

# **The Migration of Musical Instruments: On the Socio-technological Conditions of Musical Evolution**

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Music technologies reflect the most advanced human technologies in most historical periods. Examples range from 40 thousand years old bone flutes found in caves in the Swabian Jura, through ancient Greek water organs or medieval Arabic musical automata, to today's electronic and digital instruments with deep learning. Music technologies incorporate the musical ideas of a time and place and they disseminate those ideas when adopted by other musical cultures. This article explores how contemporary music technologies are culturally conditioned and applies the concept of ethno-organology to describe the nature of migration of instruments between musical cultures.

Keywords: musical instrument; NIME; ethno-organology; instrumental migration; ergodynamics.

## **Introduction**

Technology has influenced music since humans began using found objects as musical instruments. Objects, such as rocks used to crash nuts, became musical instruments when rhythmic patterns emerge with synchronised movements. Clearly, our pre-historic ancestors were not remotely doing anything close to the activity we call “music” today, but, to be very precise, neither were 17<sup>th</sup> century practitioners of music. Music and our ideas of it evolve and developments in technology underpin this evolution. Technology is never pure or independent of culture: it is always social, political, economic, psychological and historical. This becomes crystal clear when analysing the history of musical instruments. Throughout history, new musical instruments have inspired new technique, performance styles and genres. An example is the arrival of the pianoforte and how it changed the musical landscape of the 18<sup>th</sup> and 19<sup>th</sup> centuries in Europe. Here

was a loud instrument that would fill the space of a large concert hall, and it offered dynamic sound: the same note could be played both *piano* and *forte*. For some, especially harpsichord enthusiasts, it was an intrusion that had many negative and irrevocable consequences (DeNora 1995), as with the promises of the new we sacrifice features that become obliterated (until, for example, a media archaeologist of some sort revisits the technology, the practice and rediscovers interesting forgotten technical features).

Organology is the study of musical instruments, including descriptive analysis, social history and classification. In this article, the notion of ethno-organology is applied to describe the cultural features involved in new musical instrument design and how those are mobilised when the instrument is adopted in other musical cultures. This partly relates to the field of ethnomusicology as the focused study of musical cultures, but becomes more a study of technology: of musical instruments as they migrate between cultural spaces. Organology, such as that practiced by Kartomi (1990), is broad and interested in all the world's musical instruments, but it does not engage with how instruments move between cultures or people (gr. *ethnos*) and the musical impact this implies. We might, for example, trace how the lute entered European culture with the Muslim kingdoms of Spain in the Middle Ages. We would seek to understand how existing musical ideas changed with the arrival of a new instrument but also how this instrument changes in use and function when it was adopted to a new musical context. This is a techno-cultural question: it makes no sense to see technology and culture as separate entities. The ethno-organology introduced here further encompasses the study of instrument migration and cultural influences, how immaterial ideas spread through the vehicle of technology, and how technical elements are adopted to new contexts. When biological evolution is represented, the tendency is to show it as a tree branching

out, where new branches become new species or types. However, the genealogical trees of culture and technics are quite different from those of nature, as cultural and technical elements can be borrowed across species, invented, reverted or removed. A whole research field of memetics has attempted to study the cultural transmission of ideas (Dawkins 1976) and various strands of philosophy of technology have studied the migration of technical objects, for example Science and Technology Studies (e.g., Pinch and Bijker 1987; Pinch & Trocco 2002) and the philosophy of technology (e.g., Simondon 2017; Stiegler 1998; Mackenzie 2002).

### **Instruments as Vehicles of Cultural Dialectics**

The creation of new instruments is always a dialectic process that happens through changes such as new cultural forms, technological advances or architectural improvements. An example is how the makers of the pianoforte responded to demands coming from composers in relation to the dynamics of the instrument, but also from concert organisers who were able to increase the audience capacity (Campbell et al. 2004). This requirement for louder instruments meant that ergonomic considerations were often sacrificed at the cost of more thunderous performance tools (Jordà 2005: 169; Livingston 2000). In the early 20<sup>th</sup> century, we get electric amplification of instruments that previously were too low in amplitude (such as the guitar in a jazz band setting) and new electronic instruments in the form of synthesizers and tape. This changed music in innumerable ways, giving birth to stadium concerts, new genres and important developments in some artists' work, for example Bob Dylan or Miles Davis.

The technological modernity was not only obsessed with amplitude: the rationalisation of the instruments through improved engineering techniques made them more reliable and perfect in pitch, timbre and control. A parallel development took

place in the standardisation of musical notation, establishing constants in the areas of technology and performance. With the rationalisation and technical prowess we see the sacrifice of “fuzzy” or non-linear characteristics in instruments, notation, performance and interpretation. For example, the European flute was developed with linked-keys and valve mechanisms replacing finger holes. This made the instrument more uniform and tones were cleaner, but the dexterous finger control over the hole was lost, a feature that allowed for vibrato and slight pitch changes in the note. Instead of continuous analogue control, it became binary: either open or closed (Ahrens 1996). Developments like that were generally seen as a progress, a step into a new world of improved musical performance and of rationalised technology. Here the voices of the new typically cancel out any reactionary complaints that “imperfections” are disappearing.

In the 21<sup>st</sup> century we have witnessed an extraordinary boom in the research and development of digital musical instruments. This explosion is grounded in the ubiquitous availability of cheap computer hardware, but also partly caused by advances in tangible user interface technologies and new programming paradigms that provide new affordances for musicians, composers, designers and programmers (Magnusson 2010). Some argue that progress is driven by the curiosity and aesthetic demands of musicians who, in a Varèsian manner (Varèse 1966), demand new instruments for new musical ideas. But technology development is more complex than that and new ideas often emerge from the affordances of the technical elements that are enrolled. This conditioning of the tool has been dealt with in music technology design by offering a wide range of audio programming languages and environments that allow musicians to develop their own instruments or compositional systems. These systems work seamlessly with new sensors and sensor/controller interfaces and many of them are open source and free. This makes the design and implementation of novel controllers

relatively simple – a transformation of the situation as it was merely a decade ago in the field of new instrument design. On the web there is an abundance of information (on programming languages, interfaces, protocols and schematic diagrams) needed for the design of such instruments, resulting in people altruistically (which, in open source culture, results in various personal advantages) posting their inventions up on blogs, wikis, video sharing websites and social media, in order to spread their inventiveness.

Considering the ubiquity, popularity and cost effectiveness of digital technologies, it is remarkable how few original new digital musical instruments have become popular and taken into use by the general public. In fact, most new musical instruments we come across are either not digital (consider the turntable or electric string instruments) or they are digital simulations of acoustic and electronic technologies. The digital synthesizer is a good example here, copying the interface of the acoustic piano and the functionality of the electronic synth. The weakness of digital interfaces is identified as sound control, mapping, ergonomics and interface design; all topics that are defined in here as the elements of digital musical instruments that render them as epistemic tools (Magnusson 2009). It is therefore apposite to investigate why, or perhaps rather whether, this really is a weakness, for we can detect two developments in digital technology production: one is of closure, blackboxing and proprietary ownership of technologies through patents, closed source, and protected protocols (e.g., the mp3 format was licenced for 20 years and developers would have to buy a licence to support it). The other development is of open source, copyleft, open hardware and sharing of solutions. Roughly stated, the former is characteristic of Apple OS, the latter of most Linux distributions. But either way, the digital is ephemeral, invisible, immaterial and inscribable in ways that the acoustic is not, allowing for functionality that is of higher epistemic or music-theoretical nature than acoustic instruments.

Consequently, this dually blackboxed and open nature of the digital does influence musical cultures different to the one where the software or instruments are made (typically N-America, Europe and Japan). Many Asian and African musical cultures do not feel that their music is represented in digital instruments and software, with their 12 tone equal temperaments, inflexible temporal structures, and an emphasis on notes events above timbre and texture. Fortunately, the ephemeral nature of the digital, and the potential to write new systems makes it possible for any musical theory to be written in the form of software.

With the concurrent movement of blackboxed digital software and hardware technologies together with increased technical skills by musicians, we observe that we are moving away from a culture of individualistic mode of composition and production and we witness how the idea of the Romantic genius is dwindling in importance. Instead, musicians enjoy designing their own instruments, working in collaboration with others internationally in open source and open hardware contexts, often performing their pieces as part of ensembles, yet coming up with a type of musical expression that is *more uniquely theirs* than what we observe in the musical traditions of the 20<sup>th</sup> century. Paradoxically, by becoming more social in their work patterns, the new composers and producers strive for a more unique expression. We see new systems appearing, musical works in the form of installations, instruments or audiovisual work, and we observe the fact that the 21<sup>st</sup> century composer is not so occupied with the final composition anymore, the musical work, as defined by Goehr (2007). Indeed, the musician is more likely to call herself a producer than a composer, and what is produced goes well beyond the writing of notes on staff notation: they have become designers of systems of musical expression, focusing on elements that we might have called extra-musical in the 20<sup>th</sup> century of recorded music, but have now become part of natural

musicking practice. In *Sonic Writing*, I characterised this *new systematicity* as a move from the 19<sup>th</sup> and 20<sup>th</sup> century notion of *composing a work* to one of *inventing a system* (Magnusson 2019: 235). A close look into the Latin and Greek etymology of the words “composition,” (to put something together) and “system” (to stand together) shows that the meaning is not that different, although our ontological conceptions of this shift, from a 20<sup>th</sup> century musicology perspective, will render this as ground-breaking. These developments began in the middle of the 20<sup>th</sup> century, with the open work, composed instruments, improvisational ensembles and more, but yet the notions of the author, the work and the authenticity of the artistic voice were still prominent. It is perhaps only with digital technology and new production practices that we see these concepts getting less weight in descriptions of musical creativity.

### **Instruments as Organs of Musical Language**

Sometimes people assert that music is a universal language. In such a situation, musical instruments would be the organs of production of its vocabulary. They would be the media through which acultural forms of expression are communicated, free from history, geography and cultural context. But music is *not* a universal language: music changes over time, it travels and adapts to cultural contexts, and it is deeply rooted in instruments and other musical technologies. All over the world, there are households whose family members do not understand each other’s music (for example a dad not understanding his teenage daughter’s music and vice versa) and very often this rift is caused by the distinct technology used in the production and consumption of the music.

Although music is not a universal language, it is clearly a universal mode of human expression. As has been established in ethnomusicology, cultures all over the



world frame their key activities through music, from birth to death, in our daily activities of waking, transport, socialising, dancing, eating, sleeping and lovemaking to initiation rites, marriages, birth, dying, funerals, sport events, stately occasions, graduation ceremonies, or war. Music is the invisible stage of cultural rituals, a shared system of references affecting social evolution through the power of its signifiers, and serves as a source of personal identification and even hermeneutic relationship with the world. We often understand another person in our culture from their musical taste but this does not transfer easily to people of other cultures listening to the same music, since the frames of reference are different. Bob Marley is not the same in Kingston, Helsinki, London, Addis Ababa or Jakarta. However, the understanding we get of each other when playing music can be a more profound communication than that enabled by language. Expression through music reaches into parts of the brain that have to do with emotions, time and space, and memory, both personal and cultural, and musical instrument, together with the voice, are the vehicles of this expression.

Thus, music is omnipresent but contextually confined to cultural practices that can be delineated as narrowly as by urban postcodes. Looking into those cultural practices, we find that they often circulate around a specific music technology, such as a notational form, some software or an instrument – a particular type of guitar or a drum machine. Each technology or instrument presents a worldview, a field of exploration that is equally psychological, cultural and historical. However, the real meaning of the particular instrument only emerges through its application in a concrete cultural context. The instrument carries its programme (Akrich 1992) but equally, in the hands of its users, this programme is rejected, broken and readapted, as articulated in the social constructivist strand in the philosophy of technology (Pinch & Bijker 1987). A case study of an ethno-organological project – the exploration of migrating technologies

between cultural groups – might involve looking into the dialectics of how bespoke musical cultures adapt to the functionality of the drum machine, as well as how the drum machine itself is adapted to the respective cultures.

The meaning of an instrument in its cultural context will always depend on the musicians themselves. Picking up an instrument for the first time is an encounter of a special kind, full of curiosity and future expectations. The instrument is a cultural object, imbued with theory and practice. Over time, the instrument is incorporated into the motor memory (Da Souza 2017; Sudnow, 2001), and the performer begins to shape the instrument's use and body based on previous experience. I have defined the term *ergodynamics* (Magnusson 2018) to denote the latent potential for expression in instruments and the unique relationship performers have with them: instruments present subjective scope of resistance and possibilities, yet there are objective properties at play that can be discovered. The notion of ergodynamics goes beyond this subject-object dichotomy and sees the instrument as conditioned equally by its historical context, its technical elements and the musical mindset of the performer. Musical ideas thus emerge in a dialogue with the instrument, as a conversation between a performer and the object, where, at times the instrument presents itself as an interlocutor with material qualities that have to be discovered, but at other times as a medium through which music is expressed. These are two distinct phenomenological modes of our instruments, and both of them shape our thinking and our expression (Magnusson 2019: 170).

People who speak more than one natural language are familiar with how each language shapes the way we think, and musicians enjoy how different musical instruments offer different types of expression, even to the minuscule degree of string gauge, reed type or plectrum stiffness. Exploring a new instrument means we are equally finding out about ourselves and the potential of the instrument. The

ergodynamics of the instrument emerge through a dialogue and we begin to imagine possible landscapes, terrains, paths and dwellings. We begin to envision and embody how the instrument relates to other instruments and what kind of a dialogue might emerge with another musician. What identity does the instrument realise? How does the performer change when playing this instrument, how does it shape the music it enables?

Music is not a universal language, but as a localised language, it is a peculiar one. Looking at natural languages, the differences between them are not caused by the differences between the vocal organs that produces them. The voice is an organ which we have an intimate relationship with, it is part of our self, of our body image. The musical instrument is a different type of organ<sup>1</sup> and it is one that is in a phenomenological fashion oscillates between being part of our body schema and separate from it, as an alien object we engage with. Natural languages are expressed through the instrument of the voice, and they evolve in evolutionary branches that respond to environment, technology, climate and other influencing languages. Musical languages are very similar but they are further dependent on their myriad of productive organs, the musical instruments themselves. We observe that the speed of change in musical languages relates to technological developments. The importance of musical instruments in musical languages can be studied in their migration patterns: what happens to a musical culture when a technology from another part of the world is suddenly introduced into a specific musical culture? Furthermore, musical dissemination media such as streaming music and music videos enable musical influences to take place from across the world. Importantly, the way these influences are

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<sup>1</sup> The ancient Greek term for a musical instrument is *organon*, and this word is also used for bodily organs (such as a heart), tools (such as a hammer) and instruments (such as the harp).

put into local musical context is typically through using the instruments that enable or carry the specific musical expression.

The learning of a natural language involves memorising new terms, concepts, syntactic structures, and, importantly, how to express new sounds with the vocal organ. But having gained some basic success in producing the sounds required in the particular language, the sound producing organ, the voice, is quickly forgotten and the focus is on the vocabulary and grammar. There is some analogy here with learning a new musical language, but that language is always mastered with a musical instrument or the voice, it cannot be learned in silence. Furthermore, the mastering of the instrument itself never ends and the musical language evolves in tandem with an increased expressivity of the instrument. The instrument control is the necessary condition of the expression in that particular language: the capacity for sound generation is the capacity for expression. It is here that new musical instruments intrude into musical practices: the electric Miles is very different from the acoustic Miles, and whilst the instruments themselves embody some of that change in music through their affordances, it is their wider ergodynamics, their expressive qualities as well as their cultural context and history, that are more dominant factors.

Musical languages are the genres and styles as they evolve over time in bespoke geographical areas and across cultural groups. These languages can be inscribed onto media, like natural language, through descriptive and prescriptive notation, phonography or computer code. As cultural phenomena, they are necessarily dependent on the medium through which they are expressed, the musical instruments and technologies. The evolutionary form of musical languages is in many ways akin to natural languages, but it happens largely by means of technological development, and we will explore the phylogenetic nature of music technologies here below. An ethno-

organological approach analyses the way musical languages evolve through changes and developments in the technologies of their production. This happens through the migration of musical technologies, both geographically across the world, and culturally, from one group to another, within the same geographical area. It is important to conclude here that these musical languages are necessarily dependent on the material substance whether in the form of a sound producing instrument, symbolic writing or recording of the sound. What makes digital music technologies so transformative here is that, on the one hand, they democratise music, open up new communicative channels and set the stage for global collaboration, but on the other hand, they tend to homogenise and standardise music through their strongly epistemic and inscriptive nature (Magnusson 2009). It is in this context that we observe the improved technical skills of contemporary musicians.

### **Migration of Musical Instruments**

Music is grounded in materiality and embedded in history and tradition. The function and meaning of musical instruments change over time in the diverse musical cultures of the world. Ethno-organology seeks to understand how instruments establish themselves as part of a culture, where they come from, how they move through history and the way they manifest in practice in the digital age. A concrete example of this comprehensive organology, performed through detailed analysis, is outside the scope of this short article, but this might involve tracing the historical and techno-scientific conditions of musical instrument design in multiple musical histories as they develop across the world, and explore the effect of instrument design (with its borrowing, adaptation, inspiration, etc.) on wider global musical culture. It would embrace the myths, histories,

stories and legendary tales we have of musicians appropriating new instruments in their musical practice. There are plenty of examples, from Bach exploring a new piano to Miles Davis incorporating electric instruments and effect pedals. Although there is no space to dive into this exciting area of study, this article explores the theoretical basis for a project like that.

Instruments are material objects that travel geographical distances quickly and easily. They are adopted and adapted to new musical cultures, but those cultures, in turn, change because of the new musical object. Distinct traditions can adopt the same object differently. The violin is a suitable case study here: we observe how the same instrument occupies same geographical and historical space in at least two manifestations: in the form of the fiddle and the violin, depending on their socio-cultural context. We also note how the violin is held and played differently throughout the Indian subcontinent, where the instrument is adopted into a strong musical culture whose traditions weigh more than the tradition brought with the new instrument. Thus, Indian classical musicians typically sit on the floor cross-legged when playing their instruments and adopting the violin they began resting the violin's head at the sole of their feet. This frees the player's left hand, releasing it from having to support the instrument in its position and enabling quicker and freer movements across the neck.

Another case study would be the digital synthesiser: initially seen as a new instrument that required new modes of interaction (Pinch & Trocco 2002), it swung towards more familiar interfaces, such as the 12-tone piano keyboard, for no technical reason. The reason was equally economic and social, as people wanted to play the music they know, on an interface they are familiar with, and play together with other people, adhering to the musical forms of the time. The difference in ideology between synth inventors Bob Moog and Don Buchla is illustrative, with Buchla seeking new

interfaces for new sounds, rejecting the simulation of existing instruments, whereas Moog was happy to attach a piano keyboard as a controller of the synth. Moog was here being the pragmatic engineer running a business, whilst Buchla was more of an artist visionary with eyes on future music and novel instruments (Pinch and Trocco 2002). Thus, the synthesizer of the 1970s became a concretised technology, with standard vocabulary describing its elements of sound generation and physical interface. The synthesizer of the 1980s became synonymous with its music and with its use with digital audio workstation software (like Cubase) it began to be used as a sound generator originating from software with rigid time and pitch resolutions. This exciting new instrument became adopted to existing practices and the tension we are witnessing here is between that of commercial viability versus musical experiments.

The synthesiser might have been successful in the music of the West, the music of the digital audio workstation and the Western musical ensemble. But these software and hardware technologies are not fully compatible with the musical language of other traditions, such as Arabic music's understanding of pitch or Indian notions of rhythm. A quick concrete example would be the distinctive use of the pitch wheel in North African *Rai* music, where performers continually use their left hand on the pitch wheel in order to hit the microtones between the half-notes on the keyboard, thus adjusting the instrument to their musical culture (of microtonal music).

Through transmission and migration, an instrument thus enters a new ergodynamic context, with *ergomimesis* being the process in which an existing pattern of practice, whether material (the design implemented in parts of the instrument) or immaterial (the motor memory of embodied training) is aligned to a new cultural context. In the new context, the instrument is seen with fresh eyes, grounded in existing practice, but then adopted and adapted to the musical culture into which it immigrates.

This is a dialogue because neither the instrument nor the instrumentalist are neutral entities: the instrument brings a musical culture, and the instrumentalist will shape the instrument to the new musical context. In the domain of instrument design, invention and innovation, we also have established the concept of *ergophores* as the design trope that embodies concretised technical element or gestural motor memory (Magnusson 2018). Ergophores move as technical elements between cultures often implemented in local instruments, such as the stringed bow. They also move as patterns of bodily performance that can be supported by physical design in distinct musical instruments, for example frequency increasing when moving up or the right. But through an instrument's ingress into a new context, it brings with it the musical seeds of its own origin, influencing the new culture. We see this equally with acoustic, electronic and digital instruments.

### **Phylogenesis of Digital Music Technologies**

Digital music technologies have become the primary tools of Western musical culture, and they are being adopted by other musical cultures all over the world. This prompts us to question the cultural conditions and origins of contemporary music technology, and study how this new technology has impacted music making across the world, in particular with regards to the important notions of decolonisation and cultural heritage. Above we have looked at the migration of instruments and how they create hybrid situations in the cultures they enter. Another approach is to look at musical transmission *via* instruments, to study this through evolution of musical technologies, or their phylogenesis (evolution as an instrumental type) as opposed to ontogenesis (its creation in the luthier's workshop or programming environment).



If the inventions and innovations of musical technologies typically happen through the mechanisms of cultural and technical adaptation, as well as socio-technical symbiosis, how do musical instruments evolve through time? And which factors define that evolution? Phylogenetics are now increasingly taken into use in the analysis of cultural phenomena, especially within the material culture branch of anthropology (Tehrani & Collard 2002; Temkin 2004). This methodology is able to yield results that differ from the traditional historical narration of instrumental evolution, and is more closely related to the cultural genealogy than traditional history.

The biologist Niles Eldredge (co-author of the theory of punctuated equilibria) is an ardent collector of cornets, a brass instrument related to the trumpet. Eldredge's theory of *punctuated equilibria* suggests that evolution does not happen through gradual transformation of whole biological lineages, but rather through quick morphological ruptures and discontinuities, followed by longer periods of stability. Eldredge has explored technical evolution through a phylogenetic analysis of musical instruments. Instruments are subjected to different and more chaotic laws than biological evolution, as the maker of the instrument can copy inventions from other species of instruments, go back in time and implement features that have been lost for generations of instruments (Eldredge & Temkin 2007). Therefore, the evolution of cultural systems and technological artefacts can be seen to be more complex and discontinuous than biological evolution, with more branches, loopbacks in time and multiple siblings. Whereas biological systems have natural boundaries (interspecies mating is rare and hybrids do not reproduce), cultural systems are rife with lateral exchange amongst designs with technical elements jumping from one domain to another, yet they are also characterised by a surprising resistance to change that derives from equally from cultural protection and the value of tradition as well as the necessary adherence to

technical standards in the technical ecosystem. An original ancestor is never to be found, the evolution does not necessarily branch dichotomously, there can be multiple lineages originating from the same node, and branches can converge again. Technical evolution is a form of cultural evolution: it not only works from technical tendency, the collective logic of technical materiality, but also differs from biological evolution in that it can have prototypes as ancestors that result in many divergent and convergent branches. Unlike immaterial cultural elements (e.g., as analysed by the theory of memetics), technical elements have more lasting existence, since technical elements need to support existing standards and conventions. The longevity of the MIDI standard is a good example, with the new MIDI 2.0 standard having to support decades old hardware. MIDI could have had various versions or competitors, but the idea of a standard is precisely to prevent wasting energy on solutions that have already been established. This is less about seeking a diversity of solutions that compete like biological systems do.

Eldredge and Temkin point out the differences in the evolution of biological and technological systems: “In material culture, the basis of comparison is in most cases limited to features that perform the same function rather than sharing function and derived form by common ancestry. Thus, entities in question in the biological versus the cultural domain differ ontologically and epistemologically.” (Eldredge & Temkin 2007: 150). The technological system’s evolution may appear similar to biological evolution in places where traditional transmission is strong but intercultural exchange is weak. However, in the global, post-industrial and, in particular, the digital world, this is not the case anymore – most cultures now share access to the same technological tendencies. A grounded ethno-organology would therefore be required to trace the origins (which always have other origins) of the technical elements in the musical

instruments used, analysing how ideas and instruments interact and influence each other through a dialectical relationship that is always contextualised in a cultural discourse and actual musical practice.

In cultural artefacts the information resides in the object itself, but also in plans, sketches, patents, drawings, schematic diagrams, photographs and manuals. It takes a human to transfer that information through a lineage of objects and implement an alternative design. The desire for change in cultural artefacts is often dependent upon survivability on the marketplace, but also alternative engineering solutions to already patented solutions. Mutation in cultural artefacts is therefore typically more varied, which means that there can be a total breach in morphology of a thing that performs the same function. This is equivalent to saying that there is not necessarily a genetic (as in Mendelian genetics) continuity in the evolution of the cultural or technological artefact. A good example of this is how the transistor replaced the vacuum-tube (which was not necessarily an improvement in all cases) in amplifiers. There is no sense of continuity in design between the transistor and the tube but they perform principally the same function. However, as opposed to biological species and early technological inventions, the shift to (or naturalisation of) the transistor was simple, as it replaced an older and less optional technology. It should be acknowledged here though, that, from a cultural and aesthetic viewpoint there is a pronounced difference between the use of the transistor and the tube in amplifiers, the latter often considered giving a “warmer” and more authentic sound.

Digital tools are inscribed with a high dimension of musical knowledge and theory: they incorporate music through its functionality. Technologies travel and are adopted differently into source cultures. An obvious, but largely understudied, question is: how do musical cultures whose music theory is different from Western music engage

with new music software that is written from the Western music perspective? How do cultures that think differently about time, meter, tuning and harmony operate with software based on Western conventions of the above? What is the nature of the blind self-centredness of musical reference, marketing forces, power structures or colonialist elements we find in play? This has not been studied in the domain of software studies, but many of these topics have become well-known musicological problems. An example of such musicological account is how the classical European musical system was brought to Iceland through Danish colonialists and Icelandic students educated in Denmark. Here, with the new “educated” rationality, the traditional microtonal musical practice was criticised, judged primitive and irrational, and a more standardised practice of 12 tone equal temperament installed. (Þorsteinsdóttir 2016). We find innumerable such stories in all musical cultures, but this process of infiltration becomes more implicit when new musical ideas are introduced tacitly through the, apparently neutral, functionality of software.

## **Conclusion**

Musical instruments have always migrated from one culture to another, and with them musical knowledge. Musical languages are greatly dependent on the organs of the sound production: the musical instruments themselves. Digital musical instruments and audio workstations are a particular case in the evolution of musical ideas as they spread very quickly and can seem to be, at the first glance, more musically neutral than acoustic instruments. This quickly proves to be an illusion: written into these technologies are layers of musical traditions that have been abstracted into the functionality of the software. Furthermore, although digital musical instruments are simulations of real instruments with culture and traditions, their technical origins are co-dependent and

diverse. Technical evolution not only works from technical tendency, the collective logic of technical materiality, but also differs from biological evolution in that it can have prototypes as ancestors that result in many divergent and convergent branches. The functional ancestor might be structurally new and multiple lineages originate from the same node. The digital instrument has a much more complex technical evolutionary lineage, but is a condition of digital media, putting in action what some postmodern writers wrote about: the sample, the lack of historicity, the montage, the floating signifiers, the impossibility of an origin, and so on.

Although both acoustic and digital instruments evolve through discontinuous and eruptive processes, their technical tendencies and potential differ. Where the acoustic instrument maker can easily refer back to tradition, copy structures from other instruments or transform the instrument in various ways, the digital instrument maker is defined by a context of multiplicity of actors and blackboxes that resist a comprehensive understanding. The digital instrument maker is conditioned by operating systems, programming languages, hardware interfaces, communication protocols and other constraining technical elements that cannot be easily altered. Interlineage transfers between instruments are thus profoundly different in digital instruments due to the rigidity and complexity of their materials: they have different evolutionary dynamics (of much higher and more disruptive discontinuities) than acoustic instruments.

Digital organology is therefore not a simple problem. I have elsewhere written about the difficulties of classifying digital musical instruments (Magnusson, 2017). As Kartomi (1990) illustrates, there are no limitations to the number or types of analytical taxonomies that can be formulated for musical instruments. Ethno-organology can explore the way musical cultures change through the introduction of a new musical instrument or software. This involves studying changes in the musical language as an

effect of the technology introduced. The way instruments embody music theory also implies that we need to study the evolution and cultural migration of instruments. The phylogenetic analysis of musical instruments provides us with one alternative genealogy of musical instruments. We can build a taxonomy of instruments from this, but that is a taxonomy based on genetics and not their various functions, such as the sonic or ergonomic qualities. One problem with phylogenetic analysis of digital technologies (or all complex machinery) is that their underlying structure is not visible, and typically so blackboxed in strata down to machine levels and machine histories, that it becomes a difficult analytical task, but one that requires computer science, software studies and ergonomic/ergomimetic analysis. This involves the layers of new technology implementations from the level of code to the level of human gestures and how they are supported in technology. Furthermore, the field needs a stronger analytical approach into how music-technical elements travel across cultures, how the technology *carries* the music into new contexts, and what kind of musical dialogue ensues when a new technology is introduced. Hence, phylogenetic analysis can serve as an analytical tool in the evolution and adaptation of musical technologies, and thereby changes in musical language, but a comprehensive understanding of influence of the machine or the digital instrument on living musical cultures will require a wider ethno-organological approach that involves musicological analysis of languages as supported by technological elements.

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