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AUTISTIC TRAITS IN COGNITIVE AND MATERIAL ENGAGEMENT: TECHNICAL DESIGN AND MUSIC CAPABILITIES OF PALAEOLITHIC BONE FLUTES

Abstract: Bone flutes found in Palaeolithic contexts in Europe represent the earliest archaeological evidence of technically elaborated music instruments made by Palaeolithic humans. One of them was found at the site of Divje Babe, together with the Mousterian lithic assemblage typically associated with the Neanderthals. The other is the assemblage of bone flute fragments from early modern human sites of Hohle Fels, Vogelherd, Geißenklösterle, and Isturitz associated with Aurignacian lithic assemblage, but also with other numerous symbolic artefacts such as bone and ivory figurines and personal/cloth adornments. They both come from the brims of the Alps and date to modern human and Neanderthal cohabitation in Europe between 50–35 thousand years BP. While their context, manufacture technology, and modern archaeological experiment replicas are known, little has been discussed about the topics of cognition, epigenetic variations, and moods that affect the manufacture, playing, and listening to the music in the period of the Neanderthal and early modern human cohabitation. Based on the integration of insights from archaeology, evolutionary psychiatry and philosophy of cognition, we offer a cognitive archaeological discussion on how autistic traits could have influenced the development of these cognitive capabilities and particular musical inventions encountered in these cases.

Keywords: Palaeolithic bone flutes, cognition, autism spectrum disorder, autistic traits, absolute pitch.

1 Introduction

Ancient art has always been a fairly sustainable field in which to assess human cognition, mainly because it entangles pure technical processes with abstract thinking. Technical processes regarding the art encountered so far during the Palaeolithic that are reflected in the excavated artefacts are colour making, sculpting/carving, and instrument making. All of these involve knowledge of chemical processes, naïve physics, properties of the worked materials and specialised tool assemblage necessary to create it. Abstract thinking while executing the art is not only momentary but mainly a process devised far in advance—to paint, it is necessary to devise an image already before making the colour because it can dry and lose best painting properties if left to sit for too long; sculpting/carving is perceived imagination of three-dimensional object guided only by some of the features of raw material used as a blank; and in music, it is necessary to know how to apply mathematics while making the instrument to achieve right tune and pitch, and also thinking at least several bars in advance while playing the instrument. It is worth noting that technical and abstract parts are not necessarily executed by the same person, which is often so: the painter is not necessarily the colour maker, and the sculptor/carver is not necessarily the maker of carving lithic tools. The flute player is not necessarily the maker of the instrument. This persists in interpersonal links of a collective cognitive knowledge[1] and thus shows the effort and desire of society to emit and execute the art besides pure working hours calculated from the archaeological experiments required to execute a painting, sculpt, or make an instrument. Each of these materials and processes encompasses basic units of mental architecture consisting of mental actions from thoughts and memories to refined control of the action processes (Barnard et al., 2017).

Here, we will focus on the musical properties of the Palaeolithic flutes and discuss epigenetic and minimal cognitive requirements[2] necessary to produce the instrument and play the music. Most micro-theories in psychology do not directly explain the link between artefact manufacture and use in all their phases. It is impossible to predict mental architecture from the behavioural or social architectures that leave their traces in the archaeological record. Additionally, because the basic components within mental architecture are thoroughly interconnected, analogies from constituents of mental architecture to

1 And as an example of the division of cognitive labour.

2 See Killin (2017) and Currie & Killin (2019).

behavioural architecture are fraught with dangers. Pertinent macro-theoretic assumptions will either be absent or implicit. Although the problems of scaffolding from mind to behaviour within and among mental layers should not be underestimated, we can propose some criteria that may assist in the process. In the later sections, philosophical frameworks within which we can account for these will emerge.

We plan to do the following in this paper. In Section **2**, we present the archaeological findings of Palaeolithic bone flutes. In Section **3**, we investigate the technical design of the flutes and the cognitive and affective capabilities that the creation of such artefacts entails. Section **4** is dedicated to introducing several philosophical frameworks used to understand ancient cognition, like material engagement and enactivism, but also some new ones, like niche construction and predictive processing. In Section **5**, we argue that, in addition to these, we need to include the influence of psychopathologies of cognition and show, from the perspective of evolutionary psychiatry, that autistic traits could have been crucial for the cognitive feats and material inventions under consideration here.

2 Music in Their Bones

The period when bone flutes appear is notably interesting, as it is a part of a huge cognitive step in human evolution observed primarily in the spread of complex art, around 50–40 kyA BP (thousands of years ago before the present). Various humans expressed symbolic behaviour much earlier—engraving various line patterns, using colourants, and presumably using the voice and percussion for music—as far as nearly half a million years ago, but the rise of complex art forms is tightly tied to this period. Apart from cognitive evolution, an important biological evolution takes place in this period, as it is the last known period of cohabitation of two different humans known so far anywhere in the world—Neanderthals and early modern humans. Based on archaeological and paleogenetic evidence, we now know that this cohabitation occurred over tens of thousands of years, included population mixture, and ended with the gradual overflow of modern human populations over Neanderthal ones while also inheriting part of the Neanderthal genome. This genetic admixture could also have triggered the appearance of new cognitive and psychological stances in humans, as well as new psychopathologies. Knowing now that the oldest European modern human remains genetically all contain both very close or more distant Neanderthal forbearers—from 4 to 6 up to

70 to 80 generations ago (Green et al., 2010; Fu et al., 2015); it is now also difficult to tightly perceive from such a large time distance how the higher cognitive processes (language/abstract thinking) and lower cognitive processes (perception) behind artistic performance differed between them.

The appearance of collective cognitive knowledge is crucial, and whether it consists of broken or continuous cognitive traditions (temporally/spatially/(in)exclusively), that might lead, not literally, to the division of labour as the societies were not still large enough to sustain such divisions, but to the division of individual skills. Within them, cognitive-technical skills could be at least divided into high—and low-demanding ones. In general, executing complex art forms is regarded as highly demanding cognitive-technical skills, together with the ability to make fine and quality artistic media. Regarding the music, we will access it based on the technical design and music capabilities of Palaeolithic bone flutes.

Music is one of the most complex manifestations of human cognition and culture, so it is hard to understand its origins. Many scholars argue that music expression coincides with the appearance of complex language, while many contemporary cultures do not separate music from dance and have the same expression for it. It can be generally regarded as the art of expressing moods by arranging sounds and rhythm in a harmonic way that is different from noises. These moods are expressed through instrumental or vocal performance, either as composed/devised in advance, improvised/made at the moment, or a combination of these two—improvised on an already composed piece.

Music keys bring a wide array of moods expressed as they are played. In both devising a melodic/harmonic musical instrument and playing it, music is inseparable from mathematics because it revolves around intervals or distances between two or more tones played one after the other or simultaneously. The reason why instruments are designed, and music is played on a mathematical basis is that human brains are pre-set with tendencies of both visual and hearing senses to collect and group shapes and sounds into regularities. As such, music played with regular tones attains a larger variety and deeper feelings of moods than off-tune music. Nowadays, not all individuals are able to recognize these regularities, although they could improve in them if they practised. Interestingly, many individuals are naturally born with a good sense of relative pitch (Gregersen et al., 2001), and rare individuals (4% of good hearers and 1 in 10000 individuals in total) have an epigenetic variation that we refer to as absolute pitch. Physically and functionally, the auditory system of an "absolute listener" does not differ from that of a non-absolute listener. Also, an absolute listener's sense of hearing is typically no keener than that of a non-absolute listener. Absolute pitch does not depend upon a refined ability to perceive and discriminate gradations of sound frequencies but upon detecting and categorising a subjective perceptual quality. Identification (recognizing and naming a pitch) and discrimination (detecting changes or differences in rate of vibration) are accomplished with different brain mechanisms. Rather, it reflects one's ability to analyse frequency information, presumably involving high-level cortical processing. Thus, absolute pitch is an act of cognition, needing memory of the frequency, a label for the frequency (such as tone C), and exposure to the range of sound encompassed by that categorical label. As such, it is proved that cultural conditioning cannot explain reactions to harmony, dissonance, and perceptions of unison in music.

Absolute pitch may be directly analogous to recognizing colours (synaesthesia), phonemes (speech sounds), or other categorical perceptions of sensory stimuli, and it is influenced by genetic variation, possibly an autosomal dominant genetic trait (Bouvet et al., 2014). It is interesting to note a cross reference of absolute pitch with linguistics, as it is more often observed in individuals speaking tonal languages (Deutsch et al. 2006). Another fact is that absolute pitch appears much more often in special populations. It is observed that the prevalence of absolute pitch is higher among those who are blind from birth as a result of optic nerve hypoplasia and has a higher prevalence among those with Williams syndrome and those with an autism spectrum disorder (ASD) (Lenhoff et al., 2001; Martínez-Castilla et al., 2013; Loui et al., 2012; Wenhart et al., 2019). However, research found no difference between those with and those without absolute pitch on measures of social and communication skills, which are essential deficits in autistic spectrum disorders, meaning that individuals having absolute pitch sense are no smarter than those without it. These notions are worth discussing about the circumstances of when and why this epigenetic trait occurred in human evolution, as it could not be a trait originating in modern human cognitive capabilities but also of the Neanderthals as well, if not even earlier.

Tune features, playing, and range of moods of two musical instruments will be presented here—the late Neanderthal flute from Divje Babe cave (Turk et al., 2020) and the best-preserved early modern human flute from Hohle Fels cave (Munzel et al., 2016). We will show tune features based on the natural scales of the reconstructed instrument. Flutes can be played from both ends. However, the position of the mouthpiece was defined by the blowing side from which it is possible to play a wider range of clean tones when played by professional musicians, after which we will emphasise the range of moods naturally evoked by scales that can be played.

Flute from Divje babe was first contested as a pseudo-instrument (D'Errico et al., 1998; Chase, Nowell, 1998; Diedrich et al., 2015). However, remarks in contesting papers are either too descriptive or contesting authors could not agree on whether the holes are wolf or hyena teeth scores. Diedrich et al. give a broad sample of hyena gnawing tooth punctures but without any mathematical functions of average shapes and sizes of large carnivore tooth punctures. Thus, there are infinite possibilities of carnivore taphonomy, but not definite ones. On the other hand, Turk et al. conducted numerous tests with models of hyena and bear jaws and found none similar to the original ones. Finally, when arguing about the lack of manufacturing traces, all the contesters failed to consider that the flute was embedded in breccia (Turk et al., 2002). The emergence of breccia means that CaCO3-enriched water heavily dissolved the bone, leading to the loss of several layers of bone laminae, thus obliterating any shallow striation marks that could originate from manufacture. The flute from Divje babe was made on cave bear femur diaphysis and has 4 tone holes—3 on the top (anterior side), 1 on the bottom (posterior) side, and a mouthpiece on the distal end. The sound was created by direct blowing against the sharp edge. The instrument was played two-handed, with bottom perforation being used to extend the air column to twice its length. This solution was not used by modern wind instruments and implies there is no need for the double length of the instrument and a higher number of holes. An opening on the distal part has the function of a bell or closure. With a finger of the right hand, the notch on the posterior distal aspect may be formed into an additional hole. The opening provides the possibility of playing on an open or closed bell, which additionally enhances the tonal range.

Dimkaroski experimentally concluded that every change in the system, whether changing the length of the instrument, adding or removing holes or the absence of the sharp blowing edge, resulted in poorer musical expression. Played in this way, the flute has a diatonic range of three and a half octaves, and unlike modern wind instruments, it is not completely tempered and sounds more natural when playing pentatonic scales (Dimkaroski, 2014). The instrument has only 4 fundamental tones, while the rest of the tones are derived from them. Thus, the instrument itself is not devised in diatonic scale—but since the fundamental tones belong to a minor scale, the flute sounds more natural when playing minor pieces than major ones, although major ones can be well executed if the player is skilful. It is possible to play the tones in several techniques: legato, staccato, double and triple tonguing, flutter-tongue, glissando, chromatic scales, trills, broken chords, interval leaps, and melodic successions from the lowest to the highest tones. These techniques also involve specific breathing techniques in order to perform them—just like contemporary flutes.

A flute from Hohle Fels is the best-preserved specimen out of several partially preserved flutes and flute fragments, including 2 specimens from Geißenklösterle Cave and 1 specimen from Isturitz Cave. This specimen was selected because it has the highest tonal versatility. It was made on a vulture radius and has 5 tone holes on the posterior diaphysis and a mouthpiece on the distal end. The natural range of the instrument is 2 octaves, but if we look at 2 octaves chromatically, only 13 of the tones out of 24 are tempered. Nevertheless, other chromatic scale tones can be played but are not tempered. The flute has a completely diatonic scale, with the first octave being almost in the D# minor harmonic scale, while the rest of the instrument range generally belongs to this scale. It means that the maker of this instrument almost certainly had pre-devised a natural key to the instrument. Instruments in a pre-devised key are easier to play, as much less attention must be paid when producing most of the tones, which is the same as the contemporary concept when devising a musical instrument. Again, it sounded more fundamental if played in minor, but all other scales within the range of the instrument could have been played, provided that the player was skilful enough. Executing the tones using the same techniques as in the Divje babe specimen was possible.

The psychological influence of music scales and tunes upon human moods is an inseparable part of music listening, as most listeners claim to experience strong emotions in response to music at least half of the time they spend listening to it (Juslin & Lauka, 2004).[3] The notion itself is not new – in 1713, German music theorist and composer John Mattheson first published work on this topic (table). Naturally, not all persons have modelled emotions in the same way and intensity of music experiences. This study of music-induced psychological and emotional moods based on the music capabilities of Palaeolithic flutes is based on the results of the Geneva emotional music scale test. The results are presented below:

3 For more on absorption in music and emotion regulation through music, see Kalebić Jakupčević, Reić Ercegovac, & Dobrota (2021).

Key	Mood
C major	Neutral, childish
C minor	Obscure, sad
C#	Unpleasant, dark
D major	Joyous, marching
D minor	Serious, pious
D#	Tragic, sad
E major	Quarrelsome, bolstering
E minor	Effeminate, amorous
e	Furious,quick-tempered
F minor	Obscure, plaintive
F#	Danger, evil
G major/minor	Serious, magnificent
G#	Anguish, sadness
A major	Joyful, pastoral
A minor	Tender, plaintive
A#	Irresolute, mourning
B major	Harsh, plaintive
B minor	Solitary, melancholic
Bb major	Magnificent, joyful
Bb minor	Obscure, terrible

3 Can You Hear the Music, *Homo Sapiens*?

The natural key of the Dive Babe flute (when all finger holes are closed) is in the D# minor scale that evokes a tragic, sad mood. Other fundamental scales for this instrument are: F–furious/obscure/quick-tempered/plaintive; G–serious/magnificent; and Ab–anguish, sadness. When played by a professional musician, a wide range of untempered scales could be used; however, these are much harder to execute and require a high level of playing technique. As shown by the experiment, tones were possible to play in legato, staccato, double, and triple tonguing, flutter-tongue, glissando, chromatic scales, trills, broken chords, interval leaps, and melodic successions from the lowest to the highest tones. This wide array of playing dynamics can be divided into smooth ones, like legato or melodic successions, which evocate happiness and peace; irregular ones, like broken chords, interval leaps, and chromatic scales, which evocate amusement or restlessness; while varied rhythmic ones, such as staccato, double/triple/flutter tonguing, glissando and thrills evocate joy.

The natural key of Hohle Fels flute is interestingly the same – D# minor scale evokes a tragic, sad mood. Other fundamental scales for this instrument are: D–joyous/serious; F#–danger/evil; A–joyful/tender; C#–unpleasant/dark; A#–mourning. Contrary to the Divje Babe flute, when played by a professional musician, only a small range of untempered scales could be used as this instrument has 13 tempered tones out of 24. This makes Hohle Fels flute a diatonic instrument, even a chromatic one if the player has a high level of playing technique. It is also possible to play tones in techniques similar to the Neanderthal flute, adding the ambience of happiness/peace, amusement/restlessness, and joy to the music.

Several points can be observed based on the musical properties of two Palaeolithic flutes. It is obvious that the makers of the flutes were thinking about pre-devising a natural key. Most probably, it was by accident that Divje Babe's and Hohle Fels' flutes were pre-devised using the same natural key of D# minor. D# or Eb natural key is also one of the most widespread in contemporary wind instruments: alto and baritone saxophones are in D#/Eb, as well as alto clarinet, and some english horns and trumpets. Other Upper Palaeolithic flutes have not preserved the complete length of the air tube, which makes it obsolete to discuss and compare with their natural key. These 2 flutes comprise a small sample to make any conclusions and observe regularities when asking what kind of instrument Palaeolithic humans demanded. Hence, we will only examine a range of possibilities emerging from ideas of making and playing these two instruments. To pre-devise natural keys and tempered tones, around which untempered ones can also be played, the individuals with absolute pitch must have existed. Since the absolute pitch is an epigenetic variation, it is possible to trace it as far back in the past as these two flutes. Even if the flutes were made or devised by individuals having excellent relative pitch, it only means that they were practising and using their sense of pitch, as it can be improved only through rehearsing—meaning that somebody else with either absolute or excellent relative pitch was teaching them music. Besides, manufacture of the flutes itself implies the knowledge of music mathematics, most principally mastering the use of cumulative fractions, as tempered tones—which both flutes possess are measured by precisely fractioning the total length of air tube of the flute, like in almost all wind instruments. This explains Neanderthal and early modern human understanding of why holes should not be made with equal distancing, reflected on these flutes.

From a technical point of view—what tones and range of tones can be executed; we saw that these two flutes are strikingly similar. However, they are completely different in the skills required to produce their whole technical range of tones. From the contemporary player's perspective, the flute from Divje Babe is much harder to play, as all tones are to be derived from 4 tempered ones. Since the Neanderthals and early modern humans were not within the full grasp of modern music theory—as achieved by J. S. Bach, we can assume from our perspective that it was either harder to grasp the Neanderthal flute or their music was less versatile than in early modern humans. It is easier to grasp the technique of the Hohle Fels flute because it has a lot more tempered tones, so even if a player does not know how to execute untempered tones, the one can still play a lot more versatile melodies than the Neanderthal flute. Further, it implies that it is easier to learn to play the Hohle Fels flute, and thus, it is easier to transfer the music knowledge with it. However, the notion that Neanderthals were executing a complex activity in a way that logically looks like a more complicated solution to us is not new, and it was first observed in the Levallois mode of stone tool production, which for us is also logically more complex to grasp than the lamellar based technology of early modern humans.

These help us decompose problems into smaller tasks that are more easily solved because they are smaller (Beer, 2003). Decomposing problems also makes it easier for multiple individuals to collaborate on solutions, thus opening up new possibilities for outcomes in addition to the variation gained through "difference, localism, and choice" (Robson, 2008, p. xxii). Solutions can take the form of artefacts, making them available to other individuals and future generations; this opens up further opportunities to refine or apply artefacts to new uses, thus affording additional possibilities for change (Damerow, 2010). Over even longer spans of time, new brain functions or regions may prevail. Various measuring devices and scales, for e.g. provide much on this ancestral cognitive activity as they are not invented out of nothing but rather from a number of concepts, numerical algorithms, and notations, available technologies, and repurposed brain functions realised through the past and present interactions, interdependencies, and multidirectional changes of brains, bodies, and materiality.

Numerical cognition in the Palaeolithic has been assessed by different authors (Rouillon, 2006; Bender & Beller, 2018; Reese, 2002) through analysis of line and hand stencil groupings in parietal art and stringed beads and pendants, both of them encountered in late Neanderthals and early modern humans in Europe, but also elsewhere. The latest accounted find of unequivocally Neanderthal parietal art in the form of incisions (Marquet et al., 2023) strengthens the assumption about their ability to apply numerical cognition to play music. Even if argued for the absence of Neanderthal figurative art, it would not necessarily represent a separate case; detecting a figure in the visual field would be basically exploiting similar basic visual principles as non-figurative art. That "figurativeness" cannot be a cutting line in the evolution of art is also supported by the fact that many traditional communities in the past did not produce figurative representations (Robson, 1983). Evolutionary differences in neuromotor skills in *H. sapiens* might be the appearance of the pyramidal motor system and particularly its corticospinal division. The corticospinal is the chief motor system for controlling voluntary movements, requiring the greatest skill and flexibility for fine movements of the distal extremities, particularly of the fingers (Masri, 2011). It is also the last motor system to mature, and the motor system most susceptible to "learning and forgetting", that is – dependable of everyday movement practice (Martin, 2005), meaning – even if once perfectly learnt, the execution of movements will deteriorate if not regularly practised. The corticospinal system gives the ability to move each finger independently, a skill that reaches its highest degree in musicians (Passingham, 2008), but a skill which is also encouraged to train children in early childhood development. Archaeologically, we know that both Neanderthals and modern humans had this ability developed as both produced microlithic artefacts.

4 Digging Up Ecological Niches

One could ask now if the mood of the music was the same for us and them. The oldest work regarding the connection between music keys and tones to moods and feelings dates back only to the period of baroque music. As we are able to observe the evolution of Western music from the Sumerian to Baroque periods, we can fairly clearly propose that moods and tones following the hearing of various keys and tones had similar moods and feelings.[4] Is it possible, and with what certainty can we trace these moods to late Neanderthals,

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4 However, cf. hunter-gather societies which we can ethnographically analyse today and whose traditional music can be discerned from the Western influence and/or tradition (e.g., African Pygmies or Aborigines)—their music is predominantly vocal with unpitched percussion, whereas the instruments (if used) are of organic material. Here the music also has ritual and communal usage, and presumably, evokes emotions in humans.

early modern humans? From our perspective, we only see that they both expressed a variety of joyful and sad feelings through music that could be played affectively and tenderly as well. It seems that both Neanderthal's and early modern humans' feelings of joy and sadness were quite complex and nuanced.[5]

Can we speak about other special conditions in humans that often go along with an absolute sense of pitch, like autism and Williams syndrome? In the next section, we want to discuss the cognitive abilities behind these Palaeolithic cases and shed some light on them by using some of the modern philosophical perspectives on the relation between cognition and materiality. We want to dig deeper into this connection in our discussion. We will focus on the psychopathology of autism spectrum disorder (mentioned earlier in the paper) and the cognitive abilities that accompany this disorder that have the potential to explain how human development progressed in the deep past. This could then unlock a better understanding of Palaeolithic cognition.[6]

What philosophical frameworks have been used to understand the relation of ancient humans to material objects and to shed light on the ecological cognition of man, according to modern cognitive archaeology? For example, an influential framework put forward by Malafouris is the material engagement framework (Malafouris, 2013). It combines anthropology and embodied cognitive science findings and follows the tradition of embodied, enacted, embedded and extended cognition (the 4E). Enactivism is a research programme based on cognitive science and phenomenology (Varela et al., 1991; Thompson, 2007). Enactivists understand cognition as embodied and (inter) active, meaning that every living organism acquires knowledge about the world through its embodiment and through activity, through interaction with the environment. The ecological approach is built on the notion of affordances as possibilities for action in the environment (Gibson, 1979). For the material engagement approach, cognition is in-

5 Killin (2021) argues that the difference between bird-bone and mammoth-ivory flutes can be interpreted by using biological signalling theory. Thus, more sophisticated flutes could have been used as costly and hard-to-fake signals whereas bird-bone flutes low-stakes signals. Killin interprets this in the social key—as a gradual social differentiation in Upper Palaeolithic, so mammoth-ivory flutes were suggestive of both social status and skill of a performer (his unique importance in the community), whereas bird-bone flutes were suggestive of a more egalitarian society with aligned interests. Given specific emotional roles of the keys that could have been played on the two flutes you describe, Killin's proposal can be either refined or to some extent questioned.

6 One of us has written before on modern philosophical perspectives on autism (Nešić, 2023a, 2023b).

tertwined with material culture—it is an "enactive and inherently dynamic vision of participatory mentality where bodily acts and material affordances generate and constitute thought processes rather than merely execute them" (Malafouris, 2021, p. 109).

Anton Killin, for example, argued in recent work that human musicality, contrary to the standard biological adaptation or cultural technology views, should instead be understood through an evolutionary narrative of *socio-cognitive niche construction* without the use of the artificial separation of cultural and biological evolution (Killin, 2016, 2017). He proposes a coevolutionary/niche construction perspective from which to view musicality. In the hominin evolution, musicality is an integral part of the advancement of the unique hominin socio-cognitive niche. Developmental environment for children involved the expressive use of music and musicality evolved through feedback loops and social innovation, and this, in turn, led to neurological improvements that go back to better expressivity in music and so forth in the hominin niche construction (Killin, 2017, p. 9).

Niche construction theory comes from evolutionary biology and refers to the process through which organisms change their environment and steer their evolutionary path (Laland et al., 2015; Constant, Bervoets et al., 2020). There are four kinds of niche construction: (1) phylogenetic: the collective environmental modifications of an entire species, (2) sociogenetic: collective environmental modifications through the activities of a subgroup, (3) ontogenetic (personal), the individual's unique interactions with their environment, and (4) microgenetic (local): specific environmental changes occurring in the present moment (Coninx, 2023, pp. 3007-10). However, niche construction also has a dark side; negative niche construction can occur, leading to harmful environmental changes that become maladaptive and impede the well-being of individuals.

Another package of theories about life and the mind that have come to the fore in recent years is the free energy principle (FEP) and predictive processing (PP) frameworks. FEP (or active inference) purports to be a unifying framework of both biological and mental processes. In it, it is argued that an adaptive living system is organised by way of minimising its information-theoretic free-energy in engagement with the environment (Friston & Stephan, 2007). This minimization is attained either by way of predicting sensory input or through changing the environment to match what is predicted (*perceptual* and *active inference*, two ways to bring models and the world closer). This is the process of an organism attuning to its econiche. Predictive processing is a framework similar to the computational tradition that explains the workings of the brain and its cognitive processes (Clark, 2013; Hohwy, 2014). It, too, is grounded on prediction-error minimization. It is said that the brain is in the business of minimising prediction errors about the body and the world. Frameworks of Predictive Processing and the Free Energy Principle have also been used to model how niche construction can influence evolutionary processes (Constant, Ramstead et al., 2018). In predictive processing, niche construction is understood as an organism's strategy for minimising prediction error through changes in the environment to conform it to its expected states. Niche construction can be seen as active inference in the aforementioned frameworks.

In line with what was said before, the ecological niche can be viewed as a meta-learning mechanism, enabling learning of what can be learned through sensory cues. It has been argued that artifactually supported rituals can regularise behaviours and thus stabilise expectations, improving predictability (Constant, Bervoets et al., 2020). Cultural affordances also have a significant role in estimating the precision of incoming sensory inputs (so-called *cultural niche construction*)[7] —e.g., rituals supported through artefacts increase the predictability of the environment.[8] This is evident in modern and ancient humans' material culture and rituals. The handling of material objects can be plausibly accounted for in these frameworks as a way of making the environment more predictable.

5 Was it the Palaeolithic "Yakkity Yaks"?

To fully understand cognitive modernity in humans (cognitively modern humans or CMH), we need to understand emotional evolution, as argued by Withley (2020). In tracing the path of the emergence of cognitively modern humans, one must follow the evolution of mental disorders in humans and find archaeological evidence for its occurrence. Whitley notes that certain genetic studies show how the

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7 See Constant, Ramstead, et al. (2018); Kirchhoff (2018).

8 One of us has written about how certain environments (e.g., monastic) can be seen as providing shelter for autism spectrum disorder individuals in the Middle Ages. We studied the case of Hildegard of Bingen, a Benedictine abbess from the 12th century We invoked contemporary embodied and ecological approaches to cognition to be able to understand how the medieval monastic sociomaterial ecological niche played a crucial role in the inclusion of autistic individuals in the past. See Nešić, Subotić, & Nurkić (2024).

introgressive hybridization of anatomically modern humans with the Neanderthal during the Upper Palaeolithic introduced genes that are associated with mental disorders such as major depression, schizoaffective disorder, schizophrenia, and autism spectrum disorder (Whitley, 2020, p. 452). This could potentially explain shamanism's appearance in the time of the Upper Palaeolithic, as cognitive archaeologists contend.

The presented cases make us wonder if certain specific neurodivergent cognitive styles are the driving force behind such human cognitive leaps. One modern mental disorder comes to mind first because it is characterised in such a way that it plausibly explains what is encountered in the cases under consideration. Could these feats of craftsmanship be explained by the exceptional sensory capabilities of the ancient autistic individual? And how could autism, as a distinctive cognitive style, drive the cultural evolution of humans in the past? In what ways does it help steer the evolutionary trajectory?

Autism spectrum disorder (ASD or autism, formerly including Asperger's syndrome) is a neurodevelopmental disorder, a type of psychopathology, that is characterised by deficits in social interaction and social communication (i.e., in social-emotional reciprocity and nonverbal communicative behaviours) and repetitive patterns of behaviour and interests (i.e., stereotyped or repetitive movements, insistence on sameness, highly restricted, fixated interests, but also very importantly, and this is the addition of DSM-5, hyper– or hyporeactivity to sensory input) (APA, 2013, p. 50). There are both social and non-social symptoms, as we can see.

The neurodiversity movement has argued against orthodox dysfunction-based approaches to mental disorders, that a radically different perspective has to be taken on autism, advocating for social justice and the end of the pathologization of human cognitive styles. It calls for acceptance of diverse cognitive functioning (Blume, 1998; Chapman, 2021). According to this movement, deviation from the norm is neither a disorder nor a mistake needing correction. Thus, proponents of neurodiversity argue against viewing these conditions as deficiencies. Instead, disabilities such as autism and ADHD should be recognized as different "cognitive styles" rather than medical pathologies. The term "autistic persons" is preferred over "persons with autism" to highlight that neurocognitive style is a fundamental aspect of an individual's identity (Chapman, 2021). Now, ideas and concepts from the neurodiversity movement are increasingly impactful in other domains and integrated with phenomenological and evolutionary approaches to cognition.

A recent paper (Hunt & Jaeggi, 2022) proposes an evolutionary explanation for individual differences in personality and psychopathology. They discuss the prevalence and adaptive nature of specialised minds in humans, the relationship between personality traits and evolutionary theory, and the connection between personality dimensions and specific psychopathological disorders. They think we should consider anthropological research and ancestral social structures in grounding psychopathology in an evolutionary context. Hunt and Jaeggi talk about the broader phenotype of autism and subclinical forms of schizophrenia; these are the target of evolutionary explanations. The bottom line is that personality traits and psychopathological conditions may arise from a shared evolutionary process of cognitive specialisation.[9]

Several accounts have focused on positive attributes in autistic and autistic-like traits (Baron-Cohen, 2020; Del Giudice, 2018; Crespi, 2016), like visual-spatial skills, abstract spatial reasoning, detail-oriented styles (boosting 'systemising'), etc. These authors see autistic traits as specialisations. According to the famous theory by Baron-Cohen (2020), autistics are hyper-systemisers; they are the "inventors and experts in areas of their obsession" in the human social niche. So-called cognitive specialisation for different styles would help the group function better and more successfully adapt to the environment (e.g., ADHD, autism, dyslexia). For example, the rapid attentional shift in ADHD is helpful in an environment full of uncertainty and danger.[10] Visual and spatial skills, the ability to focus and an increased awareness of the external, physical world—are all associated with autism.

Autism is more commonly connected to people with savant mathematical, visual and musical talents. Connecting autistic traits and absolute pitch has not been explored in much detail, although anecdotal accounts exist. The literature is scarce and far from conclusive, but it shows that absolute pitch and autism have shared and distinct neuronal and phenotypic characteristics (Wenhart et al., 2019). In addition, studies show that music elicits special attention in children with autism, and absolute pitch is a major recurrence in autistic children (Romani et al., 2021).

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9 Justin Garson has proposed and defended a similar understanding of mental disorders in several papers and books. He argues that instead of viewing mental disorders as harmful dysfunctions (Wakefield,1992), psychiatry should make a paradigm shift from "madness-as-dysfunction" to "madness-as-strategy" (Garson, 2022).

10 One of us has written about enactive and ecological approach to autism through affordance-based framework and predictive processing (Nešić, 2023a). On general application of enactivism and ecological psychology to psychiatric disorders, see Nešić (2022).

In coherence with the ecological, enactive, and computational approaches to cognition that have been introduced in the previous Section, autism can be understood through the specific ways autistic persons contribute to the ecological niche construction. They have such cognitive capabilities as to be "pattern-seekers" (Baron-Cohen, 2020), and because of the manner in which they predict and process the sensory information, they are able to innovatively shape the niche to lower the uncertainty of the environment (Constant, Bervoets et al., 2020; Nešić, 2023a). They can shape materiality and tools in the niche through their narrow interests and expert knowledge. Through peculiar material engagement, they contribute to the cultural niche construction processes. Given all this, it appears that autistic traits have played a major role in shaping deep past human cognition and designing human niche construction. Let us close with the words of autistic advocate Temple Grandin[11]:

> "Who do you think made the first stone spear? That wasn't the yakkity yaks sitting around the campfire. It was some Asperger sitting in the back of a cave..." (Weiss, 2010).

6 Concluding Remarks

A lot of frameworks have been introduced in these few sections. We cannot say how useful all of them are. We wanted to show that the modern philosophy of cognition and its psychopathologies can offer the conceptual tools to refine our understanding of human cognition of the deep past. In this paper, we analysed archaeological cases of Palaeolithic bone flutes through philosophical frameworks that emphasise the close and essential connection between cognition and material artefacts to comprehend how musical instruments came to be made in the deep past. Particularly, we argued, from evolutionary psychiatry and philosophy of cognition and psychopathology and based on the archaeological findings of these bone flutes, that certain autistic traits have been beneficial for the invention and development of music and its instruments in the deep past. Given the topic at hand, much of this discussion can seem speculative. Thus, our modest aim was to show how these frameworks can be helpful and that there is great potential in them to apply to the problems of cognition and affectivity of humans of the deep past and not to give any final answers to those problems.

11 Temple Grandin is an exceptionally intelligent woman with high-functioning autism, holds a PhD in animal science and has authored over 200 scientific articles and autobiographical works detailing her experiences with autism.

Hopefully, these considerations could move debates in cognitive archaeology towards future developments and possible solutions.

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