# Chapter 7
# The Development of New Technology in Creative Music Applications

**Stuart Cunningham, Steve Nicholls and Steffan Owens**

**Abstract** Music has been a fundamental aspect of human existence for thousands of years. It fulfills many roles for humanity that range from the intimidating precepts of the bloodiest battles to the emotional release of the biggest celebrations. It is a key creative output channel for humans, which is on a par with the visual arts. Technology has been an important aspect in the development of music, from facilitating new instruments and methods of creating sound, to providing a vehicle by which music can be notated and its sounds recorded. The focus of this chapter is upon the relationship between musical creativity and technological development in recent history and an exploration of the influence that technology is likely to have in the future. As particular case studies, we explore how music and technology interact in two case study scenarios: (1) the creative processes surrounding music production and (2) the education of musicians, particularly in the teaching of timekeeping. It is shown that these aspects of music have remained dependent upon human influence and have been reluctant to fully embrace the possibilities offered by new technologies, unlike other areas of the music industry. Our work discusses ideas and possibilities, encapsulated within the current work of the authors, which seeks to change this situation and embrace the new musical opportunities that technology affords.

**Keywords** Music creation · Music production · Musical creativity · Musical diversity · Virtual studio technology · Digital audio · Musical timekeeping · Computer-based music instruction · Collaborative partnerships

## 7.1 Introduction

The field of music has been immensely important throughout human history and has found utility in many scenarios throughout history and for many purposes. Whether used as a tool for motivation, entertainment, relaxation, celebration, and so on, music has been ever present. As humankind has evolved and developed, so too has music, although its beginnings were quite distinct with separate cultures around



R. Earnshaw, *Art, Design and Technology: Collaboration and Implementation*, SpringerBriefs in Computer Science, DOI 10.1007/978-3-319-58121-7_7

the world having their own tuning systems, instrumentation, traditions, and customs [1]. However, during the nineteenth and twentieth centuries, the proliferation of new communication technologies, such as the Internet and digital information representation, aided by a general trend toward globalization, have shaped recent developments in the field. Many of the traditions have been preserved and developed in their own right, but the use of technology and communication has opened up opportunities for new forms of engagement with music, particularly in the creative process and in teaching and learning.

As particular examples of fields where music technology has, and continues to have, an impact, we examine two particular areas of music that are congruent with our current research activities: the process of music creation and production; and the teaching of music, specifically musical timekeeping. These two areas of research arguably epitomize two of the most vital and longest established fields within music that of creation and education. Without either, music would be extinct and arguably the need to continually evolve these practices, in-line with current technological trends (as well as other influences such as the social, economic, and political) has been a factor that has ensured music survives through time.

## 7.2 Technology and Music

### *7.2.1 A Brief History of Music and Technology*

Throughout the history of music, its ability to be notated fulfilled a crucial function in allowing music to be remembered and transported from place to place. Hence, we observe two key requirements: archival of music and its distribution. Although notation provided composers with mechanisms to incorporate performance instructions beyond the note durations and pitches, it relied upon a musician to turn the score back into audible sound. As such, notation plays a key role in all forms of music and its related activities, but on its own is a limiting factor, meaning that writing, especially when done collaboratively, and performance, often a multi-musician effort, were only possible with the requisite resources and associated education. Nevertheless, as with all forms of art, people found ways to express themselves, and entertain others, in the creation and performance of music, despite these limitations. For example, thousands of years ago, signing was used extensively, often passed down between generations of family members and laterally accompanied by rudimentary instruments.

The last quarter of the nineteenth century brought with it a range of technological innovations and inventions that laid the foundations for modern recording technology that would, for the first time, allow music performance to be captured, transported, and replayed. This revolution was led by innovators of the day such as Thomas Edison, Alexander Graham Bell, and Emile Berliner. By the end of the 1920s, the proliferation of gramophones, and popularity of analogue radio

broadcast, signifies that music production has become a major industry as up to 100 million records are sold per year [2]. Before point, the only way to consume a piece of music was to do so audibly, at a recital, or by studying the score.

This new ability to capture and preserve musical performances and recitals heralded a transition for musicians, and the music consumer, during the early twentieth century in that music could now be relistened to and shared. From the musician and recording studio perspective, the advent of multi-track recording and overdubbing, devised by seminal guitarist Les Paul, brought another significant change. Until this point in the 1940s, music recordings had to be carefully planned and orchestrated. Obtaining balance between instruments and voices was largely a matter of controlling sound levels during the recording process, either by trial-and-error microphone placement, or by manipulating microphone levels whilst recording. The process was also unforgiving; any mistake or undesirable noise in the recording would necessitate a complete re-recording and was thus resource hungry, especially in terms of time and money. Les Paul's multi-track recording process changed this, by giving musicians and engineers the ability to record multiple sound sources simultaneously or by layering them one after another. This opened up huge creative potential, where multiple parts could be performed and recorded on a piece of music by a small number of musicians, in a small space, immediately changing the dynamic of what could be achieved in a music recording and removing many of the barriers previously limiting the creativity of musicians and producers. Les Paul, notably, also recorded a number of his initial commercial recordings in his home studio, perhaps unknowingly, simultaneously giving birth to another trend that has sustained and fueled the musical diversity and capacity of the present day [3].

During the 1970s and 1980s, the music industry experiences a series of major technological shifts, largely due to the incorporation of analogue and digital electronics into the music creation, recording, and production processes. The mainstreaming of synthesizers in the 1970s and ability for a solo artist to produce an album largely independently is epitomized by artist's such as Stevie Wonder who played the majority of the instruments on his *Music of my Mind* (1972) album [4], accompanied by the TONTO (The Original New Timbral Orchestra) synthesizer system [5]. In the 1980s, the transition from analogue to digital technologies introduced the compact disc (CD) to the music consumer market and musical instrument digital interface (MIDI), along with the emergence of digital audio recording, to the musician and recording studio. The development of these, in the 1990s means that it becomes possible for a musician to have a virtual orchestra or band, along with a recording studio, in their home, without any of the physical equipment or spaces that would have previously been prerequisites. All of this is achieved via the personal computer, functioning as a music production system 'in the box.' One notable early example of this is White Town's worldwide hit *Your Woman*, released in 1997 [6] and recorded by one person using a small selection of instruments and an Atari computer [7].

This digital revolution further transformed the opportunities available to the musician. In a relatively short space of time, the synthesizer and MIDI technologies

that had previously afforded new timbral and performance opportunities had been integrated into personal computers, providing anyone with a basic musical knowledge or ability to program their own instruments and to record them, noise free, onto a hard disk. The introduction of computers and digital information to the music world led to the potential for new ways that music could be studied, written, produced, consumed, distributed, and written. The combination of the networking technologies, that underpin the Internet, gave rise to the ability for artists to collaborate in real time (or initially, nearly real time) in the writing and recording of music, allowing them to be in different parts of the world, whilst affording the possibility for them to collaborate. Laterally, the ability to record and produce collaboratively is also serviced by the availability of the cloud, permitting projects to be shared and added to by multiple contributors asynchronously.

Such music can now be distributed online via online music stores such as Apple's iTunes, Google Play, and Spotify. The broad public adoption of the Internet over the 1990s and 2000s, coupled with relatively high ratio audio compression technologies, most notoriously the combination of MP3 and Napster, meant that being able to share and distribute music could be easily achieved. This caused an eruption of copyright and intellectual property law suits against the Napster file-sharing platform, as artists and record companies saw themselves losing out on the income from music purchases. The ability to create and release music was now no longer the privilege of the few, but that of the many. Thus, the digital music revolution has been nothing short of a mass democratization, characterized by Breen [8] in an appropriate technologically influence sound bite as being a "*direct access relationship*" between the musician and the audience. However, the ability to create and distribute work does not, of course, guarantee that commercial success will follow. In this respect, the record companies and music promoters maintain precedence largely through the attributes of legacy, brand, resources, and established networks. Nevertheless, as the reader will no doubt be aware, the way in which music is consumed has changed dramatically, even in the last 10 years, and the ways in which music is produced and taught has followed suit.

### *7.2.2 Technology and Musical Creativity*

Technological change has undoubtedly influenced the way in which music is written and created. These developments have brought changes in the way that sounds can be produced and music expressed, such as through the introduction of synthesizers and MIDI control devices in the 1980s, new microphones, and laterally through the development of virtual studio technology (VST) software and digital audio workstations. Thus, the musician, as an artist analogous to a painter, is constantly being provided with new colors and textures in their palette, whilst the dimensions and characteristics of their canvas can be changed and reshaped at will. The role of the engineer and producer in these times of change has arguably become

more important than ever and one where engineers and producers have been able to develop their techniques in recording and manipulating sounds to develop their own trademarks and styles [9]. Interestingly, despite these individuals and groups becoming defined as creative practitioners in their own right, the lines, previously well-defined, between artist, engineer, and producer have become blurred to the point that they are often homogenous today.

### *7.2.3 Technology and Music Education*

Perhaps unsurprisingly, those on the music engineering and technology end of the spectrum were quite rapid to adapt their curriculum in response to the possibilities offered by the digital revolution [10]. However, the study of music and performance was not far behind and computer-based music instruction (CBMI) emerged on various platforms since as early as the 1960s and 1970s [11]; a trend that has continued to the present day. The music educator is required to engage in suitable professional development to improve their digital literacy and abilities in using technology to assist in teaching [12].

Such software tuition systems cover a range of musical aspects, such as the understanding of underpinning music theory to the performance and practice of particular musical instruments, such as the keyboard, guitar, or drums. The use of technological instruction continues in the present day but, as with the consumption of music by the audience, the features of the Internet have now augmented instruction, allowing music students to engage with tuition that may take place via audio–visual communication platforms in synchronous or asynchronous lessons and tutorials [13]. This provides opportunities for tuition from a much wider range of teachers and experts, specialist in particular techniques or styles of music, and for teachers to engage with an audience of students worldwide. However, particularly when it comes to the study of the performance of a musical instrument where technique and physicality can often be important, the digital method of remote instruction can potentially present barriers and obstacles for both student and teacher. For example, instruction of the correct bowing technique on a violin might be especially difficult without the ability for teacher and student to see each other in three dimensions and for the teacher to manipulate the bowing arm of the student, so as to achieve the correct motion. However, this is a good example of a particular problem that has been considered, and solutions proposed, by researchers active in this area [14] demonstrating the willingness of the music education community to engage with, and use, new technologies to their advantage. As such, whilst any new technology encounters resistance, the field of music education is one that is keen to experiment with new innovations.

## 7.3 Musical Creativity and Collaboration

The paradigm shift from the use of expensive commercial recording studios to recording music 'in the box' presents a demonstrable change in the way in which people interact with music production systems. The need for large-scale studios, with large mixing consoles and racks of outboard effects and processing, has been eliminated in the main [15]. This is a pattern that could also be related to a wider trend in the music industry where, due to the development of the Internet, high-quality recorded music has become easy to copy and share. Combined with developments in music streaming and distribution services, this means that a wider range of music is available to consumers [16].

The role of musicians has also changed due to the development of the Internet. Whereas the role was once to engage and build audiences through broadcast and printed media, the format and content of which was largely out of their control, many musicians are now combining the role of artist and performer with roles that make use of social media strategies for the purposes of drawing attention to themselves [17]. Examples of this might be to offer lifestyle experiences such as online chats and music tuition. Other examples might be based on regular performances or video blogs. This type of social media engagement is heavily reliant upon regular content delivery with, for example, some YouTube channel operators posting new material numerous times daily.

The increasing demands of consumers mean that in order for a musical artist to remain relevant and commercially viable, they may need to produce material and content at an increased rate. To meet these needs, music producers may wish to embrace new ways to increase productivity, creativity, and possibly quality, at a reduced cost.

Historically, in order to improve productivity, the forming of song-writing partnerships has been shown to be common practice in popular music [18]. For example, songwriters Carole King and Gerry Goffin were hired as 'staff writers' at The Brill Building in the 1960s. The Brill Building housed numerous music companies that would buy songs from competing song-writing teams producing many hit songs [19].

However, finding a suitable collaborator can be problematic. Currently, there are no computer systems that will collaborate with a user, essentially emulating a collaborator. Previous research has examined artificial intelligence (AI)-based composition, focusing on music generation, via a variety of algorithms [20]. Many compositional systems have been developed, with much research focusing on areas such as different ways to generate starting points or the behavior of different types of algorithm. The common characteristic in all of these systems was that there was a distinct point at which user interaction ceased, and then all work was carried out by the AI system. This would not, necessarily, be the case in a collaborative system.

One of our research activities is to develop an AI collaborator to assist individuals in the process of writing music. The intention of this system is that it would be able to emulate a human writing partner and to interact in an intuitive and

effective manner. The development of a collaborative AI system would involve determining key parameters and defining a set of rules in the collaborative song-writing process. It may be possible that the AI could then collaborate with a single user to create a number of musical pieces. As part of this system, there is a clear requirement for the AI system to be able to learn about its user so that it can most efficiently integrate into their workflow, providing assistance at the right times, and taking a less dominant role when the human user is in a deep period of creativity.

The nature of creative work and collaborative partnerships could mean that a range of human traits and characteristics would need to be modeled by the system. The psychology of artists working in partnership would need to be understood. Issues such as creative tension, conflict and resolution, competition, motivation and strategies for breaking creative blocks would need to be considered. Data gathering from musicians, songwriters, and producers could provide this type of expert input to the system. To address these diverse types of information and processes, we intend that our work in this field will utilize a range of research methods, such as interviews, questionnaires, and observational studies to produce the models and information that will subsequently be used to build the AI collaboration system before putting it into scenarios where it can be evaluate against a human collaborator, using both objective and subjective evaluation methods.

With the computational power that an AI collaborator would possess, increased availability of experiential data and access to creative strategies will be possible. This might increase the rate at which a music producer could compose, and possibly record, music.

## 7.4 Music Education: Timekeeping

Contemporary instrumental music tuition usually consists of a combination of aural practices and more formal musical notation, but there has been little development in formalizing the teaching practices of timekeeping for entry-level musicians. As time and financial constraints are increased on peripatetic and classroom tutors, individual and group timekeeping is, understandably, not always a priority in short instrumental tuition sessions. Timekeeping is perhaps not the most glamorous component of playing any instrument, but it is an important part of ensemble playing. From a teacher's perspective, any tool that can enhance a musical trait of a student, whilst freeing time for other elements of tuition, would be a welcome addition to the tutor's resources.

It is important to establish a definition of timekeeping in this instance. It is certainly true that musical performance does not always stick to regimented meter and note duration. Expression is a fundamental part of interpretation and performance of a musical piece, but to bend the rules of timekeeping, a performer must be familiar with those rules. Studies suggest that musicians will naturally vary in tempo when listening to or performing passages of music, slowing at the beginning

and end of musical phrases [19]; perhaps using this flexibility to imbue a sense of musical punctuation to the piece. Nevertheless, to form a fixed idea of timekeeping, a more mathematical approach is required. A set tempo has fixed markers for each beat and these beats can be used as fence-posts to determine the intervals between each expected note. Exploiting the expected interval as a comparison value to the actual value of a played note can provide distinct figure or measurement of the accuracy of a performer's timekeeping.

Research into the relationship between timekeeping and sensory motor function suggests that the effect of practice alone will improve timekeeping accuracy, and that the rate of this improvement remains similar between musicians and nonmusicians [21]. Is it possible to improve this rate of progress? The traditional practice of playing simple rhythms to a mechanical metronome can be used as one method of training a musician to improve their timekeeping accuracy. This method, however, is subjective to an extent. It is also limited by the capabilities of the equipment itself. The development of digital metronomes has now gone beyond the model of simply providing these fence-posts of interval markers. Musicians now have access to cross-rhythmic metronomes that provide much more audio information, through the use of syncopated rhythms and a wider range of frequency content, i.e., a variation from the stock cowbell audio cue found in many early digital metronomes and DAW software. This increase in audio information may be the key to improving timekeeping accuracy, although some research suggests that audio content can also be a distraction to musicians [22].

If a metronome can influence the timekeeping of musicians, it stands to reason that other musicians can affect this timekeeping. The process of entrainment in musicians is at the heart of musical performance. The natural tendency of humans to synchronize with external rhythmic stimuli inevitably leads to synchronization of musical timekeeping in a group performance [23]. The ability of an ensemble to maintain the intended tempo of a given piece will be influenced by the individual ability of each musician to keep time. Therefore, any improvements that can be made to this ability will benefit the group as a whole.

Our research into musical timekeeping aims to develop tools and techniques, likely, but not necessarily, implemented in some form of e-learning system that produces a significant improvement in the ability of musicians to improve their timekeeping. In the early stages of this work, we will conduct a range of controlled experiments using metronomes of differing timbre, speed, and in individual and group environments, to investigate how these, relatively straightforward, adjustments may impact upon timekeeping. Following this, investigation will take place into different exercises and modes of practice and how these may produce increased timekeeping accuracy. Our work in this field utilizes a strong quantitative, objective series of time measurements to determine the accuracy of participants in experiments, although it may be that later work uses experts in the field to provide a more subjective assessment of participants' timekeeping ability, to see how these correlate with the objective measurements.

It is now common practice for producers and studio musicians to use cross-rhythmic metronomes to enhance timekeeping performance. The increase in

rhythmic information provides the musician with more points of potential synchronization, through the use of beat subdivision. As timekeeping can be seen as the ability to predict the intervals between audio cues or markers, it is probable that this ability to predict becomes more consistent as more information is added, particularly at slower tempos [24, 25]. As the definition of timekeeping remains consistent, regardless of instrument type or family, the goal remains the same: to sound or produce a note at the precise moment it is expected. Differing instruments require differing physical and cognitive processes; the use of this technique could inform an adaptive teaching methodology for timekeeping in musicians. It may be possible to tailor metronomic information (ensuring that audio information does not reach the point of distraction) to improve a musician's timekeeping ability, both in the short and long term.

## 7.5 Conclusions

This work provided an insight into the way that changes in technology have interacted with the creative processes of music production and education. It is established that technology has played a crucial role in the development of music, especially when it comes to the way that it can connect to its audience, and the diverse range of ways that it can interact with learners of differing style and level. However, the introduction of these technologies has, arguably, introduced a divide; the ability to work alone and in isolation affords many resource benefits, but endangers the ability to work collaboratively and learn from more experienced musicians.

Music has certainly not been afraid to embrace technological change and use it to full advantage, especially when it comes to being able to produce more diverse and larger-scale creative works. As such, technology in music has been an enabling platform, as well as affording innovation. In our ongoing work, we look forward to not only attempt to produce a computer program that can write an interesting piece of music, but also to develop an AI collaborator that empowers and supports a human writer in their creative processes, much as a human writing partner would do.

Similarly, when it comes to training the next generation of musicians, we have shown that the use of multimedia, interactive platforms, and fast communication mechanisms has made education a more diverse and accessible opportunity. Although formal music education is still very much undertaken on a person-to-person basis, technology is used as a successful supplement and mechanism for self-tuition and practice. It is this latter area that our work in musical timekeeping is investigating. We soon hope to have developed a series of recommendations, which will subsequently be integrated into a training package that will make best and most effective use of practice time in improving musical timekeeping in musicians.

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