The 4E`s Model of Enactivism through Improvisation within DMIs

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Abstract

This paper describes how a theoretical framework focused on the 4E`s model which describe the mind as fundamentally: *embodied, embedded, extended* and *enactive*, within the paradigm of enactive music cognition can contribute to the design of Digital Music Instruments (DMIs).

From an epistemological perspective, we discuss improvisation within the Western academic music culture through two examples of DMIs created to improvise in a MIDI keyboard. We argue the 4 E`s model orientation revealing the fundamentally nature of the embodied musical mind. Ethical and practical possibilities for an enactive music cognition related to improvisation in the context of the skills and needs of 21st are suggested with the goal of helping DMIs designers and musicians to develop approaches based in possibility, imagination, and relationality, rather than in conformity to standardized practices and conventional music pedagogical purposes. Finally, we present two concrete cases of DMIs, and describe how the experience of musical improvisation with them may be seen through the prism of such theories.

1. Introduction

The acquirement of knowledge playing an instrument is essentially internalizing how an action is translated to sound [1]. Different from acoustic instruments, a specifically designed digital musical instrument (DMI) can provide an immersive and embodied musical experience without prior training, unlike the long time it takes a music student to play the basics on an acoustic instrument [2]. Khoury states that if music education is to respond to the skills and needs of 21st-century music learners, innovative learning paradigms must be explored [3].

This paper presents an enactive approach to music education within the 4E`s model which describe the mind as fundamentally: *embodied, embedded, extended and enactive*. In what follows, we demonstrate two DMIs examples and their applicability in the educational practice. The DMIs were both built on a handcrafted plywood structure, which includes all hardware components of an illuminating bar to be placed on a MIDI keyboard controller. It aims to provide visual feedback to novice pianists.

The field of embodied cognition (Varela et al., 1993) within the 4E´s model in its potentiality to express the relevance of improvisation in musicianship is outlined with the aim of responding to a broader demand for musical learning of the 21st century [3, 4].

We consider that through innovative learning technologies focused on improvisation, novice pianists and music students may explore their musical skills from the beginning of their training in the instrument [5, 6, 7]

It is important to note that this is a subjective work and present observations and understandings concerning improvisation practice in the theory of embodied music cognition considering enhancing music education.

We conclude by presenting a reflection upon music pedagogy through the 4E`s model in improvisational practice within the two presented examples of DMIs.

2. Improvisation within Enactivism

Christopher Small (1998) conceived the term "musicking" to emphasize that listening is as a seminal aspect to express the activity of music. [8, 9]. In this work we associate the enactive approach and the term "musicking" within improvisation. The specific argument that improvisation is essential within music teaching and learning is held by a growing number of music pedagogues [8, 10, 11, 12] and deeply integrates the fundamentals of music into a more comprehensive musicianship [3, 9]. Furthermore, due to the intrinsic nature of improvisation, it is considered as a highly inclusive and cross-cultural practice in which people participate in a more embodied form of music-making than that entailed in repertoire performance. Improvisation is an activity that generally

* Supported by CAPES

involves spontaneity for listening and acting and, in this task is addressed from the perspective of pedagogy.

As stated by Varela et al., (1993) "*The term enactivism was chosen to emphasize that cognition is not the representation of a predetermined world by a predetermined mind, but rather the representation of a world and a mind based on a history of the variety of actions that being in the world performs"*. The enactivist theory does not yet offer a fixed method of assessment, however its ideology proposes a set of concepts that illustrate the creative practice of self-reflection and self-assessment. Taking this into consideration, the enactivist approach reveals living cognition as fundamentally improvised [4, 13, 14, 15].

2.1 4E`s of Cognition & Music Pedagogy

Van der Schyff states that enactivism can be defined, broadly speaking, in two ways. First it may be approached according to cognition. Recently, these have been referred to as the "4E`s," which describe the mind as fundamentally: *embodied, embedded, extended and enactive*, and have characteristics in common that led them to be grouped in this way.

The 4E`s model seek to open perspectives on the conception of the human mind by exploring elements other than the brain. The 4 E`s include the body, the environment and even technologies. According to this view, cognition depends on the body - in addition to the brain - to shape and limit cognitive processes: the mind is *embodied*. While it emerges from the body as a whole, in addition to the brain, cognition is also situated, since it also needs the environment to emerge, it is *embedded* [16]. Once knowledge is *embedded*, it depends a lot on the physical and socio-cultural milieu; cognition is *extended* to the environment. The environment defines the cognitive load among other beings and technologies [9, 17]. Finally, based on these three previous principles, there is an *enactive* knowledge, since knowledge is formed through co-adaptive couplings between beings and their environment. Although these principles overlap and build, they are often referred to collectively as 4E´s model of cognition [15, 16, 17, 18].

As improvisation is argued as a situated practice that embraces adaptivity, contingency, and the unexpected [7], an exploration of improvisation through the 4E´s model may reveal new perspectives on teaching, learning, and assessment that could have profound implications for the future of musical education [12, 18].

3. DMIs – Music apprenticeship

Exploring and manipulating an instrument with somewhat arbitrary actions can lead to unexpected results and all these movements are comprehended in the learning music process [1].

McPherson et al., write that a designed digital musical instrument (DMI) can provide an immersive and embodied musical experience without prior training, opposed to the hundreds of hours needed to achieve basic tone production on many acoustic instruments [2].

The design of musical instruments to make performance accessible to novice musicians is a goal that predates digital technology [2]. Although the discussion of the DMIs design within skills development, practice, mapping and the different layers of feedback is mostly focusing on the art of performance, a large number of DMIs are designed with varying degrees of applicability in the educational practice [19].

The diversity in the framework of DMIs design can adopt several typologies related to a range of categories. For example: Inter-actors involved in a performative ecology using a DMI; the interaction input control (e.g., gestures, gloves, keyboards, mobile phones et al.,); the control parameters (e.g., pitch, duration, dynamics, timbre, vibrato, other audio effects) and the typology of the system, ranging from sequenced to generative responses [19] are dimensions adopted from [20, 21, 22].

A digital musical instrument is constituted by more dimensions than just the physical and that these dimensions are also capable of eliciting perceptual experiences and even insights [23]. It embeds musical culture and musical work practices considering that its framework is designed within a wide range of dimensions and the result will be informed by the conceptual capabilities and contextual choices of its creator [23].

Musicians and designers have several motivations to build their instruments, among them: bring greater embodiment to the activity of performing and producing electronic music; improve audience experiences of DMI performances; sound synthesis development; build responsive systems for improvisation [24] and promoting new pedagogical approaches [19].

The focus on improvisational musicianship using DMIs for education, responds to a broader demand to 21st century apprenticeship [2, 3, 25]. If the body plays a key role in determining musical learning [26], so does the socio-material and cultural environment in which it is *embedded*.

DMIs expand the traditional acoustic instruments and challenge the musical practice towards new corporeality, materiality, control and feedback [19]. An enactive approach applied to DMI design comprises users and interfaces immersed in a shared autonomy system, so both co-evolve from the experience of interaction [27]. The machine ability regulates the control input which include, for example, gestures, tangible user interface, sensors, keyboard, sound, joysticks, gloves, VR glasses, semi-haptic and haptic interfaces, and respond to this through its actuator [19]. An autonomous DMI is represented by the interface and the performer coupled through their sensors/actuators resulting in an embodied system [27].

Dobrian & Koppelman write that in trying to design an instrument that will enable expression, it is necessary to consider how the performer will provide musical expression, notably how the performer's gesture will affect the sound [28]. Figure 2. represents the flow of information between the source and the sensorimotor gestural feedback within an enactive interface.

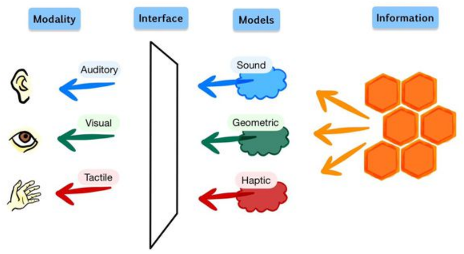

Figure 1. An enactive interface based on a draft by Monica Bordegoni, 2010.

The 4E`s model in DMIs is not only related to the feedback between action and perception, it is also linked to how this sensorimotor loop, is translated to the symbolic domain under which it operates the system control and instrument processing [27]. The communication between the performer´s gesture and the DMI sound response will determine the cohesion of the established temporary unity. Technologically enhanced listening accompanied by gestural feedback may become a tool of great significance for learners in the 21st century [3, 9, 26]. Existing between the acts of musical study, the practice of performing and listening through DMIs [29, 30] may provide music learners with a profound perception and sensibility for music that can shift the way they get into listening, improvising, performing and any activity that involves an aural sensibility [2, 3].

4. The 4E`s model within music improvisation

Thor Magnusson writes that "the analysis of digital music systems has traditionally been characterized by a phenomenological approach. The focus has been on the body and its relationship to the machine, often neglecting the system's conceptual design" [30]. His work investigates the epistemic nature of digital musical instruments dimensions. From an epistemological or music-theoretical perspective, his work addresses the culture-theoretical aspects that so prominently define their nature within eight axes: *Expressive Constraints, Autonomy, Music Theory, Explorability, Required Foreknowledge, Improvisation, Generality and Creative-Simulation.* The *Improvisation* axis indicates the degree to which the instrument lends itself to free improvisation, how responsive it is, how open for changes in real time performance and how quickly can it be adapted to those.

Considering the improvisation axis from the epistemic dimension space by Thor Magnusson, which is based on the work from Birnbaum et.al [31] and the DMI control input addressed through bodily motion, we propose an overview of digital musical instruments. In order to provide novel insights that may help inspire a richer understanding of what musical learning through improvisation within DMIs entails, the following aspects (or questions) concerning the 4E`s model are described:

• *Embodied*: focuses on the body-instrument relationships and understandings outlined by the DMI`s design. An *embodied* account describes music perception and musical action not as divorced, an intuition for melodic/harmonic/rhythmic involving more than the brain [9].

• *Embedded***:** represents the amount of music possibilities explored and developed in physical, sonic, historical, social, cultural and gendered world(s) [15]. How can a DMI be an effective improvisational tool considering the environment and all musical genres such as the carnatic music, cumbia, or simply bossa nova?

• *Enactive***:** represents how much of depth the DMI holds within the capabilities-in-action. This factor regards how the engagement with the instrument affects the learning curve [17]. How can the DMI transform the ways we engage with the world musically, sonically, socially, emotionally and so on?

• *Extended***:** Specifies how our creative possibilities can be enhanced through interactions with co-performers, technologies, and other non-organic ecological factors. How can a DMI help to facilitate the musical creative development? An *Extended* phenomenon emerges in relation with devices and environments that co-constitute music-like behaviors (and not only "afford" them) [9, 32].

The 4E`s model applied to DMIs design comprises users and interfaces immersed in a shared autonomy "*autopoietic*" system, so both co-evolve from the experience of interaction. An autonomous DMI is, therefore, an embodied system that satisfies its internal goals through its actions in the environment [27]. The enactive approach provides new possibilities for DMIs design considering the human interaction in the social cultural milieu.

5. *AMIGO* and *AM-I-BLUES* within the context of musical improvisation and the 4e`s model

In this section, we illustrate how two examples of digital musical instruments can be seen through the lens of the 4E`s model. Naturally, this is a subjective approach, and would ideally be performed by way of user surveys [31]. We took one of the two examples from a catalogue compiled across all editions of the International Conference on New Interfaces for Music Expression (NIME) with varying degrees of DMI applicability in the educational practice [19]. The second example integrates the existing technology from the first one: A handcrafted plywood structure which includes all hardware components of an illuminating bar to be placed on a MIDI keyboard.

AMIGO is a digital musical instrument that promotes embodied and enactive sense-making in music theory environment. The DMI main aim is to learn to improvise melodies [30]. Gradation colors (from yellow to red) guides the user on a physical keyboard mounted with a LED stripe. The intelligence of the system relies on its capability to derive probabilistic models of note transitions from existing musical examples encoded in the MIDI format. A computer screen translates user actions into musical notation, which can be edited and retrieved at a later stage.

From the 4E`s model perspective, *AMIGO* can be considered bordering on an *embodied* instrument since it promotes continuous integration of sensorimotor activity (action-as-perception). We consider that it cannot be thought of as an *embedded* tool since it is related only to Western music formalisms, hence it does not boost adaptive behavior within the socio-material and culture niche we may inhabit. Although *AMIGO* can be situated within a world with which it interrelates, this work is addressed to a worldwide musicianship. It is a DMI with *enactive* properties since it offers capabilities-in-action for the learning music process through improvisation and music theory contents as shown in Figure 5. Lastly, it has extended aspects since it is an intuitive tool for the creation of musical structures. Its main aim is to stimulate the learning musical process through improvisation; in our rough analysis we consider it as an extremely *extended* DMI.

Fig. 2. AMIGO's interface displaying the music notation feedback and its MIDI controller mounted with a LED stripe.

Finding the right chords to adjust a melody or the right melody to adjust a chord progression is often in the improviser's task. *AM-I-BLUES* [25] is a DMI that integrates two existing technologies: the illuminating controller interface of *AMIGO* [6] with the generative jazz model developed for the *MyJazzBand* installation [34]. The resulting DMI aims to introduce novice pianists in the improvisation of blues and jazz melodies by guiding them via the visual feedback of an illuminating keyboard. *AM-I-BLUES* fosters a musical understanding and expressiveness of the mechanics and theory of melodic improvisation within the blues/jazz idiom without music theory knowledge. Yet, the DMI was designed to consider some prior performative skills on the keyboard, as the target user is mostly restricted to novice pianists.

Fig. 3. The Illuminating Keyboard. The plywood structure holding the LED array docked to the MIDI Keyboard controller.

The major novelty of *AM-I-BLUES*, in comparison to existing illuminating keyboards, is the use of a generative system, which provides harmonic sequences on-the-fly, to which multiple optimal solutions for note selection are provided for melodic creation.

The control input of this system, the MIDI keyboard, are in our context, a *embodied* framework of a DMI, promoting intense interactive feedback between action and perception. This DMI is focused on the blues/jazz idiom and it can be situated within a world with which it interrelates, but once it is focused on Western music context, in our subjective analysis it is not *embedded*. The generative jazz model provides a way of interacting with the music including implied structure of beats and tempo for learning to improve guided by the system; therefore, we hold an opinion that it is an *enactive* system. As the system stimulates adequate motion and creative potential, we may consider it an *extended* DMI. The system is presented on Figure 3.

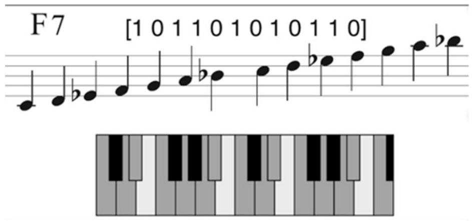

Fig. 1. One example of generated scales corresponding to the first two chords of the blues progression (F7).

The active notes, represented by a "1" in the vector, correspond to the correct notes suggested by the generative system for the Lead instrument and are illuminated in the LED bar in red, while the inactive notes are lit white (see Fig. 3).

6. Discussion

Toward the aim of a meaningful music pedagogy through the 4E`s model within DMIs, we suggest designers and musicians a reflection upon the following questions:

• *Embodied* - How can the sonic/musical result of the DMI developed from the body/mind movement provide new perceptions and experiences that provoke melodic, harmonic and rhythmic intuition [12]?

• *Embedded* - Would it be possible to improvise in another milieu with other instruments of a given culture with the DMI? What roles does the DMI in different socio-cultural environments? How a DMI within the environment could be efficient to facilitate other ecological factors of musical categories, including rhythm, pitch, harmony, voice, variation and forms?

• *Enactive* - Which contributions have the DMI to improve the capabilities-in-action of the sensorimotor capacity to improvise?

• *Extended* - What are the DMI creative possibilities to enhance or make possible interactions with co-performers, technologies, and other non-organic ecological factors [13]? How the DMI can enhance the creative development?

7. Conclusions

We believe that the underlying theoretical and conceptual foundation of the 4E`s model within the design of DMIs can contribute to the contemporary social challenges supporting the skills and needs of 21st century music learners. The enactive music cognition to improvisation detailed above does not offer a fixed method of assessment; nevertheless, we hope that it will resonates with a rich pool of ideas and research for DMIs designers and musicians.

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