure and a corresponding increase in working difficulty as the handaxe tradition persisted. 'In handaxes, flake scar count starts low (~10), significantly increases at ~1.4 mya (~15), and culminates in the extreme ~0.85-Mya condition (>20).'[105]

Besides this, relying on the quantitative study of the continuous symmetry measure (CSM) of handaxe symmetry on samples from three different but geographically near sites in Israel (Ubeidiya, ~1.4 mya; Gesher Benot Ya'aqov, ~0.78- 0.4 mya; and Ma'ayan Barukh, ~0.4-0.13 mya[106]), Saragusti (1998) found that

[105] Beyene, Yonas, et al. "The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia." *Proceedings of the National Academy of Sciences* 110.5 (2013): 1584-1591, p1589.
[106] Considering the postulated date of the site Ma'ayan Barukh and what is generally accepted as a bracket of the end of Acheulean (~ 0.3 to 0.15 mya), if we look at the data (Saragusti et al., 1998, p.822, Figure 5), all the samples from this site sit within a thin interval of the S value being between 0.1 to 0.4. Therefore, the claim could still be maintained here, even though the authors have not provided which samples from this site are made between 0.4 to 0.2 mya.

the mean S values (obtained from the CSM)[107] of these sites manifest a linear decrease (Ubeidiya, S=0.91; Gesher Benot Ya'aqov, S=0.77; Ma'ayan Barukh, S=0.27), which suggests that there was an increase in handaxe symmetry from the early to late Acheulean.

Furthermore, according to the data collated from Lycett's 2017 (Table 4.1.) paper, there is also a tendency for handaxes (if we view these site as belonging to two sets: the Olduvai set and the China set) to be made smaller, thinner, and lighter over time.

Sites	Lepolosi, Olduvai	TK, Olduvai		Fengshudao, China	Luonan, China
Dating	1.5-1.4 MYA	1.4-1.2 MYA		0.8 MYA	0.5-025 MYA
Length (Mean)	163 mm	103 mm		157.7 mm	Not provided
Width (Mean)	106 mm	67 mm		118.1 mm	Not provided
Thickness (Mean)	51 mm	38 mm		67.9 mm	58 mm
Mass (Mean)	817 g	Not provided		1131 g	979 g

Table 4.1. Morphological data of handaxes from chronologically different sites in Olduvai and China, source: Lycett, 2017

4.4.3. Handaxe symmetry and its impractical role in the Acheulean industry

Although many other characteristics of handaxe morphology are involved with the development of the Acheulean handaxe tradition, the tendency to achieve a symmetrical shape might be the most distinctive one.

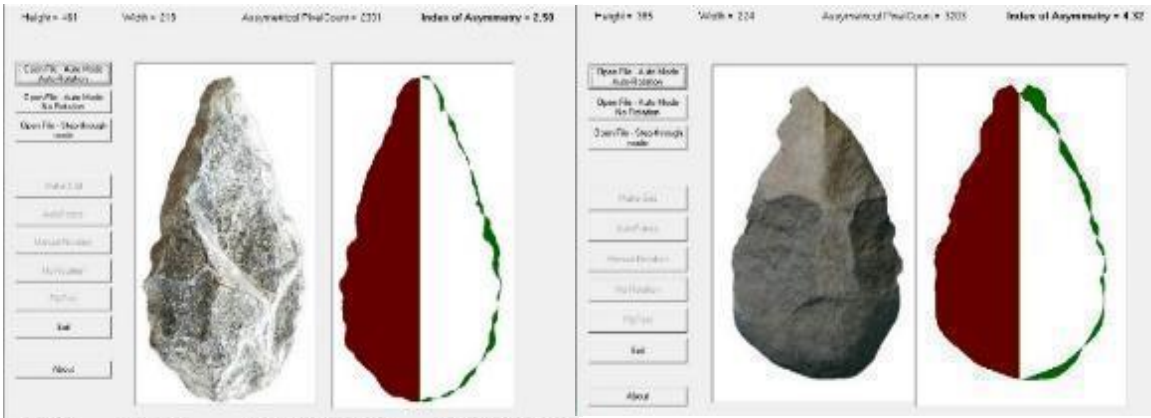
4.4.3.1. As we see in archaeological studies, the trait of symmetry seems to be common in the handaxe-bearing Acheulean sites across Europe, Africa and Asia. That is, although the total number of symmetrical specimens may differ, high symmetry (though with relatively fewer cases for early Acheulean sites) was identified at an

[107] I.e., an abstract value which denotes the distance a point (on the contour of a handaxe) will need to travel in order to make the whole outline of the handaxe symmetrical. A brief explanation of this measurement is given in 1.1., Appendix I.

extensive scale. Handaxes with a considerable degree of symmetry were made from even the very beginning of the Acheulean (e.g., at the lowest level at the site of FLKW, Olduvai Gorge, a well-made large and symmetrical handaxe was discovered and dated to ~1.698 mya., see F. Diez-Martin et al., 2015) to the much later sites in Boxgrove (dated ~524-474 kya) where nearly 80 percent (White and Foulds, 2018) of the handaxes were made with high symmetry. Also, according to White and Foulds' research (2018), it seems to be a universal trait observed among the majority of Acheulean handaxes found in British sites. Over half of British handaxes have a high symmetry. Based on their measurements, 'an unexpected 52.17% of British handaxes have AI[108] between 1.00 and 3.99—within HSC[109] 1, 2, and 3, described qualitatively as having ''virtually perfect'', ''very high'' and ''high'' symmetry, respectively.'[110] Similar results were also confirmed in studies on other Europe sites. For instance, Iovita et al. (2017) have carried out CSM tests on specimens from la Noira, a site in France, and the results indicate that handaxes from both the lower and the upper level were all made with high symmetry. Based on the Flip Test[111], Shipton's research (2018) on nine assemblages in Britain, East Africa, and India, shows that, on average, 'moderate' to 'very high' levels of symmetry had been achieved. Therefore, we may regard the symmetry as a 'type feature' of Acheulean handaxes which existed sporadically in the Early Acheulean and became much more prevalent at later times.

[108] I.e., asymmetrical index, see no.2., Glossaries. Also, see 1.2., Appendix for an explanation of the Flip Test.
[109] I.e., handaxe symmetry classes, see no.9., Glossary.
[110] White, Mark, and Frederick Foulds. "Symmetry is its own reward: on the character and significance of Acheulean handaxe symmetry in the Middle Pleistocene." *Antiquity* 92.362 (2018), p308.
[111] See 1.2., Appendix I.

Here I have carried out the Flip Test (the program is freely accessible through http://www.fliptest.co.uk./, in Hardaker and Dunn, 2005) on three handaxes from the Early and Late Acheulean as an illustration (Fig. 4.12.). The results show a clear difference (the green part) between handaxes of different levels of symmetry.



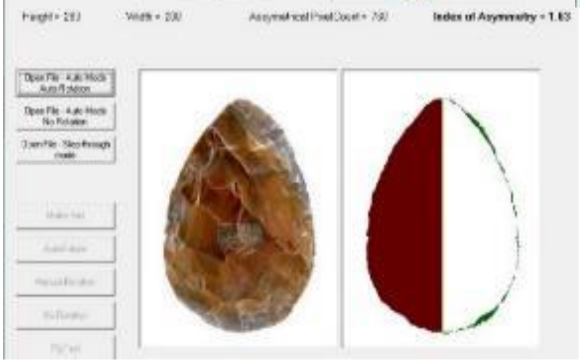


Fig 4.12. Flip tests on three handaxes.

Upper left: A rare case of 'very high' symmetry in a ~1.7-million-year-old handaxe found in Tanzania. AI value: 2.50. Upper right: An Early Acheulean handaxe of ~1.7 mya from Kenya. AI value: 4.32. Bottom left: A Late Acheulean handaxe of ~0.3 mya from Grindle Pit, England. AI value: 1.63

Source: author's own illustration.

4.4.3.2. Although symmetry is perhaps the most salient characteristic of handaxe morphology, it produces little functional benefit. According to studies on the relation between symmetry and cutting efficiency, the higher symmetric form itself does not necessarily mean better functionality (Machin et al., 2007; Key and Lycett, 2017). During these experiments, handaxes of different degrees of symmetry (based on Continuous Symmetry Measure and Principal Components Analysis) were tested. As the authors state, 'a large amount of variation in butchery time, nearly 78%, cannot be explained by any of the variables regarding handaxe morphology.'[112] In this sense, symmetry seems to have only a small role to play and it 'could be due to […] the slight gain in efficiency associated with the reduced amount of time it takes to locate a good handhold on a symmetrical handaxe.'[113] Besides this, in Key and Lycett's tests, regression statistics on Principal Component 1 (which accounts for 57.2% of handaxe shape variation) showed no significant relationship between symmetry and cutting efficiency.

4.5. Summary

As Machin et al (2007) put it, 'factors other than functional considerations for animal butchery are playing a key role in the decisions by hominin stone knappers to impose high degrees of symmetry on some of their handaxes.'[114] Such findings are consistent with the assumption of the existence of a special form of aesthetic psychology, which was realised in the Acheulean tradition in the Palaeolithic period. A kind of shared proto-aesthetic sensibility regarding symmetry (probably including other morphological traits mentioned above) might have emerged among hominin populations that rely on the Acheulean technological tradition. Based on what we have discussed in previous chapters on niche construction theory, I suggest that the occurrence of this special form of aesthetic appreciation was a result of a feedback loop between hominins' continuous niche constructing practice (i.e., 'traditionalized'

---

[112] Machin, Anna J., Robert T. Hosfield, and Steven J. Mithen. "Why are some handaxes symmetrical? Testing the influence of handaxe morphology on butchery effectiveness." *Journal of Archaeological Science* 34.6 (2007), p891.
[113] Ibid, p891.
[114] Ibid, p892.

handaxe making) and the corresponding changes in selective pressures. This is what will be discussed in the next chapter.

Chapter V: A niche construction-based framework for the origin of an Acheulean aesthetic tradition

Following chapter IV, these general points about the Acheulean should have been made clear:

1. The systematic production of Acheulean handaxes is a practice of high cost. It is so for both the individual herself and for the group or community that individual belongs to.

2. Not only had this costly practice of tool making been maintained throughout the entire Acheulean (i.e., over 1.5 million years), there were morphological refinements and improvements, which serve no practical function, being made to this stone technology chronologically.

3. Among those refinements, a high degree of symmetry is the most salient one.

Therefore, I have argued that such evidence supports the speculation that many of the Acheulean handaxes had moved beyond being just practical tools to being objects of aesthetic appreciation. Therefore, individuals in handaxe making groups might well have been extracting and enjoying the experiences through interacting with or simply beholding those finely made handaxes in a way which was detached from the immediate practical context and was related more to a socio-cultural context that is aesthetic.

In this chapter, I shall move further and provide more details about this remarkable interaction between our ancestral species and stone. I propose a framework for the hypothesis that, being a major method of the niche construction of Acheulean hominins' populations, handaxe making had led to a significant development of the aesthetic mind. This is due to a feedback loop between the 'traditionalised' practice of handaxe production and the corresponding changes in selective pressures. That is, in other words, as the match between the Palaeolithic environment and the population-level behavioural trait of handaxe reliance became stable, it generated a cumulative feedback loop of cultural niche construction. Such a loop would thus require a developed social learning system—which employed a quasi-teacher–learner relationship—to exist in the society which could sustain the cumulating social information. And in this scenario, the appearance (morphological traits) of products of this stone knapping technology were appreciated because of the capacity of signalling, i.e., handaxes as pieces of works signalled valuable qualities of the maker (Currie and Zhu, 2019). This thus marks the earliest form of an aesthetic mind which can be discerned from the archaeological record of the Acheulean handaxe industry that existed from about 1.8 to 0.3 million years ago.

In this chapter, section 1 will focus on this four-stage framework for the emergence of aesthetic sensibilities. It addresses how it is possible that the reliance and development in one kind of stone technology could lead to the aesthetic appreciation of handaxe forms. In sub section 1.2, three possible cases of regional styles of handaxe manufacturing will be given to support the framework developed here. Section 2 will turn to possible objections to this framework; they include concerns about the formation of symmetry, the usefulness of the handaxe as a tool, and social learning in the Acheulean. Section 3 will provide a discussion on the measurement of handaxe symmetry and why this is an important issue.

5.1. A framework of a hypothesis regarding the origin of the aesthetic sensibilities in Acheulean handaxe industry

As described in chapter III, niche construction produces two types of outcomes: phenotypic changes preserved through genetic inheritance and those preserved through cultural inheritance. Therefore, not just in those cases of the spread of certain human alleles, by relying on the culturally promoted competence in social learning, human niche construction could largely expand the modes of interaction with the selective environments which bring about phenotypic changes by inducing and shaping the process of cultural selection. That is, the mass of culturally preserved information and scaffolded learning environments are another source that accounts for the variety of human phenotypic traits. Think, for example, of our contemporary society; many of us may have tendencies to desire low-caloric food (e.g., low-sugar drinks, low-fat meals), for electronic visual stimuli (e.g., 3D films, VR video games), for novel tactile comforts (e.g., artificial leather, stuffed toys). These sensuous tendencies usually manifest themselves through behavioural patterns that are, to a certain extent, culturally grounded.[115] Such patterns spread among the population through many forms of social learning—modes of individual acquisition like imitation, observation, the influence of parents or peers, or outright teaching,

[115] That is, for example, the tendency for low-calory food is usually paired with culturally obtained knowledge (e.g., a high-calory diet is likely to be a cause of many diseases) or ideas (e.g., a fit appearance would be socially beneficial), and is manifested in a series of related behavioural patterns—e.g., avoiding chips, having gym sessions regularly, being more susceptible to outdoor products, ads, etc.

etc. However, in normal conditions, they spread at different rates. We do not find it hard to imagine that some novel behavioural pattern will show different fluidity when manifested in different cultures (an instance might be to consider behavioural patterns related to same-sex marriage, e.g., a pattern of seeking a same-sex partner, or a pattern of homophobia[116]). And this is because the cultural niche constructions of populations of different cultures have brought in differences in selective pressures that novel patterns would encounter. In other words, if we take a step back, this seemingly messy panorama, which displays the dynamic content of numerous patterns of behaviour with some of them spreading rapidly and some being erased, has helpfully pointed to the phenomenon of cultural selection.

One evolutionarily pertinent consequence of the joint force of continuous human niche constructions and concomitant cumulative cultural inheritance is cultural selection. Distinct from the mechanisms leading to natural selection or sexual selection, cultural selection is another mechanism of selection that acts at the behavioural level and is not biologically realised. It has direct impacts on the frequency of specific patterns of behaviours in the population (i.e., the spread of adaptive solutions). Induced by cultural niche construction, cultural selection can become intense when the practice of cultural niche construction is propagated by social learning. One example of how cultural niche construction promotes social learning is the educational systems in our modern society. Huge government budgets have been put into the construction and refinement of educational

[116] Those patterns show contextualized modes of propagation. There are counties that have legislation that recognizes and protects same-sex marriage globally while there are also regions where same-sex marriage is banned. These are facts that reflect how contextual elements (here, culturally mediated ones) can affect the frequency of some newly introduced behavioural pattern by making its process of social learning costly or vice versa.

institutions in countries worldwide. As a result of cultural niche construction at such a magnitude, social learning in our society is highly scaffolded and aided by collective cultural practices; from an early age up to an individual's maturity, nation-wide education is usually implemented by the government, and is the mechanism through which linguistic skills, basic knowledge (both practical and theoretical), core values, and social norms, etc., are transmitted to its members. This, as an important aspect of our habitual maintenance of our cultural niche, makes possible a remarkable level of synchronization of the population of *Homo sapiens* alongside other forms of cultural niche construction. Think of the diversity of disciplines and professions established (and the knowledge/information required to master them) in our society on one hand, and on the other hand, how the majority of modern inhabitants do seem to fit into it (in a general sense[117]). In this general sense, I am inclined to think that the high frequency of certain phenotypic traits among us (e.g., enhanced prosociality, reduced reactive aggressiveness) have their selective roots in our cultural practices which are persistent and extensive. Meanwhile, behavioural patterns that carry no such traits are usually selected against (e.g., being indifferent to others' emotions, behaving aggressively, not showing cooperative intentions or willingness to share). The process of an individual's social learning would need the regulation and guidance from the cultural practices of niche construction before a society as complex as ours can sustain itself.

In this regard, the research topic of HSD (i.e., human self-domestication) is worth noting. It is the idea that, in some sense analogous to animal domestication, humans,

[117] That is, through the cultural practice of modern education (again, not the only factor), society stays generally inclusive, tolerant, and co-operative, and a person's social learning experience generally secures him/her a job, so the individual can survive.

through their execution purposeful of choosing (this can be embeded in various activities such as setting up rules or laws), are domesticating themselves, resulting in evolutionary consequences at populational level. Recent studies on HSD (i.e., human self-domestication) show promising evidence for the HSD hypothesis (i.e., late human evolution since the Middle and Upper Palaeolithic was influenced by an intraspecific selection for prosociality), and as a result, many associated traits (traits similar to those that used to be found in domesticated animals) are present in modern humans. Although the exact story behind the emergence of this self-imposed selection is not clear yet, growing anatomical, physiological, and neurological evidence has been found supporting the effect of HSD. Currently known examples include: e.g., a reduction in brow ridge, nasal projection, and facial length; widening of the developmental window; and heritable hypoplasia of neural crest cell derived tissues. Based on such evidence, many have proposed that such selective pressures on prosociality had led to enhanced cooperation, reduced emotional reactivity, and increased self-control which, together, might have 'created a unique form of human tolerance allowing the expression of more flexible social skills only observed in modern humans' (Hare, 2017, p. 157) and facilitated our species' adapting to 'a uniquely complex sociocultural niche' (Gleeson, 2020, p. 18) [118].

Despite the difference in the volume of the total load of information, which seems substantial, as will be suggested later in this chapter, societies which are structurally

[118] The HSD hypothesis is consistent with the general niche construction framework that I am suggesting here. The HSD is a large topic on which I will not expand too much. The phenomenon of HSD needs more systematic studies by linking together paleoanthropological, neurological and genetic research before it can really disentangle the puzzle of how we, *Homo sapiens,* became what we are today. (For details on this topic: Wilkins, Wrangham, Fitch, 2014; Hare, 2017; Theofanopoulou et al., 2017; Wrangham, 2017; Bruner and Gleeson, 2019; Gleeson, 2020)

comparable (to those of modern humans'), had existed in the prehistoric world of hunter-gatherers. To see the full picture better, it would be helpful to start from considering social learning of one single behavioural trait. At the beginning, a newly derived behavioural pattern may occur because of individual learning. One could manage to find an adaptive strategy of behaving by personal exploration such as repetitive trial and error. Secondly, since *Homo* species live in groups, individuals who have learnt such strategies usually have regular contact with others of the same group. As a result, other members in the group would have enough opportunities to learn the way of behaving by observation, imitation, or even teaching. Therefore, such behavioural patterns can then spread among the local population if this way of behaving conveys adaptive advantages for the conspecifics who have successfully acquired those behavioural traits. If the environmental conditions stay stable (i.e., continuously behaving in this way keeps being rewarding), such traits or patterns would tend to become prevalent and lead to the formation of a behavioural tradition (it is well established that behavioural traditions exist in many primate species[119]). At this time, most of the group members would perform in accordance with a certain set of behaviours, which we will call 'Plan A', in the face of a specific setting/situation A, since it efficiently reduces the cost of individual exploration. Once the tradition is established, it acts as the given conditions for social interactions and exerts a

119 A notable example is the diffusion of food-washing behaviours observed in Japanese macaques since the 1950s (Kawai, 1959, 1965). Research shows that usually an innovation starts with a juvenile or a young adult, and the novel behaviour first gets spread among kin (like-aged individuals especially), then once the tradition has established, the young can easily learn the trick from the mother (Scheurer and Thierry, 1985, p. 493). Another well-known case is the using of natural 'sponges' in chimpanzees. The making of leaf-sponges for extracting water is widely found in wild chimpanzee communities and is thought to be a 'cultural universal'. Recently, studies have confirmed a variant form of the leaf-sponge, the moss-sponge. Some have argued that such fact (moss-sponge is more efficient in practicality) suggests a 'cumulative cultural evolution' in chimpanzee populations (Whiten et al., 1999; Hobaiter et al., 2014; Lamon et al., 2018).

selective effect on the behavioural repertoire of group members. An individual (and others who interact with him/her) might face potential extra costs for not conducting Plan A. That is, when exposed to such existing traditions that have mediated the methods and medium of the social transmission of skills, knowledge, and resources, the possible modes of interactions an individual could have with others and with her/his environments will have differential fitness consequences[120]. Or, in other cases, members of the group would have a limited chance to observe or imitate solutions other than 'Plan A', when they are in a tradition of producing Plan A. If we recall the discussion of the 'gradient of fitness' and cultural niche construction in chapter III, it is plausible to envisage that there are various solutions to challenging situations which are accessible through the process of social learning that happens within the existing cultural niche. This fact introduces a cultural dimension to the 'gradient of fitness'. That is, the match between an individual's behavioural modes and the environment will also depend on what are most available for the individual to learn by the cultural inheritance system. As a matter of fact, in a society with systematic cultural niche construction and rich cultural resources, social learning may play the most potent role in terms of providing or guiding its members to the idea matches (usually variants of the ideal ones) to different selections.

Therefore, for populations that are highly integrated with their cultural niche, selections can partly be explained by the differential success of the passing on of those socially learnt solutions for corresponding selections to other members—sons, daughters, kin, or students and on-lookers. The point to address here is important:

[120] For instance, imagine in a company where everybody uses an Android-based software to work (as a tradition), if a new employee insists on using her/his iPhone to work, this will probably impose at least extra learning costs for this person and his team.

cultural mediation can cause changes to the selective landscape of the species and generate selection for adaptive modes of behaviours at the populational level. For example, when our *Homo* ancestors began expanding their habitat into colder areas of the Earth around 0.7-0.9 mya, two major challenges (i.e., the source of the selective pressure) would be the cold environment and extreme resource fluctuations. Therefore, candidate solutions (e.g., using fire for keeping warm and cooking meat, regular hunting of large games in cold environments) must had been selected by their usefulness in tackling such challenges. In recent studies, evidence does support such a scenario. Behavioural patterns such as the habitual use of fire, hide working and ivory processing are attested during the Middle Stone Age in northern inhabitants (i.e., *Homo heidelbergensis, Homo neanderthalensis, and Homo sapiens*) (MacDonald, 2017; Mondanaro et al., 2020). Moreover, selective pressures might also drive behavioural changes in the aspect of social cognition. It is argued that harsh environments led to extended and more intimate social networks. For instance, enhanced healthcare provisioning and collaborative parenting possibly existed in Neanderthal society, and were crucial to Neanderthals' life in the North Temperate Zone (Spikins et al., 2019).

The extended evolutionary synthesis (see chapter III) thus suggests that for modern humans this cultural selection may well have become a major source of selection. *H sapiens* are not just one of the species that modify their environments to a notably comprehensive scale, but are probably also the only species that rely heavily on such cultural practices in achieving such modifications. Therefore, considering the specifics about the Acheulean described in chapter IV, or as we look back into that deep history of the *Homo*–stone relationship (from a perspective of niche construction enlightened human evolution), it is not unreasonable to think that cultural selection could have played a role in Acheulean populations.

As claimed in the previous chapter, the archaeological evidence about handaxes leaves us this fact: the lithic industry of the Acheulean ended up with a standardised tradition that emphasises the morphological elaborations of tools, while the consistent presence and chronological refinements to those morphological elaborations indicates the first appearance of culturally grounded aesthetic appreciations. Meanwhile, it leaves us a question: what mechanism there could be which nurtured this approach?

5.2. Learning the lithic repertoire—how it is that the need for social learning gave rise to aesthetic appreciation of the tradition of handaxe making

In the following section, I will draw on the perspective of the extended evolutionary synthesis (to which cultural niche construction and social learning belong) and apply it to the long period of the Lower Palaeolithic world (from ~3.3 to ~0.3 mya), and to see how the interaction between our prehistoric relatives and their surroundings might have influenced their own cultural evolution and how that relates to the emergence of aesthetic sensibilities.

In doing so, I propose a framework model, which describes the emergence of aesthetic sensibilities among hominin groups as the consequence of a cumulating/developing social learning system in Acheulean handaxe-making groups that forms a self-reinforcing loop.

Before details of the Acheulean are given, it is helpful to have a general structure here about this loop of cultural niche construction to briefly explain the interactions between the organism's activities and its selective landscape:

I. The existing niche constructing practice(s) and selective pressures relevant to these practices.

II. The emergence and spread (where social learning comes to the foreground) of a certain novel adaptive practice. This would lead to the modification of the structure of selective conditions when the novel practice becomes dominant.

III. A set of phenotypic traits (including but not limited to those involved in social learning) which facilitate the spread and stabilisation of such a practice would then be under selection pressure in this re-shaped structure of the selective landscape.

IV. Since any one of such traits can buffer selective forces which dominated the modified landscape, it confers fitness on its carrier, and can stabilise over time, at the same time eliciting further adjustments to the ecological niche of the species.

Therefore, so long as there is no major turbulence (e.g., abrupt changes to the climate or the loss of group members that lead to the unsustainability of some socially learnt practice) introduced into the selective landscape, the third and the fourth steps can form a repetitive loop (that is, if an adaptive practice became stabilized, in turn, it causes changes in the selective pressures that favour the traits that further refine the practice or reduce the cost for the preservation or retention of this tradition): i.e., I→ II→ III→ IV→ III'→ IV'→ III''→ IV''...

5.2.1. The model of Acheulean aesthetic sensibilities in the tradition of handaxe making

Now I move on to the manifestation of this structure in the Acheulean context and explain why the structure has something to do with aesthetic sensibilities. During the Lower Palaeolithic, handaxe making—a practice of niche construction which began at ~1.76 mya and had been carried out for over 1.5 million years—seems to be a suitable candidate for taking up the role in the first stage as the typical practice of niche construction. Since this type of stone working was an efficient way of solving challenging situations, this fact would in turn lead to the copying of this practice. In this way, the prevalence of the practice could become a source of selection for the behavioural trait (e.g., the processing techniques, the acquisition of related knowledge) that facilitates such practice. Therefore, this process of interaction (between the niche constructing activity of tool-making and subsequent changes in selective conditions) seemed to have built up a feedback loop. As this loop stays stable over time, it could have entailed ongoing refinements in terms of stone tool manufacturing. At this stage, the dynamic relation, between hominin groups relying on this technology on the one hand, and persistent selective pressures on the other, would then favour a complex social learning system. This is because a developed/sophisticated learning system is the mechanism that is most likely to secure the transmission of this costly stone technology (see section 4.4.1., chapter IV). In this system, intense communication/exchange of information between individuals must had been required due to the complexity of the tool making process (As explained earlier in chapter IV, the knapping process is, to an extent, unforgiving and the creation of symmetrical end products demands an integrative understanding and planning of the whole chain of substages of manufacturing. Meanwhile, knapping strategies are somewhat variable in terms of the specifics of the raw material. Therefore, since archaeological records have shown a wide presence of successful social learning of this technology[121], intense or at least frequent transfer of information is assumed. Also, as Hiscock (2014) and White et al (2019) suggest, interpersonal teaching and learning (i.e., a relationship that formed for allowing valuable information to flow from experts to novices) was likely in place (A fuller discussion on Palaeolithic learning is given in section 2.4). At this time, naturally, selective pressures would then influence both parts: the receiver would need to know who the experts are, and the sender would need to effectively show his/her credibility as a source of such information. As a result, the idea of 'a person with the right know-how' or 'a person who benefits from the knowledge of the first person' could form, and this possibly led to the differentiation of a new role in Acheulean societies—i.e., the teachers/experts (I should note here: the terms 'teacher' and 'expert' are used just for the convenience of understanding, since they tend to imply professionalization; however, based on archaeological evidence, this is not the case

[121] A relevant issue here is whether the process of Acheulean teaching or learning was mediated by language? Although a spoken language seemed unlikely to have existed in the Acheulean, I suggest that the social learning system in the Acheulean was at least assisted by some 'quasi-linguistic' processes (such as instructions). This is due to the complexity and costliness of this practice which would make mere observing and copying insufficient in terms of acquiring necessary skills. Learners would need to understand the details (e.g., the subtle changes in the point of percussion, the platform angle, and the force applied) in the long and organized sequence of actions of handaxe making. Many have suggested that the transmission of Acheulean technology would require some proto language such as gestural instruction (Morgan et al., 2015, Hiscock, 2012), see section 3, Currie and Zhu (2019) for more on this issue.

for Acheulean societies. And my use of these terms in the following does not take on such an implication). In this selective context, the learner-teacher system was in effect an adaptive buffer to the costly technological tradition of handaxe making. That is, this system operated through the way (which induces less costs) in which a learner finds the right person to learn from— the skills and expertise of the maker were advertised or displayed to those who wanted to learn through skilful making or through the morphological refinements imposed on final products. As a result, this would have led to the development of a mental capacity in the population in terms of judging the skills of making (or traces of such skills as the morphological traits would indicate). On such a basis, I suggest that it was cultural niche construction and the social learning system that is accountable for the production of those finely processed, visually appealing Acheulean handaxes, and these handaxes marked the advent of the earliest culturally driven forms of aesthetic preference and appreciation in hominin history.

Stage 1: Pre-Acheulean stone tool use

Early hominin tool-making activities spanned the pre-Oldowan and Oldowan periods. Samples from the pre-Oldowan period are comparatively rare and isolated; therefore, the evidence is still lacking to support identifying Lomekwian[122] stone tools as a stable and continuous tool-making tradition (Stout, 2017). However, by 2.6 Mya, Oldowan stone knapping started to manifest a certain level of consistent methods of manufacturing and tool forms (see chapter IV). Large numbers of

[122] The Lomekwian is suggested (by Harmand et al., 2015) to be a pre-Oldowan stone tool tradition. See no. 9 Glossary.

Oldowan tools have been discovered, and they were predominantly made from a base core (by using a hammerstone to strike one tip of the core, thus creating a sharp edge, leaving the untreated end for grasping). These tools are believed to be used in chopping actions and are termed ‘Oldowan choppers’. Besides the choppers, simple stone flakes were also widely used. According to Semaw (2009), the main tools of the Oldowan were ‘simple cores and flakes, that were made mainly with the hand-held percussion technique,’ and such a tradition ‘remained the same until the advent of the Acheulian Industry.’

Since these stone tools met practical needs such as chopping, scraping or food processing, the practice of Oldowan stone-working may have eased selective pressures concerning subsistence. This tradition of tool-making was then employed as an important practice of niche construction. As we have seen in the archaeological record, sites containing tools from the Oldowan industry were widely used in Africa, Europe and Asia.

Stage 2: The transition from the Oldowan to the Acheulean—the emergence of a handaxe tradition

Based on ‘stage 1’, stone tools that sufficed practical needs were needed and those which functioned better would be favoured. It was at this point the novel practice of handaxe-making took place. During the transition from the Oldowan to the Acheulean, a notable morphological change of stone tools took place (i.e., the advent of Acheulean pear-shaped handaxes and their further refinement by employing the skill of bifacial flaking). At this stage, the hominins’ lifeway of using and producing tools together with the tool-mediated ecological environments in ‘stage 1’ seemed to have resulted in a further growth of complexity in tool production. At this stage, selection on capacities involved in the practice of toolmaking became intense since it required ‘more’ from the maker to make a good handaxe. Here this ‘more’ refers not only to immediate physiological capabilities of conducting and organised a series of knapping actions which are more complex, but also, to a considerable level, of indirect knowledge of the practice, e.g., the knowledge of the geological distribution of suitable rock resources, physical properties of different rocks and such like (Hiscock, 2014). Besides this, studies suggest that Hominins in the early Acheulean might have an already sophisticated understanding in terms of lithic processing as different materials were treated differently (Hiscock, 2014; Diez-Martín, et al., 2018; Currie and Zhu, 2019). These facts give us assumptions that lithic expertise was needed at least to some extent, since on one hand, manufacturing was no longer an easy task, and on the other hand, rock flaking maintained its unforgiving nature (that is, once a failure happened during the process, it imposes the cost of changing a plan). In other words, as handaxe-making spread among the population, better skills of making handaxes would have been adaptive. This fact would generate strong selection on the means of preservation and transmission of the whole repertoire of the skills and knowledge.

Stage 3: The tool-dependant niche and the need for a sophisticated transmission system based on social learning

Perhaps from the early Acheulean when handaxes became so prevalent and their production became stabilised, we may say that a cultural niche based on Acheulean technology had been readily constructed. In this scenario, such a habitual practice of tool production would have become a persistent regular cost for individuals and for the society. Firstly, toolmaking could have been very integrated with daily life and regularly carried out. Secondly, in sustaining such a practice, hominins had to overcome the selection pressures described in stage 2. More specifically, there are various forms of costs in tool-making activities, just to list some based on what have been discussed in chapter IV: a. hominin groups would need a geological map of many other kinds of natural resources (water, fauna, flora, etc.) to enable a fuller exploration of desirable lithic resources; b. The transportation of raw materials; c. The irreversible process of toolmaking (i.e., when a knapper deviates from the original plan, usually the plan would need be changed; for novices, this can be a regular cost, and sometimes when a plan cannot be saved, the whole material can be wasted.); d. The physical risk one would take during the knapping (e.g., finger or eye injuries which could lead to blindness or lethal infection). Therefore, it seems clear that the maintaining of the Acheulean industry is so costly that the hominins would have to respond in an effective way.[123] Therefore, one way to solve these challenges is to become a good handaxe knapper. In this regard, teaching seems to be a good candidate which hominins would exploit in coping with this demanding yet indispensable practice. Thus, a possible teacher–learner relationship could buffer those pressures and guarantee the persistence of valuable skills and knowledge in

[123] This may raise some concern here, regarding why it was worth bearing such cost; handaxes are a much more effective tool than flakes in terms of dismembering carcasses and are reusable, in carcasses processing situations; flakes can easily become blunt and have to be thrown away (in section 2.3 a more detailed discussion will be given on handaxe practicality and carcasses processing which was common in the Acheulean).

the local population. Hiscock thus provides the A-theory (apprenticeship theory), proposing that a 'master–apprentice relationship' played a key role in this period. He also suggests, 'there is no doubt that knapping experts, perhaps specialists, existed from the Lower Palaeolithic, that is, from before 1.5 million years'.[124]

That is, by introducing a novel behavioural pattern that bonds experienced individuals with others who lack relevant knowledge, the cost of social learning (the learning of knapping skills and other information) would be decreased. In this way, the concept of a potential teacher (or simply a better knapper)[125] would be recognised in this modified niche (based on advanced tool production and the corresponding learning system). Once the handaxe industry kept being beneficial to the society (see footnote 6 above), selective pressures would drive: 1. the development of knapping-related skills and knowledge and 2. preferences for and acknowledgement of expertise and more skilled individuals.

Stage 4: The advent of the earliest form of aesthetic appreciation; a sense of 'beauty'

On the basis of 'stage 3', the practice of Acheulean handaxe-making might have led to an extended system of niche construction which consisted of not only the

[124] Hiscock, Peter. "Learning in lithic landscapes: a reconsideration of the hominid "toolmaking" niche." Biological Theory 9.1 (2014): 27-41, p. 32. Again, the term 'specialist' can be contentious. Given what we know about the possible group size of Acheulean people, it is not that likely that this level of professionalization can be sustained.

[125] Of course, there can be an issue which concerns the skills that an Acheulean teacher would need—i.e., the skill of handaxe making and the skill of teaching. For my current purpose, I focus on the former. However, it is also true that some might have better abilities at imparting knowledge than others. That is, when knapping skills displayed are same, a manifestation of teaching skills would make a difference.

production of lithic tools, the interpersonal teaching process of skills like planning, flaking, and other general knowledge, but also changes at the group level which encompassed an interpersonal relationship which is the teacher–learner relation. Such a context would make it reasonable to infer that those individuals with special knowledge and skills would be more likely to be recognised as 'experts' and thus be treated differently.[126] In other words, since it is significant to recognise someone with a high level of expertise, it was necessary for hominin groups to be able to tell a good 'teacher' (not to be conceived as a profession like in our modern society) from a bad one (Hiscock has suggested that hominins could have had what he calls the 'knapper's guild' (a group of knappers who worked together) as a source of public evaluations of one's expertise. However, from what is currently known to us, this is only plausible concerning a much later time, and evidence is still needed). Considering that the knapping process is itself a practice done publicly, one the would-be master should make sure the information indicating her/his potential is being delivered to those present. Such conditions would exert selective pressures on the tool makers possibly generating a competitive social context: only those who have successfully shown persuasive skills would be regarded by the society as a qualified group member from whom others could learn. This means skills like the exaggerations of handaxe morphology would have the potential to be recognised as the sign of true expertise on most occasions. It was at this phase that the hominin tool-making habit had given birth to perhaps the earliest form of material practice that was based on a psychology detached from material usefulness—a mental state

[126] Some have put forward a further assumption: 'given the importance of the skills involved, the benefits of possessing them, and the cost to teachers in time and effort of providing them, learning opportunities would not have been freely available' (Currie and Zhu, 2019, p. 9).

that values the information or message some object is sending (rather than the immediate pragmatic uses), an aesthetic sensibility for this practice. Such a fact made it possible that the production of unpractical lithic tools was conducted with an over-concern on the morphological and visual traits of handaxes. More specifically, highly symmetrical shape, rare material colour, finely arranged scars, and even decorations are obviously strong visual stimuli which means they could be employed as an effective carrier of information about skill level. This to some extent explains many archaeological discoveries: a wide variety of raw materials were used to produce handaxes (basalt, quartz, flint, obsidian, ironstone, and even animal bones); some handaxes were made nearly perfectly symmetrical (similarly, some intended asymmetry as well); some handaxes were probably made with an intentional design, e.g., with a hole in it or with a fossil shell situated in the middle (see, Chapter IV). Just as Currie and Zhu (2019, p.9) put it, 'The advantages of displaying stand-out levels of skills led to the production of artefacts which significantly exceeded the requirements of ordinary use […] given that these were exercises in advertisement rather than practical projects, it did not matter that their display-function sometimes compromised or even negated their usefulness', e.g., the one made from a hippopotamus femur.[127]

Nevertheless, selective pressures would act on the learners as well. The capabilities of discerning a reliable sign of mastery in knapping were equally important. As research has implied, although children in hunter-gatherer groups tend to learn from only their attachment figure at an early age, as they grow up, they

[127] Refer to section 4.2.4., Chapter IV, for illustrations and a discussion of morphological traits that are mentioned here and examples of bone handaxes.

‘are more likely to learn from those whose knowledge can be trusted as reliable regardless of if they are an attachment figure or not’ (Boyette and Hewlett, 2017, p. 777). In a case study on Chabu hunter-gatherers in Ethiopia, only 14% (based on 28 participants) of Chabu adolescents mentioned a willingness to go (i.e., a preference for) hunting with their attachment figures (fathers). As to the partner with whom they wish to hunt, 54% of the adolescents reported that ‘individuals who were recognised as the best hunters, had extensive forest knowledge, or were exceptionally good teachers’ would be the ideal one (Jilo and Hewlett, 2016;). That is, even though the data above is from societies of modern humans, it is reasonable to assume that during the Acheulean culture, on the learner’s side, it was also beneficial for individuals to have a ‘correct’ preference for tools (handaxes);. Individuals would have to be able to discriminate good ‘teachers’ (although direct instructions need not be present constantly) from different learning situations.

With these considerations in mind, we may assume that, with the existence of social learning, those beneficial preferences were likely to spread among groups and became prevalent. In that case, a tradition of handaxe making, which might in turn influence the practice of niche construction, could form in the society. This scenario seems plausible since: the right kind of preference is beneficial; a widely accepted tradition based on beneficial preferences buffers the learning costs (selective pressures) of discriminating; lower costs on the learner’s part leads to higher learning efficiency of beneficial phenotypic traits in future generations.

To briefly summarise stage IV: the stable niche constructing practice of advanced handaxe-making had modified the selective environments of hominins to a large degree. Those mediated selective pressures could then facilitate the establishment of a teaching–learning system and led to the elaboration of handaxe forms—those carefully and beautifully made handaxes which manifested obvious non-practical concerns in the making process—and the corresponding appreciation of those forms.

5.3. The traditionalised handaxe industry and localised norms of handaxe making

Once we accept this framework of the Acheulean handaxe industry (that is, accepting a cultural niche construction view on this populational-level practice), one thing that might occur is the appearance of localised norms of handaxe manufacturing due to specific changes of selective pressures in local populations (That is, the idea of cultural niche construction—i.e., context specific practices—would lead to context specific modifications in selections.). Moreover, if those norms are found to have more to do with aesthetic preference, they support the framework as further evidence. The question is: do we have such evidence?

Based on recent studies (Paula Garcia-Medrano et al., 2018, 2020; John Gowlett, 2020a, 2020b; Mark White et al., 2019), I suggest that there seems to be as least three of such cases: the Kilombe style, the Boxgrove style, and the 'S-twist' style (which is widely found in Acheulean sites in East Anglia and south of the Thames).

5.3.1. The Kilombe asymmetric handaxes

Kilombe is an extinct volcano in central Kenya where many archaeological sites are found. The Acheulean presence in this area lasted for more than half a million years (from ~1.0 mya to ~0.46 mya). Though more detailed dating of stratigraphic levels is still needed, many of the Kilombe handaxes show a distinct trait of a slight asymmetric rightward curve. According to Gowlett, this is highly characteristic of Kilombe handaxes, and was deliberately made by the makers (Gowlett, 2020, figure 9 and 11). Inspections of the surface trimming indicate that the makers were skilled enough but for some reason they did not remove the asymmetric part. On the face of it, this morphological variant of handaxes may denote a localised aesthetic preference; however, to better support this presumption, we need more information from future research about the original context where those handaxes were made.

5.3.2. The Boxgrove tranchet style

The site of Boxgrove is not known only for the high degree of craftsmanship put into the handaxes, it has also produced well preserved details about the ecological background of the late Acheulean industry that exited there. This allows us to make more accurate correlations about the handaxes on site and their environmental conditions.

On the one hand, studies have shown that Boxgrove handaxes exhibit a specific knapping strategy—following a series of shapings, a final finish was usually made on the tip of the handaxe causing a marked removal. This way of finishing is known as 'tranchet flake removal' (Garcia Medrano et al., 2019, 2020). And it is a special morphological trait that is characteristic of Boxgrove. Besides this, based on studies of the stratigraphical contexts (e.g., the formation of sediments), researchers have suggested that the levels (level 3/4, level 4u, and level 4 in particular) where the majority of the handaxes are from (area Q1/B, Boxgrove) were less than 100 to 150 years apart in terms of their deposition (Garcia Medrano et al., 2019). This estimation is also suggested (a $<$100 year span) in earlier research (Roberts and Parfitt, 1999).

With such facts, the scenario seems plausible: within several generations, a local style of handaxe manufacturing took place among hominin groups living at Boxgrove.

5.3.3. The S-twist handaxes

Compared with the other two, the S-twist style is more widely spread. It existed at many sites across East-Anglia and the southern Thames (including e.g., Foxhall Road, Elveden, Hitchin, and Dartford) during two substages of the interglacial stage MIS 11[128], the MIS 11a and MIS 11c, with MIS 11b being a cold interval). The S-twist handaxe refers to handaxes whose edge displays an ogee curve when looking at all its four sides. According to White et al. (2019), this morphological trait is missing from all other British interglacials and is rare on a global scale, thus it is characteristic of these MIS 11 British sites. Along with other evidence such as the geographical distance between those sites (a radius of ~50 km) and sources of raw material (the area is rich in flint), White et al. argue that during the warm period of MIS 11c, this twisted phenomenon that emerged ‘in East Anglia and adjacent regions north of the Thames could plausibly be the product of just one or two local hominin groups.’[129]

[128] I.e., Marine isotope stages, see no. 12., Glossaries.
[129] White, Mark, Nick Ashton, and David Bridgland. "Twisted handaxes in Middle Pleistocene Britain and their implications for regional-scale cultural variation and the deep history of Acheulean hominin groups." Proceedings of the Prehistoric Society. Vol. 85. Cambridge University Press, 2019, p. 73.

By including MIS 11c into the picture, a possible history of the British twisted handaxes is proposed (White et al., 2019): at first, Acheulean groups who settled in East Anglia made twisted handaxes; later during the cold interval of MIS 11b, the harsh climate pushed those groups to the South Thames where they may have survived the cold conditions and continued making twisted handaxes in MIS 11a; however, the contact with other hominin groups without a twisted handaxe tradition might have led to the disappearance of this trait (this can be supported by the absence of this trait in the same area in the following interglacial, MIS 9).

With little evidence supporting the by-product and the functional view, this twist style is believed to be a deliberate design or stylistic choice that reflected a shaping preference of the maker (Ashton, 2016; White et al., 2019).

To summarise here briefly, where no clear practical end could be identified, three morphological traits of handaxes are presented here as cases of the existence of three different localised norms of handaxe shaping which were probably motivated by different aesthetic preferences.[130] It seems reasonable that with more thorough investigation and the developing methodology applied to archaeological studies, we should expect more such cases in the future. I should also reckon that, even though there seems no published study, so far, indicating any potential gain or loss of practicality in terms of these peculiarities in shape, evidence of a potential relevance

[130] As for how exactly such aesthetic preference might take place, my tentative guess will be: 1. a personal innovation view (i.e., some eminent knapper in the group might have imposed personal choices in the finishing stage of handaxe making, perhaps as a way of displaying, and this choice of style quickly spread through social learning), and 2. an accidental view (i.e., the morphological trait could be accidentally caused, and people might just happen to like it and start to copy it, since the copying of such traits requires skills, they fit into the framework of selective cultural niche construction and got preserved as part of the local tradition). Considering the small size of the Acheulean groups and the reliability of their social learning, these two guesses seem possible.

of practicality could nevertheless pose a challenge to this view, should such evidence emerge.

5.4. Potential challenges and further discussions regarding this framework

5.4.1. Symmetry as an intended goal

When seeing those exceptionally made handaxes, one could reasonably ask whether the most noted characteristic of handaxes, i.e., the exceeding degree of symmetry, was intentionally made at all? Was it a technically inevitable outcome of bifacial processing or was it an inadvertent result of hominins' perceptual bias? Following is some evidence for the intentional view:

Derek Hodgson (2011, 2015, 2019) proposes a developmental view of human cognitive comprehension on symmetry. Firstly, during the early period, the interest towards symmetry might 'have evolved as a by-product of enduring perceptual mechanisms for the detection of important forms.'[131] As cognitive capacities continued to evolve, the 'increased interconnectedness and density of neural tracts [...] may improve both the rate and amount of cross-referencing that could take place between various parts of the cortex.'[132] This could then lead to the 'sensory exploitation' of symmetry since the production of it induces a positive neural response due to the perceptual fluency (i.e., a subjective feeling of ease during the processing of perceptual stimuli, and research has now confirmed the effect that

[131] Hodgson, Derek. "The first appearance of symmetry in the human lineage: where perception meets art." Symmetry 3.1 (2011), p. 47.
[132] Ibid, p. 47

more fluent processing can lead to more positive assessment of the stimulus)[133]. Secondly, when it comes to the later stage of the Acheulean, where the cognitive awareness of visual information was enhanced and when symmetry became a more discernible trend, and also when a significant increase in brain size (~1000 cm^3 for *H. erectus* and ~1200 cm^3 for *H. heidelbergensis*) took place, he argues that such patterns fit an evolving picture of hominins' ability to intentionally produce symmetrical handaxes should be well within the capacity of Acheulean handaxe makers. In such a scenario, the appreciation of symmetry in the human lineage is explained through a progressive course of the evolution of the cognitive capacity, which in the general sense, is an outcome of the interactions between the hominins and their changing niche.

From a more technical approach, Shipton et al. (2018) also argue for the intentional view based on experiments. Firstly, regression analyses were carried out on two relationships: a. between bifaciality (i.e., the manner of flaking on both surfaces of a stone core in order to achieve a bifacial end-product) and symmetry; b. between reduction intensity (i.e., the accumulating flake count as the knapping process goes on) and symmetry. During the experiments:

[133]Here it is worth mentioning that the perceptual fluency involved with symmetry processing does not come out from nowhere. It has an evolutionary root. The symmetry in handaxes is the type of arranged visual content that shows the reflectional symmetry. This type of visual arrangement is widely seen in the biological world. Most animals show bilateral symmetry (i.e., what we call bilaterians), as for plants, many of them also have bilateral and radial symmetry (e.g., as shown in the flowers and the fruits). Within this broad set are predators, conspecifics, and food resources of human, therefore, detecting symmetry is evolutionarily important for survival. Also, from the perspective of evolutionary psychology, it has long been suggested that symmetrical human face is preferred because symmetry in human body is an honest signal for fitness (Fink, 2002; Rhodes, 2006; Buss, 2008). As a result, symmetry becomes a trigger of the fluent processing effect—i.e., objects carrying symmetrical patterns efficiently facilitate successful identifications of important targets—which can activate the neural rewarding system and lead to pleasurable experience (Hodgson, 2019, Flavell et al., 2020).

a. The level of symmetry was obtained by the Flip Test (see 3.1.2., section 3 for an explanation of the test).

b. Bifaciality was measured by 'the ratio of the number of scars on the more intensively flaked surface to the number of scars on the less intensively flaked surface'.

c. Reduction intensity was measured by 'the scar density index'.

For the first relationship, only one of the tested sites showed a significant relevance. For the latter, no significant relationship was found between the variables. Therefore, the results indicated that symmetry is a property independent of the reduction intensity and the degree of bifaciality (Shipton et al., 2018, p. 7-8), so symmetry is an intentionally imposed feature and not a by-product of the manufacturing process.

Besides the analysis of archaeological records, the authors conducted an experiment on transmission chains of handaxe shape. This enabled them to track the changes in symmetry, and if symmetry was a result of perceptual bias, it would persist along the transmission chain. During the experiment: 1. four handaxe drawings

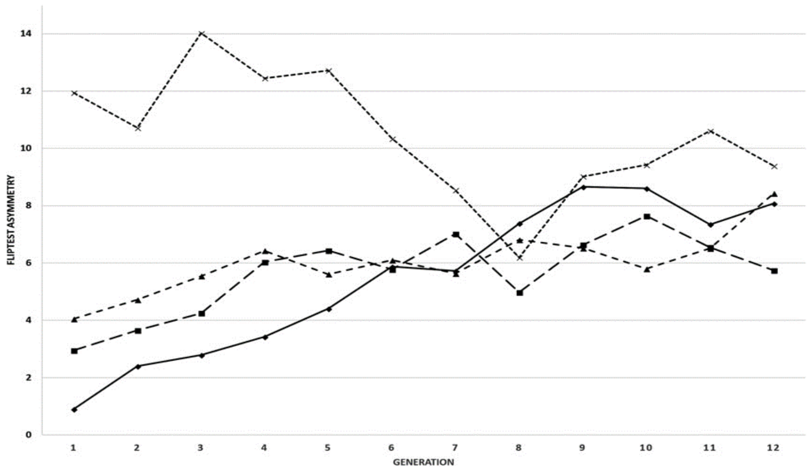


Fig 5.1. The trajectory of AI along 4 groups of transmission chain
Shipton et al., 2018, p4.

(morphologically different with one of them being asymmetrical) were given to the first four participants who were asked to copy these drawings as best as they could; 2. these copies were then given to another four participants who were also asked to copy the copies; 3. in total, 44 participants were involved in the experiment, and following such rules, researchers eventually obtained 48 drawings (including 4 initial samples) which can be classified into 4 groups. Each of them formed a 12-generation transmission chain (Fig. 5.1). As the results showed, initial samples ended up with obvious morphological distortions: the three groups starting with initial samples which represent highly symmetrical Acheulean handaxes exhibited a trend toward asymmetry while the asymmetrical group became more symmetrical. That is, it seems that, for modern humans and possibly for Acheulean agents, the copying errors which resulted from visual misperception would lead to obvious asymmetry. Although the perceptual bias did have some influence on the asymmetry group, it had not led to high symmetry during the experiment. At least the bias is not strong enough to overcome misperception asymmetries. Moreover, if a strong perceptual bias for symmetry existed, why was it the case that no other artefacts in the Acheulean period manifested similar emphasis on symmetry as what we see in handaxes? Therefore, this research suggests that symmetry in handaxes is independent of the methods used while producing. And it seems to be a deliberately imposed morphological characteristic.

There is evidence from other sources which also support the view that the imposition of symmetry in handaxes was not 'caused' by potential functional need. Hutchence and Debackere (2018) tested the relationship between handaxe utility (which, as defined in the paper, is represented by handaxe thinness and the straightness of edges) and symmetry in four British sites. Relying on bivariate correlation analysis, they have confirmed: 1. a weak correlation between the asymmetry index and thinness and straightness; 2. no correlation between the asymmetry index (AI) and the handaxe breadth/length ratio. The authors conclude that symmetry is more suggestive of a variably applied design choice by knappers rather than a functional concern.

Based on the study of British Acheulean sites, White and Foulds (2018) also claim that the imposition of symmetry was a deliberate act by the makers of handaxes. The context of raw material is relevant. Large nodules of raw materials seemed to have been used more often for handaxe production at sites such as Hoxne and Boxgrove, in which highly symmetrical handaxes were found. This fact allows a 'higher level of shaping and, consequently, greater levels of symmetry. The other subgroups are usually found where smaller river cobbles were used, the form of the blanks being better suited to less intensively worked pointed handaxes with long tips, poorly worked butts and high cortex retention.' Although their research data seems to confirm this description, this is not sufficient to say that the resultant symmetry-related differences were an epiphenomenon of the method of manufacturing (e.g., partial or circumferential edge working) caused by raw material conditions. On the contrary, as the authors point out:

a. The wide variation observed in ovate assemblages (i.e., the ones produced by high reduction intensity).

b. The use of existing traits and the mirroring of natural patterns or irregularities on stone blanks to achieve better symmetry in pointed assemblages (i.e., limited level of reduction intensity).

c. The production of nearly perfect symmetry in pointed assemblages (e.g., the Furze Platt Giant).

This evidence supports the idea that symmetry was not merely a side effect but a variably applied design feature (similar to Hutchence and Debackere, 2018). It may thus be very unlikely to suggest that these were all accidental, and the behaviours through which Acheulean knappers managed to cope with challenging conditions (such as incorporating natural parts of raw materials into the design of a handaxe) implies that hominins were 'mindful of' symmetry (White and Foulds, 2018, p. 313-314).

Here we need to think about the different levels of intentionality. More specifically, we need to specify what the level of attention to or awareness of symmetry was among Acheulean agents. At one end, we might think of them as consciously deploying the concept of symmetry and following conscious goals to make a handaxe more symmetrical. This seems unlikely however, given the limited cognitive capacities of the Acheulean agents compared with modern humans. Certainly, we do not have to assume that those agents were literally conceiving symmetry in such a way. An analogy can be helpful here. For photographs, there is a noted rule which involve the placing of the subject matter (e.g., a figure or a face) against the background in a way where the subject matter sits in the 1/3 of the image—the rule of thirds. Usually, photographs which conform to this rule could be taken by people with no understanding of the rule. That is, they simply took a photo that they 'felt was right'. However, this rule can be explicitly formulated too, and people then possess the concept of such a rule and would often intentionally produce pictures correspond to it. The point to be suggested here is that: there can be a tendency to execute some activity/practice in a certain way (which can be stable even for generations and can be intentional just as the action of taking photos), but with what exact manner the activity/practice is done is not conceptualised by the agents. This may well have been the case for Acheulean knappers regarding their practice of making symmetrical handaxes.

As a short summary, it may be reasonable to suggest that the manifestation of a preference for symmetry is not an isolated episode of cognitive activities. It is a contextualised behaviour that should be understood within its surroundings. Importantly, even though there could possibly have been an innate tendency to attend to or to prefer stimuli that were symmetrical, this would not be sufficient in explaining the whole developmental history of a long-standing technological industry that relied on the practice of producing symmetrical tools. Without a significant role played by social learning in maintaining such a cultural practice, this activity of handaxe making would not have been such a stabilized and trans-generationally expressed behavioural trait of the population. For Acheulean hominins, they might well have a level of perceptual bias toward symmetry, and they could be capable of consciously attending to symmetry; however, neither was symmetry directly available as an accompanying by-product of their practice of handaxe making nor could the perceptual bias overcome copying errors. That is, it might require the existence of a strong and persistent intention for the maker to achieve that level of symmetry exhibited in the archaeological record. Such an assumption is better understood as we take the material context and the cases of symmetrical handaxes made with successful reconciliation with material constraints into consideration. With only a level of perceptual bias, this industry cannot develop.

5.4.2. What could we say about the observed period of stasis of the degree of symmetry in handaxes from British sites?

If we accept the viewpoint that symmetry was an intentional goal for early humans, given what I just said previously, there should be an observable increase in the degree of handaxe symmetry in archaeological records over time. As has been shown in chapter IV, at a general scale, the Acheulean industry as a whole (from 1.8 mya to 0.3 mya) has a pattern of a chronological increase in handaxe refinements (of which the degree of symmetry is one aspect). However, such increase seems to be absent in Late Acheulean British sites (White and Foulds, 2018). One explanation for this stasis of symmetry is because of the change in the investment-and-return ratio of handaxe making. That is, once a level of high symmetry is reached, it requires much higher investment (this would include not only 'the time of learning and practice' but other factors such as 'high quality raw material') to reach a higher level. In other words, suppose it requires 3 units of investment to achieve AI class 3 (i.e., asymmetry index 3.00-3.99, corresponding to 'high symmetry' according to the Flip Test), then it might require 8 units of investment to achieve AI class 4 and perhaps 12 units for class 1. Considering how remarkable symmetry was already achieved in those British sites, e.g., Boxgrove reached an AI ~2.5-3.0 (Shipton et al., 2018; White and Foulds, 2018), it would simply be too technically and economically demanding to achieve. And this is plausible, especially for a prehistoric society in the late Acheulean, although individual cases of handaxes showing a very high level of symmetry did occur sporadically, but not at a site-level.

On the other hand, from a more general time scale, the pattern of a chronological progression of symmetry can be seen. For instance, the study of three geographically close sites in Israel (dated to 1.4 and 0.78-0.13 mya, respectively) shows a clear decrease in CSM values which indicates increased symmetry (Saragusti, 1998). Besides, focusing on sites in the Konso Formation, Ethiopia, Beyene (2013) also claims that 'between ∼1.6 and ∼1.2 Ma, an increase of workmanship is seen in handaxe form, resulting in better tip shape and plan form symmetry'. Furthermore, for another two younger sites, KGA-18, KGA-20 (dated ~0.85 mya), 'Symmetry of form is substantially advanced in some of these handaxes, with circumferential flaking accompanied by advanced plan symmetry and substantial thinning.' Schick and Toth's recent comparison (2017) of two Ethiopian sites (dated to 1.0 and 0.5 mya, a time span of half a million years) confirms this pattern, 'the latter assemblage overall shows much higher symmetry indices […] in combination with relatively smaller biface size than the earlier assemblage.' Compared with the fact that most of the British sites discussed above are dated between MIS-9 to MIS-13 (roughly, ~524 to ~337 kya with two major glacial events, MIS 12 and MIS 10), the time scale seems to explain, at least partially, the stasis. In short, this observed stasis of morphological symmetry in British sites is likely due to a constraint of costliness or a relatively narrower scale of sampling.

5.4.3. The Oldowan-Acheulean transition

5.4.3.1. Practicality: handaxes are good at heavy tasks such as butchering

Regarding the key issue of functionality in an evolutionary framework, it requires a certain level of practical benefit to allow the production of handaxes to be accepted by hominids at the beginning of the Acheulean industry. Evidence (Semaw et al., 2009) from a large number of sites in Africa (e.g., in Algeria, Ethiopia, Kenya, South Africa, Tanzania, Uganda) indicates the Oldowan 'simple cores and flakes' remained the same until the advent of the Acheulian industry. This entails a concern about the balance between practicality and impracticality, as we now know that handaxes carry aesthetic features that are made not for practical reasons; however, they must have been practical enough as a tool to outperform (or at least be as good as) their predecessor—Oldowan choppers. Therefore, a comparative investigation in practicality will be useful in terms of the Acheulean handaxe and other tools that were contemporarily used. Studies have been carried out to test the practicality of handaxes relative to other stone tools such as simple flakes[134] and retouched flakes (which, as suggested by available records, were also widely employed by hominids). The relationship between symmetry and functionality have also been tested in experiments.

Generally, handaxes do not notably out-perform other flake tools in terms of their overall cutting efficiency; however, handaxes are not functionally inferior to flakes

[134] Handaxes can also function as a source of fresh flakes and be sharpened whereas flakes alone can only be used as the end tool. Refer to footnote 6.

either. During all cutting tasks (Key and Lycett, 2017), handaxes and flakes show no significant differences regarding the total time taken to accomplish the whole experiment. In a butchery experiment (Galan and Dominguez-Rodrigo, 2014), handaxes show a better performance than flakes. Contexts of cutting tasks seem relevant to handaxe practicality. Handaxes are significantly more efficient in cutting tasks in which relatively large and resistant objects are to be cut while the flakes are better for cutting tasks that involve relatively small objects and thus require precision (Key and Lycett, 2017).

In addition, degree of symmetry in a handaxe does not appear to correlate with better functionality. (Machin et al., 2007; Key and Lycett, 2017). During the experiments, handaxes of different degrees of symmetry (based on a Continuous Symmetry Measure and Principal Components Analysis) were tested. As the authors state, 'a large amount of variation in butchery time, nearly 78%, cannot be explained by any of the variables regarding handaxe morphology.' In this sense, symmetry seems to have only a small role to play and it 'could be due to […] the slight gain in efficiency associated with the reduced amount of time it takes to locate a good hand hold on a symmetrical handaxe.' Besides, in Key and Lycett's tests, regression statistics on Principal Component 1 (which accounts for 57.2% of handaxe shape variation) showed no significant relationship to cutting efficiency.

There is a threshold effect (as has been mentioned in 4.2.4.1., Chapter IV) relevant here. In butchering tasks, the size of a handaxe affects its cutting efficiency by way of a threshold effect. A handaxe of the size of ~10 mm tends to be the most efficient. In one experiment based on morphologically different handaxes, a strong pattern is identified: handaxes below the threshold become markedly inefficient (Key and Lycett, 2017). Another experiment (Galan and Dominguez-Rodrigo, 2014) has indicated that handaxes of a small size (of 88 and 106 mm in length) are prominently effective in terms of de-fleshing and provide ‘higher return rates in butchery activities than simple and retouched flakes.’ This might be a reason why the majority of handaxes were made to a relatively narrow size specification.

5.4.3.2. Other speculations

Since the variation of handaxe size and shape within a certain level is independent of potential changes in functionality, there could reasonably be a zone of ‘free play’ during the manufacture of handaxes. That is, hominids were able to explore the various possibilities of material shape processing by means of stone knapping. Researchers have proposed that other advantages of handaxes may have been the key to the motivations underlying their production, such as their use-life and resilience to blunting (Key and Lycett, 2017). For instance, the importance of the edge has been mentioned in many studies since the edge properties of flakes and handaxes are different (the edge of a flake tool is usually straight and homogenous while a handaxe edge is serrated). In certain contexts of cutting, the edge may be more important than symmetry (Machin et al., 2007). In this regard, handaxes can in some circumstances be more practical than flakes and choppers. However, relevant comparative evidence is still lacking at the moment.

There are descriptive claims of handaxes being a more efficient tool in terms of their shape. Handaxes have a longer overall edge length, better force distribution, a more ergonomic shape, the potential of retouching/resharpening, and being applied multi-purposely, all of which could be regarded as an advantage compared with Oldowan tools (Simao, 2002; Schick and Toth, 2009). However, at the moment, these claims clearly need the support of experimental evidence. More recently, Gowlett (2020) argues that the symmetrical form is more resistant to torsion and is more economic in design. Thus, the symmetry saves both physical and cognitive cost in terms of working and teaching. They all seem to be potential candidates when contemplating the flake-to-handaxe substitution. However, after the practice of handaxe making became a habitual task for hominin populations, and with the evidence we have at hand, it appears that a concern with functionality and practicality alone might not fully account for the high level of interest that hominins put into the handaxe morphology observed later in time. The transition of Oldowan-to-Acheulean is a highly debated and complex topic; the speculations here are presented to support the functional superiority (though to a moderate extent) that was enjoyed by the handaxe. However, it could be the joint force of many other factors (e.g., the cognitive evolution of *Homo erectus* which indicated by the over one third leap in the cranial volume compared with *Homo habilis*) that finally determined the transition to this major tool form.

5.4.3.3. Evidence of heavy-duty work for early stage handaxe using

Based on what has been said in section 2.3.1. to 2.3.3., the cutting efficiency of handaxes is better than simple stone tools in heavy tasks like butchering. So, do we have evidence for the possible existence of such heavy tasks (e.g., large game hunting activities which involve many ways of animal carcass processing, such as cutting, skinning, dismembering, and smashing) in the early Acheulean?

If there is evidence for a habitual need for processing animal bodies (large game hunting) in the early Acheulean, the spread of Acheulean technology would seem plausible from a functional perspective. According to the analysis of animal fossils on archaeological sites, Layton et al. (2012) claims that the origin of an increased proportion of meat in the diet of hominins is between the appearance of *H. erectus* and 1.8 mya. Meanwhile, in one study which has identified the earliest case of porotic hyperostosis[135], which is believed to be a result of anaemia, Dominguez-Rodrigo et al (2012) argue that the intake of meat was an integrated part of hominins' diet since 1.5 mya. Such evidence therefore suggests that systematic group hunting could have existed in early Acheulean times and heavy cutting tasks would constitute a significant part of the daily life of Acheulean hominins.

Thus, with the discussions above, it makes sense to say that the development of the Acheulean handaxe out of the Oldowan tradition was at least driven partly by a practical concern.

5.4.4. Is there evidence of a complex social learning system in Palaeolithic societies?

It is harder to retrodict (reconstruct) the process of social learning from archaeological remains than to do so concerning the process of tool making. Unlike the evidence of handaxe morphology (e.g., mirrored contours along the given

[135] A pathological condition in which one's bones and related tissues become spongy and porous.

midline on a handaxe specimen is the evidence of this specimen having a symmetric form), evidence of a developed social learning system (the scaffolded learning environments in which individuals gain new information from others in the society), however, is indirect and rare. In this regard, in treating what may count as 'evidence', candidates can come from at least 3 aspects: 1. the costliness of maintaining the stone technology in Acheulean populations; 2. traces of possible instances of social learning in Acheulean societies; 3. social learning in other but related species (e.g., *Homo sapiens*). The first aspect is emphasised in the proposed framework and in Chapter IV; in short, it is the view that the Acheulean way of handaxe production is such a formidable task that makes it implausible to suggest individual learning through mere social exposure or individual exploration. The second and the third aspect will be discussed here.

As for the traces of Acheulean social learning, though evidence is rare, the earliest cases of such material evidence may still reach as early as the late Lower Palaeolithic and the early Middle Palaeolithic. Being more than just interesting, but impressive, in a study focused on the childhood development of Neanderthals, Penny Spikins et al. (Spikins et al., 2014) have provided 4 examples (3 are from the Lower Palaeolithic and 1 the Middle Palaeolithic) of handaxes in miniature size which are suggested to be toy handaxes for children[136]. The Middle Palaeolithic one (suggested to be as old as 250 kya) is only 4.4 cm in length and 17 g in weight. These small handaxes are well-made, however, they are too small to be of any practical use. This thus increases the possibility that they were made by proficient knappers for instructive

[136] Considering the scarcity of specimen, I suggest that whether this was an established tradition remains to be further supported.

purposes.

Similarly, in Stapert's work (2007), where sites (including the Boxgrove Quarry 1/B, and later sites of the Rhenen industry) with small sized stone tools are discussed, the author suggests that those miniature tools were finished products given by skilled knappers (or parents) or unfinished practice pieces left by the children[137]. And therefore, teaching among individuals could possibly exist in the Lower and Middle Palaeolithic. Moreover, the oldest evidence for Stapert's claim comes from Boxgrove at Quarry 1/B (see 1.2. for the dating of this site) where pieces of poorly made handaxes (as attempts by learners) are found alongside other finely made ones (i.e., works of experienced knappers). So, it could be inferred that complex social learning might have happened among the Boxgrove inhabitants in the late Acheulean at about MIS 13 (~ 500,000 years ago).

There is one issue though. That is, how can such evidence of the possible involvement of children be suggestive of a developed social learning system proposed in section 1? Because seemingly, the cognitive and motor-controlling demands for making a functioning handaxe can go far beyond the capabilities of Neanderthal children, and thus it does seem unlikely that the kind of direct teaching of knapping skills would take place between experienced knappers and children, however, such a finding of 'toy' handaxes do support the framework since it reveals the complexity of the Neanderthal social learning system. That is, those miniature handaxes indicate a scaffolded social learning structure, in which adults were

[137] According to Stapert (2007), this suggestion is based on such facts—first, the specimens in question are just too small to be used in the most practical daily tasks (e.g., butchering tasks for handaxes); second, the presence of the small sized tools shows traces of both competent and incompetent skills; third, many of the sites are not scarce in raw material.

producing 'customised' versions of important tools for their offspring. Unlike the process of direct teaching where valuable information and practical objects are being simultaneously transferred from one experienced individual to another unexperienced one, the behaviour of making toys denotes the need for social scaffolding (enculturating). Just as Spikins et al. put it, this would 'allow children to become familiar with the cultural, social and emotional context of using such objects.'[138] In the more general sense of cultural niche construction, this represents a stabilised match between selective pressures and phenotypical traits that tuned to those pressures. If the reproduction or spread of valuable information and skills from 'experts' to 'novices' in a systematic way constitutes a form of complex social learning, then the providing of toys from 'experts' (presumably parents) to children also constitutes a form of social learning which is no simpler. In the toy case, the difference is: the transmission of the skill is facilitated by the specially designed version of it, that is, by providing the proxy of it (considering our societies as an example, toys are extensively used to prepare the young for the valuable information that required for the cultural niche construction). Besides this, it sounds unnatural to envisage a society in which there are regular toy making behaviours but without behaviours of teaching among individuals.

Therefore, for the purpose of my arguments here, if there is a society where toys are regularly made, this only makes it more credible to accept the possibility that such a society might have evolved a sophisticated system of teaching as well (though it remains speculative). Nevertheless, if we take into consideration the whole span of

[138] Spikins, Penny, et al. "The cradle of thought: growth, learning, play and attachment in Neanderthal children." Oxford Journal of Archaeology 33.2 (2014): 111-134, p. 126.

the Acheulean, then the safer way to put it is that: a complex social learning system, which sustains habitual teaching and learning behaviours among group members, likely existed at least in the later stage of the Lower Palaeolithic. Another point to be made here is that: for another important issue concerning the level of involvement of Palaeolithic children in their societies, the perspective of toy making may provide valuable insights since it gets around the issue of determining whether the makers of some failed piece (aside from a lack of skills, the reason for such failure can be due to the quality of raw material or accident) were children or not.

In later times, as it became the Upper Palaeolithic, evidence of teaching becomes clearer. Firstly, according to Stapert (2007), from the Hamburgian (late Upper Palaeolithic, ~15 kya) site Oldeholtwolde, refitting analysis has indicated the existence of 'academic' cores—'cores worked by an expert knapper in what seems to be a demonstration for the benefit of young pupils.'[139] There are cores excavated at the site that are believed to show 'some kind of educational interaction' (ibid, p. 21 and figure 5). Based on residual study, it is suggested that the teaching might be carried out between a presumed 'teacher' and a learner who sat 1.5 m from each other. Similarly, in recent work by White et al. (2019), a trio of near-identical handaxes were found in their primary context at the site of Foxhall Road; they were placed around a central focus which the excavator thought to be a hearth. The authors have suggested that this fact indicates a situation with high level copying—where individuals were sitting together, observing and following the knapping series of the model. Even though skill gradations have not been identified in this case, such

[139] Stapert, Dick. "Neanderthal children and their flints." PalArch's Journal of Archaeology of Northwest Europe 1.3 (2007): 16-39, p. 21.

high-fidelity copying seems likely to involve close teaching. Since the specimens came from their primary context, and were supported by further evidence (e.g., gradations of skills), the site of Foxhall Road may count as the second Lower Palaeolithic example (Boxgrove being the other and earlier one) which indicates an event of close teaching and learning.

Secondly, the geographical separation of manufacture stages may also imply a developed teacher–learner relationship. While it seems highly plausible that hominins would select and transport raw materials needed for handaxe making (as Hiscock suggests, we can reasonably regard this behaviour as one aspect of the costliness of stone tool production based on practical concerns), other similar behaviours of stone tool makers may indicate another aspect of their mind which is not practicality guided, that is, the need to display their expertise. The following paragraph describes perhaps the earliest available evidence for such a claim, though being later than the Acheulean, I hope that Acheulean, or at least Late Acheulean evidence might be found in the future.

According to Sinclair (2015), the whole process of handaxe making consists of three different stages (a. the procurement and preliminary shaping of raw materials; b. the major thinning of blanks; c. the finishing of end products), and archaeological excavations have identified that these stages were achieved in a geographically distinct manner. 'At the Solutrean (~ 20 kya) site of Les Maitreux […], as one would expect, basic rough outs are brought into the site and an extensive thinning process is performed on the site, but the final elaborate and visible surface retouching of the pieces is undertaken elsewhere.' (Sinclair, 2015, p. 111) That is, there were two shifts in the manner of manufacture: from a to b and from b to c. As stated above, although ‘a to b’ can be understood in terms of production economics, the same explanation might not apply to ‘b to c’. Such patterns point to the potential scenario of skill display, i.e., ‘the geographical isolation of the final surface finishing of the piece allows the expertise of the toolmaker to be highlighted and made public’ (ibid, p. 111). However, as for the existence of the practice and tuition of knapping skills, more direct evidence comes only from the later Magdalenian (younger than 20,000 years) culture which followed the Solutrean. At the site of Les Etiolles, as Sinclair puts it, ‘a single structure in which three distinctly different levels of skilled knappers can be identified, radiating concentrically out from a central hearth: highly skilled, less skilled and beginner level. It is hard to imagine that there was not a transfer of information between the knappers of different levels of expertise in this context or that this concentric separation of skill is random.’ (ibid, p. 111).

In thinking about eligible evidence for Palaeolithic teaching and learning, the third aspect is to investigate this same behaviour in the extant relatives of Palaeolithic hominins, i.e., *Homo sapiens*. However, in this respect, I suggest that we should take a cautious view on interpretations (for more detailed discussions on this point, see: Currie and Zhu, 2019, section 4). One major worry is the applicability of inter-species observations since modern humans are anatomically and cognitively different. Therefore, evidence of this kind is provided out of a defensive rather than a supportive way of thinking: if teaching is absent in societies of modern humans, this would impose a serious challenge to the assumption that it exited in the Acheulean societies of our *Homo* ancestors who were cognitively more limited. As Currie and

Zhu suggest, 'the hope is not that evidence of teaching in modern hunter-gatherer societies will raise the probability of the hypothesis very high, but rather that, by protecting it from a substantially undermining counter-argument, it will prevent it from falling very low.'[140]

With these points in mind, we may say that evidence of teaching behaviours does exist in different cultures of modern populations. For example: among the Chabu people in Ethiopia, the Aka People in Central Africa, and the village people living in the Papua Province of Indonesia, studies have shown the existence of direct instruction, demonstration, and intervention from the expert. Also, learners show the capability of discriminating a good teacher from a bad one. In the case of Papua Province village, the apprenticeship focusing on producing stone adze heads could last 10 years (Hewlett, 2013; Dira and Hewlett, 2016; Boyette and Hewlett, 2017).

5.5. Summary

Here I summarise the case study of the Acheulean handaxe industry that has been discussed in Chapter IV and V. During a journey into Lower Palaeolithic societies which relied on stone tool technologies, in Chapter IV, we have gained several key ideas about the Acheulean technocomplex. Firstly, we have explored the general pictures of prehistoric stone tool traditions and aesthetic practices. Being the second oldest and most long-lived stone technological tradition known, the Acheulean handaxe technology is much more developed and therefore is more cognitively

[140] Currie, Greg, and Xuanqi Zhu. "Aesthetic sense and social cognition: a story from the Early Stone Age." Synthese (2019): 1-20, p. 9.

demanding in terms of the execution. Meanwhile, many of the Acheulean tools seems to carry morphological traits that had been valued aesthetically. This predates other prehistoric activities that manifest possible traces of an aesthetic aspect as well, such as the making of the 'painting kit', the geometric engravings on ochre blocks and ostrich eggshells, and the wearable decorations (e.g., the eagle talon pendant and the shell necklace), etc. After that, explanations are given to show how this advanced technology can be a costly practice both for the individual and the community. However, in spite of the costliness, chronological refinements in handaxes morphology are seen in archaeological records. Among those refinements, many are argued to be features that are aesthetic, including the 'type feature' of symmetry.

Therefore, in Chapter V I provide a model—by drawing on the idea of niche construction—which explains why such morphological traits of handaxes were valued aesthetically in relation to the developmental patterns of the cultural tradition of handaxe production. To put the story very briefly:

a. Selective pressures were the major force that favoured the practice of tool making since about 3.3 million years ago.

b. The Acheulean industry, as a techno-complex that evolved from the Oldowan industry, imposed novel selective pressures (costliness) on the acquisition of the practice of handaxe making (which involves skills learning and other aspects of the practice), and thus provided opportunities for aesthetic elaboration.

c. A developed social learning system was then favoured by selection because it buffered those selective pressures largely by reducing the cost of high-fidelity transmission of skills and knowledge.

Therefore, in Acheulean societies with such a complex learning system, there are individuals whose skills and knowledge were advertised to others who wanted to learn through the displays of handaxe making. Meanwhile, people living in those societies may have developed a capacity to exercise judgements and to form preferences, not just about the appearance of a handaxe, but also about the knowledge and skills that were put into the making of this handaxe. Furthermore, this proposed model is tested by examining the archaeological evidence we have about, e.g., the perceptual bias for handaxe symmetry, potential gain in practicality of handaxes compared with Oldowan tools, systematic large game hunting in early Acheulean, complex social learning in Lower and Middle Palaeolithic. Therefore, this aesthetic sensibility was neither fully innate nor purely cultural but was an adaptive phenotypic trait that was mediated by both: it could be partly Baldwinized and could be affected by the local norms. It is on such basis that this following claim is plausible: The Acheulean practice of handaxe making, which began about 1.8 mya, gradually developed into an aesthetic tradition.

5.6. Conclusion

In order to conclude this thesis, I say that a contextualist perspective which draws upon the extended evolutionary dynamics is a framework that best help us understanding human aesthetic activities. In Chapter I, it is explained that how our aesthetic practices can be closely related to the socio-cultural and evolutionary context in which we live. Chapter II further argues that to fully appreciate this contextualist view, we need to note the limitation of aesthetic theories which take an evolutionary psychological stance and extend the evolutionary context by re-evaluating the concept of evolution. This has pointed to the general phenomenon of the constant interplay between organisms and their selective landscapes they are facing. In Chapter III, by drawing upon the theory of niche construction, it is argued that the idea of an aesthetic niche provides mechanisms that better integrate ideas of aesthetics and of evolution. Chapters IV and V then elaborate this framework by focusing on Acheulean handaxes. By giving a model which identifies the practice of handaxe making as a mode of niche construction, it is suggested that specific aesthetic sensibilities could have formed during the Acheulean as a result of the development of a techno-cultural practice which became stabilized within Lower Palaeolithic hominin populations. I suggest that Acheulean society, through its aesthetic appreciation of this tradition, marked the earliest aesthetic culture in the human lineage.

With archaeological evidence, the emergence of this culture supports the view that the nature of our (and of our hominin predecessors') aesthetic activities is both biological and cultural. Furthermore, what is also of importance is to see that such activities are phenotypic traits that are expressed and embedded in an evolving selective landscape (i.e., an evolving aesthetic niche). They are constantly shaped by and are shaping this landscape by bringing about biological and cultural consequences.

Appendix:

Obtaining symmetry: a technical summary and some discussions

So far, though the phrase 'handaxe symmetry' has received extensive discussion, one important issue should not be overlooked, that is, how the data of symmetry is obtained. Because in any case, as this process is done by the hands of the observer, modern humans, it is of importance to exclude the perceptual and cognitive bias in the procedure of symmetry assessment. In other words, the measurement of handaxe symmetry should be conducted in a way that would likely have corresponded to the Acheulean ways of judging symmetry. It is in this sense, it seems that, between the most precise and the most intuitive methodologies, currently a better option is to adopt the middle road. In the following, I provide a short summary of ways of measuring symmetry in part 3.1, and then a discussion about them in 3.2.

1. Methodologies—the measurement of symmetry

Since symmetry is a prominent feature of the Acheulean handaxe industry, the methodology archaeologists use in testing the degree of handaxe symmetry thus plays an important role.

However, one question might follow—what is the best method? As there is not a unanimous view in terms of such methodology, diverse ways of determining handaxe symmetry are employed in research about handaxe symmetry. Here I present four methods of measuring handaxe symmetry: the CSM Test, the Flip Test (Hutchence and Devackere have recently designed the AS-check method which is similar to the Flip Test but will not be discussed here), the Absolute Symmetry Test and the Eyeball Test. Except for the absolute symmetry test, the other three methods are widely employed in archaeological studies.

1.1. In 1998, Saragusti proposed the first quantitative test for handaxe symmetry, i.e., the Continuous Symmetry Measure (CSM) (Saragusti et al., 1998). The goal of the CSM is to determine how much symmetry there is in the target handaxe. Roughly speaking, this way of measuring symmetry follows such steps: first, the normalisation of different specimens in order to prevent a size effect; second, designating a number of representative points that describe the contour of the specimen. (The exact number of points is subject to the needed density of the specific specimen. Theoretically, more points would describe the contour more precisely. During Saragusti's experiment, 133 to 343 coordinate points were used.) Third, generating the nearest symmetrical contour of the specimen is based on the original vertices; Fourth, calculating the minimum distance that each vertex would need to move to overlap its counterpart in the nearest symmetrical form. In such a way, we obtain an amount which represents the total distance those original points have moved to overlap its nearest symmetry by summing up the individual distances in step four. The definition of this amount was given by Saragusti as follows: 'the minimal distances that the vertices of a shape have to undergo, in order for the shape to attain the desired symmetry.' (Saragusti, 1998, p. 819) Therefore, the sum of the distance (represented by 'S values') could be used as a proxy for the degree of symmetry (the smaller the distance is, the more the specimen's shape is closer to symmetry), and this method was then adopted by others (e.g., Machin et al., 2007, Iovita et al., 2017).

1.2. The Flip Test is another widely used quantitative measure of symmetry (Hardaker and Dunn, 2005; Hutchence and Debackere, 2018; Shipton, 2018; White and Foulds, 2018). As shown in Fig 2. (cited from Hardaker and Dunn, 2005), the target specimen would be digitised firstly to obtain the ventral and dorsal outlines.

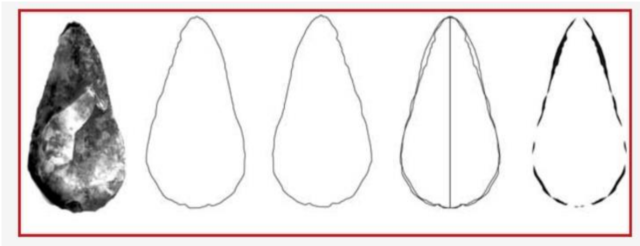


Fig 1. From left to right: a. Sample handaxe; b. Ventral outline; c. Dorsal outline; d. Ventral + dorsal outline; e. Asymmetric area (shades part).

Then the two outlines would be superimposed according to the long axis. The difference between the outlines would be marked out by coloured pixels which represent the degree of deviation from perfect symmetry. Each test would be standardised in terms of pixel scales to allow comparison across specimens. This Flip Test software outputs a numerical index of asymmetry (AI) and a graph that directly shows the asymmetric pixels of each handaxe. According to the authors' formula, the Index of Asymmetry falls in the range of 1-10, with lower values indicating higher symmetry. Hardaker and Dunn have further proposed a 6-level classification which correlates the AI values and their descriptively observable handaxe symmetry (i.e., the HSC): Class 1: AI value (1.0-1.49)→ Virtually perfect; Class 2: AI value (1.5-2.99)→ Very High; Class 3: AI value (3.0-3.99)→ High; Class 4: AI value (4.0-4.99)→ Moderate; Class 5: AI value (5.0-5.99)→ Low; Class 6: AI value (6.0 and above)→ Very low. They also suggest that the Flip Test is a simple and easy to use alternative to the CSM.[141]

1.3. Further, Li et al. (2016), have recently proposed another quantitative measurement of symmetry, the absolute symmetry test, which is based on actual volumes of objects. By applying 3D scanning, researchers obtain the digital reconstruction of the sample. Following this, the reconstruction is segmented into two parts along the long axis, and the volume of each part would then be accurately calculated using the software Avizo Fire 3D. Reasonably, 'the closer the volume of each segmented portion is […] the higher the degree of symmetry of the handaxe, and vice versa.'[142] Accordingly, the authors propose the following formula:

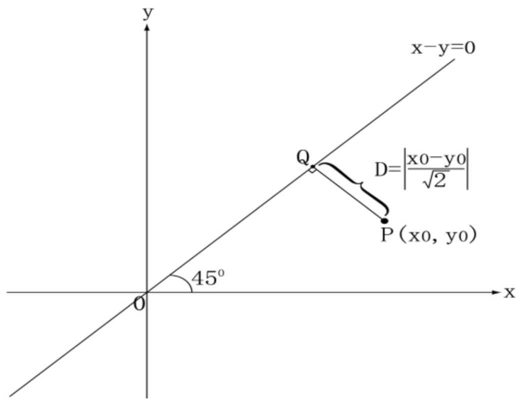


Fig 3. The illustration of D
(deviation from equality)
Li et al., 2016, Appendix A, p71.

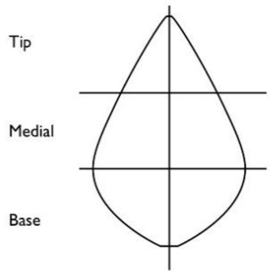
$$D = \left|\frac{x0 - y0}{\sqrt{2}}\right|$$

where *x*0 and *y*0 are the volume values of the parts of a handaxe, the *D* stands for 'the deviation of a handaxe's two halves from equality' and is described by the absolute distance value, as shown in Fig 3. In this sense, according to the authors, every D value gives a denotation of symmetry, a lower value means less deviation and higher similarity in segmental volume and thus, higher symmetry.

[141] Hardaker, Terry, and Stephen Dunn. "The Flip Test-a new statistical measure for quantifying symmetry in stone tools." Antiquity 79.306 (2005).
[142] Li, Hao, Kathleen Kuman, and Chaorong Li. "The symmetry of handaxes from the Danjiangkou Reservoir Region (central China): A methodological consideration." *Quaternary International* 400 (2016), p66.

1.4. Besides the quantitative studies mentioned above, McNabb suggests a qualitative approach, i.e., the Eyeball Test (McNabb, 2004; Sinclair and McNabb, 2005; Cole, 2015; McNabb, et al., 2018). As explicitly implied by the name, perhaps the most direct way of having some understanding of the degree of handaxes' symmetry is by observation of the shape. According to Sinclair and McNabb (2005), symmetry can be examined 'by dividing the tool horizontally into three equal portions bisected on the long axis.'[143] Specifically, a sample handaxe would be bisected vertically by its middle line and be divided horizontally into three parts by the two parallel trisection lines. In such manner, each specimen would be divided into 3 comparable sections (i.e., tip, medial and base) consisting of 6 parts (Fig 4. a). Symmetry is then assessed by eye on a yes or no scale for each of the three sections and could be divided into eight categories (Fig 4. b) with category 1 representing the most symmetrical and category 6 the least.

(a)



(b)

Eyeball symmetry	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Tip	Yes	Yes	Yes	No	No	No	No	Yes
Medial	Yes	Yes	No	Yes	No	No	Yes	No
Base	Yes	No	No	Yes	Yes	No	No	Yes

Fig 4. Levels of symmetry in the Eyeball Test.
Sinclair and McNabb, 2005, Appendix I.

2. Discussions

These above-mentioned methods do raise concerns as to how we understand the composition of an assemblage and the imposition of symmetry in handaxes by

[143] McNabb, John, et al. "The large cutting tools from the South African Acheulean and the question of social traditions." Current Anthropology 45.5 (2004), p658.

Acheulean individuals, since different ways of measuring generate different conclusions about symmetry. Clearly, one potential problem lies in the difference between two-dimensional and three-dimensional measurements: the specimens with high symmetry values produced by tests based on 2D measuring might have a low value in 3D measuring tests. Such a fact presents the question of which method better reflects the actual process of handaxe making during which morphological symmetry is a concern. This question then puts a challenge to the absolute symmetry test which relies upon the calculation of the volume. That is, the volume of each half of the raw material might not be something that worries Acheulean individuals when the handaxes were being made. Since the volume is not proven to be the goal, it may or may not correlate with symmetry. In other words, although the test is quantitatively accurate, it might not be so accurate in the sense of how the knappers saw the knapping process. Therefore, one thing that is worth mentioning here might be the visual perception of Acheulean agents. As we should not presuppose that early human in the Lower Palaeolithic would share similar cognitive competence with us (*Homo sapiens sapiens*), such as complex verbal language and social signal systems, we should neither assume that hominins achieved a sophisticated quantitative assessment of symmetry during the handaxe making practice.

In such case, the Eyeball Test does appear to hold some advantage, even though it takes a non-quantitative approach. As McNabb puts it, ‘if symmetry was important to the original knappers, appreciation by eye would have been the method through which they judged the results of their handiwork. A simple eyeball test of symmetry does therefore reflect this process’ (McNabb, 2009). At the present stage, the Flip Test and the Eyeball Test seem to be the more ‘natural’ and perhaps more ‘realistic’ ways of representing the symmetry assessing task that was performed in the early hominins’ mind. However, there are some worries for the Eyeball Test.

The worry would be the perceptual reliability. As many studies have pointed out, there are differences in visual processing between populations of contemporary hunter-gatherers and people living in industrialized societies. These studies indicate that participants from different cultures show different susceptibilities toward the same visual illusion tests. For example, in the Muller-Lyer illusion test (Segall et al., 1966), it suggests that individuals from 17 different cultural backgrounds (11 groups of African agriculturalists, one group of African foragers, one group of Australian aboriginal foragers, one group of Filipino horticulturalists, one group of South African goldmine laborers, one group of South Africans of European descent, and one group of Americans) would respond differently. One marked result is that participants from the U.S. (compared with the other 16 cultures) show significantly stronger susceptibility to such illusions; they tended to perceive the parallel lines as different in lengths. That is to say, environmental conditions are relevant to the development of human visual capacities resulting in various responses by individuals when exposed to similar visual signals. Such a fact thus entails that for qualitative measurements such as the Eyeball Test, the ‘Yes’ or ‘No’ evaluation for handaxe symmetry by researchers can be problematic since it is highly possible that the standards/thresholds by which a modern human and an Acheulean knapper would judge something to be symmetrical are different. One possible guess at this stage would be: because modern humans are consistently exposed to a high intensity of symmetrical stimuli, the ‘symmetry threshold’ for us might be higher than that of the ancient hominins.

Again, it is of importance not to distort the way in which Acheulean agents did employ the assessment of symmetry of a handaxe being held in front of them. Currently, the Flip Test is a good way to obtain data about handaxe symmetry since it is a more realistic method; also, it is quantitative and easy to carry out.

Glossary:

Archaeological glossaries and technical terms used in the case study (chapters IV and V):

1. **Acheulean**: The prehistorical tool-making tradition that existed across Africa, Europe and Asia and had a time span of more than one and a half million years (from ~1.76 mya to ~0.1 mya). The most typical feature of this tradition is the wide production of bifacially and symmetrically manufactured stone handaxes.

2. **AI**: I.e., Asymmetrical index (Value range: 1-10, with smaller values indicate higher symmetrical degree) which is obtained by Flip Test. (see 1.2., Appendix I)

3. **Assemblage**: The sum of all the archaeological artefacts, which are contextually associated, found at a site.

4. **Boxgrove**: A Lower Palaeolithic Acheulean site (dated ~ 500 kya) located in West Sussex, in south-east England. It becomes one of the most important sites in the UK due to the fact that it contains large amounts of fauna and lithic artifacts in primal condition, producing detailed insights into the life of the Acheulean inhabitants lived in this area.

5. **Eyeball Test**: The qualitative measurement of handaxe symmetry based on eye observation. (Appendix 1.4)

6. **Flake**: A thin piece of stone that are detached (knapped) from a larger stone core by a hammer-stone. Stone flakes were widely used during the Lower Palaeolithic as a

cutting instrument. In later times they were also used as blanks to make other tools such as scrapers, arrowheads, etc.

7. **Hammerstone:** A hard stone used as a hammer during the knapping process of stone tool production to strike off lithic parts from a stone core. In later Acheulean, the use of the technique of soft hammering enabled handaxe knappers to make finer control over the shaping of handaxes.

8. **Handaxe**: Or 'biface'. A bifacially worked kind of stone tool, usually exhibiting a triangular, oval shape or tear-shape, which counts as the type-fossil for Acheulean.

9. **HSC**: I.e., Handaxe symmetry classes, a descriptive scale for handaxe symmetry proposed by Hardaker and Dunn (2005). It consists of 6 levels with each level denotes a corresponding span of AI value (See 1.2., Appendix I).

10. **Hominin**: A member of the taxonomic tribe '*Hominini*' that consists of the *genus Homo*, to which *Homo sapiens* (i.e., anatomically modern humans) and other extinct species (e.g., the members that will be mentioned in this thesis are Homo erectus, *Homo Heidelbergensis, and Homo neanderthalensis*) belong.

11. **Lomekwian:** Lomekwian is suggested to be a distinct pre-Oldowan stone tool tradition. It is termed by Harmand et al (2015), whose team at Lomekwi 3, an archaeological site in Kenya, have excavated by far the earliest known stone tools (~ 3.3 mya).

12. **MIS**: I.e., Marine isotope stages. They refer to the historically alternating climate stages between warm and cool of the Earth. Speculations about the climate are deduced from oxygen isotope data in the marine sediment samples.

13. **Palaeolithic**: Or the 'Old Stone Age', it refers to the long period of between ~3.4 mya to ~10 kya. It is divided into Lower Palaeolithic (until ~300 kya), Middle Palaeolithic (until ~50 to ~30 kya) and Upper Palaeolithic (until ~10 kya).

14. **Site**: A place in which evidence for past human behaviours is identified. It can be further classified based on its function (e.g., habitation sites, butchering sites, etc.).

Bibliography:

Alexander, Richard. “Evolutionary Selection and the Nature of Humanity. ”*Darwinism and Philosophy.* 2005.

Ames, Kenneth M, and Herbert D G Maschner. *Peoples of the Northwest Coast : Their Archaeology and Prehistory*. New York, Thames And Hudson, 2000.

Ananth, Mahesh. “Psychological Altruism vs. Biological Altruism: Narrowing the Gap with the Baldwin Effect.” *Acta Biotheoretica*, vol. 53, no. 3, Dec. 2005, pp. 217–239.

Ashton, Nick. “The Human Occupation of Britain during the Hoxnian Interglacial.” *Quaternary International*, vol. 409, July 2016, pp. 41–53.

Aubert, M., et al. “Pleistocene Cave Art from Sulawesi, Indonesia.” *Nature*, vol. 514, no. 7521, 1 Oct. 2014, pp. 223–227.

Averett, Susan L., et al. “For Better or Worse: Relationship Status and Body Mass Index.” *Economics & Human Biology*, vol. 6, no. 3, Dec. 2008, pp. 330–349.

Baars, B. "The biological cost of consciousness." *Nat. Proc 10* (2012).

Badyaev, Alexander V. “Evolutionary Significance of Phenotypic Accommodation in Novel Environments: An Empirical Test of the Baldwin Effect.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 364, no. 1520, 12 Mar. 2009, pp. 1125–1141.

Badyaev, Alexander V. “Evolutionary Significance of Phenotypic Accommodation in Novel Environments: An Empirical Test of the Baldwin Effect.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 364, no. 1520, 12 Mar. 2009, pp. 1125–1141.

Baedke, Jan. "Expanding Views of Evolution and Causality: Workshop Cause and Process in Evolution, Konrad Lorenz Institute for Evolution and Cognition Research , Vienna, May 11th, 2017." *Journal for General Philosophy of Science / Zeitschrift Für Allgemeine Wissenschaftstheorie*, vol. 48, no. 4, 2017, pp. 591–594.

Bar-Yosef Mayer, Daniella E., et al. "On Holes and Strings: Earliest Displays of Human Adornment in the Middle Palaeolithic." *PLOS ONE*, vol. 15, no. 7, 8 July 2020.

Barkai, Ran. "Lower Paleolithic Bone Handaxes and Chopsticks: Tools and Symbols?" *Proceedings of the National Academy of Sciences*, vol. 117, no. 49, 27 Oct. 2020, pp. 30892–30893.

Bartalesi, Lorenzo. "From the Aesthetic Mind to the Human Cultures: Towards an Anthropology of Aesthetics." *Aisthesis. Pratiche, Linguaggi E Saperi Dell'estetico*, vol. 12, no. 1, 17 June 2019, pp. 15–26.

Bertamini, Marco, et al. "Testing Whether and When Abstract Symmetric Patterns Produce Affective Responses." *PLoS ONE*, vol. 8, no. 7, 1 July 2013.

Beyene, Yonas, et al. "The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia." *Proceedings of the National Academy of Sciences* 110.5 (2013): 1584-1591.

Bird, Douglas W., et al. "Variability in the Organization and Size of Hunter-Gatherer Groups: Foragers Do Not Live in Small-Scale Societies." *Journal of Human Evolution*, vol. 131, June 2019, pp. 96–108.

Bird, Douglas W., et al. "Variability in the Organization and Size of Hunter-Gatherer Groups: Foragers Do Not Live in Small-Scale Societies." *Journal of Human Evolution*, vol. 131, June 2019, pp. 96–108.

Bleasdale, Madeleine, et al. "Ancient proteins provide evidence of dairy consumption in eastern Africa." *Nature communications* 12.1 (2021): 1-11.

Boas, Franz, and George Hunt. “The Social Organization and the Secret Societies of the Kwakiutl Indians”. *US Government Printing Office*, 1897.

Boas, Franz, and George Hunt. *The Social Organization and the Secret Societies of the Kwakiutl Indians*. Washington, D.C, G.P.O, 1897.

Boas, Franz. *Facial Paintings of the Indians of Northern British Columbia*. *Google Books*, Read Books, 1 Apr. 2013.

Boutel, A., and T. Lewens. “The Descent of Culture.” *British Journal of Aesthetics*, vol. 54, no. 4, 2014, pp. 489–492.

Boyette, Adam H., and Barry S. Hewlett. “Teaching in Hunter-Gatherers.” *Review of Philosophy and Psychology*, vol. 9, no. 4, 6 July 2017, pp. 771–797.

Brom, Krzysztof. “Abrasion-Induced Holes in the Bivalve Shells from the Baltic Sea: Implications for Palaeontological Studies.” *Geoscience Notes*, vol. 2, 6 June 2014, pp. 9–14.

Bruner, Emiliano, and Ben T. Gleeson. “Body Cognition and Self-Domestication in Human Evolution.” *Frontiers in Psychology*, vol. 10, 21 May 2019.

Bunn, Henry T., and Alia N. Gurtov. “Prey Mortality Profiles Indicate That Early Pleistocene Homo at Olduvai Was an Ambush Predator.” *Quaternary International*, vol. 322-323, Feb. 2014, pp. 44–53.

Bunn, Henry T., and Travis Rayne Pickering. “Bovid Mortality Profiles in Paleoecological Context Falsify Hypotheses of Endurance Running–Hunting and Passive Scavenging by Early Pleistocene Hominins.” *Quaternary Research*, vol. 74, no. 3, Nov. 2010, pp. 395–404.

Bunn, Henry, Travis Pickering, and Manuel Domínguez-Rodrigo. "How Meat Made Us Human: Archaeological Evidence of the Diet and Foraging Capabilities of Early Pleistocene Homo in East Africa." *The Oxford Handbook of the Archaeology of Diet*. Oxford University Press, August 10, 2017.

Burdett, Emily R. R., et al. “A Diverse and Flexible Teaching Toolkit Facilitates the Human Capacity for Cumulative Culture.” *Review of Philosophy and Psychology*, vol. 9, no. 4, 1 June 2017, pp. 807–818.

Burkart, Judith M., et al. “Looking for Unity in Diversity: Human Cooperative Childcare in Comparative Perspective.” *Proceedings of the Royal Society B: Biological Sciences*, vol. 284, no. 1869, 13 Dec. 2017, p. 20171184.

Buss, D. M., et al. “Adaptations, Exaptations, and Spandrels.” *The American Psychologist*, vol. 53, no. 5, 1 May 1998, pp. 533–548.

Butterfield, Jeremy. “Laws, Causation and Dynamics at Different Levels.” *Interface Focus*, vol. 2, no. 1, 18 Aug. 2011, pp. 101–114.

Cadée, Gerhard C. “Rolling Cockles: Shell Abrasion and Repair in a Living BivalveCerastoderma EduleL.” *Ichnos*, vol. 23, no. 3-4, 6 Sept. 2016, pp. 180–188.

Callaway, Ewen. “Oldest Homo Sapiens Fossil Claim Rewrites Our Species’ History.” *Nature*, 7 June 2017, www.nature.com/news/oldest-homo-sapiens-fossil-claim-rewrites-our-species-history-1.22114, 10.1038/nature.2017.22114.

Cao-Lei, Lei, et al. "DNA methylation signatures triggered by prenatal maternal stress exposure to a natural disaster: Project Ice Storm." *PloS one 9.9* (2014): e107653.

Carey, Nessa. The epigenetics revolution: How modern biology is rewriting our understanding of genetics, disease, and inheritance. *Columbia University Press,* 2012.

Carney, James. "The Role of Aesthetic Style in Alleviating Anxiety About the Future." 2020.

Carroll, Joseph. "Dutton, Davies, and Imaginative Virtual Worlds: The Current State of Evolutionary Aesthetics." *Aisthesis. Pratiche, linguaggi e saperi dell'estetico* 6, no.2 (2013), p81-93.

Carroll, Joseph. "Evolutionary Literary Theory." *A Companion to Literary Theory*, 16 Apr. 2018, pp. 423–438.

Carroll, Joseph. "Minds and Meaning in Fictional Narratives: An Evolutionary Perspective." *Review of General Psychology*, vol. 22, no. 2, June 2018, pp. 135–146.

Carroll, Joseph. "Steven Pinker's Cheesecake for the Mind." *Philosophy and Literature*, vol. 22, no. 2, 1998, pp. 478–485.

Carroll, Joseph. *Literary Darwinism : Literature and the Human Animal*. New York ; London, Routledge, 2004.

Carroll, Noel. *UW Press - : Theories of Art Today Edited by Noël Carroll*. *Uwpress.wisc.edu*, Apr. 2000.

Cartwright, Richard L. "Negative Existentials." *Journal of Philosophy*, vol. 57, no. 20, 1960, pp. 629–639.

Chase, Jonathan M., and Mathew A. Leibold. Ecological niches: linking classical and contemporary approaches. University of Chicago Press, 2003.

Chen, Xiong, et al. “The Moderating Effect of Stimulus Attractiveness on the Effect of Alcohol Consumption on Attractiveness Ratings.” *Alcohol and Alcoholism*, vol. 49, no. 5, 23 May 2014, pp. 515–519.

Christensen, Bo T., et al. “Perceptual Fluency Effects in Judgments of Creativity and Beauty: Creative Objects Are Perceived Fluently yet They Are Visually Complex.” *Journal of Cognitive Psychology*, vol. 32, no. 1, 12 Nov. 2019, pp. 45–66.

Cole, James. “Examining the Presence of Symmetry within Acheulean Handaxes: A Case Study in the British Palaeolithic.” Cambridge Archaeological Journal, vol. 25, no. 4, 15 Oct. 2015, pp. 713–732.

Cole, James. “Handaxe Symmetry in the Lower and Middle Palaeolithic: Implications for the Acheulean Gaze.” *Settlement, Society and Cognition in Human Evolution: Landscapes in Mind*, 1 Mar. 2015, pp. 234–257,.

Corbey, Raymond, et al. “The Acheulean Handaxe: More like a Bird’s Song than a Beatles’ Tune?” *Evolutionary Anthropology: Issues, News, and Reviews*, vol. 25, no. 1, 2 Jan. 2016, pp. 6–19, 10.1002/evan.21467.

Cosmides, Leda, and John Tooby. "Evolutionary psychology: A primer." (1997).

Creanza, N., and M. W. Feldman. “Complexity in Models of Cultural Niche Construction with Selection and Homophily.” *Proceedings of the National Academy of Sciences*, vol. 111, no. Supplement_3, 14 July 2014, pp. 10830–10837.

Creanza, Nicole, Laurel Fogarty, and Marcus W. Feldman. "Models of cultural niche construction with selection and assortative mating." (2012): e42744.

Crispo, Erika. “THE BALDWIN EFFECT and GENETIC ASSIMILATION: REVISITING TWO MECHANISMS of EVOLUTIONARY CHANGE MEDIATED by PHENOTYPIC PLASTICITY.” *Evolution*, vol. 61, no. 11, Nov. 2007, pp. 2469–2479.

Crittenden, Alyssa N., and Stephanie L. Schnorr. “Current Views on Hunter-Gatherer Nutrition and the Evolution of the Human Diet.” *American Journal of Physical Anthropology*, vol. 162, no. S63, Jan. 2017, pp. 84–109.

Csibra, Gergely, and György Gergely. “Natural Pedagogy as Evolutionary Adaptation.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1567, 12 Apr. 2011, pp. 1149–1157.

Currie, G., Zhu, X. Aesthetic sense and social cognition: a story from the Early Stone Age. Synthese 198, 6553–6572 (2021).

Currie, Greg, et al., eds. Aesthetics and the Sciences of Mind. *OUP Oxford*, 2014.

Currie, Gregory. "Aesthetic explanation and the archaeology of symbols." *The British Journal of Aesthetics* 56.3 (2016): 233-246.

Currie, Gregory. "Art and the anthropologists." Aesthetic science: Connecting minds, brains, and experience (2012): 107-128.

Currie, Gregory. "The master of the Masek Beds: handaxes, art, and the minds of early humans." T*he aesthetic mind: Philosophy and psychology* (2011): 9-31.

Currie, Gregory. *Aesthetics and Cognitive Science*. Edited by Jerrold Levinson. *Oxford Handbooks Online*, Oxford University Press, 2 Sept. 2009.

Currie, Gregory. An ontology of art. *Springer,* 1989.

Currie, Gregory. *Arts and Minds*. 1 Nov. 2004.

Cuthbert, Bruce N. "The RDoC framework: facilitating transition from ICD/DSM to dimensional approaches that integrate neuroscience and psychopathology." *World Psychiatry* 13.1 (2014): 28-35.

Cutting, James E. "Mere Exposure and Aesthetic Realism: A Response to Bence Nanay." *Leonardo* 50.1 (2017): 64-66.

Cutting, James E. "Gustave Caillebotte, French Impressionism, and Mere Exposure." *Psychonomic Bulletin & Review*, vol. 10, no. 2, June 2003, pp. 319–343.

Cutting, James E. "Mere Exposure and Aesthetic Realism: A Response to Bence Nanay." *Leonardo*, vol. 50, no. 1, Feb. 2017, pp. 64–66.

Danchin, Étienne, et al. "Beyond DNA: Integrating Inclusive Inheritance into an Extended Theory of Evolution." *Nature Reviews Genetics*, vol. 12, no. 7, 1 July 2011, pp. 475–486.

Davies, Stephen. "Evolution, Aesthetics, and Art: An Overview." *The Routledge Handbook of Evolution and Philosophy,*2017

Davies, Stephen. "Evolution." *The Oxford Handbook of Western Music and Philosophy*, 15 Dec. 2020, pp. 676–703.

Davies, Stephen. "The Evolutionary Value of an Aesthetic Sense." *Aisthesis. Pratiche, Linguaggi E Saperi Dell'estetico*, vol. 6, no. 2, 29 Dec. 2013, pp. 75–79.

Davies, Stephen. *The Artful Species : Aesthetics, Art, and Evolution*. Oxford, Oxford University Press, 2014.

Day, Rachel L., Kevin N. Laland, and F. John Odling-Smee. "Rethinking adaptation: the niche-construction perspective." *Perspectives in biology and medicine* 46.1 (2003): 80-95.

De la Torre, I. “Early Stone Tools and Cultural Transmission: Resetting the Null Hypothesis [Comment].” *Current Anthropology*, vol. 58, no. 5, 1 Oct. 2017, pp. 662–663.

De la Torre, Ignacio. "The origins of the Acheulean: past and present perspectives on a major transition in human evolution." *Philosophical Transactions of the Royal Society*

De la Torre, Ignacio. “The Origins of Stone Tool Technology in Africa: A Historical Perspective.” Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 366, no. 1567, 12 Apr. 2011, pp. 1028–1037.

De la Torre, Ignacio. “The Origins of the Acheulean: Past and Present Perspectives on a Major Transition in Human Evolution.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 371, no. 1698, 13 June 2016, p. 20150245.

Dennett, Daniel C. “The Baldwin Effect: A Crane, Not a Skyhook.” *PhilPapers*, MIT Press, 2003, philpapers.org/rec/DENTBE.

Diez-Martín, Fernando, et al. “A Faltering Origin for the Acheulean? Technological and Cognitive Implications from FLK West (Olduvai Gorge, Tanzania).” *Eprints.ucm.es*, 20 Aug. 2019, eprints.ucm.es/id/eprint/62573/.

Diez-Martín, Fernando, et al. “The East African Early Acheulean of Peninj (Lake Natron, Tanzania).” *Vertebrate Paleobiology and Paleoanthropology*, Aug. 2018, p. 129.

Diez-Martín, Fernando, Policarpo Sánchez-Yustos, and Luis de Luque. "The East African Early Acheulean of Peninj (Lake Natron, Tanzania)." *The Emergence of the Acheulean in East Africa and Beyond*. Springer, Cham, 2018. 129-151.

Dira, Samuel Jilo, and Barry S. Hewlett. "Learning to spear hunt among Ethiopian Chabu adolescent hunter-gatherers." *Social Learning and Innovation in Contemporary Hunter-Gatherer*s. Springer, Tokyo, 2016. 71-81.

Dissanayake, Ellen. "Genesis and development of «Making Special»: Is the concept relevant to aesthetic philosophy?" *Rivista di estetica* 54 (2013): 83-98.

Dissanayake, Ellen. “An Ethological View of Music and Its Relevance to Music Therapy.” *Nordic Journal of Music Therapy*, vol. 10, no. 2, July 2001, pp. 159–175.

Dissanayake, Ellen. “Komar and Melamid Discover Pleistocene Taste.” *Philosophy and Literature*, vol. 22, no. 2, 1998, pp. 486–496, muse.jhu.edu/article/26947/summary, 10.1353/phl.1998.0039.

Dissanayake, Ellen. “Retrospective on Homo Aestheticus.” *Journal of the Canadian Association for Curriculum Studies*, 1 Sept. 2003.

Dissanayake, Ellen. “The Artification Hypothesis and Its Relevance to Cognitive Science, Evolutionary Aesthetics, and Neuroaesthetics.” *Cognitive Semiotics*, vol. 5, no. fall2009, Jan. 2009.

Domínguez-Rodrigo, Manuel, et al. “Earliest Porotic Hyperostosis on a 1.5-Million-Year-Old Hominin, Olduvai Gorge, Tanzania.” *PLoS ONE*, vol. 7, no. 10, 3 Oct. 2012, p. e46414.

Dutton, Denis. “Aesthetics and Evolutionary Psychology.” *PhilPapers*, Oxford University Press, 2003.

Dutton, Denis. *“The Art Instinct Beauty, Pleasure, & Human Evolution*. New York, Ny [U.A.] Bloomsbury Press, 2010.

Ellen Dissanayake. “The Core of Art—Making Special.” *Journal of the Canadan Association for Curriculum Studies*, vol. 1, no. 2, 2019.

Elton, Charles. *Animal Ecology*. London, Methuen, 1971.

Eric Alden Smith, and Bruce Winterhalder. *Evolutionary Ecology and Human Behavior*. New York, Aldine De Gruyter, 1992.

Erlandson, Jon M., and Todd J. Braje. "Archeology and the Anthropocene." Anthropocene 4 (2013): 1-7.

Feldman, Ruth. “The Neurobiology of Human Attachments.” *Trends in Cognitive Sciences*, vol. 21, no. 2, 1 Feb. 2017, pp. 80–99.

Flavell, Jonathan C., et al. “Competing for Affection: Perceptual Fluency and Ambiguity Solution.” *Journal of Experimental Psychology: Human Perception and Performance*, vol. 46, no. 3, Mar. 2020, pp. 231–240.

Flavell, Jonathan C., Harriet Over, and Steven P. Tipper. "Competing for affection: Perceptual fluency and ambiguity solution." *Journal of Experimental Psychology: Human Perception and Performance* 46.3 (2020): 231.

Foddy, Bennett, and Julian Savulescu. "Addiction and autonomy: can addicted people consent to the prescription of their drug of addiction?" *Bioethics* 20.1 (2006): 1-15.

Fokt, Simon. “The Cluster Account of Art: A Historical Dilemma.” *Contemporary Aesthetics*, vol. 12, 2014, p. N/A, philpapers.org/rec/FOKTCA.

Franzén, Nils. “Aesthetic Evaluation and First-Hand Experience.” *Australasian Journal of Philosophy*, vol. 96, no. 4, 28 Jan. 2018, pp. 669–682.

French, Jennifer C. “Demography and the Palaeolithic Archaeological Record.” *Journal of Archaeological Method and Theory*, vol. 23, no. 1, 11 Jan. 2015, pp. 150–199.

Frigg, Roman, and Catherine Howard. “Fact and Fiction in the Neuropsychology of Art.” *PhilPapers*, 2011, philarchive.org/rec/FRIFAF-2.

Fuentes, Agustin. “Human Niche, Human Behaviour, Human Nature.” *Interface Focus*, vol. 7, no. 5, 18 Aug. 2017, p. 20160136.

Fuentes, Agustín. “Integrative Anthropology and the Human Niche: Toward a Contemporary Approach to Human Evolution.” *American Anthropologist*, vol. 117, no. 2, Feb. 2015, pp. 302–315.

Galán, A. B., and M. Domínguez-Rodrigo. "Testing the efficiency of simple flakes, retouched flakes and small handaxes during butchery." *Archaeometry* 56.6 (2014): 1054-1074.

Gangestad, Steven W. et al. “TARGET ARTICLE: Evolutionary Foundations of Cultural Variation: Evoked Culture and Mate Preferences.” *Psychological Inquiry 17* (2006): 75 - 95.

Gangestad, Steven W., et al. “Changes in Women’s Mate Preferences across the Ovulatory Cycle.” *Journal of Personality and Social Psychology*, vol. 92, no. 1, 2007, pp. 151–163, 10.1037/0022-3514.92.1.151.

Gangestad, Steven, et al. “TARGET ARTICLE: Evolutionary Foundations of Cultural Variation: Evoked Culture and Mate Preferences.” *Psychological Inquiry*, vol. 17, no. 2, 1 Apr. 2006, pp. 75–95, 10.1207/s15327965pli1702_1.

Gao, Xing. “Paleolithic Cultures in China.” *Current Anthropology*, vol. 54, no. S8, Dec. 2013, pp. S358–S370.

García-Medrano, Paula, et al. “The Mental Template in Handaxe Manufacture: New Insights into Acheulean Lithic Technological Behavior at Boxgrove, Sussex, UK.” *Undefined*, 2019.

García-Medrano, Paula, et al. “The WEAP Method: A New Age in the Analysis of the Acheulean Handaxes.” *Journal of Paleolithic Archaeology*, vol. 3, 2 May 2020.

Gariépy, Jean-François, et al. “Social Learning in Humans and Other Animals.” *Frontiers in Neuroscience*, vol. 8, 31 Mar. 2014.

Gartus, Andreas, et al. “What Experts Appreciate in Patterns: Art Expertise Modulates Preference for Asymmetric and Face-like Patterns.” *Symmetry*, vol. 12, no. 5, 2 May 2020, p. 707.

Gaut, Berys. “The Cluster Account of Art Defended.” *The British Journal of Aesthetics*, vol. 45, no. 3, 1 July 2005, pp. 273–288.

Gazzaniga, Michael S. Cognitive Neuroscience: The Biology of the Mind, 4th Edition, 2014, Chapter 4.

Geraads, Denis. “Faunal Change in Eastern Africa at the Oldowan – Acheulean Transition.” *HAL Archives Ouvertes*, 2018.

Giller, Paul S. *Community Structure and the Niche*. London ; New York, Chapman And Hall, 1984.

Gleeson, Ben Thomas. *Masculinity and the Mechanisms of Human Self-Domestication*. 30 May 2017.

Gowlett, J., et al. “At the Heart of the African Acheulean: The Physical, Social and Cognitive Landscapes of Kilombe.” *Livrepository.liverpool.ac.uk*, Cambridge University Press, 2015, livrepository.liverpool.ac.uk/2035919/.

Gowlett, John A J. “Deep Structure in the Acheulean Adaptation: Technology, Sociality and Aesthetic Emergence.” *Adaptive Behavior*, vol. 29, no. 2, 30 Oct. 2020, pp. 197–216, 10.1177/1059712320965713.

GRANT, JAMES, and Stephen Davies. “Review of the Artful Species: Aesthetics, Art, and Evolution.” *Mind*, vol. 123, no. 491, 2014, pp. 883–886.

Griffiths, P. E., and R. D. Gray. “Developmental Systems and Evolutionary Explanation.” *Journal of Philosophy*, vol. 91, no. 6, 1994, pp. 277–304, 10.2307/2940982.

Griffiths, Paul E. “Developmental Systems Theory as a Process Theory.” *Www.scinapse.io*, 19 July 2018.

Griffiths, Paul E. “Genetic, Epigenetic and Exogenetic Information in Development and Evolution.” *Interface Focus*, vol. 7, no. 5, 18 Aug. 2017, p. 20160152.

Griffiths, Paul E., and Russell D. Gray. “Discussion: Three Ways to Misunderstand Developmental Systems Theory.” *Biology & Philosophy*, vol. 20, no. 2-3, Mar. 2005, pp. 417–425, 10.1007/s10539-004-0758-1.

Griffiths, Paul Edmund. “Molecular and Developmental Biology.” *PhilPapers*, Malden, MA: Blackwell Publishers, 2002, philpapers.org/rec/GRITPO-5.

Griffiths, Paul, and Karola Stotz. *Genetics and Philosophy*. 2013.

Griffiths, Paul. “The Baldwin Effect and Genetic Assimilation: Contrasting Explanatory Foci and Gene Concepts in Two Approaches to an Evolutionary Process.” *PhilPapers*, Oxford University Press, 2006, philpapers.org/rec/GRITB.

Grinnell, Joseph. “The Niche-Relationships of the California Thrasher.” *The Auk*, vol. 34, no. 4, 1917, pp. 427–433.

Guida, Maria Clara, et al. "Intergenerational inheritance of high fat diet-induced cardiac lipotoxicity in Drosophila." **Nature communications** 10.1 (2019): 1-14.

Hall, Katie, et al. “Chimpanzee Uses Manipulative Gaze Cues to Conceal and Reveal Information to Foraging Competitor.” *American Journal of Primatology*, vol. 79, no. 3, 27 Nov. 2016, p. e22622.

Han, Fei, et al. “The Earliest Evidence of Hominid Settlement in China: Combined Electron Spin Resonance and Uranium Series (ESR/U-Series) Dating of Mammalian Fossil Teeth from Longgupo Cave.” *Quaternary International*, vol. 434, Apr. 2017, pp. 75–83.

Hanania, Rima, and Linda B. Smith. “Selective Attention and Attention Switching: Towards a Unified Developmental Approach.” *Developmental Science*, vol. 13, no. 4, 14 Oct. 2009, pp. 622–635.

Handley, Carla, and Sarah Mathew. “Human Large-Scale Cooperation as a Product of Competition between Cultural Groups.” *Nature Communications*, vol. 11, no. 1, 4 Feb. 2020, 10.1038/s41467-020-14416-8.

Hardaker, Terry, and Stephen Dunn. "The Flip Test-a new statistical measure for quantifying symmetry in stone tools." Antiquity 79.306 (2005).

Hare, Brian. “Survival of the Friendliest:Homo SapiensEvolved via Selection for Prosociality.” *Annual Review of Psychology*, vol. 68, no. 1, 3 Jan. 2017, pp. 155–186, 10.1146/annurev-psych-010416-044201.

Hare, Brian. “The Self-Domestication Hypothesis: Evolution of Bonobo Psychology Is due to Selection against Aggression.” *Animal Behaviour*, vol. 83, no. 3, Mar. 2012, pp. 573–585, 10.1016/j.anbehav.2011.12.007.

Harkin, Michael E. “Potlatch in Anthropology”, *In International Encyclopedia of the Social and Behavioral Sciences*, Neil J. Smelser and Paul B. Baltes, (eds.) vol. 17 (2001): 11,885-11,889.

Harkin, Michael. “International Encyclopedia of the Social & Behavioral Sciences || Potlatch in Anthropology | Harkin, M.E. | Download.” *In.booksc.me*, 2015.

Harmand, Sonia, et al. "3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya." Nature 521.7552 (2015): 310.

Harrison, Anna C., and Susan A. O’Neill. “Children’s Gender-Typed Preferences for Musical Instruments: An Intervention Study.” *Psychology of Music*, vol. 28, no. 1, Apr. 2000, pp. 81–97.

Haselton, Martie G., and Steven W. Gangestad. “Conditional Expression of Women’s Desires and Men’s Mate Guarding across the Ovulatory Cycle.” *Hormones and Behavior*, vol. 49, no. 4, Apr. 2006, pp. 509–518.

Henshilwood, Christopher S., et al. “A 100,000-Year-Old Ochre-Processing Workshop at Blombos Cave, South Africa.” *Science*, vol. 334, no. 6053, 14 Oct. 2011, pp. 219–222.

Henshilwood, Christopher S., et al. “Klipdrift Shelter, Southern Cape, South Africa: Preliminary Report on the Howiesons Poort Layers.” *Journal of Archaeological Science*, vol. 45, 2014, pp. 284–303.

Hewlett, Barry S., et al. "Social learning among Congo Basin hunter–gatherers." *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 366.1567 (2011): 1168-1178.

Hewlett, Barry S., et al. “Social Learning among Congo Basin Hunter–Gatherers.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1567, 12 Apr. 2011, pp. 1168–1178.

Hewlett, Barry S., Richard EW Berl, and Casey J. Roulette. "Teaching and Overimitation Among Aka Hunter-Gatherers." *Social Learning and Innovation in Contemporary Hunter-Gatherers*. Springer, Tokyo, 2016. 35-45.

Heyes, Cecilia. “Culture.” *Current Biology*, vol. 30, no. 20, Oct. 2020, pp. R1246–R1250, 10.1016/j.cub.2020.08.086.

Heyes, Cecilia. “Enquire Within: Cultural Evolution and Cognitive Science.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 373, no. 1743, 12 Feb. 2018, p. 20170051.

Hiscock, Peter. “Learning in Lithic Landscapes: A Reconsideration of the Hominid ‘Toolmaking’ Niche.” *Biological Theory*, vol. 9, no. 1, 14 Jan. 2014, pp. 27–41.

Hiscock, Peter. Learning in lithic landscapes: a reconsideration of the hominin “toolmaking” niche." Biological Theory 9.1, 2014.

Hobaiter, Catherine, et al. “Social Network Analysis Shows Direct Evidence for Social Transmission of Tool Use in Wild Chimpanzees.” *PLoS Biology*, vol. 12, no. 9, 30 Sept. 201.

Hodgson, Derek, and Jan Verpooten. “The Evolutionary Significance of the Arts: Exploring the By-Product Hypothesis in the Context of Ritual, Precursors, and Cultural Evolution.” *Biological Theory*, vol. 10, no. 1, 18 June 2014, pp. 73–85, 10.1007/s13752-014-0182-y.

Hodgson, Derek. "Symmetry and humans: reply to Mithen's ‘Sexy Handaxe Theory’." Antiquity 83.319 (2009): 195-198.

Hodgson, Derek. "The Cognitive Mechanisms Deriving from the Acheulean Handaxe that gave rise to Symmetry, Form, and Pattern Perception." *Handbook of Cognitive Archaeology*. Routledge, 2019. 241-260.

Hodgson, Derek. "The first appearance of symmetry in the human lineage: where perception meets art." *Symmetry* 3.1 (2011): 37-53.

Hodgson, Derek. "The symmetry of Acheulean handaxes and cognitive evolution." *Journal of Archaeological Science: Reports 2* (2015): 204-208.

Hodgson, Derek. The cognitive mechanisms deriving from the Acheulean handaxe that gave rise to symmetry, form, and pattern perception, 2018.

Hoehl, Stefanie, et al. "'Over-Imitation': A Review and Appraisal of a Decade of Research." *Developmental Review*, vol. 51, Mar. 2019.

Holt, R. D. "Bringing the Hutchinsonian Niche into the 21st Century: Ecological and Evolutionary Perspectives." *Proceedings of the National Academy of Sciences*, vol. 106, no. Supplement_2, 10 Nov. 2009, pp. 19659–19665.

Hosken, David J., and Clarissa M. House. "Sexual selection." Current Biology 21.2 (2011): R62-R65.

Huang, Yu-Feng, and Po-Jang Hsieh. "The mere exposure effect is modulated by selective attention but not visual awareness." *Vision research* 91 (2013): 56-61.

Huang, Yu-Feng, and Po-Jang Hsieh. "The Mere Exposure Effect Is Modulated by Selective Attention but Not Visual Awareness." *Vision Research*, vol. 91, Oct. 2013, pp. 56–61.

Hublin, Jean-Jacques, et al. “New Fossils from Jebel Irhoud, Morocco and the Pan-African Origin of Homo Sapiens.” *Nature*, vol. 546, no. 7657, 1 June 2017, pp. 289–292.

Hutchence, L., and S. Debackere. "An evaluation of behaviours considered indicative of skill in handaxe manufacture." *Lithics–The Journal of the Lithic Studies Society* 39 (2019): 36-51.

Hutton, John S., et al. "Associations between screen-based media use and brain white matter integrity in preschool-aged children." *JAMA pediatrics* 174.1 (2020): e193869-e193869.

Hyman, John. “Art and Neuroscience.” *PhilPapers*, Apr. 2010, philpapers.org/rec/HYMAAN.

Iovita, Radu, et al. “High Handaxe Symmetry at the Beginning of the European Acheulian: The Data from La Noira (France) in Context.” PLOS ONE, vol. 12, no. 5, 17 May 2017.

Iovita, Radu, et al. “Operationalizing Niche Construction Theory with Stone Tools.” *Evolutionary Anthropology: Issues, News, and Reviews*, vol. 30, no. 1, Jan. 2021, pp. 28–39.

Irvin, Sherri. “Is Aesthetic Experience Possible?” in Greg Currie Nj, Matthew Kieran, Aaron Meskin & Jon Robson (eds.), *Aesthetics and the Sciences of Mind*, Oxford University Press. pp. 37-56. 2014.

Irvin, Sherri. “Is Aesthetic Experience Possible?” *PhilPapers*, Oxford University Press, 2014.

Ishizu, Tomohiro, and Semir Zeki. "A neurobiological enquiry into the origins of our experience of the sublime and beautiful." *Frontiers in human neuroscience* 8 (2014): 891.

Jablonka, Eva. “The Evolutionary Implications of Epigenetic Inheritance.” *Interface Focus*, vol. 7, no. 5, 18 Aug. 2017, p. 20160135.

Jerardino, Antonieta, and Curtis W. Marean. “Shellfish Gathering, Marine Paleoecology and Modern Human Behavior: Perspectives from Cave PP13B, Pinnacle Point, South Africa.” *Journal of Human Evolution*, vol. 59, no. 3-4, Sept. 2010, pp. 412–424.

Ji, Li-Jun, et al. “Global Processing Makes People Happier than Local Processing.” *Frontiers in Psychology*, vol. 10, 26 Mar. 2019.

John J. Shea, “Lithics Basics.” Stone Tools in the Paleolithic and Neolithic Near East: A Guide, Cambridge University Press, Cambridge, 2013, pp. 17–46.

Johnco, Carly, et al. “They Do Get Prettier at Closing Time: A Repeated Measures Study of the Closing-Time Effect and Alcohol.” *Social Influence*, vol. 5, no. 4, Oct. 2010, pp. 261–271.

Jordan, Jillian J., et al. “Uncalculating Cooperation Is Used to Signal Trustworthiness.” *Proceedings of the National Academy of Sciences of the United States of America*, vol. 113, no. 31, 20 July 2016, pp. 8658–8663.

Kaminski, Juliane, et al. “Evolution of Facial Muscle Anatomy in Dogs.” *Proceedings of the National Academy of Sciences*, vol. 116, no. 29, 17 June 2019, pp. 14677–14681.

Kan, Sergei. *Symbolic Immortality: The Tlingit Potlatch of the Nineteenth Century*. *Ehrafworldcultures.yale.edu*, Smithsonian Institution Press, 1989.

Kandel, Eric R., et al., eds. Principles of Neural Science, 5th ed., New York: McGraw-Hill Professional, 2012.

Kawai, Masao. “Newly-acquired pre-cultural behavior of the natural troop of Japanese monkeys on Koshima islet.” *Primates 6* (2005): 1-30.

Kendal, Jeremy, et al. “Human Niche Construction in Interdisciplinary Focus.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1566, 27 Mar. 2011, pp. 785–792.

Kendal, Jeremy, et al. “Human Niche Construction in Interdisciplinary Focus.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1566, 27 Mar. 2011, pp. 785–792.

Key, Alastair J. M., et al. “Modelling the End of the Acheulean at Global and Continental Levels Suggests Widespread Persistence into the Middle Palaeolithic.” *Humanities and Social Sciences Communications*, vol. 8, no. 1, 2 Mar. 2021.

Key, Alastair JM, and Stephen J. Lycett. "Influence of handaxe size and shape on cutting efficiency: a large-scale experiment and morphometric analysis." *Journal of Archaeological Method and Theory* 24.2 (2017): 514-541.

Key, Alastair JM, and Stephen J. Lycett. "Reassessing the production of handaxes versus flakes from a functional perspective." *Archaeological and Anthropological Sciences* 9.5 (2017): 737-753.

Khatibi, Mina, and F. Khormaei. “Biological Basis of Personality : A Brief Review.” 2016.

Killin, Anton. “The Arts and Human Nature: Evolutionary Aesthetics and the Evolutionary Status of Art Behaviours.” *Biology & Philosophy*, vol. 28, no. 4, 15 Mar. 2013, pp. 703–718.

Killin, Anton. “Where Did Language Come From? Connecting Sign, Song, and Speech in Hominin Evolution.” *Biology & Philosophy*, vol. 32, no. 6, 30 Nov. 2017, pp. 759–778, 10.1007/s10539-017-9607-x.

Kipfer, Barbara Ann. Encyclopedic dictionary of archaeology. Cham: Springer International Publishing, 2021.

Kohn, Marek, and Steven Mithen. "Handaxes: products of sexual selection?" *Antiquity* 73.281 (1999): 518-526.

Kuukasjärvi, Seppo, et al. "Attractiveness of women's body odors over the menstrual cycle: the role of oral contraceptives and receiver sex." *Behavioral Ecology* 15.4 (2004): 579-584.

Ladewig, Julia, et al. “Leveling Waddington: The Emergence of Direct Programming and the Loss of Cell Fate Hierarchies.” *Nature Reviews Molecular Cell Biology*, vol. 14, no. 4, 13 Mar. 2013, pp. 225–236, 10.1038/nrm3543.

Laland KN et al. Does evolutionary theory need a rethink? *Nature* 514, 2014, p161-164.

Laland KN, Blake Matthews, and Marcus W. Feldman. "An introduction to niche construction theory." *Evolutionary ecology* 30.2 (2016): 191-202.

Laland KN, et al. The extended evolutionary synthesis: its structure, assumptions and predictions. *Proc. R. Soc. B*. Vol. 282. No. 1813, 2015.

Laland KN, O’Brien M J. Cultural niche construction: An introduction. *Biological Theory*, 2011, 6(3): 191-202

Laland, Kevin N. "Exploring gene–culture interactions: insights from handedness, sexual selection and niche-construction case studies." *Philosophical Transactions of the Royal Society B: Biological Sciences* 363.1509 (2008): 3577-3589.

Laland, Kevin N. "Extending the extended phenotype." *Biology and Philosophy* 19.3 (2004): 313-325.

Laland, Kevin N., and Kim Sterelny. "Perspective: seven reasons (not) to neglect niche construction." *Evolution* 60.9 (2006): 1751-1762.

Laland, Kevin N., et al. "More on how and why: cause and effect in biology revisited." *Biology & Philosophy* 28.5 (2013): 719-745.

Laland, Kevin N., et al. "The Extended Evolutionary Synthesis: Its Structure, Assumptions and Predictions." *Proceedings of the Royal Society B: Biological Sciences*, vol. 282, no. 1813, 22 Aug. 2015, p. 20151019.

Laland, Kevin, et al. "Does Evolutionary Theory Need a Rethink?" *Nature News*, vol. 514, no. 7521, 9 Oct. 2014, p. 161, www.nature.com/news/does-evolutionary-theory-need-a-rethink-1.16080, 10.1038/514161a.

Lamarque, Peter. "Palaeolithic cave painting: A test case for transcultural aesthetics." *Aesthetics and rock art* (2005): 21-35.

Lamon, Noemie, et al. "Wild Chimpanzees Select Tool Material Based on Efficiency and Knowledge." *Proceedings of the Royal Society B: Biological Sciences*, vol. 285, no. 1888, 10 Oct. 2018, p. 20181715, 10.1098/rspb.2018.1715.

Larson, Christina M., et al. "Ovulatory Shifts in Women's Attractions to Primary Partners and Other Men: Further Evidence of the Importance of Primary

Partner Sexual Attractiveness.” *PLoS ONE*, vol. 7, no. 9, 12 Sept. 2012, p. e44456, 10.1371/journal.pone.0044456.

Layton, Robert, et al. “Antiquity and Social Functions of Multilevel Social Organization among Human Hunter-Gatherers.” *International Journal of Primatology*, vol. 33, no. 5.

Leivers, Samantha, et al. “Sperm Competition in Humans: Mate Guarding Behavior Negatively Correlates with Ejaculate Quality.” *PLoS ONE*, vol. 9, no. 9, 24 Sept. 2014, p. e108099.

Lepre, Christopher J., et al. “An Earlier Origin for the Acheulian.” *Nature*, vol. 477, no. 7362, 31 Aug. 2011, pp. 82–85, 10.1038/nature10372.

Leshner, Alan I. "Addiction is a brain disease, and it matters." *Science* 278.5335 (1997): 45-47.

Levinson, Jerrold. “Aesthetic Supervenience.” *Southern Journal of Philosophy*, vol. 22, no. S1, 1984, pp. 93–110, philpapers.org/rec/LEVAS-4.

Levinson, Jerrold. “What a Musical Work Is.” *The Journal of Philosophy*, vol. 77, no. 1, Jan. 1980, p. 5, 10.2307/2025596.

Levy, Neil. "Addiction is not a brain disease (and it matters)." *Frontiers in psychiatry* 4 (2013): 24.

Lewens, T. “KIM STERELNY the Evolved Apprentice: How Evolution Made Humans Unique.” *The British Journal for the Philosophy of Science*, vol. 65, no. 1, 30 May 2013, pp. 185–189.

Lewens, Tim. “The Extended Evolutionary Synthesis: What Is the Debate About, and What Might Success for the Extenders Look Like?” *Biological Journal of the*

Linnean Society, vol. 127, no. 4, 21 May 2019, pp. 707–721, 10.1093/biolinnean/blz064.

Lewis, David MG, et al. "Why women wear high heels: Evolution, lumbar curvature, and attractiveness." *Frontiers in Psychology* 8 (2017): 1875.

Li, Hao, et al. “Handaxes in South Africa: Two Case Studies in the Early and Later Acheulean.” *Quaternary International*, vol. 480, June 2018, pp. 29–42.

Li, Hao, Kathleen Kuman, and Chaorong Li. "The symmetry of handaxes from the Danjiangkou Reservoir Region (central China): A methodological consideration." *Quaternary International* 400 (2016): 65-72.

Li, Nan, Marcus W. Feldman, and Shripad Tuljapurkar. "Sex ratio at birth and son preference." *Mathematical Population Studies* 8.1 (2000): 91-107.

Lorblanchet, Michel, et al. *The First Artists : In Search of the World’s Oldest Art*. London ; New York, New York, Thames & Hudson Ltd, 2017.

Lycett, Stephen J. “‘Most Beautiful and Most Wonderful’: Those Endless Stone Tool Forms.” *Journal of Evolutionary Psychology*, vol. 9, no. 2, June 2011, pp. 143–171, 10.1556/jep.9.2011.23.1.

Lycett, Stephen J., et al. "Factors affecting Acheulean handaxe variation: Experimental insights, microevolutionary processes, and macroevolutionary outcomes." *Quaternary International* 411 (2016): 386-401.

Maccari, Stefania, et al. "The consequences of early-life adversity: neurobiological, behavioural and epigenetic adaptations." *Journal of neuroendocrinology* 26.10 (2014): 707-723.

Machin, A.J., Hosfield, R.T. and Mithen, S.J. (2005) Testing the functional utility of handaxe symmetry: fallow deer butchery with replica handaxes. *Lithics: the Journal of the Lithic Studies Society*, 26. pp. 23-37.

Machin, Anna J., Robert T. Hosfield, and Steven J. Mithen. "Why are some handaxes symmetrical? Testing the influence of handaxe morphology on butchery effectiveness." *Journal of Archaeological Science* 34.6 (2007).

Machin, Anna. "The role of the individual agent in Acheulean biface variability: a multi-factorial model." *Journal of Social Archaeology* 9.1 (2009): 35-58.

Madey, Scott F., et al. “They Do Get More Attractive at Closing Time, but Only When You Are Not in a Relationship.” *Basic and Applied Social Psychology*, vol. 18, no. 4, Dec. 1996, pp. 387–393.

Madhav, K. C., Shardulendra Prasad Sherchand, and Samendra Sherchan. "Association between screen time and depression among US adults." *Preventive Medicine Reports* 8 (2017): 67-71.

Makin, Alexis D. J., et al. “A Gaze-Driven Evolutionary Algorithm to Study Aesthetic Evaluation of Visual Symmetry.” *I-Perception*, vol. 7, no. 2, 15 Mar. 2016.

Malafouris, Lambros. “How Does Thinking Relate to Tool Making?” *Adaptive Behavior*, 1 Sept. 2020.

Malafouris, Lambros. “Mark Making and Human Becoming.” *Journal of Archaeological Method and Theory*, vol. 28, no. 1, 29 Jan. 2021, pp. 95–119, 10.1007/s10816-020-09504-4.

Manapat, Michael, et al. “Information, Irrationality and the Evolution of Trust.” *Papers.ssrn.com*, 29 Oct. 2012.

Marshack, Alexander. “Some Implications of the Paleolithic Symbolic Evidence for the Origin of Language.” *Current Anthropology*, vol. 17, no. 2, June 1976, pp. 274–282, 10.1086/201716.

Maynard, Olivia M., et al. “Association of Alcohol Consumption with Perception of Attractiveness in a Naturalistic Environment.” *Alcohol and Alcoholism*, vol. 51, no. 2, 16 Aug. 2015, pp. 142–147.

McGuigan, Nicola, et al. “From Over-Imitation to Super-Copying: Adults Imitate Causally Irrelevant Aspects of Tool Use with Higher Fidelity than Young Children.” *British Journal of Psychology*, vol. 102, no. 1, 17 Jan. 2011, pp. 1–18.

McInerny, Greg J., and Rampal S. Etienne. “Pitch the Niche - Taking Responsibility for the Concepts We Use in Ecology and Species Distribution Modelling.” *Journal of Biogeography*, vol. 39, no. 12, 20 Nov. 2012, pp. 2112–2118, 10.1111/jbi.12031.

McNabb, John & Cole, James & Hoggard, Christian. “ From side to side: Symmetry in handaxes in the British Lower and Middle Palaeolithic. ” *Journal of Archaeological Science: Reports*. 2019.

McNabb, John, and James Cole. "The mirror cracked: Symmetry and refinement in the Acheulean handaxe." *Journal of Archaeological Science: Reports* 3 (2015): 100-111.

McNabb, John, et al. "The large cutting tools from the South African Acheulean and the question of social traditions." *Current Anthropology* 45.5 (2004): 653-677.

Menary, R. “The Aesthetic Niche.” *The British Journal of Aesthetics*, vol. 54, no. 4, 1 Oct. 2014, pp. 471–475, 10.1093/aesthj/ayu045.

MENARY, RICHARD. “Neural Plasticity, Neuronal Recycling and Niche Construction.” *Mind & Language*, vol. 29, no. 3, Mar. 2014, pp. 286–303, 10.1111/mila.12051.

Meskin, Aaron, et al. *Mere Exposure to Bad Art the British Journal of Aesthetics Advance Downloaded From*. 2010.

Mesoudi, Alex, and Alex Thornton. “What Is Cumulative Cultural Evolution?” *Proceedings of the Royal Society B: Biological Sciences*, vol. 285, no. 1880, 13 June 2018, p. 20180712, 10.1098/rspb.2018.0712.

Meyer, Matthias, et al. “Nuclear DNA Sequences from the Middle Pleistocene Sima de Los Huesos Hominins.” *Nature*, vol. 531, no. 7595, Mar. 2016, pp. 504–507, 10.1038/nature17405.

Miller, Geoffrey F. The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature. United States: Knopf Doubleday Publishing Group, 2001.

Miller, Saul L., and Jon K. Maner. "Scent of a woman: Men’s testosterone responses to olfactory ovulation cues." *Psychological science* 21.2 (2010): 276-283.

Miller, Saul L., et al. “The Basis of Shooter Biases.” *Personality and Social Psychology Bulletin*, vol. 38, no. 10, 18 June 2012, pp. 1358–1366.

Mithen, Steven. “‘Whatever Turns You On’: A Response to Anna Machin, ‘Why Handaxes Just Aren’t That Sexy.’” *Antiquity*, vol. 82, no. 317, 1 Sept. 2008, pp. 766–769, 10.1017/s0003598x00097374.

Moncel, Marie-Hélène, and Nick Ashton. “From 800 to 500 Ka in Western Europe. The Oldest Evidence of Acheuleans in Their Technological, Chronological, and Geographical Framework.” *Vertebrate Paleobiology and Paleoanthropology*, 2018, pp. 215–235.

Moncel, Marie-Hélène, et al. “Assemblages with Bifacial Tools in Eurasia (Third Part). Considerations on the Bifacial Phenomenon throughout Eurasia.” *Comptes Rendus Palevol*, vol. 17, no. 1, 1 Jan. 2018, pp. 77–97.

Moncel, Marie-Hélène, et al. “The Assemblages with Bifacial Tools in Eurasia (First Part). What Is Going on in the West? Data on Western and Southern Europe and the Levant.” *Comptes Rendus Palevol*, vol. 17, no. 1, 1 Jan. 2018, pp. 45–60.

Mondanaro, Alessandro, et al. “A Major Change in Rate of Climate Niche Envelope Evolution during Hominid History.” *IScience*, vol. 23, no. 11, Nov. 2020, p. 101693, 10.1016/j.isci.2020.101693.

Morgan, T. J. H., et al. “Experimental Evidence for the Co-Evolution of Hominin Tool-Making Teaching and Language.” *Nature Communications*, vol. 6, no. 1, 13 Jan. 2015, 10.1038/ncomms7029.

Morgan, T. J. H., et al. “The Evolutionary Basis of Human Social Learning.” *Proceedings of the Royal Society B: Biological Sciences*, vol. 279, no. 1729, 27 July 2011, pp. 653–662, 10.1098/rspb.2011.1172.

Morriss-Kay, Gillian M. “The Evolution of Human Artistic Creativity.” *Journal of Anatomy*, vol. 216, no. 2, Feb. 2010, pp. 158–176.

Mühlenbeck C, Liebal K, Pritsch C, Jacobsen T. Differences in the Visual Perception of Symmetric Patterns in Orangutans (Pongo pygmaeus abelii) and Two Human Cultural Groups: A Comparative Eye-Tracking Study. *Front Psychol*. 2016 Mar 30.

Muller, Antoine, et al. “Measuring Behavioural and Cognitive Complexity in Lithic Technology throughout Human Evolution.” *Journal of Anthropological Archaeology*, vol. 48, no. dsfd, Dec. 2017, pp. 166–180.

Nanay, Bence. *Aesthetics as Philosophy of Perception*. *Oxford University Press*, Oxford, New York, Oxford University Press, 14 Jan. 2016.

National Bureau of Statistics of China, Women and Men in China, Facts and Figures, 2019. https://data.stats.gov.cn/search.htm?s=%E4%BA%BA%E5%8F%A3

Nesse, Randolph M. “Runaway Social Selection for Displays of Partner Value and Altruism.” *Biological Theory*, vol. 2, no. 2, June 2007, pp. 143–155, 10.1162/biot.2007.2.2.143. Accessed 28 Aug. 2019.

NEWELL, ANDREW J., et al. “Bedload Abrasion and the in Situ Fragmentation of Bivalve Shells.” *Sedimentology*, vol. 54, no. 4, Aug. 2007, pp. 835–845, 10.1111/j.1365-3091.2007.00862.x. Accessed 27 Feb. 2022.

Niego, Amy, and Antonio Benítez-Burraco. “Williams Syndrome, Human Self-Domestication, and Language Evolution.” *Frontiers in Psychology*, vol. 10, 18 Mar. 2019.

O’Brien, Michael J., and Kevin N. Laland. “Genes, Culture, and Agriculture.” *Current Anthropology*, vol. 53, no. 4, Aug. 2012, pp. 434–470, 10.1086/666585.

O’hanlon, Michael. *Paradise Portraying the New Guinea Highlands*. Londen Trustees Of The British Museum, 1993.

O’Hear, Anthony. “Evolution and Aesthetics.” *Royal Institute of Philosophy Supplement*, 2005.

Odling-Smee, F. J., Laland, Kevin N., and Marcus W. Feldman. Niche construction: The neglected process in evolution. *Princeton University Press*, 2003.

Odling-Smee, John, et al. “Niche Construction Theory: A Practical Guide for Ecologists.” *The Quarterly Review of Biology*, vol. 88, no. 1, Mar. 2013, pp. 3–28, 10.1086/669266.

Palmer, S., et al. “Hidden Knowledge in Aesthetic Judgements Preferences for Color and Spatial Composition.” *Semantic Scholar*, 2011.

Palumbo, Letizia, et al. “Scaling of the Extrastriate Neural Response to Symmetry.” *Vision Research*, vol. 117, Dec. 2015, pp. 1–8, 10.1016/j.visres.2015.10.002.

Pante, Michael, et al. “Bone Tools from Beds II–IV, Olduvai Gorge, Tanzania, and Implications for the Origins and Evolution of Bone Technology.” *Journal of Human Evolution*, vol. 148, 1 Nov. 2020, p. 102885.

Papineau, David. “Social Learning and the Baldwin Effect.” *PhilPapers*, Routledge, 2005, philpapers.org/rec/PAPSLA.

Papineau, David. “The Cultural Origins of Cognitive Adaptations.” *Royal Institute of Philosophy Supplement*, vol. 56, Dec. 2005, pp. 24–25.

Pargeter, Justin, et al. “Understanding Stone Tool-Making Skill Acquisition: Experimental Methods and Evolutionary Implications.” *Journal of Human Evolution*, vol. 133, Aug. 2019, pp. 146–166.

Pargeter, Justin, Nada Khreisheh, and Dietrich Stout. "Understanding stone tool-making skill acquisition: Experimental methods and evolutionary implications." *Journal of human evolution* 133 (2019): 146-166.

Perry, George H, et al. “Diet and the Evolution of Human Amylase Gene Copy Number Variation.” *Nature Genetics*, vol. 39, no. 10, 9 Sept. 2007, pp. 1256–1260, www.nature.com/articles/ng2123, 10.1038/ng2123.

Pianka, Eric R. *Evolutionary Ecology*. San Francisco, Calif, Benjamin Cummings, 2000.

Pickard, Hanna, and Steve Pearce. *Addiction in Context*. Oxford: OUP, 2013.

Piddocke, Stuart. “The Potlatch System of the Southern Kwakiutl: A New Perspective.” *Southwestern Journal of Anthropology*, vol. 21, no. 3, 1965, pp. 244–264, www.jstor.org/stable/3629231.

Pinker, S. “The Cognitive Niche: Coevolution of Intelligence, Sociality, and Language.” *Proceedings of the National Academy of Sciences*, vol. 107, no. Supplement_2, 5 May 2010, pp. 8993–8999.

Pinker, Steven. *How the mind works*. Princeton University Press, 2021.

Pocheville, Arnaud. “The Ecological Niche: History and Recent Controversies.” *Handbook of Evolutionary Thinking in the Sciences*, 9 Oct. 2014, pp. 547–586, 10.1007/978-94-017-9014-7_26.

Podlipniak, Piotr. “The Role of the Baldwin Effect in the Evolution of Human Musicality.” *Frontiers in Neuroscience*, vol. 11, 6 Oct. 2017, 10.3389/fnins.2017.00542.

Portera, M., and Lorenzo Bartalesi. “Aesthetic Preferences: An Evolutionary Approach.” *Semantic Scholar*, 2016.

Portera, Mariagrazia, and Mauro Mandrioli. "Tastes of the Parents: epigenetics and its role in evolutionary aesthetics." (2015): 46-76.

Portera, Mariagrazia. “Babies Rule! Niches, Scaffoldings, and the Development of an Aesthetic Capacity in Humans.” *British Journal of Aesthetics*, vol. 60, no. 3, 2020, pp. 299–314.

Portera, Mariagrazia. “Habitual Behaviour and Ecology: Why Aesthetics Matters.” *Aisthesis. Pratiche, Linguaggi E Saperi Dell?Estetico*, vol. 11, no. 1, 2018, pp. 159–171, philpapers.org/rec/PORHBA, 10.13128/Aisthesis-23280.

Portera, Mariagrazia. “Why Do Human Perceptions of Beauty Change? The Construction of the Aesthetic Niche.” *Environment & Society Portal*, 12 Jan. 2017.

Prokop, Pavol, and Jana Švancárová. "Wearing high heels as female mating strategy." *Personality and Individual Differences* 152 (2020): 109558.

Prum, Richard O. "Aesthetic evolution by mate choice: Darwin's really dangerous idea." *Philosophical Transactions of the Royal Society B: Biological Sciences* 367.1600 (2012): 2253-2265.

Prum, Richard O. "Coevolutionary aesthetics in human and biotic artworlds." *Biology & Philosophy* 28.5 (2013): 811-832.

Putt, Shelby S., et al. “THE ROLE of VERBAL INTERACTION during EXPERIMENTAL BIFACIAL STONE TOOL MANUFACTURE.” *Lithic Technology*, vol. 39, no. 2, 20 June 2014, pp. 96–112.

Radovčić, Davorka, et al. “Surface Analysis of an Eagle Talon from Krapina.” *Scientific Reports*, vol. 10, no. 1, 14 Apr. 2020, 10.1038/s41598-020-62938-4.

Rayner, Alan D M. *Degrees of Freedom Living in Dynamic Boundaries*. Published By Imperial College Press And Distributed By World Scientific Publishing Co, 1997.

Reber, Rolf, et al. “Effects of Perceptual Fluency on Affective Judgments.” *Psychological Science*, vol. 9, no. 1, Jan. 1998, pp. 45–48, 10.1111/1467-9280.00008.

Redies, Christoph. “Combining Universal Beauty and Cultural Context in a Unifying Model of Visual Aesthetic Experience.” *Frontiers in Human Neuroscience*, vol. 09, 28 Apr. 2015, 10.3389/fnhum.2015.00218.

Rendell, Luke, et al. “Runaway Cultural Niche Construction.” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1566, 27 Mar. 2011, pp. 823–835, 10.1098/rstb.2010.0256.

Richerson, Peter J, and Robert Boyd. *Not by Genes Alone : How Culture Transformed Human Evolution*. Chicago ; London, University Of Chicago Press, 2008.

Richhariya, Shlesha, et al. “A Pupal Transcriptomic Screen Identifies Ral as a Target of Store-Operated Calcium Entry in Drosophila Neurons.” *Scientific Reports*, vol. 7, no. 1, 14 Feb. 2017, p. 42586.

Richter, Daniel, et al. “The Age of the Hominin Fossils from Jebel Irhoud, Morocco, and the Origins of the Middle Stone Age.” *Nature*, vol. 546, no. 7657, June 2017, pp. 293–296, 10.1038/nature22335.

Ringel, Gail. "The Kwakiutl potlatch: History, economics, and symbols." *Ethnohistory* (1979): 347-362.

Risdale, Frank. "A Discussion of the Potlach and Social Structure." *Totem: The University of Western Ontario Journal of Anthropology* 3.2 (1997): 3.

Rusch, Hannes, and Eckart Voland. "Evolutionary aesthetics: an introduction to key concepts and current issues." *Aisthesis. Pratiche, linguaggi e saperi dell’estetico* 6.2 (2013): 113-133.

Ryan, Timothy M., and Colin N. Shaw. “Gracility of the Modern Homo Sapiens Skeleton Is the Result of Decreased Biomechanical Loading.” *Proceedings of the National Academy of Sciences*, vol. 112, no. 2, 22 Dec. 2014, pp. 372–377.

Sano, Katsuhiro, et al. “A 1.4-Million-Year-Old Bone Handaxe from Konso, Ethiopia, Shows Advanced Tool Technology in the Early Acheulean.” *Proceedings of the National Academy of Sciences*, vol. 117, no. 31, 13 July 2020, pp. 18393–18400, 10.1073/pnas.2006370117.

Sapolsky, Robert. *Behave : The Biology of Humans at Our Best and Worst*. London, Vintage, 2018.

Saragusti, Idit, et al. "Quantitative analysis of the symmetry of artefacts: Lower Paleolithic handaxes." *Journal of Archaeological Science* 25.8 (1998): 817-825.

Schellekens, Elisabeth. “On the Rise of the Aesthetic Mind: Archaeology and Philosophy.” *Aisthesis. Pratiche, Linguaggi E Saperi Dell’estetico*, vol. 8, no. 1, 18 May 2015, pp. 113–122.

Scheurer, J., and B. Thierry. “A Further Food-Washing Tradition in Japanese Macaques (Macaca Fuscata).” *Primates*, vol. 26, no. 4, Oct. 1985, pp. 491–494.

Schick, Kathy, and Nicholas Toth. "Acheulean industries of the Early and Middle Pleistocene, Middle Awash, Ethiopia." *L'Anthropologie* 121.5 (2017): 451-491.

Schulz, Armin W. “Enhancing Thoughts: Culture, Technology, and the Evolution of Human Cognitive Uniqueness.” *Mind & Language*, 24 Nov. 2020, 10.1111/mila.12320.

Scott-Phillips, Thomas C., et al. “THE NICHE CONSTRUCTION PERSPECTIVE: A CRITICAL APPRAISAL.” *Evolution*, vol. 68, no. 5, 26 Jan. 2014, pp. 1231–1243, 10.1111/evo.12332.

Semaw, Sileshi, et al. “The Early Acheulean ~1.6–1.2 Ma from Gona, Ethiopia: Issues Related to the Emergence of the Acheulean in Africa.” *Vertebrate*

Paleobiology and Paleoanthropology, 2018, pp. 115–128, 10.1007/978-3-319-75985-2_6.

Semaw, Sileshi, Michael Rogers, and Dietrich Stout. "The Oldowan-Acheulian transition: is there a “Developed Oldowan” artifact tradition?" Sourcebook of Paleolithic transitions. Springer, New York, NY, 2009

Shackelford, Todd K., et al. “Mate Guarding and Frequent In-Pair Copulation in Humans.” *Human Nature*, vol. 17, no. 3, Sept. 2006, pp. 239–252.

Sharon, Gonen, and Naama Goren-Inbar. "Soft percussor use at the Gesher Benot Ya ‘aqov Acheulian site." *Mitekufat Haeven* 28 (1999): 55-79.

Shea, Nicholas. “Developmental Systems Theory Formulated as a Claim about Inherited Representations.” *Philosophy of Science*, vol. 78, no. 1, Jan. 2011, pp. 60–82, 10.1086/658110.

Shipton, C. “Biface Knapping Skill in the East African Acheulean: Progressive Trends and Random Walks.” *African Archaeological Review*, vol. 35, no. 1, Mar. 2018, pp. 107–131.

Shipton, C. and Clarkson, C. (2015). Handaxe reduction and its influence on shape: an experimental test and archaeological case study. *Journal of Archaeological Science: Reports* 3 408-419.

Shipton, Ceri, Chris Clarkson, and Rommy Cobden. "Were Acheulean bifaces deliberately made symmetrical? Archaeological and experimental evidence." *Cambridge Archaeological Journal* 29.01 (2018): 1-15.

Shipton, Ceri. "Biface knapping skill in the East African Acheulean: Progressive trends and random walks." *African Archaeological Review* 35.1 (2018): 107-131.

Shipton, Ceri. “Imitation and Shared Intentionality in the Acheulean.” *Cambridge Archaeological Journal*, vol. 20, no. 2, June 2010, pp. 197–210, 10.1017/s0959774310000235.

Sibley, Frank. *Approach to Aesthetics: Collected Papers on Philosophical Aesthetics*. *PhilPapers*, Oxford University Press, 2001.

Simão, Jorge. "Tools evolve: the artificial selection and evolution of Paleolithic stone tools." *Behavioral and Brain Sciences* 25.3 (2002): 419-419.

Sinclair, Anthony. “All in a Day’s Work? Early Conflicts in Expertise, Life History and Time Management.” *Cambridge University Press,* 2015.

Sinclair, Anthony. “The Technique as a Symbol in Late Glacial Europe.” *World Archaeology*, vol. 27, no. 1, 1995, pp. 50–62.

Singh, Devendra. “Female Mate Value at a Glance: Relationship of Waist-To-Hip Ratio to Health, Fecundity and Attractiveness.” *Neuro Endocrinology Letters*, vol. 23 Suppl 4, 1 Dec. 2002, pp. 81–91, pubmed.ncbi.nlm.nih.gov/12496738/.

Sinha, Chris. “Ontogenesis, Semiosis and the Epigenetic Dynamics of Biocultural Niche Construction.” *Cognitive Development*, vol. 36, Oct. 2015, pp. 202–209, 10.1016/j.cogdev.2015.09.006.

Sinnott-Armstrong, Walter, and Hanna Pickard. "What is addiction." Oxford handbook of philosophy of psychiatry (2013): 851-64.

Skov, Martin, and Marcos Nadal. “Art Is Not Special: An Assault on the Last Lines of Defense against the Naturalization of the Human Mind.” *Reviews in the Neurosciences*, vol. 29, no. 6, 28 Aug. 2018, pp. 699–702, 10.1515/revneuro-2017-0085.

Sober, Elliott, et al. *Unto Others : The Evolution and Psychology of Unselfish Behavior*. Cambridge, International Society For Science And Religion, 2007.

Spikins, Penny et al. "The cradle of thought: growth, learning, play and attachment in Neanderthal children." *Oxford Journal of Archaeology* 33.2 (2014): 111-134.

Spikins, Penny et al., "Living to Fight Another Day: The Ecological and Evolutionary Significance of Neanderthal Healthcare," *Quaternary Science Reviews* 217, *Neanderthals: Ecology and Evolution (2019)*: 98–118.

Stapert, Dick. "Neanderthal children and their flints." *PalArch's Journal of archaeology of northwest Europe* 1.3 (2007): 16-39.

Stephen J. Lycett, Kerstin Schillinger, Metin I. Eren, Noreen von Cramon-Taubadel, Alex Mesoudi,Factors affecting Acheulean handaxe variation: Experimental insights, microevolutionary processes, and macroevolutionary outcomes, *Quaternary International*,Volume 411, Part B,2016,Pages 386-401.

Sterelny, Kim, and Paul Griffiths. *Sex and Death : An Introduction to Philosophy of Biology*. Chicago, Ill., University Of Chicago Press, 1999.

Sterelny, Kim, and Peter Hiscock. "Symbols, Signals, and the Archaeological Record." *Biological Theory*, vol. 9, no. 1, 14 Jan. 2014, pp. 1–3.

Sterelny, Kim. "The Archaeology of the Extended Mind." *Andy Clark and His Critics*, 23 May 2019, pp. 143–158.

Sterelny, Kim. "A Paleolithic Reciprocation Crisis: Symbols, Signals, and Norms." *Biological Theory*, vol. 9, no. 1, 14 Jan. 2014, pp. 65–77.

Sterelny, Kim. "A Review of Evolution and Learning: The Baldwin Effect Reconsidered Edited by Bruce Weber and David Depew." *Evolution and Development*, vol. 6, no. 4, July 2004, pp. 295–300, 10.1111/j.1525-142x.2004.04035.x.

Sterelny, Kim. "Afterword: Tough Questions; Hard Problems; Incremental Progress." *Topics in Cognitive Science*, 25 Apr. 2019, 10.1111/tops.12427.

Sterelny, Kim. "From Hominins to Humans: How Sapiens Became Behaviourally Modern." *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1566, 27 Mar. 2011, pp. 809–822, 10.1098/rstb.2010.0301.

Sterelny, Kim. "Social Intelligence, Human Intelligence and Niche Construction." *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 362, no. 1480, 24 Jan. 2007, pp. 719–730, 10.1098/rstb.2006.2006.

Stotz, Karola. "Why Developmental Niche Construction Is Not Selective Niche Construction: And Why It Matters." *Interface Focus*, vol. 7, no. 5, 18 Aug. 2017, p. 20160157.

Stout, Dietrich, and Erin E. Hecht. "Evolutionary neuroscience of cumulative culture." *Proceedings of the National Academy of Sciences* 114.30 (2017): 7861-7868.

Stout, Dietrich, and Nada Khreisheh. "Skill Learning and Human Brain Evolution: An Experimental Approach." *Cambridge Archaeological Journal*, vol. 25, no. 4, 15 Oct. 2015, pp. 867–875.

Strathern, Andrew, and Marilyn Strathern. "Self-Decoration in Mount Hagen. "*Backworth*, 1971.

Strathern, Andrew. *The Rope of Moka : Big-Men and Ceremonial Exchange in Mount Hagen, New Guinea*. Cambridge, Univ. Pr, 2007.

Stroud, Natalie Jomini. "Selective Exposure Theory." *The Decision Lab*, 2014, thedecisionlab.com/reference-guide/psychology/selective-exposure-theory/.

Sundman, Ann-Sofie, et al. “Long-Term Stress Levels Are Synchronized in Dogs and Their Owners.” *Scientific Reports*, vol. 9, no. 1, 6 June 2019.

Takahashi, Kazutoshi, and Shinya Yamanaka. "A decade of transcription factor-mediated reprogramming to pluripotency." *Nature reviews Molecular cell biology* 17.3 (2016): 183-193.

Teachman, Jay. “Body Weight, Marital Status, and Changes in Marital Status.” *Journal of Family Issues*, vol. 37, no. 1, 11 Nov. 2013, pp. 74–96.

Terashima, Hideaki, and Barry S Hewlett. *Social Learning and Innovation in Contemporary Hunter-Gatherers*. Edited by Hideaki Terashima and Barry S. Hewlett. *Replacement of Neanderthals by Modern Humans Series*, Tokyo, Springer Japan, 2016.

Theofanopoulou, Constantina, et al. “Self-Domestication in Homo Sapiens: Insights from Comparative Genomics.” *PLOS ONE*, vol. 12, no. 10, 18 Oct. 2017, p. e0185306, 10.1371/journal.pone.0185306.

Thomas, James, and Simon Kirby. “Self Domestication and the Evolution of Language.” *Biology & Philosophy*, vol. 33, no. 1-2, 27 Mar. 2018.

Thornhill, Randy, and Steven W. Gangestad. *The Evolutionary Biology of Human Female Sexuality*. *Oxford University Press*, Oxford, New York, Oxford University Press, 25 Sept. 2008.

Tomasello, Michael, and Amrisha Vaish. “Origins of Human Cooperation and Morality.” *Annual Review of Psychology*, vol. 64, no. 1, 3 Jan. 2013, pp. 231–255.

Tomasello, Michael. “The Ultra-Social Animal.” *European Journal of Social Psychology*, vol. 44, no. 3, Apr. 2014, pp. 187–194, 10.1002/ejsp.2015.

Tooby, John, and Leda Cosmides. “Does Beauty Build Adapted Minds? Toward an Evolutionary Theory of Aesthetics, Fiction and the Arts.” *SubStance*, vol. 30, no. 1/2, 2001, p. 6, 10.2307/3685502.

Toth, Nicholas, and Kathy Schick. "The importance of actualistic studies in Early Stone Age research: some personal reflections." *The cutting edge: new approaches to the archaeology of human origins* (2009): 267-344.

Toth, Nicholas, and Kathy Schick. “An Overview of the Cognitive Implications of the Oldowan Industrial Complex.” *Azania: Archaeological Research in Africa,* vol. 53, no. 1, 2 Jan. 2018, pp. 3–39.

Tumler D., Basell, L. & Coward, F. 2017. Human perception of symmetry, raw material and size of Palaeolithic handaxes. *Lithics: the Journal of the Lithic Studies Society* 38: 5–17.

Turk, Matija, et al. “The Mousterian Musical Instrument from the Divje Babe I Cave (Slovenia): Arguments on the Material Evidence for Neanderthal Musical Behaviour.” *L’Anthropologie*, vol. 122, no. 4, Sept. 2018, pp. 679–706, 10.1016/j.anthro.2018.10.001.

Tylén, Kristian, et al. “The Evolution of Early Symbolic Behavior in Homo Sapiens.” *Proceedings of the National Academy of Sciences*, vol. 117, no. 9, 3 Mar. 2020, pp. 4578–4584.

Uller, Tobias, and Heikki Helanterä. “Niche Construction and Conceptual Change in Evolutionary Biology.” *The British Journal for the Philosophy of Science*, vol. 70, no. 2, 1 June 2019, pp. 351–375, 10.1093/bjps/axx050.

van Leeuwen, Edwin J. C., et al. “The Development of Human Social Learning across Seven Societies.” *Nature Communications*, vol. 9, no. 1, 25 May 2018, 10.1038/s41467-018-04468-2.

Vandermeer, J H. “Niche Theory.” *Annual Review of Ecology and Systematics*, vol. 3, no. 1, Nov. 1972, pp. 107–132, 10.1146/annurev.es.03.110172.000543.

Vernot, Benjamin, et al. “Unearthing Neanderthal Population History Using Nuclear and Mitochondrial DNA from Cave Sediments.” *Science (New York, N.Y.)*, vol. 372, no. 6542, 7 May 2021.

W. Schulz, Armin. “Niche Construction, Adaptive Preferences, and the Differences between Fitness and Utility.” *Biology & Philosophy*, vol. 29, no. 3, 6 Mar. 2014, pp. 315–335.

Waddington, Conrad Hal. *The strategy of the genes*. Routledge, 2014.

Walton, Kendall L., et al. “Aesthetics.” *Oxford Art Online*, 2003.

Walton, Kendall L., et al. “Categories of Art.” *The Philosophical Review*, vol. 79, no. 3, July 1970, pp. 334–367.

Walton, Kendall L., et al. “How Marvelous! Toward a Theory of Aesthetic Value.” *The Journal of Aesthetics and Art Criticism*, vol. 51, no. 3, 1993, p. 499.

WALTON, KENDALL. “Aesthetics-What? Why? And Wherefore?” *Journal of Aesthetics and Art Criticism*, vol. 65, no. 2, Mar. 2007, pp. 147–161.

Wang, Wei, et al. “Comparison of Handaxes from Bose Basin (China) and the Western Acheulean Indicates Convergence of Form, Not Cognitive Differences.” *PLoS ONE*, vol. 7, no. 4, 19 Apr. 2012, p. e35804, 10.1371/journal.pone.0035804.

Watkins, John. “A Note on Baldwin Effect.” *The British Journal for the Philosophy of Science*, vol. 50, no. 3, 1 Sept. 1999, pp. 417–423, 10.1093/bjps/50.3.417.

Wei, Guangbiao, et al. “First Discovery of a Bone Handaxe in China.” *Quaternary International*, vol. 434, 1 Apr. 2017, pp. 121–128.

Wenban-Smith, Francis. "Handaxe typology and Lower Palaeolithic cultural development: ficrons, cleavers and two giant handaxes from Cuxton." *Lithics* 25 (2004): 11-21.

White, Mark, and Frederick Foulds. "Symmetry is its own reward: on the character and significance of Acheulean handaxe symmetry in the Middle Pleistocene." *antiquity* 92.362 (2018): 304-319.

White, Mark, et al. “Twisted Handaxes in Middle Pleistocene Britain and Their Implications for Regional-Scale Cultural Variation and the Deep History of Acheulean Hominin Groups.” *Proceedings of the Prehistoric Society*, vol. 85, 1 Dec. 2019, pp. 61–81.

White, Tom S., et al. “Molluscan and Ostracod Successions from Dierden’s Pit, Swanscombe: Insights into the Fluvial History, Sea-Level Record and Human Occupation of the Hoxnian Thames.” *Quaternary Science Reviews*, vol. Complete, no. 70, 2013, pp. 73–90.

Whiten, A., et al. “Cultures in Chimpanzees.” *Nature*, vol. 399, no. 6737, 17 June 1999, pp. 682–685, www.nature.com/articles/21415#ref-CR17, 10.1038/21415.

Whitfield, John. “Biological Theory: Postmodern Evolution?” *Nature*, vol. 455, no. 7211, 1 Sept. 2008, pp. 281–284, www.nature.com/articles/455281a, 10.1038/455281a.

Wilkins, Adam S., et al. "The 'Domestication Syndrome' in Mammals: A Unified Explanation Based on Neural Crest Cell Behavior and Genetics." *Genetics*, vol. 197, no. 3, July 2014, pp. 795–808.

Wilson, David Sloan. "Human Groups as Adaptive Units." *PhilPapers*, Oxford University Press, 2005, philpapers.org/rec/WILHGA-4.

Wingfield, Chris, John Giblin, and Rachel King. *The Pasts and Presence of Art in South Africa: Technologies, ontologies and agents*. McDonald Institute, Cambridge, 2020.

Wrangham, Richard W. "Hypotheses for the Evolution of Reduced Reactive Aggression in the Context of Human Self-Domestication." *Frontiers in Psychology*, vol. 10, 20 Aug. 2019, 10.3389/fpsyg.2019.01914.

Wrangham, Richard W. "Two Types of Aggression in Human Evolution." *Proceedings of the National Academy of Sciences*, vol. 115, no. 2, 26 Dec. 2017, pp. 245–253.

Wynn, Thomas, and Forrest Tierson. "Regional Comparison of the Shapes of Later Acheulean Handaxes." *American Anthropologist*, vol. 92, no. 1, 1990, pp. 73–84, www.jstor.org/stable/681391.

Wynn, Thomas, "The Handaxe Aesthetic." *Core.tdar.org*, 2015, core.tdar.org/document/395510/the-handaxe-aesthetic.

Wynn, Thomas, *First sculpture: Handaxe to figure stone.* Nasher Scupture Center, 2018.

Wynn, Thomas. "Archaeology and Cognitive Evolution." *Behavioral and Brain Sciences*, vol. 25, no. 3, June 2002, pp. 389–402.

Wynn, Thomas. “Handaxe Enigmas.” *World Archaeology*, vol. 27, no. 1, June 1995, pp. 10–24.

Xenakis, Ioannis, and Argyris Arnellos. “Aesthetic Perception and Its Minimal Content: A Naturalistic Perspective.” *Frontiers in Psychology*, vol. 5, 19 Sept. 2014, 10.3389/fpsyg.2014.01038.

Zaidel, Dahlia W. "Brain and art: Neuro-clues from intersection of disciplines." *Neuroaesthetics* (2009): 153-170.

Zaidel, Dahlia W., et al. "An evolutionary approach to art and aesthetic experience." *Psychology of Aesthetics, Creativity, and the Arts* 7.1 (2013): 100.

Zaidel, Dahlia. “Neuroscience, Biology, and Brain Evolution in Visual Art.” *The Aesthetic Mind: Philosophy and Psychology*, 2012.

Zajonc, R.B. “Mere Exposure: A Gateway to the Subliminal.” *Current Directions in Psychological Science*, vol. 10, no. 6, Dec. 2001, pp. 224–228.

Zangwill, Nick. “Aesthetic Judgment (Stanford Encyclopedia of Philosophy).” *Stanford.edu*, 2019, plato.stanford.edu/entries/aesthetic-judgment/.

Zhang, Shuangquan, et al. “Ma’anshan Cave and the Origin of Bone Tool Technology in China.” *Semantic Scholar*, 2016.

Zutovski, Katia, and Ran Barkai. “The Use of Elephant Bones for Making Acheulian Handaxes: A Fresh Look at Old Bones.” *Quaternary International*, vol. 406, June 2016, pp. 227–238, 10.1016/j.quaint.2015.01.033.