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Ever-shifting roles in building, composing and performing with digital musical instruments

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ABSTRACT

It is widely accepted that computational technologies shape the relationship of musicians, instrument builders and composers with music, affecting various socio-cultural realisms in music. In this article, I discuss in what ways music-making still emerges as a social construct, even as a result of the mutual cooperation with human musicians and AI-powered autonomous instruments. I argue that building, making, and performing with a digital musical instrument has undergone a gradual socio-technological change that has affected art, science, technology, culture and communities in general. I support my investigation through the current performance and composition practice of the autonomous AI-terity musical instrument.

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Introduction

It might not seem surprising anymore that the recent changes in technological imaginary practices in arts involve the latest artificial intelligence technologies and deep learning algorithms. AI models have been the most recent trend for artists to experiment with advanced technologies. There is an explosion in the application of artificial intelligence in academia, with a creative and arts-based research interest to build machines that have the full potential of provoking human creativity. The creative industry has experienced major developments that led to a large expansion of focus in exploring possible combinations and solutions for various tasks that go beyond what humans can do; in services like entertainment, advertising and streaming. The growing use of AI in music to support musical creativity is also well known. In music, deep learning models are employed through more advanced computational methods such as generative adversarial networks (GANs), recurrent neural networks (RNNs), convolutional neural networks (CNNs) for optimisation, prediction, style transfer, audio generation, and classification. The current methods and models shape the implications of AI's usage in music practices, and they are not limited to only automation anymore. In fact, the research in artificial intelligence applied to music shows a wider spectrum of interests in forming technologies and musical instruments, aiming to ascribe

a certain amount of musical agency¹ to a musical instrument (Tatar & Pasquier, 2019). Such autonomous features and intelligent behaviours offer alternative performance possibilities to musicians.

At the same time, these technologies challenge the musician's understanding of their potential applications in music, notably in musical practice that is more adjacent to arts-technology research and development. Not only the lack of transparency of AI technologies (Schmidt et al., 2020) and resulting lack of trustworthiness (Mitchell, 2019) but associating the autonomous behaviour of AI models to human embodied experience with music (Collins, 2007; Tatar & Pasquier, 2019) shows an increasing number of concerns in relation to the nature of AI technologies. Some important aspects of AI's autonomous power in music have hardly been discussed in detail so far in relation to human's music-making experience; what is the social connection of the autonomous behaviour of the musical instrument to the specific subject of music – the human musician? Is the autonomous musical instrument part of human musician's identity, part of individual self-musicianship, or is it

¹ I use the term musical agency with consideration on the ways *agency* arises through the autonomous acts of the musical instrument that support establishment of musical identity (Tanaka, 2006) on a collective level, regulating social actions, coordination and building a basis for collaborative music action between musician and the musical instrument (Karlsen, 2011).

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something that occurs to human musicians as a separate, an alternative as in *otherness*? If so, could it be considered as a tool of liberation or an act of imagination of a musical instrument that provides a music making, which is completely independent of the human musician?

Central to the distinctive concerns, in this article I address the current use of artificial intelligence technologies in the creative practice of instrument builders, unbinding the ever-shifting relational roles between musician and musical instrument. Computation technology's available power to autonomously affect music-making does not simply outline music, but *co-determine* how music can *be present for* (Ihde, 1990) and perceived by human musicians. Further in the article, I present the AI-terity musical instrument as a precedent for reflecting my viewpoints on implications of social and technological transformations in building, making, composing and performing with digital musical instruments. It is important to examine further how transformations and appropriations are recognised in the domain of research and artistic practice of music technologies.

Human connection to digital musical instrument

When we step into a studio or onto a stage, confront the keyboard of a synthesiser or a computer, or pick up an unusual new instrument, we are being drawn into the music through a particular relationship that allows us to make sense of our musical actions. The relationship takes place through the ineluctable nature of available technologies, and between the musical instruments as embodied objects of culture and the human bodies that inhabit and use them. In this complex relationship, technological and socio-cultural factors (shared ideas, embodied behaviours, expectations, beliefs, interpretations, our histories, etc.) set conditions for us, for the interactions we develop and for the musical experience we create with musical instruments (Tahiroğlu, Magnusson, et al., 2020).

The complex relationship exists in all music with all instruments. Since the primary focus of the article is on digital musical instruments,² this for sure merits further inquiry; how then do digital musical instruments contribute to a music-making experience? How do musicians and instrument builders consider the complexity and diversity of the technologies, at the same time linking music to a whole range of new practices

and social actions? It is in parts something we know; all music appears as a *synthesis of cognitive processes* in human activities associated with humanly organised sounds (Blacking, 1974). Blacking (1974, p. 26) describes the music-making experience in two forms of patterns that occur in the process: *patterns of human organisation* and *the patterns of sound produced as a result of organised interaction*. The former is often described as social relations, connections, circumstances and activities. It includes learned behaviour, social inhibitions and musical values that predictably are consequences of a particular socio-cultural environment. Blacking further explains with the latter that in music practice, the artist, musicians add the patterns of sound, emulating a form of experience and interaction with the socio-cultural circumstances and making use of existing socio-cultural factors.

Musical practices with digital instruments are built on similar underlying principles. It is just that in digital music practices, while the underlying principles remain the same, musicianship, technology, composition and the performance environment are all often conceptualised to the degree that they become embedded in people's musical instrument building practice, thinking about music, themselves and their relationship with their communities. This embedded practice feeds into the music itself, which further impacts audience experience. A very important thing to take into account is the capacity of individuals in such embedded practice; they are not just producers of new sounds, they are also builders, they are composers. For instance, composing music for digital musical instruments requires producing alternative notating systems including the programming code and the hardware electronics used in the piece. The alternative notating system often includes an audio-visual performance setup in which the piece will be presented to its audience. Then the notion of composition transforms into 'systems design, which involves integrating an assemblage of heterogeneous elements- hardware, code, protocols and standard' (Magnusson, 2019, p. 120). D. Andrew Stewart's *Still Life: Eviction*, a composition for the *T-Stick* instrument is a good example in which the emulated techniques on wind instruments have been modelled as part of the composition and built into the instrument's audio synthesis module (Malloch & Wanderley, 2007). *NOISA Etude #3* (Vasquez et al., 2017) and *Church Belles* (Waite, 2016) are other composition examples, which were built on the design criteria that were set for building the instruments. These compositions can be thought of as part of the musical instruments, in terms of their forms, features and behaviours. The compositions could also be described as systems utilised through the ways their compositional ideas are

² Here I am referring musical instruments where the digital sound generator is separate from the control interface (Malloch et al., 2006), at the same time, instruments that adequately reflect instrument building in the matter of; building meaningful and impactful performer-instrument-audience-environment experience with its own physical and interfacing shape, sound-action space, sonic indications and performance practice.

employed in the building principles, structures of the instrument.

The embedded practice of building musical instrument shifts relational roles between the *musical actors*,³ composers may also take the role of a developer of an interactive system, rather than the person producing notated scores (Johnston, 2016; Magnusson, 2019). These roles could be seen as a dynamic set of orientations, which are shifted at different times during a live performance, or in the moment of building the instrument (Gurevich, 2017). Morreale et al.'s (2018) survey shows that *New Interfaces for Musical Expression* – NIME⁴ developers often see their musical instruments as inseparable from their music piece. Johnston (2016) describes the issue of in-separation of musical instrument from its musical piece as *composed instrument*. In fact, it is not surprising to see the relational roles in instrument building have already been an established practice in the NIME community. It is centred around rapidly evolving technologies associated with digital music practices, which become the subject of creative and artistic exploration.

The key technological aspects are based on exploring the domain of Art-Technology, in particular using computational tools on building, developing and performing with digital musical instruments. Computation exists as direct in digital musical instruments as electric to rock music and as physical as reed or pushing buttons in clarinet (Tahiroğlu, Magnusson, et al., 2020). Here what I mean with computation is simply the ways musicians interfacing the technology and effecting the computation technology to bring up a capacity to let music become present through digital musical instruments (Ihde, 1990). Computation in one way shapes our cognitive processes on both embodied and conceptual levels, having an influence on the structure and aesthetics of the resulting music-making experience (McPherson & Tahiroğlu, 2020).

The AI-terity musical instrument

Following this line of thought, we have been building and developing the AI-terity musical instrument since January 2020 in our Sound and Physical Interaction – SOPI research group in Aalto University, School of ARTS. AI-terity is a deformable, non-rigid musical instrument



Figure 1. AI-terity is a deformable, non-rigid musical instrument that comprises an AI method to generate audio samples.

applying AI to generate audio samples for real-time audio synthesis. We presented the initial version of the instrument at the Ars Electronica Festival 2020 and at the New Interfaces for Musical Expression 2020 conference (Tahiroğlu, Kastemaa, et al., 2020). Figure 1 shows the new physical appearance of the instrument in which stiffness and physical deformability turns into an opening of the instrument's folded shape. Partially folded shape of the instrument gives further opportunity to the musician to access the instrument in a number of different ways. It is possible to physically deform the instrument, bend, twist with a handheld contact and through that explore its soundworld.

Audio synthesis module in AI-terity

The audio synthesis is built on a specific kind of generative adversarial network (GAN), using deep neural networks – machine learning models which contain a series of layers of artificial neural network components for generating audio samples. GAN models are good at learning the overall traits of sounds over very brief time periods. GAN is a recurrent generative adversarial network, a type of generative model where two neural networks – known as generator and discriminator – compete towards each other (Goodfellow et al., 2014). The discriminator network tries to distinguish between real and generated data (e.g. images or audio samples), and is firstly trained with a known data set. The generator network aims to produce data that the discriminator cannot tell apart from real data. During training, both networks become better at their respective tasks through back propagation, resulting in a network that generates very realistic data.

The advanced computational features within the audio synthesis domain, allowed us to explore numerous options that are more embodied in the performative practice of the instrument. The process resulted in a particular

³ Magnusson (2019) argues that *transformation of tradition* in new music practices constitutes transformations in the ways we perceive 'the instrument, the score, the composer, the performer, the audience, etc' as musical actors.

⁴ New Interfaces for Musical Expression (NIME) is an established research field that shares and supports the knowledge and recent work since 2001. The period that started with NIME conferences saw a boom in the interest of building, developing and practicing a wide variety of digital musical instruments and it questioned broadly the complex relationship between music practices and new technologies.

focus to develop a *digital idiomatcity* to the AI-terity instrument. For that purpose, we implemented a novel hybrid architecture, GANSpaceSynth,⁵ applying features of the GANSpace (Härkönen et al., 2020) method to the GANSynth (Engel et al., 2019) model. The greatest advantages of the GANSpaceSynth deep learning model is the ability to specify particular audio features to be present or absent in the generated audio samples. Rather than randomly sampling the distributed audio features in latent space, having the possibility to control the generative features in the GAN model built up a unique sonic characteristic in the AI-terity instrument. Even though the relationship between points in the latent space to the generated audio samples is complex, AI-terity provides an opportunity to explore GAN latent space in a more structured way.

Autonomous features and otherness

The instrument modulates the parameters of a granular synthesiser, which uses samples from the GANSpace Synth latent space. The instrument keeps track of a specific position in the latent space, which we call the synthesis centre point (SCP). The SCP can be moved along the three-dimensions of the latent space, spanned by the three most significant audio features found in the trained checkpoint. These audio features are used to generate audio samples in real-time. The point can be moved by the musician manipulating the instrument and by the instrument autonomously. The musician can navigate through the latent space by deforming different parts of the instrument.

The goal of the instrument's autonomous behaviour is based on the musician's choices in the state of performing, aiming not to allow the musician to stay in one place too long in latent space. This is done by tracking the interaction rate of the musician. The interaction rate is the running average of the change in the instrument's position in latent space over time. If the interaction rate is low for long enough, we assume the musician has found an interesting position in the latent space. These subtle changes in musical actions are intimately connected to what has been performed recently and to a state of playing with rarely taken exploratory musical actions. Tracking such conditions makes the instrument autonomously move the SCP in latent space to generate audio samples. The autonomous behaviour aims to make the musician explore the AI-terity instrument, not on the basis of what has imagined is possible, but with a challenge of

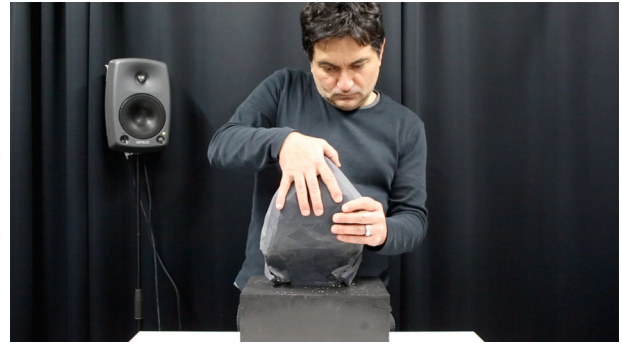


Figure 2. The composition *Uncertainty Etude #2* is written by the artist researchers involved in the building phase of the instruments and the piece is performed by Koray Tahiroğlu, one of the artist researchers in this project.

discovering new ways of playing that could emerge from the instrument itself.

The appearance of new sounds on the synthesis level in the moment of playing and being able to gradually move through sonic space, allow musicians to explore a whole new range of musical possibilities with the instrument. In order to explore the features of the instrument, we composed the piece *Uncertainty Etude #2*, entitled to reflect the autonomous behaviour of the AI-terity instrument. Figure 2 shows the studio-recording session of the piece. The composition keeps the musician in a state of *uncertainty*, providing a continuously changing but an identifiable musical response. It is of course an unusual behaviour one might expect from a musical instrument to change its sounding characteristic in an exceedingly autonomous way throughout the performance. At the same time, being able to deal with autonomous behaviour allows the musician to build up a connection with the AI-terity instrument, which unfolds into a particular type of human-technology relationship.

The term *alterity relationship* was coined by Ihde (1990), describing one of the phenomenological modes of technological mediation that appears in the human-technology relationship. The nature of the relationship may be characterised by mutual cooperation and or conflict. The term appears to have been introduced as a way to address differences between the independent decision-making orientations, bringing up an equal sense of *interacting with something other than me* as discussed by Ihde. In this sense, the AI-terity instrument does not appear to be a *third party* but rather as the *other*. The term *other* is often used in relation to an alternative view of our world where *the other* can be identified as a separate, distinct entity, *other of two* (Ihde, 1990). A common-sense view of *alterity relationship* with technology, for reasons of convenience, rather is a social construct, which is in principle, one of mutual cooperation. In other words, the

⁵ GANSpaceSynth is an open source project and available at https://github.com/SopiMlab/DeepLearningWithAudio/tree/master/04_ganspacesynth

autonomous nature of the AI-terity operates not only by an autonomous action of the instrument but through a process of mutual interaction between the instrument and the human musician.

In Tatar and Pasquier's (2019) autonomy spectrum, AI-terity's autonomous behaviour falls into a category where the behaviour is complex enough as to not be purely reactive, but the behaviour's goal and methods of reaching the goal do not represent features to be fully autonomous. AI-terity's autonomous behaviour changes in response to the performance of the composition and keeps the musician to remain in an unusual and uncertain state of playing. The composition is performed together with the AI-terity instrument and the musician who does not take the instrument as an instrument to be played but as an agent that is *other* with autonomous traits to be heard. It is a common ground in the field of performance art, where a performer can develop or create a relationship with any object in order to produce and express something different and exciting to the audience in a specific way by means of a performance. In this type of relationship with the AI-terity instrument, performing with the *other* builds up a type of social connection in which the performer and the instrument can come together to achieve musical actions.

My ambition here is to use the term social in its given situation, under which the social to be applied to a joint action that emerges between a non-biological object, an agency and a human musician. More specifically, I aim to examine how the social is formed in a *collective* that is composed of a human musician and an autonomous musical instrument. Actor-network theory (ANT) is a guide to better understand the idea of building social connection in which the autonomous instrument will join in the social as an agency (Latour, 2005). Since Latour explains agency, not only as a reserved term to human actors, but as 'anything that does modify a state of affairs by making a difference' (Latour, 2005, p.71), so we can question whether the autonomous instrument makes a difference in the course of music-making and any parts of that difference could be recognised or not. The answer, yes, suggests to focus on the activities of the social and to Latour's description of the social as made of 'associations between heterogeneous elements' (Latour, 2005). It must be taken into account that the social dimension of the music has been widely discussed in ethnomusicology studies. These investigations have been carried out to show possible connections between evolution of music and human social capabilities (Schulkin & Raglan, 2014). From an evolutionary perspective, music can be seen as a form of cultural communication that has a capacity for emotional resonance and emotional impact (Savage, 2019). At the same time, the focus on the social aspect

mostly centred around human social contact, networks, communities, identities and development of musical genres in different musical worlds (Cohen, 1993).

In this section, I do not claim to provide a comprehensive definition or account of the social implications of the emergence of new musical instruments. It is also not my intention to provide digital musical instruments' social aspects and what might be expected of new musical instruments and their social consequences on the listeners and communities. I discuss an issue that remains largely in the exploratory nature of *social connection to digital musical instruments*. Here I provide an approach, rather than a single, overarching concept. The following account of social connection is helpful in understanding this section: I focus on social connections through the relational roles and interests that appear between human or non-human actors, in their active involvement in building and making musical instruments as well as performing or *musicking*⁶ experience with them. The social connections can be investigated through the relationship between musicians in an ensemble, artistic inspiration from one musician or composer to another, the exchange of design ideas in communities and the relationship between musician and the instrument.

Social connection to an autonomous digital musical instrument

The AI-terity instrument demonstrates how the social connection between the musician and the instrument can come about to be more a reciprocal relationship. In the first instance, this relationship is the interpretation of the musical action (activity) that is not one of the acts of the musician in performance but is a part of a social connection related to the mutual action of the instrument and the musician. In such a social situation, both human musician and autonomous instrument exist naturally in musical activity where the social situation transforms itself into an 'assembling, collecting and composing' (Latour, 2005).

There are a number of precedents for interaction performance and improvisation systems that foster similar kinds of relations, Lewis's (2000) *Voyager* being one famous example. *Voyager* is an interactive musical environment, a composition, a computer programme that allows musicians to engage with a 'virtual improvising orchestra'. It is a computer-driven improvisation system that performs an independent behaviour by generating 'complex musical responses to the musician's playing' (Lewis, 2000). The autonomous behaviour is built on an

⁶ Christopher Small (1998) coined the term *musicking* as a verb to emphasise the social nature of music as something that people do.

internal process that analyses various aspects of human musician's performance in real-time, such as pitch input and improvised actions in what has been played. Voyager is acknowledged as one of the most performed work by computer music composers since 1987 and holds a special place in human–computer interaction (Steinbeck, 2018). The autonomous structure combines a number of techniques that are described in Voyager's own musicality and through the ways the system has been involved in improvisational music. The techniques include assigning algorithms for specified microtonal pitch set, simultaneous multiplicities of timbres, sonic behaviour groupings as well as melody, volume and tempo ornamentation (Lewis, 2000). In that sense, the autonomous characteristics of the Voyager are significantly different from the AI-terity instrument, in possible ways the Voyager responds in an improvisation with a human musician. Lewis (2000) describes the independent behaviour of the system questioning the nature of human identity in a given situation in which the identity could continuously be reimagined through the exchanged feedback, perspectives, negotiations and interactions. Doing that, he aims to encourage to think about the personality or identity of the Voyager being conditioned in an act of music improvisation, '*articulated through sonic behaviour*' as well as in relation to the human musician. Lewis approaches the autonomous identity of the musical instrument from a perspective referring the identity of the Voyager to the human expression. Consequently, he calls Voyager a vehicle that drives our human creativity and intelligence, as such, it is *a tool of liberation*, rather than a self-independent identity (ibid).

In a similar manner, Auslander (2009) discusses the autonomy of a digital musical instrument by looking into the relationship between a musician, Mari Kimura and a robotic musical instrument, GuitarBot. GuitarBot is a large, sculptural looking musical instrument designed by Eric Singer. It has four strings, each independently can be controlled through a mechanical slide and a plectrum. The instrument could be computer programmed to play. Kimura wrote the composition and the programme GuitarBotar for GuitarBot to perform the written score as well as improvise together with her in a live music performance. Auslander (2009) points out that despite the mechanical movements, the instrument retains the essence of the human musician. GuitarBot has all the attributes of a body-type that can move physically, as it can lean back and forth. The ability to move the string and control it through the mechanical interface of a slider would likely lead to larger musical actions to be programmed and performed. Auslander's observation reveals the autonomous characteristic of the GuitarBot throughout identifying Kimura's particular relationship

with the instrument in the moment of the music performance. In fact, Kimura herself describes GuitarBot as a separate entity. Auslander mentions that the ways Kimura positions her bodily movements towards GuitarBot show that she actually perceives GuitarBot as another musician (Auslander, 2009).

It is clear that GuitarBot is not a genuinely autonomous musical instrument compared to the AI-terity instrument. GuitarBot performs only the given score and does not make any musical decisions. What is really interesting here is that the autonomous characteristic of the instrument is mainly observed as part of Kimura's *individual self-musicianship*. She does not '*qualify the instrument as a subject apart from her*' (Auslander, 2009) and yet she performs music in the presence of her instrument. But this is not to preclude other instruments not to be considered as playing at an autonomous level. Indeed, it can be argued that all musical instruments must be considered as such. However, Auslander calls it 'apparent autonomy' which is an effect created through Kimura's relationship with the instrument. Arguably, it possesses an identity and an *otherness* could be observed in this level of autonomy as '*GuitarBot acts as Kimura's Other in this performance*'. There is an alterity relationship with GuitarBot and its autonomous interpretation is strongest in the realms of social connection between Kimura and the instrument.

The notion of 'autonomous entity' does not signify the possession of super-powers, but indicates that the entity or *agent* characteristics of an autonomous instrument are more completely developed and that their fundamental creative acts in music are brought into more direct focus through human musicians. This is but one instance of how the autonomous identity of AI models or other digital instruments in general becomes present in relation to the social connections they constitute in the act of music making with human musicians. However, we must realise that the autonomous identity of the musical instrument is shifting the relational roles between musician and musical instrument. Exceptional autonomous-behaviour potential of the instruments may be to a great extent hereditary in applied particular algorithms, but they are involved in the development of particular musical ideas, that do shift some innate aspect of the musician or instrument.

It is possible to see that in the course of my discussion on the autonomous behaviours of AI-terity, Voyager and GuitarBot instruments, it is the social connection of the instrument to the human musician that creates and reinforces the musical idea itself. This is not something we can ignore, but instead, we must keep it in mind in case we want to strengthen the autonomous behaviour of the instrument.

Transformations in digital musical instruments

So far only the general aspects of social connections with autonomous instruments in digital music practices and shifting relational roles have been considered. This section is more directly concerned with the embedded principles of building, composing and performing that are connected to the emergence of new music technologies. Music technologies from all research and practice communities, all genres, at all times offer various opportunities for integrating the sound-producing techniques and human tendency to engage with music, enhancing (maximising) digital musical instruments' functions with numerous fundamental capabilities and their aesthetic appeal. Music has been profoundly affected by the progression of digital technologies. Over the last decades, digital music practices have been closely linked to the increased access to digital media (through online remote sources in the internet and others) and the dynamic communication in all types of digital art forms between artists and their audiences. Consequently, our relationship with music is on the edge of digital technologies and its involvement with a fluid community of creators, developers and practitioners, supporting a diverse range of interactions and social or individual goals (Goddard & Tahiroğlu, 2013; Parkinson & Tahiroğlu, 2013).

This perspective draws on the notion of music as an art form of human social activity, a practice in its various forms (instrumental, vocal, or ensemble) that is in a state of transition in its relationship with technology. In particular, I stress the interplay of technology and socio-cultural factors, considering both as necessary for a further understanding of the phenomenon; making, building and performing with digital musical instruments.

Socio-cultural factors allow us to understand the values and beliefs shared in music, coordinate us with specific actions with musical sounds, and provide a set of motivation for the construction of new skills and competence. Moreover, our listening behaviour, our judgement of sounds in view of musical ideals, our responses to a given aesthetics in music, our responses to familiarity and complexity of that music and the situation in which music is performed depends on the factors at a broader level of cultural (our) interpretations. Stage, for instance, has a socio-cultural identity for music performance, representing a social norm for performer and audience. Similarly, what is to be considered as musical instrument, its sonic-indications, in which particular musical behaviour occurs depends on the cultural lens we use. Therefore, understanding the *cultural embeddedness of technology* (Ihde, 1990, 2010) in digital music practices is important to discuss critically technological

rationality in building and performance practices of digital musical instruments. It is not my main intention to define or redefine social science meaning of culture or anthropological or scientific concept of culture, but rather approach the word *culture* as a set of norms that are in one way embodied in practice in a particular community. My main intention here is to question further; in what ways technology further enhances the influence of the socio-cultural factors in digital musical practices?

Transformation of technologies

Green (2008) presents a notable approach to socio-cultural constraints and technology-as-practice ideas in music, distinguishing through Feenberg's (2003, 2010) primary and secondary instrumentalisation ideas. In the primary instrumentalisation view, the object or artefact is considered in an abstract generalised sense (decontextualisation); then the object is described only in descriptions which serve a goal (reductionism); consequences of actions shielded, or disconnected such that processes can continue with no additional effort from the actor (automatism); and finally, the technology is positioned so that functional affordances can be turned towards advantages of the actor (Feenberg, 2003). Secondary instrumentalisation is all about establishing the social meaning of the artefact (Feenberg, 2003). When using the technology, a particular device, we have our own histories as well as a context informing our sense of intention. Finally, the device itself discloses a strategic advantage that affords re-appropriation by its users. It is important to note here that primary and secondary instrumentalisation is analytically distinct (Feenberg, 2003). The initiative and social process that is involved in the secondary instrumentalisation properties help to assess the primary instrumentalisation, situating it in a wider context by reflecting social values to the design.

Arising from technology-as-practice and music-as-practice ideas, Green highlights how social factors affect and facilitate changes in the function of technology and music. The assumption of change of function or appropriation of technologies is a foundational premise for most digital musical instruments. In other words, it is a common practice in digital musical practices that we take technology from somewhere else, from another discipline or from another field and appropriate it in our practice. Doing that does not necessarily mean taking the whole baggage of its culture or tradition, but rather, it is in relation to the need to address the ways that allow for the integration of technology into our practice. The examples can vary from laptop or desktop computer to depth camera, game console or mobile phones, micro-controller technologies or programming languages, etc.

Appropriation of technologies encompasses digital musical practices, through which new ideas about their use are explored.

Technological appropriation is often associated with resourcefulness or ingenuity in adapting, incorporating tools to one's situation (Dourish, 2003; MacLean et al., 1990). The process of appropriation opens up a new disclosive space that facilitates change in the function of technology and music. Ihde (1990) argues that science changes through its instruments, appropriation of technology reveals the exploitation of change in music.

Technology appropriation in the AI-terity instrument involves algorithms that are designed for pitched-audio sample generation and for image generation with editable features. The appropriation here involves the use of generative adversarial networks, GANs, a type of artificial neural network methods applied in image processing in the first place. Another part of the appropriation deals with the instrument's ability to generate musical forms. This process involves a combination of 'audio building' methods with the use of different programming languages, including Python and Pure Data. The Python module also includes the built-in processing module PyExt, which provides the basic functions for executing TensorFlow modules and audio sample generation. Transformation in AI-terity is in programmers' decision of the original models, from the initial introduction of their algorithmic function and into the stage of their appropriated role in the process of composition of a musical idea.

A recent briefing-report on the use of artificial intelligence in the cultural and creative sectors shows that artists build their technological solutions appropriating open source programming libraries provided by big corporate companies, Google, Facebook, etc. (Research for CULT Committee, 2020). Appropriation of the artificial intelligence algorithms happens through freely available and open source software, commonly published in platforms such as Github. Open source software libraries for machine learning, such as TensorFlow or Keras, make it possible for artists and musicians to access, build, manipulate and apply the deep learning models to music-making practices.

Technologies into communities of instrument builders

Open source communities have always been prioritising code sharing, supporting a wide community of contributors and developing *community values* that members attach to their actions. These community values result in questioning not only the intellectual properties, copyrights or capitalist economies, but also in relation to

practises of participatory culture, *voluntary collaborative labour*, appropriation and shared responsibility (Ceraso & Pruchnic, 2011). Further development of open source projects is highly appealing in the communities of music technology. Open source projects build up a capacity for accumulations and transmissions of cultural knowledge,⁷ which feed into the loops between technologies and musical practices.

Technology appropriation ties with cultural appropriation in possible ways people take up 'technologies into the social, economic and political spheres of their lives' (Lindtner et al., 2012 pg.77) and the ways in which people take 'intellectual property, cultural expressions or artefacts, history and ways of knowledge' in their own world (Schneider, 2003 citing the Resolution of the Writers' Union of Canada 1992 in Ziff & Rao, 1997, p. 1). As may be envisioned, the ideas, practices and values travel with the change, modifications, variations and revisions, ultimately shaping appropriations in the communities of institutions, conventions, practitioners, scholars, artists and musicians. There are many communities coming into music technology that exhibit alternative musical aesthetics and cultures of adoption to the built, re-creating digital musical instruments.

Communities inherit *cultural knowledge* from other practices, disciplines, from cultural institutions and appropriate it in their own practice. How, and to what extent, appropriation is accepted by a community has as much relevance as the practice and application of its principles by the practitioners of that community. Born (1995) looks into the development of musical technologies through social and cultural processes of cultural institutions involved in artistic production. She examines the crucial role culture plays in the development of new audio technologies in all possible ways it is involved in music technologies. The critical argument here is that social and cultural factors of technological practices in cultural institutions affect aesthetic, philosophical discourses on promoting and developing musical innovations. It is worth considering this argument here as an attempt to illustrate the association between certain aesthetic practices and musical innovations, a tendency that has not previously been illustrated in the existence of a connection between social, cultural, and technological determinants of institutions. Therefore, it is not necessary to view the practice of technology in the community of instrument builders as a monolithic 'scientific' entity. Social factors (community of interest – community of practice) and cultural conditions (appropriation)

⁷ Gary Tomlinson introduces a model for the evolution of human association with musicking, which reflects the interaction between technology and human relationship within particular cultural domains, between cultural features and ecological processes (Tomlinson, 2015, p. 42).

make the function of the technology (appropriation) in music-making present, demonstrating that digital musical instrument building, composing and performing has been a process that has involved social and technological shifts, transformations and appropriations in view of research, art, science and community as a whole.

Conclusion

In the interest of drawing some connections between human musicians and autonomous musical instruments, in this article, I intended to consider presenting a viewpoint on the current use of advanced computational technologies in the creative practice of instrument builders. More specifically, I made an attempt to discuss the social and technological transformations in this process. Following Blacking's underlying music-making principles, I also made an attempt to explain in what ways music becomes present through a social construct, a result of a mutual cooperation with AI-powered autonomous instruments. It is true, of course, the latest artificial intelligence technologies are powerful to turn a musical instrument into a musical agency that may have its own objectives and self-purpose in music. The overall discussion should be seen as a preliminary effort to explore how the use, practice, experimentation of advanced computational technologies in instrument building lead us to think further about music, art, philosophy, engineering, design, musicianship, technology, the community of people and our interactions with all these. I intended to support my investigation through the current performance and composition practice of the AI-terity musical instrument. In view of the social aspect of the *collective intelligence* in the moment of performing with the AI-terity instrument, there are good reasons to consider artificial intelligence applied to musical instruments as *agents* whose intelligence and autonomous behaviour is inseparable from human musicians.

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