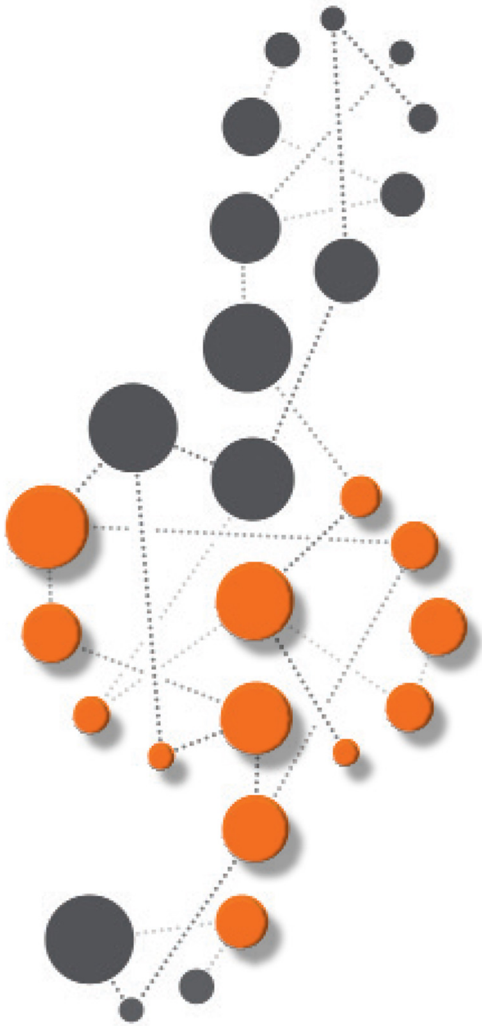
Psychological Perspectives on Musical Experiences and Skills

Research in the Western Balkans and Western Europe



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9. 4E Music Cognition in Theory and Practice

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Introduction

The last few decades have witnessed a shift in focus in research on musical experience and cognition. Existing frameworks that emphasise on information-processing, as well as approaches interested in the neural or behavioural correlates of musical experience, have been complemented by a novel perspective that offers a broader synthesis of psychological, physiological, neural, and ecological levels. This orientation, known as 'embodied music cognition' (e.g., Leman, 2007), has provided fascinating insights into current discourses in music research. According to this view, the cognitive processes underlying musical activities such as perceiving a melody, imagining a tonal cadence, learning to play a guitar solo, composing a song, or performing with a band, are thought to emerge from a variety of bodily-based (e.g., motor, visceral, affective) factors, suggesting that musical minds are grounded in low-level processes much more than previously assumed. For instance, research has shown that musical perception is shaped by instrument-specific motor expertise (Overy & Molnar-Szakacs, 2009); that making music together often relies on non-verbal forms of communication and reciprocal bodily adaptations (Badino et al., 2014); and that our capacity to remember musical stimuli is facilitated by previous sensorimotor familiarisation with the musical material (Schiavio & Timmers, 2016). In brief, this orientation explores the processes and mechanisms that underlie our ability to participate in musical activities—whether by actively making music or listening—from a wide-ranging, body-based perspective that decentres

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the more traditional focus on the information-processing of individual cognisers. Recently, this broadening view has extended beyond the body to include the social and material environment in which bodies are situated. To account for the complex patterns of reciprocal causation unfolding between brains, bodies, and environments, musical minds are now conceived of as Embodied, as well as Embedded, Extended, and Enactive (or 4E).

Aims

While the 4E framework offers a promising addition to music research, it was first developed in other scholarly domains. As such, its implications for our understanding of music and its experience are still not yet fully developed. The aim of this chapter is thus to introduce this orientation to readers who may not be familiar with it and who are interested in music. In particular, we offer a series of musical examples that speak to each 'E' distinctly, spanning musical domains such as perception, (remote) learning, performance, and development. Our intention here is to suggest that the 4E framework can provide a clearer view (when compared to more traditional frameworks) on how bodily interaction with an environment shapes musical experience and learning, and how this perspective reveals a continuum between musical activity and human flourishing more generally. We first illustrate the main principles of the 4E approach by tracing its origins in the fields of philosophy, psychology, and cognitive science. We then turn to explore what each E entails for musical cognition. We should note that our analysis is meant to offer only a preliminary overview of the rich variety of conceptual resources and possible applications stemming from a 4E approach to musicality; it is not intended to provide a complete account of the whole framework as it applies to other domains.

Main discussion

The 4E framework

One of the main assumptions of the multi-disciplinary school of thought developed under the umbrella term of 4E cognition is that mental life is best understood as a dynamic unity between bodily (neural, motor, emotional) and environmental (social, physical, cultural) factors (see Newen et al., 2018). We say 'dynamic unity' because the emerging organism-world network is instantiated by a recurrent interplay of factors inherent to three main components—brain, body, and environment—giving rise to multiple states and configurations (e.g., thoughts, behaviours, etc.). Accordingly, we may understand the 4E orientation as an exploration of the various relationships formed between organisms and the world. Fuchs (2020) addresses this reciprocity in terms of what he labels the 'circular structure of embodiment'. This involves sets of downward and upward processes between (1) brain and body as well as (2) brain-body systems and the world. To address the first point, we may consider empirical research showing that bodily states can alter one's perceptual experience: when feeling tired or carrying a heavy weight, for example, hills are seen as steeper, and distances are experienced as greater (Bhalla & Proffitt, 1999). Perceptual experiences are here understood to depend on what Johnson (2007) labels 'visceral connection with the world' (p. 12), which originates in our bodily sensations. Other examples come from the domain of linguistics, where a wealth of empirical studies suggest that different abstract concepts are mapped into bodily-based knowledge (see Casasanto, 2009; Gibbs, 2006). As reported by Hostetter and Alibali (2008), for instance, recent experimental work has shown that the understanding of metaphorical sentences such as 'grasping a concept' is primed by experiencing a related action (e.g., grasping something) before reading the sentence (Wilson & Gibbs, 2007). In the next section, we will centre our discussion on the corporeal roots of musical perception, suggesting that bodily knowledge plays a primary role in driving musical experience and that it shapes how we acquire musical competencies in learning settings.

The second point raised by Fuchs (2020)—the reciprocal interplay of organisms and the world—is best understood when considering how bodily feelings, motor activity, and sensorimotor experiences play out in ecological settings that go beyond the individual subject. The rich variety of bodily aspects that permeates our mental life, in other words, is always contextual and open to the diverse contingencies that make up the world we inhabit. As such, we can widen the dynamics of *embodied* cognition to include environmental factors. This means that cognition can also be conceived of as *embedded*. Our bodies are immersed in environmental dynamics, beginning at the earliest stages of life. And these dynamics involve histories of interaction with people, things, places, and events that shape our possibilities for thought and action as well as our socio-cultural presence (see Chemero, 2009). The co-dependencies between living systems and the environment have been studied both ontogenetically and phylogenetically (see Malafouris, 2013; Oyama, 2000), leading to richer understandings of how brain-body systems function when coupled with a given ecological niche. We discuss this embedded dimension from a musical perspective in the next section, where we offer some examples from pedagogical settings.

The claim that cognition is *extended* aims to increase our comprehension of what the organism-world nexus described above entails (see Clark, 2008). Consider how living systems often manipulate objects and exploit the structures of the world when a task is particularly demanding. Musical notation, for instance, helps people remember, teach, perform, and reproduce music more easily. To account for such internal-external integration, extended approaches often rely on a principle of functional similarity. This involves the idea that external structures may play a functional role akin to those structures that are internal to the cogniser (Clark & Chalmers, 1998). A classic example used to illustrate this is when someone uses a tool—say, a notepad—to remember something. In this case, it can be argued that the role of the tool is functionally similar to the person's biological memory. Accordingly, memory need not be limited to the biology of the agent; cognition can thus extend into the environment where it shapes and is shaped by socio-material interactions. When applied to musical contexts, this extended dimension can be approached from different angles. In the next section, we will specifically focus on music performance, exploring how instruments and other external (e.g., social) factors may contribute to drive music-making.

The idea that cognition is *enactive* connects with insights from the previous embodied-embedded-extended claims to describe the set of interactions between agent-environment that contribute to bringing forth a world of meaning (Varela et al., 1991). The basic idea here is that to survive and flourish, living beings must develop viable patterns of interactivity with their world, regulated by their needs and physiology as they adjust to ecological contingencies (Di Paolo et al., 2017). These interactions allow for the emergence of a world of salience, where things and other agents become meaningful in relation to the organism's concerned point of view on the world (its self). Importantly, this approach highlights a deep continuity between biological and mental processes, as well as the active role living systems play in shaping the worlds they live through (Thompson, 2007). Shortly, we consider musical development from this enactive perspective, suggesting that the acquisition of musical competencies reflects the sense-making dynamics associated with human flourishing more generally.

4E music cognition

To summarise our discussion above, the 4E view holds that the mind is *embodied*, as cognition is grounded in sensorimotor experience; *embedded*, as our being-in-the-world is immersed within wider ecological dynamics; *extended*, as tools and other features of the environment may be functionally integrated with cognition; and *enactive*, as mind and life compose a unity based on a variety of adaptive sensorimotor couplings whereby a world of salience and meaning is brought forth.

Before we move on, we should note that each of the Es connects with thought and research in different domains of cognitive science, which converge and diverge in various ways. For example, conceptions of what embodied cognition entails differ with regard to the role that should be ascribed to the active body in cognition. Some consider the body as an important mediating domain between inner and outer realities, as it provides the basis for instantiation of the corporeally-based representations in the brain that are fundamental to cognition (Shapiro, 2010). Others see the body as a cognitive domain in its own right, arguing that the role of mental representation has been overemphasised (Chemero, 2009). Additionally, there is ongoing discussion over the degree to which cognition can be properly understood as *extended*. Some theorists argue that while the body plays a central role in cognition (e.g., in the generation of corporeal and action-based representations), cognition should not be understood as extending beyond the body and brain (Adams & Aizawa, 2009). By contrast, other authors have made compelling arguments that some cognitive tasks are impossible to realise without the incorporation of environmental factors. For example, Louise Barrett (2011) explains how creatures with relatively simple neural structures (e.g., insects and spiders) are able to perform surprisingly complex cognitive acts (such as building webs, hunting, and finding mates) by including environmental features as integrated aspects of their cognitive domain.

Although aspects of the 4E approach are under debate, this orientation is nevertheless gaining traction across various domains as a useful framework for research and theory—it offers an important interdisciplinary meeting point for scholars interested in studying mental life from a distributed, relational perspective (Newen et al., 2018). Most importantly, a 4E perspective shifts the focus from individual agents and neural processes to brain-body systems and their histories of co-specification with the world. This approach has inspired a number of new perspectives on music-related areas of cognition such as emotion, empathy, and creativity. Whereas these aspects of mental life have often been studied in terms of responses, predispositions, and processes that play out within the domain of individual agents, 4E approaches have shown that these domains can be understood in terms of histories of dynamic interactivity between agents and the socio-material environments they inhabit and shape (Krueger & Szanto, 2016; Schiavio et al., 2017a; van der Schyff & Krueger, 2019). In what follows, we explore how these interactive dynamics play out in musical contexts, with an emphasis on perception, learning, performance, and development. It should be noted that while we treat each E separately, each subsection should not be considered independent from the others. In fact, because there are necessary overlaps between all 4Es, insights associated with one can also be relevant for others.

Embodied music cognition: From music perception to learning

Music listening is an activity that plays a crucial part in a musician's life and often permeates the lives of non-musicians as well. While 'the perception of pitch and consonance are among the oldest topics in Western science' (Large, 2017, p. 5), giving rise to multiple perspectives and theories, recent literature has shown a special interest in models based on prediction (see, e.g., Huron, 2006; Koelsch et al., 2018). One of the central ideas here is that predictions about the musical stimulus are internally generated by a listener via learned statistical regularities, so that the sensory input can be judged in terms of its violation or confirmation of such predictions. Accordingly, internal representations are supposed to govern perceptual activity through a variety of deliberate or spontaneous associations developed through exposure (see also Pearce, 2018).

An embodied approach to music perception can complement similar models by highlighting the role of body and action in shaping perceptual experience. This move has two main consequences. The first concerns what is emphasised in explaining music perception, while the second involves how the actual process plays out. The former point is best understood when considering that perceptual ability is shaped not only by (e.g., passive) exposure to musical culture, but also by the active engagements one has experienced in music-making activities. Indeed, a range of empirical studies has shown that expert musicians display strong activation of the motor cortex during listening tasks, reflecting their ability to associate specific actions with the music being listened to (see D'Ausilio et al., 2006; Haueisen & Knösche, 2001). The development of these neural connections through practice and learning, it has been suggested, plays a critical part in how music perception works, which leads to the second point listed above. This involves the idea that the motor schemata one has learned through musical practice are re-enacted during listening, leading to an enhanced perceptual experience, as if one were actually playing the music itself (Cox, 2016; Overy & Molnar-Szakacs, 2009).

This active process has been described as embodied simulation (see Gallese, 2005). The theory holds that learned repertoires of action not only drive our behaviour, but also shape our perception of actions (and sounds) performed by others. As Gallese and Sinigaglia note (2011), many studies have shown that performing a particular action activates the same parieto-premotor areas recruited when observing that very same action executed by someone else. This mechanism is based on the firing of a neural population known as mirror neurons, and has important implications for our understanding of musical perception. For example, it has been argued that simulation-like processes influence our capacity to predict the beat of a perceived musical stimulus through interactions between auditory and motor-planning regions of the brain (Patel & Iversen, 2014). According to this view, bodily factors are seen to constrain our predictive ability. Another fascinating contribution in this area involves the study of music-colour synaesthesia[1] from a sensorimotor account proposed by Caroline Curwen (2018; 2020), who argues that such a phenomenon might be best understood as fundamentally continuous with our real-life engagements with the world. Her research posits a profound unity between imaginative and perceptual processes, where both are seen as rooted in bodily experience. More generally, the idea that action underlies our perceptual and imaginative ability echoes earlier insights developed by the French philosopher Maurice Merleau-Ponty (1945/1962). While his work focused mostly on visual perception, many of his observations are also applicable to music. Merleau-Ponty notes that to acquire a way of perceiving involves a new use of one's own body, enriching and recasting the body image. Accordingly, the living body is not an object among others—it is a 'grouping of lived through meanings which moves towards its equilibrium' (p. 153, emphasis added, quoted in Crossley, 2015). This insight has important consequences for activities such as musical learning, where students often perceive and imitate the actions of other people in their environment. As Merleau-Ponty suggests, this requires a style of perceiving that makes use of the bodily power of action, rather than an acquisition of external knowledge through exposure. Of particular interest here is recent work that emphasises the role of the teacher's body in helping students acquire their musical skills (Simones et al., 2015; 2017). Such contributions examine how gestures, interaction, and other modes of

1 Generally speaking, this can be defined as a type of synaesthesia where the perception of certain sounds immediately evokes an experience of colour (see Ward et al., 2006).

virtual online communication can facilitate the learning process, and how specific musical behaviours are optimised through participation, improvisation, active experience, and dialogue (see, e.g., Borgo, 2005; 2007). This is further examined in recent research from Bremmer and Nijs (2020), who provide an illuminating perspective on how music teachers use their bodily resources to actively construct a meaningful learning environment. Here, actions, adaptations, and collaborations are seen as integral parts of the pedagogical space—they encourage creative interaction whereby learners can develop the patterns of action-as-perception involved in musical expression and communication (see also Laroche & Kaddouch, 2015).

These examples begin to illustrate how the embodied approach to cognition has important implications for music research, highlighting the body as a fundamental source of significance and meaning-making. In what follows, we expand on these insights to explore how the processes described here may include a broader social milieu.

Embedded music cognition: The case of remote musical learning

In this section, we outline some possibilities concerning how the embedded dimension of cognition can help us think about the dynamics of interactive learning environments, with a focus on remote learning contexts. Indeed, while the embedded dimension might be most obvious in face-to-face contexts—where performers or students and teachers interact in the same physical space—recent technological developments have made it possible for musicians to work together online in real time. And with the advent of the COVID-19 pandemic, virtual learning environments have become especially important. With this in mind, we will first look at these kinds of environments through the embedded lens before moving on to consider extended and enactive aspects in turn.

The idea of 'remote learning' is often closely connected with technology-based pedagogical settings. However, as indicated by Dabbagh (2007), this phenomenon taps into a long tradition that stretches back to pre-internet and pre-digital distance education formats based on correspondence and home study (see Hanson et al., 1997). But whereas older forms of distance learning were teacher-centred and focused on a relatively fixed curriculum and delivery, recent models involve more joint musicking activities, as well as a range of technology-enhanced possibilities intended to stimulate collaborative learning (Ehrmann & Collins, 2001). Ideally, these kinds of approaches may produce a community of interacting individuals, which may be conceived of as:

> a dynamic whole that emerges when a group of people share common practices, are interdependent, make decisions jointly, identify with something larger than the sum of their individual relationships, and make long-term commitment to well-being (their own, one another's, and the group's). (Shaffer & Anundsen, 1993, p. 26)

Remarkably, this collaborative aspect presents important similarities with the kinds of relationships built in face-to-face settings, suggesting that remote interaction may not be less meaningful than in person forms. Recently, Schiavio et al. (2020) explored the range of perspectives and thoughts that music teachers working in different settings shared with regard to learning and ensemble skills. They found that one of the most common factors discussed in enhancing such skills was the ability to listen and respond to others, highlighting the collaborative dimension of learning and making music. In addition, it emerged that 'comparing yourself to the class' was deemed a fundamental factor among other learning abilities, suggesting that open dialogue and reciprocal feedback can play a key role in nurturing talent and learning. This aligns with research by Wu et al. (2014), who have shown that students who learn in web-based environments can achieve more satisfying results when compared to learners with fewer opportunities for interactive study.

The types of community-building that develop in physical spaces can also emerge in settings where collaboration is virtual, providing important benefits for students who are geographically distant from each other. Here, learners can offer support, share thoughts, beliefs, and ideas through virtual educational platforms, as well as complement existing pedagogical methods more or less informally. This is a distinctive attribute of the virtual environment in which participants are immersed. As individuals engage and interact with one another, they can actively shape the digital landscape, thereby forging novel synergies that may surpass what is possible in traditional settings. Although the end results may resemble those attainable in face-to-face interactions, the modes of engagement within this specific digital realm are uniquely crafted, enabling types of interactions that are inherently digital, such as simultaneous contributions from geographically dispersed participants, one-to-many discussions, and dynamic multimedia integration.

Of course, these possibilities proved exceptionally valuable during the recent COVID-19 pandemic, facilitating the transition of music lessons into virtual settings given the necessary restrictions imposed in numerous countries. But while technologically mediated learning afforded many opportunities during this period, the necessity of online teaching during the pandemic also revealed the difficulties that can arise when students' social 'embeddedness' in a pedagogical environment is (almost) entirely virtual. This issue sparked a wealth of scholarly exploration dedicated to analysing the challenging pedagogical dynamics inherent in online music learning contexts (e.g., Adam & Metljak 2022; Biasutti et al., 2022, 2023; Novković Cvetković, 2023). To take one example, a study of online instrumental teaching at the Faculty of Music at University of Arts in Belgrade during the pandemic (Mutavdžin et al., 2021) revealed that, to be successful, online music environments need to foster students' ability to engage in self-regulated learning. However, to achieve this, students need to feel supported in virtual learning contexts – it is necessary that they are embedded within an interactional social environment that supports and guides their emotional, technical, and creative development; that demonstrates care for their progress and well-being; and where they can develop meaningful relationships with their peers and teachers, and with the technologies they use. Self-regulated learning, in other words, is not isolated learning; it is motivated, given meaning and context, and flourishes only when it is situated within a broader ecology of learning. Due to the inherent 'remoteness' of virtual environments, attaining a such interaction and support requires additional levels of care and guidance. This means that the development and maintenance of an online learning environment 'requires a conscious commitment to it and careful planning of the teaching/learning process' (p. 292)—where are ongoing attention is given to the perspectives of the teacher and the students, and the broader socio-cultural and technological context in which they are embedded.

As noted by Crow (2006), many performers, teachers, and learners often find it helpful to work with computers to support specific musical needs. This ranges from platforms that assist the trained musician in writing complex scores to more intuitive loop-based sequencers and accompaniment generators. Because such tools also allow users to interact remotely, they are particularly useful for educational purposes: students can form communities of practice through these resources (Makrakis, 2014), assisting each other in various ways—through brainstorming, peer feedback, and so on. Consider, for example, how constructive dialogues in online forums, or similar platforms, have proved useful to enhance both basic and advanced psychological skills such as the investigation of new ideas as well as high-order decision-making (Biasutti, 2011).

From an embedded perspective, it is important to note that the kinds of learning environments described here are not fixed but rather evolve in a symbiotic relationship with the individuals that populate them. Indeed, there is a bidirectional dependency between the users and the shared worlds of practice they create. This intersubjective network involves adaptations that require the development of problem-solving skills and empathy, and encourages the fluid integration of individual and collective aspects that stand at the basis of an inclusive learning environment. As such, it can foster cultural and social understandings that drive various musical dynamics. For instance, sharing a particular musical issue in an online forum (say, how to arrange a piece for lute for a modern orchestra) may stimulate others to explore their creative potential and find novel outcomes. In this case, the learning space can be transformed by innovative musical solutions reflecting different cultural and musical needs, expertise, and taste. Creative possibilities can be negotiated and developed contextually, giving rise to a circle of reciprocal influences where individual and social dimensions inform one another. In the next section, we explore this aspect in more detail by focusing on the kind of relationships musicians often develop with their instrument and ecological surroundings.

Extended music cognition: Mutual incorporation and music performance

In most cases, performing music alone or with other individuals involves the use of analogue or digital musical instruments. It has been argued that musicians form important relationships with these instruments in the contexts of improvisation or score-reproduction. Nijs et al. (2013; see also Nijs, 2017), for example, address this point in terms of incorporation and transparency: instruments may be transparent to the musicians because they become part of one's cognitive ecology. Consider, for example, how the flow and structure of musical passages during improvisation are developed in the process of performing, and are built upon through the act of playing. To do this, the musician relies on the possibilities of the body in close interaction with the instrument, which have been refined over practice. Because the instrument is a central aspect of the creative process, it can be argued that it plays a crucial role in improvisatory activity (see Ryan & Schiavio, 2019; van der Schyff, 2019). The instrument, in other words, becomes part of the performer's 'extended' cognitive system as it serves the specific function to generate (and not simply reproduce) musical expressions.

The physical relationships musicians establish with their instruments are not the only types of connection that emerge here. Musicians regularly build emotional relationships with the unique sonic and physical characteristics of a specific violin, cymbal, guitar, and so on. Instruments also have histories, which include their use in particular repertoires, the development of the physical materials and design properties required to produce the sounds they do,[2] as well as various communities of musicians who have exploited different aspects of their sonic potential in shared musical events. This connects the extended dimension with a broader embedded socio-cultural environment. Examining these extended-embedded relationships can also frame how we think about other material and cultural relationships, for example where artefacts are used to store musical information and guide practice. For instance, the practice of re-producing a musical score, as is common

2 Consider, for instance, the addition of octaves in modern pianos, or a (lower) seventh string in some electric guitars. Another example could be the 'preparation' of instruments where additional objects are placed on the strings or body of the instrument to alter its tonal characteristics (e.g., John Cage's music for prepared piano; this practice is also common in contexts of free improvisation).

in Western contexts, often involves developing a relationship with the composer and the style and historical period they are associated with, as well as recordings of previous performances, to inform an individual's interpretation. These social, historical, and aesthetic aspects of the performer-instrument relationality can be further modulated on the basis of particular contextual contingencies, where, for example, instruments might require a modification to better accommodate the expressive needs of a given style, or where a score or musical practice is reinterpreted.

Musical activity involves a continuous negotiation between bodily, external (tools, instruments), and embedded (socio-cultural) dimensions, where instruments, other people, as well as cultural and historical factors, participate in guiding one's musical activity in various ways. The example of remote learning discussed above offers an interesting example of how these Es intersect. The technology serves to facilitate perceptual and communicative faculties, while also allowing the participants to meet in a virtual space where local agent-environment systems extend into and influence each other. While the Es do overlap with each other, they can provide different perspectives and insights on the same phenomena. To take another example, musical notation can be seen, from an extended perspective, as a tool that facilitates performance in real-time situations, serving a function similar to that of musical memory. Viewed from the embedded perspective, however, music notation is also a cultural product that necessarily involves norms and narratives framed relative to certain historical periods.

Enactive music cognition: The flourishing of human musicality

These embodied, embedded, and extended aspects involve the active creation of meanings that span and shape personal, social, and cultural worlds. This is highlighted by the enactive dimension of the 4Es, which explores how living systems bring forth (or 'enact') domains of meaning—most fundamentally, through the development of (survival-relevant) repertoires of perception-as-action. This activity is driven by a natural tendency for living systems to actively explore the world and its contingencies. The development of human musicality, we suggest, follows a similar trajectory when (since early infancy) it involves an impulse to regulate and optimise a behavioural attunement with the environment through sonic discovery (Malloch & Trevarthen, 2018). As infants manipulate things (e.g., objects, toys) in their peripersonal space to gain familiarity with their properties, they also improve their own motor and perceptual capacities—including those linked with the association of sounds and movements. In other words, they start to develop a repertoire of basic music-related actions that drive and motivate their further musical discoveries, allowing them to play with things and produce sounds that can be further reorganised in various ways (Schiavio et al., 2017b).

These early musical behaviours are transformed and optimised through a series of perception-action loops, leading towards specific goals and outcomes. For instance, the squeezing of a toy may produce a unique sound that infants could associate with a behavioural configuration (e.g., the 'squeezing' grip) and its experiential results (e.g., a feeling of surprise). In this process, various pragmatic understandings of the environment and their own motor possibilities are acquired, which may serve further musical and non-musical actions. The latter, for example, include possibilities to improve perceptual capacities related to the control and prediction of various behaviours, thereby minimising sensations of surprise or fear when a sound is produced contextually (e.g., when a toy falls from a table and hits the floor). But when adopted to achieve musical goals, these actions may lead to more complex and satisfying ways of playing in which sonic outcomes are produced with increased precision.

This vignette captures one key tenet of the enactive approach, namely the understanding of cognitive life as situated action: organisms generate rolling patterns of interactivity with their niches, which in turn constitute a 'sensorimotor self' (Di Paolo et al., 2017). Importantly, the relationships with the world infants establish through these sonic discoveries do not arguably adhere to a predetermined agenda, but rather emerge within a synergistic nexus of ecological and biological factors. Musical minds and musical life are continuous with each other, as both musical and personal growth are understood to include embodied, embedded, and extended aspects.

From an embodied perspective, it could be suggested that the range of musical activities described here originate in an active attunement with the environment, where the body plays a major role in discovering novel behaviours and experiences. The body drives discovery because it is at the same time a means (manipulating objects is necessary for exploratory activity) and an end (the infant's repertoire of action is shaped by its adaptive behaviours). As such, this natural inclination to explore the environment can also be seen, from an embedded perspective, as an early manifestation of the transforming dialogue between organisms and the world. When objects and things are manipulated, they may reveal novel characteristics that could invite new engagements and trigger further motivated actions. By rotating a toy, infants may be fascinated by its hidden side, thereby acting to explore its various (e.g., sonic) properties. When adequate expertise is gained, and infants can use objects to produce and play with sounds—for example, by hitting a toy car on the floor—there is a strong sense in which the object becomes 'transparent', resulting in the incorporated extended dynamics that prefigure those discussed above with regard to musical instruments. The object, in line with such a perspective, becomes part of the infant's cognitive system, serving a musical function that facilitates the task of producing sounds in a specific way. In this threefold characterisation, musical development might be understood as an enactive phenomenon rooted in exploratory meaning-making: infants establish sensorimotor relationships with their milieu, giving rise to basic behavioural configurations constituting an early repertoire of musical actions.

Conclusion

An understanding of the musical mind as embodied, embedded, extended, and enactive provides new angles to look at the concrete dynamics in which musicking takes place. It eschews the dichotomies between mind and body and between body and world, placing renewed emphasis on the continuity between biological and cognitive processes at the heart of human musicality (see also Honing, 2018). In this chapter, we have examined different musical contexts to articulate parallels between the general 4E framework and its musically relevant contexts. We have highlighted how the whole brain-body system affects music perception, showing how it can help us re-examine its role in pedagogical contexts. Drawing on recent literature in the field, we have then considered cases of remote pedagogies. Here, agents compensate for the lack of close bodily connection (as in individual teaching) by actively participating in each other's learning. They co-create, modify, and optimise their environment, giving rise to circular dynamics where individuality and collectivity are synergistically transformed. This organism-world coupling has been further discussed when observing how musicians develop unique connections with their instruments to facilitate their musicking in various ways. As we saw lastly, exploring musical development from an enactive perspective brings together the embodied, embedded, and extended dimensions by conceiving skill acquisition as a sense-making process rooted in action and exploration. In all, 4E accounts of music cognition can help us approach different musical contexts from a perspective that conceives the (musical) mind as a relational phenomenon, based on an adaptive coupling between organisms and the world. Future work may build on this intuition to study how more exploratory activities in pedagogical settings can be implemented, examining the behavioural, emotional, and neural trajectories at the basis of various musically relevant brain-body-world synergies; how these synergies involve things and other people; how cultural norms may affect one's exploratory impulse; and how bodily factors drive musical creativity and discovery.

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