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Dylan van der Schyff
University of Melbourne, Melbourne Conservatorium of Music,
234 St. Kilda Rd. Southbank, VIC 3006, Australia
dylan.vanderschyff@unimelb.edu.au

Musicality, Teleodynamics, and the Evolution of Biocultural Systems

Abstract

Debates over the biological meaning of human musicality have tended to play out within a theoretical orientation that explains evolution largely in terms of "adaptations". While this orientation has produced some important insights, it also imposes rather strict distinctions between the products of "nature" and "culture" in the human phenotype. Accordingly, it is argued that the "adaptationist lens" may not be sufficient to capture the emergence and significance of complex forms of behaviour that draw on multiple physiological, cognitive, and environmental components. This paper outlines an alternative "biocultural" approach that appears to dissolve the apparent dichotomies associated with the adaptationist perspective – one that considers the emergence and meaning of human musicality in terms of dynamic feedback and feedforward effects that span genes, brains, bodies, and the socio-material environments. The paper also suggests that a biocultural approach demands a reassessment of the relevance of the notions of "agency" and "teleology" within evolutionary theory. To this end, I develop some tools for thought drawn from enactive and 4E cognitive science; and I make some suggestions for how the phenomenon of (musical) improvisation might offer useful heuristics for understanding the "teleodynamical" factors involved in the evolution of biocultural systems.

Keywords

evolutionary musicology, biocultural coevolution, teleodynamics, 4E cognitive science, improvisation

Music is ubiquitous in human life. From developmental contexts with infants and primary care givers, to complex performances, ceremonies, celebrations, rituals, and other cultural events, music shapes the social and cultural environments that give our lives meaning (Tomlinson 2015). Music is expressed and experienced through the bodily interaction with an array of technologies (instruments, digital devices, and so on) and involves a diverse range of activities and experiences such as singing, dancing, drumming, composing, listening, and more (Small 1998; Perlovsky & Nikolsky 2020). Music can help us to heal physical and psychological ailments, regulate emotions, strengthen social affiliations, and express aspects of human life that cannot be easily captured in words (Blacking 1995; DeNora 2000; Sacks 2007). Musical activities are also central to every known human society, past and present.

But despite the apparent centrality of music for human experience, its biological meaning – its relationship to human survival and flourishing – remains a topic of debate (Davies 2012; Honing *et al*. 2015; Huron 2001; Killin 2016; Killin 2017; Lawson 2014; Patel 2008; Patel 2010). For the most part, these debates have played out against an orthodox theoretical background that explains biological evolution largely in terms of "adaptations" (Tomlinson 2015). This term refers to naturally selected physical, cognitive, and behavioural traits that directly contribute to the survival of a species (and the replication of its genetic information). While this approach has produced some important theories and arguments, it is also problematic when faced with complex forms of behaviour that draw on multiple physiological, cognitive, and environmental components. In the case of music research, the adaptationist orientation has tended to impose a kind of dichotomy, where the existence of musicality in the human phenotype is understood *either* as an adaptation *or* as a cultural product (Patel 2018; Patel 2023; van der Schyff & Schiavio, 2017). Neither side of this binary appears well-poised to win out over the other. Claims that music is solely a product of culture tend to assume a rather narrow view of what musicality involves, often conceiving of music as it relates to pleasure, entertainment, or some sort of abstract aesthetic experience. This perspective risks neglecting the profound developmental, social, and therapeutic aspects of musical experience – aspects that are indicative of music's deep relevance for human well-being. However, it is precisely the recognition of music as a complex phenomenon, spanning biological, social, and cultural dimensions, that introduces problems for attempts to explain the origins of music in terms of a singular adaptive status – a serious issue for "music-as-adaptation" arguments.

In what follows, I discuss an alternative approach that eschews the dichotomy imposed by the orthodox adaptationist orientation. This "biocultural" or "coevolutionary" perspective develops recent thinking in theoretical biology, archaeology, dynamical systems, and other fields to consider the emergence of human musicality in terms of dynamic feedback and feedforward effects that span genes, brains, bodies, and socio-material environments (Tomlinson 2015; van der Schyff, Schiavio & Elliott 2022). Following a brief overview of the adaptationist orientation, I consider how a more integrated, synergistic, coevolutionary perspective may better account for the emergence of complex universal human behaviours like music and language – where cultural activity plays a role in shaping the environments that produce the selective pressures that guide biological development. I then attempt to advance the discussion by considering how the recursive, "improvisational" dynamics inherent in the biocultural approach demands a reassessment of the relevance of the notions of "adaptivity", "agency", and "teleology" within evolutionary theory. To conclude, I suggest some tools for thought drawn from work associated with 4E cognitive science; and I briefly consider how the practice of (musical) improvisation might offer useful heuristics for understanding the "teleodynamical"[1] factors involved in the evolution of biocultural systems.

Adaptation and the musical animal

Darwin's observations and insights (Darwin 1859; Darwin 1871) transformed how we conceive of biological systems. His work dissolved the idea that evolution should adhere to some grand plan or that it is guided by the hand of a divine "watchmaker" (Paley 2008 [1802]). Rather, the forms and behaviours exhibited in nature are the products of a "blind" process in which organisms adapt to their environment through natural forms of selection that play out over cycles of reproduction – variations in form and behaviour among an interbreeding population that are survival enhancing are understood to be "naturally selected". Over the past century, Darwin's insights have been revised by research and theory in genetics and evolutionary psychology (Dawkins

1976; Pinker 1997; Tooby & Cosmides 1992). Thinkers in these fields have posited an influential Neo-Darwinian approach that traces natural selection to the genes themselves: random mutation in the genome produces physiological and behavioural traits; traits that enhance the survival of the animal, and therefore the continuation of the associated genes, are passed on to the next generation. The survival relevant characteristics that naturally selected genetic information produces in organisms are referred to as "adaptations", which manifest as phenotypic traits. Such traits reflect the fitness of associated genes to a given environment over evolutionary time and are often described as "chosen" by the mechanism of natural selection. The assumption is that only phenotypes that arrive at optimal fit are assured of survival in the long-term – i.e., "survival of the fittest" (see Sober 1984).

The fitness of a given gene, and the phenotypic trait it is associated with, is understood in terms of "abundance" and "persistence" (Dawkins 1976). The first term refers to surplus offspring and the resulting population growth of an interbreeding species. The second term describes long-term survival associated with reproductive stability. Toward these ends, the process of fitness optimization is thought to govern the morphology of organisms, as well as their cognitive capacities and behaviours. This includes complex forms of human thought and action, which are understood to be guided by an array of cognitive "modules" in the brain that have been shaped by natural selection to process specific types of information in ways that contribute to the survival of the individual and the replication of their genetic information (Barrett & Kurzban 2006; Coltheart 1999; Pinker 1997). By this light, the human mind is not understood to be adapted for modern life; rather, it is biologically optimized for a Paleolithic hunter-gatherer environment. Therefore, many of the perceptions and experiences associated with contemporary culture are thought to be dependent on mental components (modules) that evolved in our pre-human ancestors. Accordingly, thinkers in evolutionary psychology make strong distinctions between aspects of the human phenotype that are thought to be directly indicative of bona fide adaptations, and those that involve the repurposing and combining of adaptations to serve cultural functions that are not survival relevant (see Pinker 1997; Sperber 1996; Sperber & Hirschfield 2004; Tooby & Cosmides 1989; Tooby & Cosmides 1992).

In brief, the "adaptationist" lens assumes a separation between the products of "nature" and "culture", where the latter is assumed to have little influence over the former. For example, while language is often heralded as the human cognitive adaptation par excellence (for its survival value and putative localizability in specific brain regions), other communicative faculties are deemed to be biologically meaningless; it is argued that their relevance for human survival is negligible and that they should therefore be studied as cultural products that co-opt suites of adaptations selected to serve other survival

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The term *teleodynamics* has been used in various contexts with reference to systems that act in their own self-interest. Teleodynamics is therefore a defining characteristic of living systems, which emerge through self-organizing processes (e.g., autocatalysis and self-assembly of the cell membrane) and develop forms of (goal-directed) action and perception that allow them to make sense of the world in ways that contribute to their continued survival. Accordingly, teleodynamics plays out over manifold contexts and timescales (nutrition, reproduction, evolution), and extends to the enactment of higher-order processes such as cognition, mind, sentience, social life, culture, language, music and so on (see Deacon 2012; Logan 2007; Logan 2015).

relevant functions in our pre-human ancestors. This way of thinking lies at the heart of claims by writers like Pinker (1997), who argue that although music is enjoyable and significant for many aspects of modern human life, it has no meaning from an evolutionary perspective: as cheesecake is to our nutritive needs and gustatory sensing abilities, so is music to our auditory, emotional, and communicative capacities.

Similar assumptions have guided thinking in music psychology and philosophy of music. It is often suggested that the key to understanding music perception and cognition may be found in how music plays with linguistic capacities and certain perceptual adaptations – such as those associated with audio scene analysis (see Trainor 2015) – and that the cultural repurposing of these capacities allows for the parsing of musical works and performances (Pinker 1997). The conception of music as a cultural product has also led psychologists and philosophers to puzzle over how music can elicit such strong emotional experiences when it supposedly has no direct connection the kinds of goal-oriented responses associated with survival and well-being in everyday life. It has been suggested, therefore, that emotional experiences associated with music must be different from (e.g., "impoverished" versions or symbolic of) real emotions (Scherer & Coutinho 2013; Sloboda 2000).

Recent research is challenging these assumptions by embracing a wider conception of what human musicality entails. For example, neuroscientist Stephan Koelsch (2013) has traced the neurophysiological correlates of positive emotions evoked by musical experience. In doing so, he has shown how "music-evoked emotions are related to survival functions and to functions that are of vital importance to the individual" (Koelsch 2013, p. 232). The positive psycho-physiological effects of music are also well documented in the music therapy literature; and research in ethnomusicology, sociology, and developmental studies have highlighted the manifold roles music plays in everyday life (e.g., in ritual and ceremony, empathy and social scaffolding, identity formation, emotional regulation, and more; Small 1998; DeNora 2000). Likewise, arguments for the adaptive significance of musicality draw on multi-disciplinary research that appeals to the ubiquity and importance of musical activity across all known human cultures, and the way musicality emerges early in life in many social environments (Blacking 1976; Cross 2003; Parncutt 2006; Solis & Nettl 2009). Scholars also point to music's communicative potentials in non- or pre-linguistic contexts as possible indicators for why musicality might be understood as a survival-enhancing aspect of the human phenotype. Here, compelling connections are made with a range of developmental, perceptual, and communicative factors associated with mother-infant bonding, child rearing, and social cohesion in our pre-human (and pre-linguistic) ancestors (Benzon 2001; Dissanayake 2000; Dunbar 2012; Mithen 2005; Tolbert 2001). Music-as-adaptation arguments also point to evidence of musical artefacts in the archaeological record (e.g., bone flutes dated at 40,000 years BCE; see Higham *et al.* 2012; Morley 2013). And some researchers have cautiously posited the existence of musically relevant genes (see Patel 2008, pp. 371–372) and adapted brain areas (Peretz 1993; Peretz 2006; Peretz 2012; Peretz & Coltheart 2003).

In all, current research and theory tells a richer story of what music means for human life. Music is not viewed simply as a product for pleasure and entertainment, nor only as an object of aesthetic contemplation. Rather, music is as an essential part of what it means to be and become human – it is a central way we experience, communicate, and construct meaning within the social and material environments we inhabit. But while these observations and insights provide compelling evidence for the deep importance musical behaviour has for the human animal, they do not necessarily provide an irrefutable "music-as-adaptation" argument. As mentioned above, the fact that music spans the biological and socio-cultural dimensions of human life, and takes on so many forms of behaviour, makes it extremely difficult (if not impossible) to trace its emergence in the human phenotype to a specific suite of naturally selected adaptations (Killin 2016; Tomlinson 2015). Again, this does not negate the important role that musical (or music-like) behaviour may have played in human evolution. It does suggest, however, that the biological meaning of music and other complex human capacities (including language) cannot be properly captured by a strict (either/or) adaptationist approach.

In connection with this last concern, the past few decades have seen a decentring of the adaptationist orthodoxy in favour of more dynamical approaches. Here evolution is explored as an array of interacting factors, including genes, bodies, and aspects of the socio-material environments they are embedded within (Jablonka & Lamb 2005; Laland, Odling-Smee & Myles 2010; Moore 2003; Richerson & Boyd 2005; Sterelny 2012). Among other things, this perspective highlights the active role living systems play in the construction or "enactment" of the environmental niche that produces the selection pressures that guide the evolutionary development of the phenotype (Varela, Thompson & Rosch 1991). And so, while genes are still seen as the "target" of natural selection, evolution is now understood to involve a range of other factors that play out in a synergistic fashion over various time scales.

Adaptivity and Agency

An interesting aspect of these more recent conceptions of evolution involves modelling the feedforward and feedback effects that the actions of organisms have in relation to their environments (see Oyama 1985; Oyama, Griffiths & Gray 2001). Crucially, this approach alters the evolutionary equation by highlighting the inherent "adaptivity" in biological systems (Thompson & Stapleton 2009). As we have seen, the idea of *adaptation* involves the apparently non-teleological "selection" of survival-enhancing mutations – a random or "blind" process devoid of any intention, plan, or goal. *Adaptivity*, by contrast, describes a living system's ability to behave in ways that may ensure its survival within contingent and changing environments – a feature that can be discerned in even the simplest life forms (e.g., a bounded metabolism or a "cell").

To survive within a contingent milieu an organism must be able to develop stable relationships with features of the environment, but it must also have the flexibility to reconfigure or enact new relationships as needs be. At the most basic levels, these processes are driven by thermodynamic imperatives associated with maintaining metabolic functions within ranges that are conducive to survival (Varela, Thompson & Rosch 1991). However, adaptivity also necessarily involves the "meta-metabolic" (Barrett 2018) factors involved in engaging with the material and social ecology. These factors include the various forms of perceptually-guided action an organism engages in to makes-sense of the environment, develop viable patterns of action and interaction, and thereby bring forth a world of salience (Di Paolo, Cuffari & De Jaegher

2017; Thompson 2007). In exhibiting adaptivity, the organism also influences the environment it inhabits, creating new pressures that, in turn, require new forms of adaptivity. So, although organism and environment are mutually determining aspects of the same evolving system, their relationship nevertheless involves an "interactional asymmetry" (Di Paolo 2005) since it is through the adaptive sense-making activity of the organism that the lifeworld is brought forth and maintained.

This last insight introduces the idea of "agency" into the biological equation. Where *adaptivity* may be seen as an operational concept that describes the self-organizing processes involved in maintaining the lifeworld of a specific organism, the idea of *agency* extends such descriptions to include the varieties of sensorimotor actions whereby an autonomous organism acts on its own behalf (Di Paolo, Buhrmann & Barandiaran 2017). Agency (and the capacity to *act*) is therefore differentiated from other adaptive biological processes since it involves the self-organisation of "epistemic" cycles associated with the enactment of repertoires of goal-directed action, and the relevant forms of body-based meaning generation (and "knowledge") associated with regulating the organism-environment system (e.g., self-monitoring). These cycles span the types of "minimal" agency required for basic forms of perceptually-guided action – e.g., sensing and nutrition – to more complex (co)operations associated with intersubjectivity and the social body. In human worlds, the latter entail a range of behaviours involved in communication, the co-enactment of social spaces and meanings, and social cohesion more generally. These more complex forms of socio-cultural agency include musical and linguistic acts (Di Paolo, Buhrmann & Barandiaran 2017, Di Paolo, Cuffari & De Jaegher 2018).

The concepts of adaptivity and agency introduce intriguing new dimensions for thinking about the evolution of biocultural systems. As mentioned above, these concepts highlight the self-organizing, "circular" or "co-arising" relationship between organism and environment – where an organism's sense-making activity shapes the environment in an ongoing way (Thompson 2007; Varela, Thompson & Rosch 1991). In human and pre-human worlds, these kinds of dynamics include social and cultural behaviours, which originate and evolve through shared or relational forms of adaptive sense-making. Importantly, these behaviours also shape environmental dynamics, introducing new selective pressures that influence genes and gene groups, morphology, cognition, and behaviour – this results in new, shared cognitive capacities and behavioural patterns, which then introduce new selective pressures and so on. Further on, I explore how the dynamics of adaptivity and (joint agency) draw into question the strong anti-teleological perspective that has dominated evolutionary thinking. First, however, I consider how a coevolutionary stance may provide new, more integrated perspectives on the interaction of biological and cultural factors in human evolution, exploring the emergence of human toolmaking and musicality as paradigmatic examples.

The Coevolutionary Stance

A key aspect of the biocultural coevolutionary approach involves the recognition that organisms play an active role in shaping the environmental niche they evolve with. As mentioned above, this process entails the development of feedback cycles: the sense-making activities of organisms alter selective pressures in the environment, which, in turn, affects the biological development of the organisms, and so on. Additionally, social interactions can develop into patterns of activity that stabilize over extended periods. These behaviours may be passed down inter-generationally resulting in the emergence of "cultural epicycles" (Tomlinson 2015). While such epicycles may develop independently for long periods, they may eventually feedforward into the evolutionary process by producing alterations to environmental conditions. Such alterations introduce new selective pressures into the organism-environment system, resulting in morphological, behavioural, and cognitive changes (Killin 2016; Laland, Odling-Smee & Myles 2010; Skinner *et al.* 2015; Wrangham 2009).

While we cannot know with certainty what kinds of actions and experiences characterized the cultural epicycles of our pre-human ancestors, we do have several converging points of evidence that can help to model what the process of coevolution might have entailed. A key example of such evidence is the biface Palaeolithic stone hand axes discovered in the archaeological record. At first glance, these axes appear to originate from processes involving careful planning, and the forms of abstract, representational thinking this implies; they are highly consistent in their functional and aesthetic qualities, which does seem to indicate a method in their conception and manufacture (Wynn 1996; Wynn 2002). However, it is argued that the hominins of the early Palaeolithic likely did not possess the capacities for the combinatorial forms of cognition required to form the abstract mental templates and "top-down" thinking associated with planned production. Instead, it is thought that Palaeolithic technologies emerged from "bottom-up" processes guided by the morphology of the body and its motor possibilities, unplanned social interaction (emotional-mimetic), and the incremental enactment of environmental affordances[2] (Davidson 2002; Gamble 1999).

The idea is that as agents engaged adaptively with the materials they discovered in their environments, their unplanned exploratory actions (grasping, striking, and so on) revealed the forms, qualities, and uses of such materials (e.g., the flaking of stone creates a sharp edge that affords cutting and scraping). These self-organizing behaviours and possibilities for material transformation were further stabilized as individuals interacted with each other in increasingly coordinated ways (Ingold 1999). Coordinated activities were driven by a basic propensity for types of social entrainment, where agents bring their actions in line with others by *dynamically attending* to the social and material environment – a process that involves a synthesis of vision, sound, movement, and feeling, where shared patterns of action and perception are enacted between agents (Large & Jones 1999; McGrath & Kelly 1986; Sterelny 2012). Over time these processes resulted in more complex chains of patterned action that were passed between individuals and from generation to generation (Gamble 1999; Ingold 1999; Leroi-Gourhan 1993 [1964]).

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The term *affordances* describes the possibilities for action offered by the environment to a given agent in relation to the agent's corporeal structure and motor abilities. Developmental factors such as growth, skill acquisition, learning, and evolution can change the affordances available to a given animal or species (see Chemero 2009, pp. 135–162). As Gibson writes: "An affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behaviour." (Gibson 1979, p. 129)

These "action loops" (Donald 2001) then began to stabilise within cultural epicycles, which may have included other forms gestural, vocal, and rhythmic coordination.

In brief, the suggestion is that the self-organising, socially entrained action loops associated with Palaeolithic toolmaking paved the way for further dynamical couplings between various trajectories in the social and material environment. These couplings became increasingly stable over time, resulting to the emergence of repeatable patterns of behaviour in the cultural epicycle. In this way, pre-linguistic cultural knowledge could be transmitted through direct, embodied forms of engagement (see Tomlinson 2015, p. 75). The establishment of such culturally embedded behaviour then set the stage for new selective pressures to emerge in environment. In addition to morphological shifts that afforded better grasping and manipulation of objects, these pressures may have contributed to cognitive changes that supported the ability to combine techniques and artefacts, and to plan the outcomes of a production process – as one finds in the tools and other artefacts of the Upper Palaeolithic, which display multiple components (and require other tools) in their construction (axes with handles, bows and arrows, bone flutes, statues). Such forms of thinking also characterize other cultural phenomena, such as music and language – both of which involve the ability to produce and parse hierarchical and combinatorial forms of communication (e.g., grammar and syntax, rhythmic structures, melodic and harmonic forms, timbral relationships, and so on).

Like toolmaking, the emergence of music-relevant features may have been guided by the intersection of corporeal and material factors and the basic proclivity of social animals toward forms of coordinated action. For example, it has been suggested (Tomlinson 2015) that musical rhythm may be traced to the coordinated motor patterns of early toolmakers. This possibility is supported by comparative cross-species research that highlights the relationship between rhythmic behaviour and social cohesion (e.g., Knight, Spiro & Cross 2017; Large & Gray 2015; Tunçgenç & Cohen 2016; Yu & Tomonaga 2015). Other supporting research (Ravignani, Delgado & Kirby 2016) has modelled the evolution of rhythm in contemporary lab environments, showing that when random percussive sounds are presented to a group of participants, the group tends to organize that information into recurrent rhythmic structures. Additionally, when subsequent generations of participants were asked to imitate the rhythms of previous groups, they were able to do so recognizably, but also produced variations (either by accident or intentionally) special to their cohort. These observations support a conception of cultural transmission based on mimesis and entrainment, as well as the idea that musical behaviour may be based in general propensity to structure the sounds we discover in our environments in new ways (see Fitch 2017).[3]

Additionally, developmental studies show strong correlations between the emergence of rhythmic behaviours and the onset of vocal forms of communication, including speech in humans and the "gesture-calls" produced by modern primates and other mammals (grunts, pants-hoots, growls, howls, barking, and so on). It is argued that the emergence of vocal musicality (and language) may be traced to the development of repertoires of similar types of gesture-calls in our prehuman ancestors. These calls may have reflected the timbral and rhythmic characteristics of prehuman environments, the patterns of motor activity involved in production, and the rhythms of socialization (e.g., increased coordination, turn taking, social entrainment) that developed in the emerging cultural epicycle (see Tomlinson 2015, pp. 89–123). Here we may also consider insights from research in affective science, which examines the roles of feeling, emotion, and empathy in communication and meaning making across interpersonal contexts. As social animals relate the perceived actions and emotional states of other agents to their own bodily conditions, they must negotiate patterns of coherence and interference within and across corporeal and environmental domains (McGrath & Kelly 1986; Large & Jones 1999). The interruption of stable patterns of behaviour, or the introduction of new actions, results in an increase in entropy between the bodily, neural, and socio-material trajectories in the system. This shift may produce a negative affect (feeling, emotion). As the system self-organizes toward regaining stability, a positive affect may arise. Similar processes have been observed in the early communications between infants and primary caregivers who, through the synergistic negotiation of patterns of stability and instability, co-enact repertoires of gesture and vocal utterances that are relevant to the well-being of both agents (Reddy, Markova & Wallot 2013; Trevarthen 2017). Researchers have shown that these processes involve non-linear interactions that converge and stabilize across *the body* (the development of repertoires of corporeal articulation and the muscular linkages required to support them); *the brain* (the self-organisation of patterned and recurrent brain activity and the emergence of convergent neural trajectories); and *the environment* (the enactment coordinated behaviour, and the stabilization of social relationships) (see Colombetti 2014). Importantly, in these contexts the development of meaningful action, shared understandings, knowledge, and joint agency arise adaptively and recursively, "they are shaped and adjusted as the history of interaction unfolds" (Fantasia, De Jaegher & Fasulo 2014, p. 6).

Similar kinds of adaptive, "improvisational" dynamics may have played key roles in the developing social worlds of Palaeolithic hominis. Early "protomusical" communications would have been limited to face-to-face expressions involving a limited number of vocal utterances and gestures. Once in place, however, such behaviours slowly developed into more complex chains of communication, which led to the emergence of more sophisticated forms of interpersonal understanding and joint agency (Tomlinson 2015). The development of these capacities contributed to forms of social scaffolding that promoted individual and social well-being (Dunbar 1996; Dunbar 2003; Knoblich & Sebanz 2008; Sterelny 2012). In brief, the coevolutionary perspective suggests that protomusical behaviours may have enabled various forms of behavioural stabilization (e.g., through rhythmic and vocal entrainment), interpersonal emotional regulation, and stronger group cohesion. The development of these factors also afforded new forms of co-operative engagement with the material environment. The impact of these socio-material behaviours in the cultural epicycle then feedforwards into the broader environment, weakening existing constraints and thereby introducing new selective pressures (Tomlinson 2015). These shifts promoted the biological development of more complex forms of social cognition, increased neural plasticity, and the ability

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Relatedly, it is thought that the knapping process involved in Palaeolithic toolmaking could have involved engagement with the resonant qualities of stones and flakes (Killin 2016; Zubrow, Cross & Cowan 2001), and that this may have supported early types of music-like communication and listening (Morley 2013, p. 120).

think at a "distance" or "offline" from momentary events (Bickerton 1990; Bickerton 2002; Carruthers & Smith 1996; Tomasello 1999). This resulted in new ways of employing environmental and social resources; the production of complex, multi-component artefacts (e.g., musical instruments); sophisticated forms of cultural activity (e.g., ritual); and the more complex, combinatorial, and hierarchical forms communication and cognition associated with music and language (see Tomlinson 2015; van der Schyff, Schiavo & Elliott 2022).

From Optimization to Viability

The coevolutionary stance does not argue that factors such as natural selection have no role to play in understanding evolutionary processes. It does suggest, however, that there are a range of other forces involved and that organisms have more influence over their own development than is implied by a strict adaptationist model. As we have considered, the ways that living systems develop and evolve are guided by their own embodied sense-making (Varela, Thompson & Rosch 1991). This means that the patterns of perception and action that characterize an organism, and the social milieu it interacts with, are not best understood simply as the product of a set of "internal" genetic programming that correspond with a pre-existing "external" environment. Rather, relationships and behaviours emerge from a fundamental proclivity to move and sense, to reach out to the world – genes, behaviour, and environment stand in a non-linear, dynamical, or "dialectical" relationship to each other (Lewontin, Rose & Kamin 1984; Pigliucci 2001). This view, again, highlights the conditions of *adaptivity* and *agency* inherent to living systems. In doing so, it also shows the environment not as an external domain "out there" but as an integral aspect of a non-decomposable organism-environment system that evolves over time as a product of the organism's sense-making behaviour (Chemero 2009).

This implies that evolution cannot be understood strictly in terms of fitness optimization. Instead, a bio-cultural approach implies a logic of *viability* (Varela, Thompson & Rosch 1991). This distinction is important because where the notion of optimization imposes a highly prescriptive framework for biological development (what does not meet the constraints of optimization is not permitted to endure), *viability* entails a more open-ended view where what may occur is constrained only by the boundaries of the possible – successful phenotypes demonstrate behavioural, cognitive, and morphological traits that are *sufficient* for their continuation. From this perspective natural selection still operates, however it does so in a more "pragmatic" manner whereby nature reuses and modifies what works and discards what does not (see Varela, Thompson & Rosch 1991, p. 195).[4]

By decentring the focus on fitness optimization, we highlight the self-organizing and adaptive nature of biological networks (Varela, Thompson & Rosch 1991) and thereby reframe the evolutionary question.[5] If, as Richard Lewontin (1983) argues, "we do not further our understanding of evolution by appealing to 'laws of nature' to which all life must bend, then we must ask how, within the general constraints of nature, organisms have constructed environments that are the conditions for their further evolution and reconstruction of nature into new environments" (Lewontin 1983, p. 163). This concern may be illuminated by the coevolutionary account of the emergence of toolmaking and musicality, and notably by the fact that this view (re)introduces teleological concerns into the evolutionary discussion.

Toward a Naturalized Teleology

As discussed above, the bio-cognitive capacities that support complex tool-making, music, and language emerged from basic self-organizing processes of adaptive behaviour – which stabilized over time and contributed to the conditions that permitted heightened forms of joint agency and a range of goal-directed behaviours. While the coevolutionary process itself is not understood as moving toward a pre-given goal – nor as following some plan or design – aims and purposes nevertheless enter the equation as the history of coupling between organisms and environments unfolds. And the ways that this plays out may be understood to involve an emergent process, one that traces a trajectory from basic forms of adaptivity and salience associated with metabolic regulation and survival, through degrees of agency whereby meanings, purposes, and strategies begin to appear on the scene. The cultural epicycles enacted by our Palaeolithic ancestors would have been increasingly characterized by such teleological factors, where agents worked together to teach, learn, and make with specific outcomes in mind. And if these goal-driven behaviours did indeed influence biological development – which seems very likely – then teleological factors will have to be present in our accounts of evolution.

Teleological arguments have been essentially taboo in the biological sciences for well over a century (see Haig 2020). Part of the reason for this involves the concern to maintain a materialist framework for scientific thought and research – i.e., to avoid metaphysical or intelligent design arguments. The anti-teleological stance is justifiable given the intellectual and cultural environment from which it emerged. However, prominent authors argue that the rejection of teleological factors has gone too far, resulting in a kind dogmatic over correction (Dennett 2017; Haig 2020). This issue addressed in the work of Hans Jonas (1966), who notes an innate purposefulness in the adaptive, self-maintaining behaviours of living systems; and who therefore argues for a conception of "teleology as a causal mode of nature itself, or immanent teleology, and not transcendent teleology such as might have been exercised by the creator of the existing system of nature in once creating it as it is" (Jonas 1966, p. 34). Likewise, as David Haig (2020) comments, it may be argued that Darwin's project was not to eliminate teleology from biology. Rather, it was to explain how a world full of creatures who behave

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While the logic of optimization may help to model the evolutionary processes behind relatively simple biological functions in controlled settings, this approach is arguably far less effective in complex animals, whose physiologies, cognitive capacities, and behaviours evolved and combined over a range of timescales and in manifold contexts with differing selective pressures. Interestingly, this diversity can result in "internal conflicts" that can have challenging consequences for many animals. For example, see Haig's (2020) discussion of these issues in the context of sexual reproduction.

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In line with this, the assumption that our cognitive capacities should be traceable to suites of naturally selected "modules" in brain has been upset by research that highlight the plastic and emergent properties of neural structures as they develop in context (Besson & Schön 2012).

purposefully in interaction with the environment could arise within a material universe – to provide a *naturalized teleology*. We can begin to rethink this possibility by, again, adopting a more recursive, multi-levelled approach to biological processes.

At the level of atoms and molecules the laws of physics and chemistry rule. However, once we arrive at the level of the gene and gene groupings it becomes difficult to separate out relationships with larger organic structures and their functional purpose in the life of an animal.[6] At the level of the organism, the nature of a living system as *self-distinguishing* (as self-making and self-sustaining via its own activity) implies a "point of view" on the world – one that selects what courses of behaviour are viable in terms of its continuation (Weber & Varela 2002). This calls back to the "interactional asymmetry" mentioned earlier, highlighting again how adaptivity and agency extend basic metabolic functions as organisms that can engage in selective behaviours "will be able to generate a normativity within their current set of viability conditions and for themselves" (Di Paolo 2005, p. 437). Such processes necessarily involve self-monitoring, as well as the ability regulate internal relationships with environmental conditions. This means that it is not only the goal itself (e.g., nutrition) that is important, but also the sensorimotor capacities and environmental constraints (the efficient causes) in which the behavioural dynamics play out – it is the ability to move and sense adaptively (e.g., a bacterium's ability to swim and select) that allows for the emergence of goals that contribute to an organism's viability in a precarious environment. This recursive, emergent view of teleology in living systems extends to the level of social interaction, where complex multi-agent behavioural patterns emerge as agents monitor and enact normative balances between self and other. These patterns are increasingly shaped by forms of joint agency, allowing new meanings and purposes to arise within the context of the shared lifeworld.

As Dennett (1991, 2017) notes, it is important to recognize that such emergent patterns of purposeful behaviour are real in the material sense – they involve the complex interactions of genetic, neural, muscular, and environmental trajectories that are comprised of physical "stuff" (atoms, molecules, neurons, muscles, limbs, sense organs, objects in the environment, and so on). What is required, then, are research models that examine how such self-organising dynamics play out and influence each other at different levels of complexity and over different time scales – how, at different ontological levels, new behavioural properties emerge and exhibit specific effects on the system as a whole; and how agency, purposes, and goals arise within the complex web of material (and socio-cultural) forces associated with adaptive behaviour (see Koutroufinis 2014; Koutroufinis & Pikarski 2020). Importantly for the current discussion, this naturalized approach may help us to incorporate teleology into a materialist biocultural model to better explain how purposes and goals emerge from and shape the viable patterns of movement and interaction that characterized the cultural epicycles of early Palaeolithic societies.

Teleodynamics, Improvisation, and the 4E Framework

The discussion above suggests that evolution should not be thought of only as something that *happens to* a gene, an animal, or a population. We also need to consider what living systems do – how organisms act and interact with and within their environments; how the various phase transitions that arise through such activity lead to the emergence of purposeful behaviour; and how this may affect the environment and, in turn, the further development of the animal. This perspective finds an interesting conceptual antecedent in A. N. Whitehead's (1978) philosophy, where the relationships between organisms, environments, and events are understood in terms of a dynamically interactive "process ontology", which is characterised by the enactment of the "actual" though the "accidental creativity" (adaptive, improvisational capacities) inherent in biological systems. Thus the "actual occasions" – the relevant events, relationships, and organism world configurations – that emerge from these creative processes can be viewed as "teleological selves, the final form of which does not exist in them as a preformed program at the beginning of their self-formation, but rather develops gradually as an actualization of intrinsic tendencies" (Koutroufinis 2021, p. 17). Following this insight, Koutroufinis notes that as actual occasions emerge, they add "relevance to certain features of their environment while making others irrelevant. This means that 'actual occasions' are inextricably linked with certain characteristics of their environment, which they select and appropriately include in the process of their self-formation" (Koutroufinis 2021, p. 17).

These insights highlight the "teleodynamic" nature of living systems – a term that refers to the recursive and emergent nature of agency and purpose as properties of living agents (Deacon 2012; Logan 2015). Teleodynamics can be observed in the self-organizing patterns of behaviour as an agent develops ways of interacting with the material aspects of their environment, which results in the enactment of affordances and the emergence of new goals and purposes. However, and as we have seen in the example of Paleolithic toolmaking, it is also present in multi-agent contexts, where individuals bring their movements in line with each other to realize specific tasks.[7] Not surprisingly, teleodynamics are an important factor in musical development (Schiavio *et al*. 2017). Consider Eric Clarke's account of a young child encountering a musical instrument for the first time:

> "On first encountering a xylophone, the child's more-or-less unregulated experiments with hands or sticks will result in all kinds of accidental sounds. With unsupervised investigation, the child may discover that different kinds of actions [. . .] give rise to differentiated results [. . .], and even that these distinctions can themselves be used to achieve other goals. Perceptual learning […] resulting from manual/aural exploration leads to further perceptual learning about the possibilities of tune building, or expressive function." (Clarke 2005, p. 23)

This is a good example of how affordances, goals, and understandings arise and develop in a self-organizing way, often beginning with unplanned and

6
As Haig (2020) argues, evolution displays a "forward looking" character to due to the recursion involved in the reproduction and replication of genetic material. It is what a gene *does* that it ensures for its continuation in the population—how it functioned in the past is responsible for its current presence in the genome; and, as such, the gene will tend to what did in the past in in the present. Haig offers the example of how genes that cause hearts to pump, and thereby circulate oxygen in the body, can be understood to function for that purpose; it is the past functioning of the heart that results in the current presence of genes that produce functioning hearts.

7
Additionally, it may also be argued that teleodynamics play out over evolutionary timescales and across species as the needs, behaviours, and morphologies of one species develops in interaction with those of another (e.g., the symbiotic relationship between bees and flowers).

"accidental" exploratory movements. Teleodynamics are also central to joint musical behaviour, where agents constantly initiate and adapt to shifts in the musical environment to keep a performance "alive" (van der Schyff *et al*., 2018). The ability to do this depends, again, on the fundamental capacity to self-monitor and make sense of the actions of others by dynamically attending to movement, sound, feeling and other perceptual domains.

As musicians work together, they develop shared abilities to adjust to perturbations and to realize shared musical goals. And while these kinds of dynamics are present in all types of musical activity, they are especially noticeable in forms that involve high degrees of improvisation (Walton & Chemero 2014; Walton *et al*. 2015; Walton *et al*. 2017). These musical practices have interesting parallels with the self-organizing dynamics associated with bio-cultural evolution and serve as compelling examples of how (musical) plans, strategies, and goals may emerge through forms of group action. Indeed, improvisers work with varying amounts of pre-planned material – and sometimes with none. Through various sensorimotor process improvising musicians negotiate patterns of behaviour by which a musical environment is brought forth. They also introduce perturbations that challenge stable patterns, thereby initiating phase transitions that contribute to the development of the music (Borgo 2022; van der Schyff *et al*. 2018). Although these forms of musical action may begin with little or no planning, they often exhibit complex emergent properties that arise from the joint agency of musical agents in adaptive interactivity with the social and material environment they co-enact (van der Schyff, Schiavio & Elliott 2022). Additionally, as improvisers work together over longer time periods, they often establish recognizable patterns of musical behaviour that gives their ensemble an identifiable sound (an *identity*) – these patterns are juxtaposed, adapted, and deconstructed in various ways as the social musical system develops.

Improvisational dynamics align closely with the processes of cultural evolution discussed above (e.g., the lab study of the evolution of rhythm). Musical improvisation also bears similarities with the emergent account of human musicality provided by the coevolutionary approach. And more generally, musical and other forms of improvisation reflect and indeed, depend upon, the baseline adaptive and teleodynamic capacities inherent in living systems. Likewise, some authors have used music as a strong metaphor to help explain biological evolution, showing the interesting ways that the complex, dynamic, adaptive, and "improvisational" processes found in musical development mirror those in biological evolution as it unfolds across different ontological levels (genes, organism, environment, culture) (Noble, 2018). Furthermore, improvisation is currently being explored as an extension of the *embodied*, *embedded*, e*xtended*, and *enactive* (4E) approaches that are reframing thought and research in the biological and cognitive sciences (e.g., Borgo 2022; Torrance & Schumann 2019). Developing this connection holds interesting implications for the biocultural approach as the intersecting dimensions of the 4E framework offer useful comparative vantage points that may aid in modelling the adaptive, interactional, and "improvisational" dynamics of multi-agent sense-making in evolving socio-material environments (see van der Schyff & Schiavio 2017). Concision prevents a full account of what this might entail. However, roughly speaking, a 4E perspective on coevolution might be sketched out in the following way:

> *Embodied*: this dimension explores the central role the body plays in driving the emergence cognitive processes. It focuses on how sight, sound, feeling, and coordinated movement led to the production of artefacts with specific characteristics; and how such activity guided the emergence of more complex forms of thought, communication, and production.
>
> *Embedded*: this dimension accounts for the environmental conditions in which patterns of activity, communication, and production arise. It focuses on the ecological constraints and selective pressures that influence, and are influenced by, the adaptive behaviour of agents within a social and material milieu—from the niches constructed by our early ancestors to the growing influence of the cultural epicycle on the environmental dynamics.
>
> *Extended*: this dimension explores how the embodied and embedded aspects of bio-cultural development necessarily involve cognitive couplings with other agents (social entrainment, mimesis, joint action) and with nonbiological objects or cultural artefacts (tools, musical instruments, other technologies). It examines how embodied-embedded minds are extended and shaped by social and material factors (see Malafouris 2013).
>
> *Enactive*: This dimension describes the emergent and evolving world of salience and meaning that arises through the perceptually-guided activity of living systems. As such, it considers the types of purposes, goals, and understandings that emerge through processes of adaptivity and agency, and how these play out in "improvised" ways across embodied, embedded, and extended domains.

Note that these four overlapping dimensions can serve as both ontological and phenomenological frameworks. That is, a 4E model can help us to describe the nature of a bio-cultural organism-environment system – what it is and how its properties develop overtime through recursive feedback and feedforward effects. Here, constraints, adaptivity, and the emergence of affordances might be mapped over various timescales via the interactivity of corporeal, social-material, and environmental cultural factors. And the enactment of goals, purposes, and meanings could be plotted as the system evolves from states characterized by "creative accidents" to the establishment of more stable repertoires of action and thought. The intersecting focal points offered by the 4E approach might also help to model the mutually influencing "cycles within cycles" that characterize the coevolutionary model: organism environment feedback loops; the dynamics of evolving cultural epicycles and the multi-agent teleodynamic systems that comprise them; and the "internal" cycles of neural activity, hormone release, gene expression and so on.[8] Phenomenologically, the 4E framework provides a starting place to query the experience of adaptivity, co-operation, and the emergence of meaning and function via exploratory and improvisational action. Indeed, this framework

8
It is understandable that some might object to terms like "goals", "meanings" and "purposes" in the context of non-or preconscious (or even non-living) systems. Perhaps here one might speak instead of the "functionalities" and that maintain the persistence of a complex dynamical system more generally – and how, then, in living systems, these functions are directed towards survival, which forms the basis for the emergence of a teleological context.

can be used to examine the nature of musical (and other) experience as it plays adaptively out across active, feeling bodies; tools, instruments, and technologies; and within socially and culturally embedded contexts (Schiavio & van der Schyff 2018; van der Schyff & Krueger 2019; van der Schyff, Schiavio & Elliott 2022). Notably, this model holds promise for exploring continuities between the experience of the act of improvisation (musical or otherwise) and the adaptive processes that drive human development and biological evolution more generally.

Coevolutionary and 4E approaches may help us look beyond unresolvable nature-culture dichotomies by revealing deep continuities between biological, cognitive, and cultural aspects of human life. In doing so, they may open new understandings of how music and culture arose and evolved throughout a long, integrated, and interactive relationship with our biological heritage. These models can also help us to rethink the role of purposes, goals, and meaning within evolutionary processes and how the cultural act of musical improvisation reflects, and might help to illuminate, the emergent "improvisational" teleodynamics inherent in biological systems.

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Dylan van der Schyff

Muzikalnost, teleodinamika i evolucija biokulturnih sustava

Sažetak

Debate oko biološkog značenja čovjekove muzikalnosti težile su odigravati se unutar teorijske orijentacije koja evoluciju najviše objašnjava u pogledu »prilagodbi«. Premda je ta orijentacija donijela važne uvide, također nameće prilično stroga razlikovanja između proizvoda »prirode« i »kulture« u čovjekovu fenotipu. Sukladno tome, ovdje se argumentira da »adaptacionistička leća« možda nije dovoljna za dohvaćanje pojave i važnosti kompleksnih oblika ponašanja osnovanih na više fizioloških, kognitivnih i okolišnih komponenata. Ovaj članak ocrtava alternativan, »biokulturni« pristup za koji se čini da uklanja načelne dihotomije povezane s adaptacionističkom perspektivom – pristup koji razmatra pojavu i značenje čovjekove muzikalnosti u pogledu dinamičkih povratnih (feedback) *i unaprijednih (*feedforward) *učinaka koji se dotiču gena, mozga, tijela i sociomaterijalnog okružja. U članku se također predlaže da biokulturni pristup zahtijeva ponovno ocjenjivanje važnosti pojmova »djelovanje«* (agency) *i »teleologija« unutar evolucijske teorije. U te svrhe razvio sam neke misaone alate, izvučene iz enaktivne i 4E kognitivne znanosti, te dajem neke prijedloge za to kako fenomen (muzičke) improvizacije može ponuditi korisnu heuristiku za razumijevanje »teleodinamičkih« čimbenika povezanih s evolucijom biokulturnih sustava.*

Ključne riječi

evolucijska muzikologija, biokulturna koevolucija, teleodinamika, 4E kognitivna znanosti, improvizacija

Dylan van der Schyff

Musikalität, Teleodynamik und die Evolution biokultureller Systeme

Zusammenfassung

Debatten über die biologische Bedeutung der menschlichen Musikalität tendierten dazu, sich innerhalb einer theoretischen Ausrichtung abzuspielen, die Evolution weitgehend vom Konzept der „Anpassungen" her auslegt. Während diese Ausrichtung einige wichtige Einblicke gewährt hat, erlegt sie auch vergleichsweise strenge Unterscheidungen zwischen den Produkten der „Natur" und der „Kultur" im menschlichen Phänotyp auf. Dementsprechend wird argumentiert, dass die „adaptationistische Linse" unter Umständen nicht ausreicht, um die

Herausbildung und Gewichtigkeit komplexer Verhaltensformen zu erfassen, die auf diverse physiologische, kognitive und umweltbezogene Komponenten zurückgreifen. Dieser Aufsatz umreißt einen alternativen „biokulturellen" Ansatz, der die grundsätzlichen Dichotomien der adaptationistischen Perspektive aufzulösen scheint – einen Ansatz, der die Entstehung und Bedeutung der menschlichen Musikalität unter dem Aspekt dynamischer Rückkopplungs- (feedback) und Vorwärtskopplungseffekte (feedforward) einordnet, die Gene, Gehirne, Körper und soziomaterielle Umwelten überspannen. Überdies legt das Paper nahe, dass eine biokulturelle Herangehensweise eine Neubewertung der Relevanz der Begriffe „Handlungsfähigkeit" (agency) und „Teleologie" innerhalb der Evolutionstheorie erfordert. Zu diesem Zweck entwickle ich einige Denkwerkzeuge, die aus der enaktiven und 4E-Kognitionswissenschaft abgeleitet sind. Zudem unterbreite ich Vorschläge, wie das Phänomen der (musikalischen) Improvisation als nützliche Heuristik dienen könnte, um die „teleodynamischen" Faktoren zu erfassen, die an der Evolution biokultureller Systeme beteiligt sind.

Schlüsselwörter

evolutionäre Musikologie, biokulturelle Koevolution, Teleodynamik, 4E-Kognitionswissenschaft, Improvisation

Dylan van der Schyff

Musicalité, téléodynamiques et évolution des systèmes bioculturels

Résumé

Les débats autour de la signification biologique de la musicalité humaine se sont généralement inscrits dans une approche théorique privilégiant une interprétation de l'évolution en termes d'« adaptations ». Bien que cette perspective ait permis des avancées importantes, elle impose également des distinctions rigides entre les produits de la « nature » et ceux de la « culture » dans le phénotype humain. Ainsi, il est soutenu que le prisme adaptationniste ne suffit peut-être pas à rendre compte de l'émergence et de la signification de formes de comportement complexes mobilisant de multiples composantes physiologiques, cognitives et environnementales. Cet article propose une approche « bioculturelle » alternative, qui semble dissoudre les dichotomies apparentes associées à la perspective adaptationniste – une approche qui considère l'émergence et le sens de la musicalité humaine à travers des effets dynamiques de rétroaction et d'anticipation impliquant les gènes, le cerveau, le corps et les environnements socio-matériels. L'article suggère également que cette approche bioculturelle nécessite une réévaluation de la pertinence des notions d'« agentivité » et de « téléologie » dans la théorie de l'évolution. À cette fin, je développe quelques outils conceptuels issus des sciences cognitives et énactives 4E et je propose quelques pistes sur la manière dont le phénomène de l'improvisation (musicale) pourrait offrir des heuristiques utiles pour comprendre les facteurs « téléodynamiques » impliqués dans l'évolution des systèmes bioculturels.

Mots-clés

musicologie évolutionniste, coévolution bioculturelle, téléodynamique, sciences cognitives 4E, improvisation