SAE INSTITUTE BRUSSELS

Artificial Intelligence In Music Mixing And Mastering: Is it a Risk to Jobs?

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Course Code: AU7M5_en 16T3
Date of submission: 02/09/2018
Word count: 10406

Declaration

I hereby declare that this major project is a result of my own research and writing except when stated otherwise. I also declare that this work has not previously been submitted to this university or any other university.

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02/09/18, Leuven

Abstract

Artificial Intelligence technology has started to be integrated into the music industry. There are a lot of varying opinions on this, and by gaining insight into the views of music industry professionals and A.I. researchers, we can make predictions and prepare ourselves for the future of the music industry.

Table of Content

1) Introduction

This major project will be about the use of artificial intelligence in music mixing and mastering and how this affects musicians and engineers in the music industry.

a) Purpose of This Research

The purpose of this paper is to provide a clear insight into the use of artificial intelligence as a tool in the music industry, focusing primarily on the mixing and mastering processes. With a deeper understanding of the use of A.I. in music mixing and mastering, we can then determine how this impacts musicians and engineers now and in the future. Gaining knowledge of these growing technologies in the music industry is useful to better prepare ourselves in this ever-changing industry. The invention of the internet greatly affected musicians and record companies because they underestimated the power that the internet would have on music sales (see the Warez scene). We can learn from those past mistakes by being better prepared for all of the possible outcomes that artificial intelligence could have on the music industry. It's important for musicians and mixing and mastering engineers to be aware of the technological changes currently occurring in the music industry if they want to stay relevant. This paper can thus be used to gain an insight into the artificial intelligence technologies currently being used in the music industry.

b) Defining the Research Questions

The main goal of the research is to determine what impact artificial intelligence technologies will have on music mixing and mastering jobs. To answer this question it's necessary to ask the following additional research questions:

- How do musicians feel about the use of technology?
- How do amateur and low-budget musicians feel about these technologies?
- What is the likelihood of professional or amateur musicians using these technologies?
- How do mixing and mastering engineers feel about these technologies?
- Will mixing and mastering engineers consider collaborating with these technologies?

c) Hypothesis

This paper presents the hypothesis that, based on evidence which will be presented further in this paper, it is highly likely that artificial intelligence will impact almost every job in the future, including music mixing and mastering. The integration of artificial intelligence technologies could have a positive impact on the industry by offering engineers new tools to use in their work. However, there is uncertainty about the long-term impacts of these technologies on the music mixing and mastering industries, which could possibly be negative if they end up fully replacing human engineers in the music industry.

While some people may be reluctant to use A.I. mixing and mastering services, they may be useful primarily for amateur musicians and music producers who have a low budget. Professional musicians may be more likely to continue working with traditional mixing and mastering engineers due to their larger resources and possible funding from record labels. This may result in a smaller clientele base for mixing and mastering engineers due to some musicians opting for lower costing A.I. services, but they may continue to receive business from more established professional musicians which may be enough to keep them afloat amidst the likely transformations to the music industry as a result of artificial intelligence technologies.

2) Artificial Intelligence in Music Mixing and Mastering

a) Clearly Defining Artificial Intelligence

i) Evolution of Technology in the Second Half of the 20th Century and the 21st Century

It’s hard to deny that technology is one of the central parts of our lives today. Technology has transformed our world in many different ways. Computers haven’t only become more powerful over the last 60 years, but also smaller and cheaper. Since 1955, the cost of computer memory has halved every couple of years (Tegmark, 2017). We can clearly see this in the graph in figure 1.

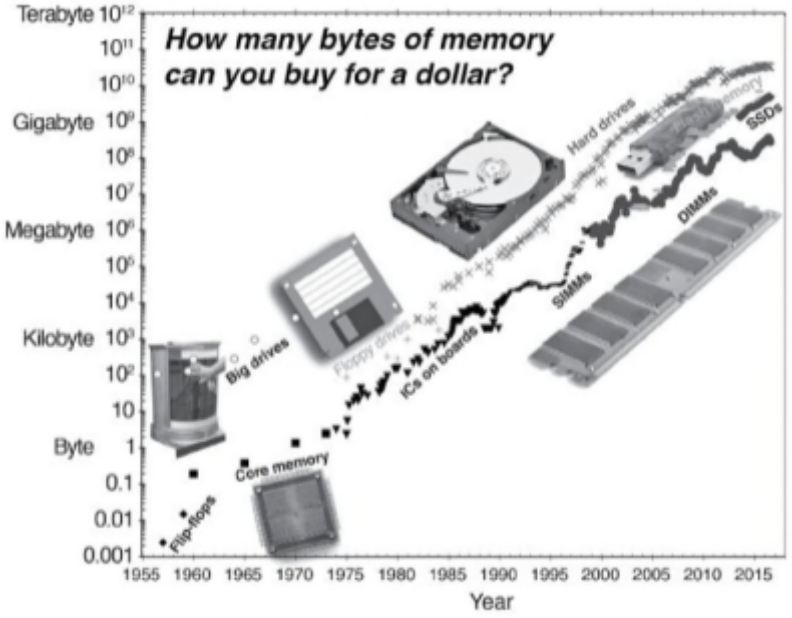

Figure 1: The growing amount of computer memory available for one US dollar since 1955 to 2017. Graph from the book Life 3.0 by Max Tegmark, page 59 (2017).

The lowering of the cost of computer memory is one of the key reasons why technology is ever more present in our lives today (Tegmark, 2017). It has helped transform computers and has allowed them to spread from “the building sized computing facilities of yesteryear into our homes, cars and pockets” (Tegmark, 2017, p.67). Technology progresses in a similar way our own universe grew, with our universe exponentially growing from a speck smaller than an atom to the massive universe we know now. It progressed with each doubling step causing the following step. Following this same principle, every time technology gets twice as powerful, the newer and more powerful technology can often be used to develop the next more powerful successor. There are of course physical limits to this, as there’s a limit to how small a transistor can be made, but it’s worth noting that when one piece of technology can no longer be improved then it can eventually be replaced by a superior technology. Transistors were invented to replace vacuum valves, and transistors are now being replaced by integrated circuits. We have no way of knowing what the next big computational advancement will be but we do know that we’re far away from reaching the limits imposed by the laws of physics. The progression of technology means that we now have computers that can out-remember any biological system (Tegmark, 2017).

Much of this progress wouldn't have been possible without the aid of Alan Turning (1912-1954), the British mathematician and codebreaker (Hodges, n.d.). He played an important role in developing the computational systems that are still used today in artificial intelligence. In 1950, he developed "the Turing test" which was invented to determine whether a computer could think like a human. During the test, a human and a computer are hidden from a human interrogator, who in turn, asks the human and the computer the same set of questions, and any possible set of questions can be asked. The computer and the human answer the questions, however, they each have different goals. The computer has been programmed to pretend they are a human, and the human is simply being a human. Once all of the questions have been answered, the interrogator must decide which of the two responders is the human. If they get it repeatedly wrong, and the computer has successfully managed to trick the interrogator, then the computer has passed the Turing test (Goldberg, 1994).

The Turing test was passed for the first time at Turing Test 2014 held at the Royal Society in London (University of Reading, 2014). However, some artificial intelligence experts are sceptical. Stevan Harnad, professor of cognitive sciences at the University of Quebec in Montreal, said the following on the matter: "It's nonsense, complete nonsense. We have not passed the Turing test. We are not even close" (Sample and Hern, 2014).

While Turing was responsible for the initial research, modern research in artificial intelligence was advanced at a 1956 conference at Dartmouth College. While writing a proposal for the said conference, assistant professor of mathematics John McCarthy coined the term "artificial intelligence" (Goldberg, 1994).

ii) Defining Intelligence, Artificial Intelligence and Machine Learning

To define artificial intelligence, we first need to understand what the concept of intelligence truly is. Max Tegmark, professor of physics at MIT and author of Life 3.0, defines intelligence as the "ability to accomplish complex goals" (Tegmark, 2017, p.50). He also states that artificial intelligence researchers believe that intelligence is about information and computation and not flesh, blood or carbon atoms, meaning that there's no reason why machines can't one day be as intelligent as us (Tegmark, 2017).

Other definitions of human intelligence specify the capability of a quick and effective response to novel situations. More specific definitions focus on human capabilities such as perceptions through the five senses, memory, learning from experience, problem-solving, communication, mathematics, and the experience of emotion (Wilson, 1983).

Artificial intelligence (A.I.) can be defined as machines that are mimicking humans in various fields, from conversation to chess (Goldberg, 1994). In other words, it's a field of computer science devoted to researching the use of digital computers to emulate the functions carried out by human brains. These can be functions such as understanding natural languages, understanding information obtained through the sense, and solving complex problems (Wilson, 1983).

The goal of a lot of A.I. research is to build "general A.I." or A.G.I. (artificial general intelligence). The A.I. of today is "narrow", meaning it can accomplish a few goals very well, whereas A.G.I. focuses on "broad intelligence" which is more similar to human intelligence. If created, A.G.I. would be able to accomplish any goal, including learning, at least as well as humans (Tegmark, 2017).

Although we don't yet have A.G.I., the number of tasks that computers are now able to do at least as well as humans is growing. This is represented in figure 2, with the mountains representing the difficult tasks for computers, and the rising sea level represents what they are currently able to do (Tegmark, 2017). This suggests there may be a possibility of having A.G.I. in the future.

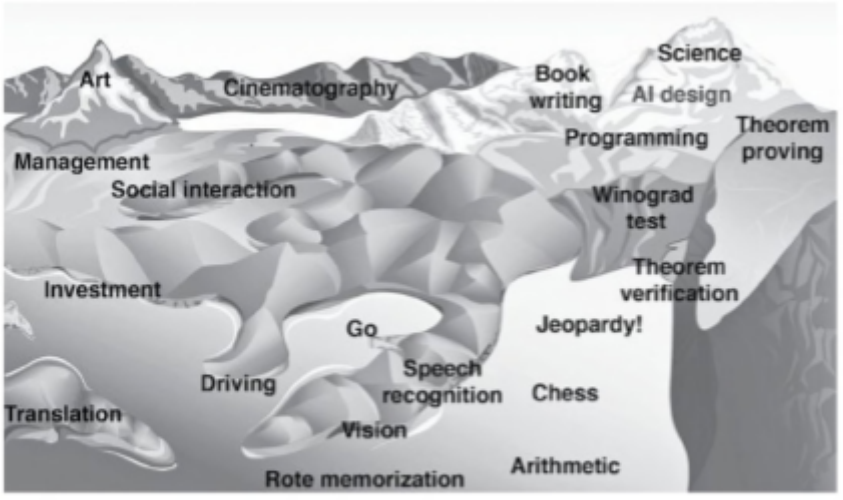

Figure 2: Illustration of Hans Moravec's "landscape of human competence" from the book Life 3.0 by Max Tegmark, page 53.

As shown in the figure 2 illustration, Chess is one of the tasks that A.I. can successfully do better than humans. When this first happened, it was an important landmark in A.I. development. Although the rules of the game can easily be taught to a computer, and a computer can calculate chess moves quicker than a human, it was widely believed that certain intuitive aspects of chess would always give a human an advantage over a computer. However, by 1990 this theory would be proven wrong when the program Deep Thought defeated several chess grandmasters (Goldberg, 1994). More recently, a similar computer program AlphaGo beat the Go world champion, Lee Sedol, in 2016. AlphaGo's victory is viewed as a profound milestone for humanity. KeJie, another top-ranked Go player, said the following on the matter: "Humanity has played Go for thousands of years, and yet, as AI has shown us, we have not yet even scratched the surface… The union of human and computer players will usher in a new era… Together, man and AI can find the truth of Go" (Tegmark, 2017, p.89). This collaboration of human and computer can help us deepen our understanding and thrive in many different fields, such as investment strategy, political strategy and military strategy (Tegmark, 2017). Many people are optimistic about the possibilities brought by the future of A.I., however many others view the A.I. movement in another light.

One of the technologies developed from artificial intelligence is 'machine learning' which gives computers the ability to learn. It's the driving force behind many of A.I.'s most recent breakthroughs according to Max Tegmark. It's machine learning that's behind the algorithms that run video or music recommendations on streaming platforms and push notifications on our mobile phones. Machine-learning algorithms have greatly influenced how we consume media today, including music (Roettgers, 2016).

iii) The Future of A.I. and Its Possible Impacts

As previously mentioned, one of the biggest goals of the A.I. movement today is to successfully develop human-level A.G.I. If that is successfully accomplished, then the logical succession would be superhuman A.G.I., meaning an artificial intelligence system that can outsmart all humans. If that were to happen, what would follow is known as the "intelligence explosion". In 1965, British mathematician Irving Good explained it as the following: "Let an ultraintelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultraintelligent machine

could design even better machines; there would then unquestionably be an 'intelligence explosion,' and the intelligence of man would be left far behind. Thus the first ultraintelligent machine is the last invention that man need ever make, provided that the machine is docile enough to tell us how to keep it under control" (Tegmark, 2017, p.4). There is valuable concern surrounding superhuman A.G.I., should it come to fruition, due to the uncertainty of its outcomes. This is an important topic that should be discussed at length, however, for this paper, we will focus on the A.I. that will impact our lives the most in the near future which is narrow A.I. that can successfully perform one or a few tasks at human or superhuman level.

It's hard to deny that A.I. has many of the skills that are central to being human, such as accomplishing goals, having intuition, understanding language, and being creative. This suggests that even before we develop A.G.I., artificial intelligence has the ability of greatly impacting our lives and how we view ourselves. Everything we love about our civilization is a result of our intelligence, so if those things can be amplified by A.I., this could potentially make our lives even better. Information technology has already positively impacted our lives in many ways and in almost every sector such as science, finance, manufacturing, transportation, healthcare, energy, and communication. A.I. has the ability to improve these sectors in many more ways (Tegmark, 2017). It appears that A.I. will be a prominent part of most businesses going forward. The CEO of Google, Sundar Pichai, emphasised that the shift to A.I. is as important as the invention of the internet and smartphones, stating the following: "We are at a seminal moment in computing. We are evolving from a mobile-first to an AI-first world" (Roettgers, 2016).

Although it could impact many sectors, artificial intelligence also has the risk of leaving many people jobless. Many economists agree that inequality is growing but there is disagreement about why this is happening and whether or not it will continue. MIT economist Erik Brynjolfsson and his MIT collaborator Andrew McAfee agree that it's related to technology. They argue that technology drives inequality in three ways:

1) By replacing old jobs with ones requiring more skills
2) Since 2000, an ever-larger share of corporate income has gone to those who own the company as opposed to those who work there
3) The digital economy often benefits superstars over everyone else.

However, many people are optimistic, stating that automated jobs will replace old jobs with new ones that are even better, similar to what happened during the Industrial Revolution. Many other people still argue that the situation is different today and that an ever-larger group of people will become not only unemployed but unemployable. Some argue that after physical and mental jobs, the next boom will be in creative jobs. However, pessimists argue that creativity is just another mental process that A.I. will eventually master and that computers will also be able to take over creative jobs. Another optimistic argument is that the next boom will be in new technology-enabled professions that don't even exist yet. Despite these broad points of view, statistics currently show that there is a lack of jobs being created by computer technology. In Figure 3, we can see the most popular jobs in the U.S. in 2015. There are no new jobs created by computer technology until the twenty-first place "software developers, applications and systems software" (highlighted in yellow). This shows that we need to take the possible impact of A.I. on jobs seriously as it could have a negative impact on the jobs of millions of U.S. citizens, not to mention the worldwide impact it could have on employment (Tegmark, 2017).

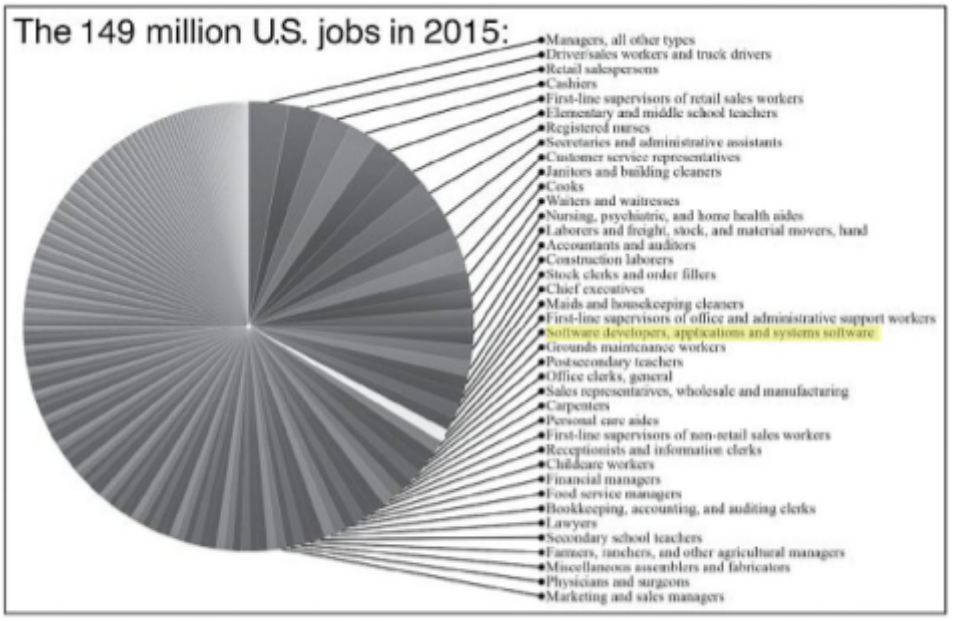

Figure 3: Pie chart with data from the U.S. Bureau of Labor Statistics showing the occupations of 149 million Americans who had a job in 2015, with the 535 jobs sorted by popularity. All occupations with over a million workers are labelled. Graph from the book Life 3.0 by Max Tegmark (p.125).

It's worth noting however that the impact A.I. could have on employment may not result in negative circumstances. If societies successfully redistribute the wealth created by A.I., this could make everyone better off and could be a solution for possible unemployment. Many economists argue that if this doesn't happen, then inequality will greatly increase.

If planned correctly, a low-employment society has the possibility of prospering financially and people would be able to get their sense of purpose from activities other than jobs. As a result of the advancements of A.I. in the workplace, many people are advising children to prepare themselves for jobs that machines are currently bad at such as jobs involving people, unpredictability and creativity (Tegmark, 2017). There is no way to guarantee, however, that those jobs won't one day also be taken over by A.I.

iv) Subgroups of the A.I. Movement

In the growing conversation about artificial intelligence and what its aims should be, three main points of view have taken form. There are the techno-sceptics, the digital utopians and the beneficial-A.I. movement. The techno-sceptics are sceptical of the probability of building superhuman A.G.I. or they think that it won't be built for hundreds of years so there's no use in talking or worrying about it now. The digital utopians are optimistic that superhuman A.G.I. will be created this century and welcome it with open arms, viewing it as the next natural step in the cosmic evolution. The beneficial-A.I. movement also think that there's a high probability that we'll see superhuman A.G.I. in this century but are uncertain about the positive outcomes of it, and they think we should ensure a positive outcome by doing adequate research in A.I.-safety (Tegmark, 2017).

There are also a lot of other strong opinions surrounding artificial intelligence that haven't been mentioned, however many of them are based on misconceptions and misinformation about A.I. which have been debunked (Tegmark, 2017). For this reason, we will only focus on the opinions that take form in the scientific and A.I. community.

b) History of the Use of A.I. in Music

As we've previously seen, A.I. research is present in many different fields and the arts are no different. In music, much of the A.I. research seems to be primarily focused on the detection of musical events and signals, and music composition. While there is no clear start to the research of A.I. in music, there was already research being done in the early 1980's, so we will focus on the research that has been carried out since then. In the 1983 Leonardo journal article "Computer Art: Artificial Intelligence and the Arts", Stephen Wilson said the following on the A.I. research being done in the arts at the time: "Although interesting artworks have been made, there is a wide feeling that the artistic potential of computers has been exploited only to a limited degree.

However, research now going on in artificial intelligence (AI) could radically alter the way one thinks about making artworks". By then, artists had already incorporated digital computers in their works and had used them to produce graphics, videos, words, and music. Artists were using chance and random factors in computer programs to compose music and make visual art. Using these programs, the artists were unable to predict what the computer was going to produce. These developments in A.I. allowed the artist to produce new types of art that weren't possible previously. Wilson was already speculating an A.I. driven future and encouraged artists to explore ways to 'humanise' computer systems (Wilson, 1983).

Going further to the 1990's, and more research has been done specifically in the field of A.I. applications in music. By 1994, there were A.I. systems produced to be able to detect unwanted sounds, such as clicks, in old audio recordings with the purpose of restoring them. The results were positive and Czyzewski said the following on the system: "The learning detection algorithm allows to discern impulsive disturbances from normal percussive or transient events. The learning algorithm is also more effective than the traditional techniques when applied to the restoration of missing samples by the processing of old audio recordings" (Czyzewski, 1994).

Also in 1994, there was an A.I. system dedicated to the detection of events in musical signals that performed tasks such as musical pattern recognition, impulse noise detection and analyzing of transient states in musical instrument sound. Only people who have a "musical ear" can detect some of these musical events, so having an A.I. system that can accomplish these tasks is useful for recognising events in sound that are not usually easily detectable by humans (Kostek, Czyzewski and Zielinski, 1994).

In 2015, Eduardo R. Miranda and Duncan Williams summarised the research of A.I. in music in the following way: "Traditionally, Artificial Intelligence systems for music have been designed with note-based composition in mind, but the research we present here finds that Artificial Intelligence has also had a significant impact in electroacoustic music, with contributions in the fields of sound analysis, real-time sonic interaction and interactive performance-driven composition, to cite but three". As we can see, the application of A.I. in music is a very broad field. For this reason, we will focus our research solely on music mixing and mastering and not composition and recording.

They then go on to specify the goals of A.I. in electroacoustic music as “assisted composition, human-like performance rendering of scores, sound organisation and/or advanced synthesis control”. A.I. can be employed in music to create human-like performances of music sequenced or scored by humans. There are also systems which can compose new music based on a specific database of source material that it uses to create a new song (Miranda and Williams, 2015). A recent example of this is Sony’s Flow Machines which composes songs in a specific style of an artist (The Beatles, for example) based on databases of that artist’s music (Flow Machines, n.d.). On the predictions of the next twenty years of A.I. in music, Miranda and Williams said the following: “This research is providing us with better understandings of how our brain works. Such understanding is bound to result in new technological and also theoretical developments for music. Unfortunately, scientific progress on this front has so far been largely insignificant for music, as most of this progress has been on visual processing. The truth is that auditory processing turns out to be fiendishly more complicated than had been previously thought. Consequently, our current understanding of how the brain processes music lags far behind our understanding of other brain functions. Despite a fair amount of research that is being developed within the emerging field of cognitive neuroscience of music, progress so far has been disappointing and profoundly irrelevant to musicians in general, and in particular to the electroacoustic community” (Miranda and Williams, 2015). We can see that there is still a lot of research to be done in A.I. for music. With that said, let us take a look at the current research being conducted in A.I. for music mixing and mastering.

c) Automatic Mixing

i) Definition of Mixing and Automatic Mixing

In music production, mixing is the process that transforms multiple tracks or recordings into one song (Deruty, 2016). Recorded tracks almost always need a significant amount of processing before being ready for distribution. Some examples of the processing done to tracks during the mixing stage are level balancing, panning, equalisation (EQ), dynamic range compression and artificial reverberation (De Man, Reiss and Stables, 2017).

Automatic mixing is A.I. assisted mixing that aims at producing a mix without human intervention (Deruty, 2016). It can be fully automated, with no human mixer, or it can be A.I. aided mixing by a human mixing engineer. The authors of the paper “Automatic Multi-track Mixing Using Linear Dynamical Systems” explained automatic mixing as such: “Currently, professional music post-production is performed by a highly skilled engineer with years of training. Using structured techniques, a parameterized, generative version of this process that is applicable to a variety of source audio is possible” (Scott et al., 2011). Mixing engineers are not yet rendered jobless by automatic mixing software, but there are a lot of common ways that people mix music that can be applied to A.I. systems. These automatic mixing systems can then emulate human mixers with the aim of making it sound as close as possible to what an engineer would produce (Rumsey, 2013). An automatic mixing system can quickly provide a starting point to a mix, allowing the engineer to take responsibility for the more creative parts of mixing. In this case, automatic mixing can be seen as a sort of ‘digital assistant’ (De Man, Reiss and Stables, 2017).

ii) History of Automatic Mixing

There is no clear beginning of the research into automatic mixing. However, there is a paper from the 1997 AES convention in New York on the use of A.I. in mixing. In the paper, the authors describe introducing A.I. functions in their digital mixing console: “In a first attempt to provide the user with more intelligent aids on the mixer and to exploit the digital processing power, some artificial intelligence functions have been added, in order to get a first software aided mixing support. [...] We think this approach opens a new way of designing (low cost) mixing consoles, where hardware is very simplified and most processing power is devoted to support the sound engineer's mixing job, thanks to more and more helpful artificial intelligence functions” (Baldini, Nottoli and Paterlini, 1997). This seems to be one of the earliest applications of A.I. in mixing.

The term ‘automatic mixing’ was coined by audio engineer Dan Dugan and it first referred to the automatic gain handling of a microphone for speech. Around 2007, Enrique Perez Gonzalez developed the meaning of automatic mixing to include stereo panning of multitrack audio. Between 2007 and 2010, he went on to automate more mixing processes such as level, EQ, and delay correction. This is considered the starting point of the ‘automatic mixing’ field (De Man, Reiss and Stables, 2017).

iii) The Situation Today and for the Future

Over the last few decades, music production went from being something only possible in large and expensive studios to something virtually anybody can do in their homes. New digital production tools have changed the way we consume and interact with music today (Scott et al., 2011). This widespread access to at-home production techniques has allowed music production on limited budgets. Musicians can now also distribute their own music for little or no cost (De Man, Reiss and Stables, 2017). Despite the easy access to music production techniques today, a lot of skill is involved in producing high-quality, professional-sounding results. Learning how to mix or master appropriately takes a lot of time and training (Scott et al., 2011). While professional music engineers train and practice for years, an amateur music producer will likely produce sonic problems while recording, for example (De Man, Reiss and Stables, 2017). Thus, there is still a need for mixing or mastering assistance for amateur musicians and music producers.

Automatic mixing can be a possible solution for musicians and music producers that seek a professional-sounding mix on a low budget. By producing a mix quickly and without the need of human involvement, home recording becomes a more affordable option for budget-limited musicians, and they can then focus solely on the creative aspects of music production and increase their productivity. While automatic mixing can be useful for musicians and music producers, it can also be useful for mixing engineers. They are often under pressure to produce high-quality mixes quickly and at a low cost, and although they're not likely to relinquish complete control of mixing to A.I. systems, they can be used to help them work more efficiently. By assigning time-consuming and tedious tasks to the automatic mixing software, this could be helpful to mixing engineers who can then focus solely on the creative side of mixing. Other than the previously mentioned uses, automatic mixing can also be useful for mixing the sound at a small venue that has no sound engineer, for a band rehearsal, or for a conference PA system. Automatic mixing can also be used for automatic music composition, to produce a fully automated music production system from start to finish (De Man, Reiss and Stables, 2017).

Although the research into automatic mixing has come a long way over recent decades, almost all of the work in the field is focused on mixes with two channels at most. The lack of work in the automatic mixing of multi-track music is a problem that needs to be solved before it can be seen as a viable competitor to mixing engineers (De Man, Reiss and Stables, 2017). Other than that, other shortcomings of automatic mixing are that it can currently only address a few goals of mixing when there are many. More research is needed to fill the gaps in the automatic mixing system's skills if it's going to stand a chance at emulating human engineers (Deruty, 2016). If these issues can be resolved, this could revolutionise the music production workflow over the next ten years. Further research in this domain could see its implementation in growing fields such as augmented and virtual reality systems and video game audio, as well as in film audio. More work in this field could also help to uncover the governing rules of music mixing and particular mixing styles by analysing a large amount of data. If successful, this could allow the automatic mixing software to mimic the style of a specific mixing engineer or to create a mix that fits a specific musical style (De Man, Reiss and Stables, 2017).

d) Automatic Mastering

i) Definition of Mastering and Automatic Mastering

According to music technology author Francis Rumsey, "Mastering is a process of 'finishing' in audio production that aims to unify and improve the final quality of a project" (Rumsey, 2010, p.65). Automatic mastering is, similarly to automatic mixing, a system that removes the need for a human engineer by having the tasks involved with mastering be performed by A.I. software. Researcher Stylianos-Ioannis Mimilakis suggested that one of the main tasks carried out by mastering engineers is the process of equalisation required to unmask wanted sounds that have been masked by other sounds in the mix, for example. It is observed that when equalising music, mixing and mastering engineers aim towards a subconscious target frequency response curve (Rumsey, 2013). Using this info to train A.I. systems, you can, therefore, create an artificial mastering engineer that can equalise a mix in a convincing manner.

ii) How Technology Has Affected Mastering

Mastering music during the analogue age usually involved optimising the audio to account for the limitations of the delivery medium. With the invention of digital audio, the new transparency of the digital music delivery medium meant that mastering engineers had to rethink the need for mastering. Today, the delivery medium most used is streaming services and digital downloads which can allow music to be played on many different devices that provide different levels of audio quality, meaning that the mastering engineer today has to take into account these challenges. The rise of at-home music production has also provided a new demand for mastering services. The same technology that has allowed musicians to record themselves, also allows them to distribute and market their music by themselves. This has no doubt changed the music industry as it has introduced autonomy in music production, allowing one person to write, record, mix, master and distribute their music all by themselves. This autonomy has produced challenges, however, as a lot of these at-home recordings have been done by people with little knowledge of how to produce high-quality sound. A lack of technical knowledge could be considered negative when taking into account the current norms surrounding what may be considered a “good” or a “bad” recording. This can cause issues with recordings, which then if not mixed correctly, can produce further issues when the mix reaches the mastering process (Rumsey, 2010).

As a result of the new autonomy of music production, we’ve seen a rising number of online automatic mastering services. These services master the provided song solely with the information included in the audio signal and do not rely on any additional information such as the desired distribution platform or genre-based mastering preferences. Thus, all decisions are taken out of the client’s hands, which can be appealing for people with little to no knowledge of mastering, and it is convenient for time-limitations and budget-limitations (Piotrowska, Piotrowski and Kostek, 2017). One of the most notable examples of these automatic mastering services is LANDR. Created in 2014, it has currently been used over two million times (LANDR, n.d.). Music production website “Pro Tools Expert” conducted an online survey to find out which mastering service is considered the best according to their users. They mastered five songs using LANDR, Cloudbounce, and iZotope Ozone 8’s Mastering Assistant and had users decide out of the three, which mastered version of the song sounded the best, without knowing which mastering service was which. Over 1000 users completed the survey, and as we can see in figure 4, the results suggest that LANDR is the preferred service with a 46% approval rating (Cooper, 2017).

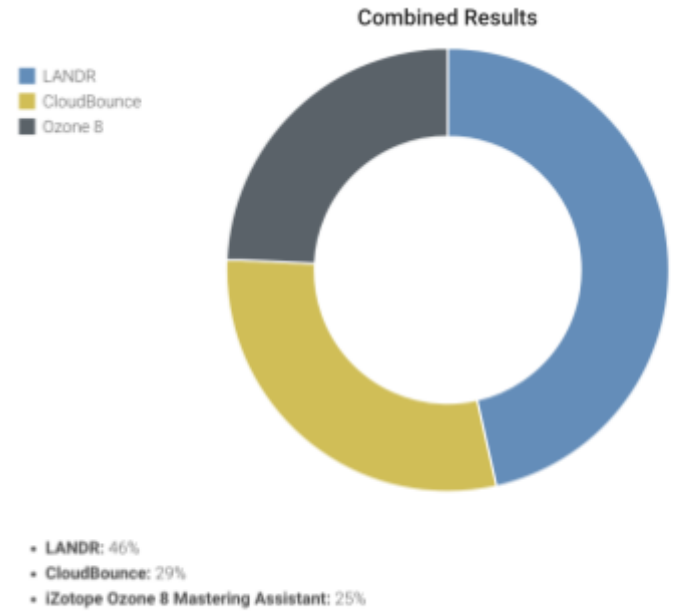

Figure 4: Results of automatic mastering services poll from Pro Tools Expert (www.pro-tools-expert.com).

A similar test was also carried out by Pro Tools Expert, where users were asked to choose their favourite mastered version of a track. Three songs were mastered by a mastering engineer, a mixing engineer, and LANDR. They received around 700 results for each test, and they proved that LANDR is a valid competitor for mixing and mastering engineers (Cooper, 2017).

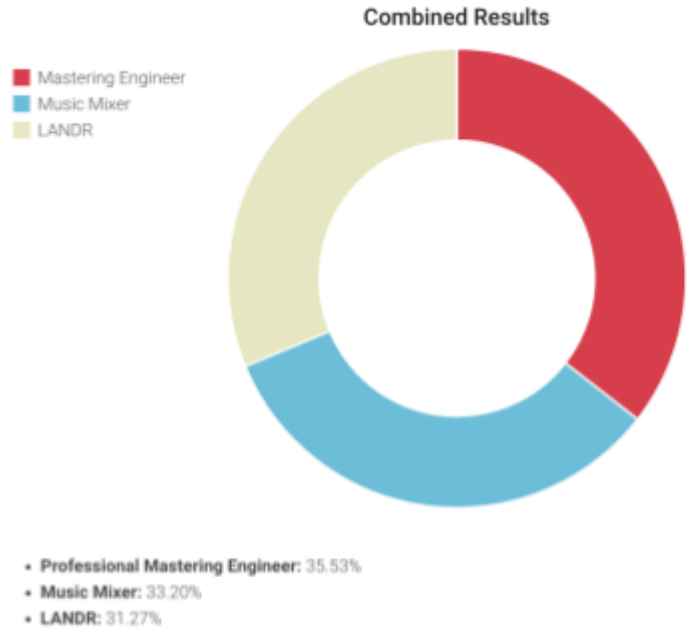

Figure 5: Results of mastering poll from Pro Tools Expert (www.pro-tools-expert.com).

Overall, people preferred the mastering engineer's version of the mastered track, but the results were very close. As we can see from figure 5, LANDR was behind the mastering engineer by just over 4% (Cooper, 2017).

e) Issues Relating to A.I. in Music Mixing and Mastering

There is a lot of potential in the use of A.I. in science and art. However, the very mention of it causes a lot of controversy for some people (Duisberg, 1984). Here are some of the possible issues related to A.I. in music mixing and mastering.

The use of A.I. in music production has raised some questions about the ownership of the music. For example, who is the composer if A.I. has been used in the creation of the music (Miranda and Williams, 2015)? These same questions arise with mixing and mastering. If the mixing and mastering were done by an A.I. software, is there a need to give credit to the creators of that software recognising them as mixing or mastering engineer? If these A.I. services become an integral part of the music industry in the future, then this needs to be addressed.

If we relinquish control of mixing and mastering processes to A.I. software, then we are conforming to the software creator's views of what a good mix or master should sound like. As there is no way for a computer to distinguish between good and bad sounding music, this must be decided by the programmer, so there is no objective way to create an automatic mixing or mastering system (Miranda and Williams, 2015). This could remove a lot of the creative processes involved with mixing and mastering. A possible solution to this would be to provide the client with more control of the mixing or mastering software if they wish to personalise the mix or master rather than simply following the programmer's algorithm.

Some people may be bothered by the use of A.I. systems in the production of music. The electroacoustic community seems to be less bothered by this than people of the classical music community for example (Miranda and Williams, 2015). This comes down to personal choice, and while some may choose not to use these services, many others will likely embrace it. People who were brought up with technology as an integral part of their lives may not be so bothered by the use of an A.I. software being used in the music production chain, while someone with a more traditional point of view may be uninterested in the use of these technologies. The authors of the paper "Ten Years of Automatic Mixing" said the following on the subject:

“Throughout the history of technology, innovation has traditionally been met with resistance and scepticism, in particular from professional users who fear seeing their roles disrupted or made obsolete. Music production technology may be especially susceptible to this kind of opposition, as it is characterised by a tendency towards nostalgia, skeuomorphisms and analogue workflows, and it is concerned with aesthetic value in addition to technical excellence and efficiency” (De Man, Reiss and Stables, 2017).

Another issue with these A.I. services is that they are possibly putting mixing and mastering engineer’s jobs at risk. As we’ve previously seen in this chapter, A.I. has the possibility of affecting many jobs in many different industries, so it is reasonable to be uncertain of the future of mixing and mastering engineer’s jobs. Other than the risk to engineer’s jobs, if A.I. mixing and mastering services take over in the music production industry, then this could be problematic for musicians as well. One of the main advantages of music production engineers over A.I. services is that you can work with a human that can fully comprehend what you desire of the mixing or mastering process of your music. The subtleties involved with fulfilling a client’s request is something very difficult to incorporate in A.I. services, especially with software such as LANDR that provides the user with no options as they have a ‘one size fits all’ approach to music mastering. This may not be something that some musicians want, and that is something that a mastering engineer will have an advantage over. If the essential communication between engineer and client is well established and maintained throughout the mixing or mastering process, then the client is more likely to have realistic standards and be able to fully explain what they want their finished product to sound like. The ‘chemistry’ between an engineer and a client is a valuable relationship that helps both parties complete their work better, so removing this connection can leave some artists in the dark about what is actually happening to their music (Rumsey, 2010).

3) Methodology

a) Research Plan

To appropriately attempt to answer the research questions of this paper, interviews and a survey were conducted. The interviews were with music industry professionals and experts in the artificial intelligence movement. Through the survey and interviews that were conducted, we were able to see broad perspectives of different people in the music and artificial intelligence industries and were able to understand their views on these technologies. This can then be used to make educated predictions of what the future of the music industry looks like.

During the interviews, music industry professionals such as mixing and mastering engineers were asked if they have ever used A.I. systems to assist them in their work, what their views are of these technologies, and what they think the likelihood of A.I. services taking over their jobs is. Artificial intelligence experts were asked what their predictions are for future jobs in relation to A.I. and if a low-employment society is a possible outcome.

There was an online survey conducted to determine the use of A.I. services in music mixing and mastering among a wider range of musicians, including amateur musicians. The survey asked musicians questions about their budget allocated to music production and whether this affects their choice of mixing and mastering services, how likely they are to use A.I. services to mix and master their music as opposed to hiring an engineer and what their views of these A.I. technologies are.

Through these interviews and survey, there was a significant amount of information that could be used to answer the research questions.

b) Limitations of the Research

One of the main limitations of this research is that there are no definitive and certain answers to any of the research questions due to the fact that we have no way to accurately predict what will happen in the future in relation to A.I. in the music industry. Thus, the answers to the questions will simply be educated guesses, based on what a group of people think. These predictions can still be useful to gain an insight into the

patterns of the music industry and these can be used to better prepare ourselves for the future regardless of the outcome.

Another limitation is the lack of access to musicians and their opinions. The survey was posted online in various groups and pages devoted to music on the social media site Facebook. This limits the respondents to internet and Facebook-using musicians, ignoring musicians that aren't on those platforms. To get more accurate data results, a survey should be conducted with both musicians online and elsewhere. Since the data was only from online musicians, it may not be accurate enough to paint a broad picture of the music industry.

4) Results

The online survey was created to confirm or disprove the following three hypotheses:

1) Amateur musicians are more likely to have a lower music production budget compared to professional musicians (there is an expected correlation between budget and the occupational level of musicians).
2) Musicians younger than 35 are more likely to use A.I. software to produce their music (there is an expected correlation between age and feelings on the use of technology).
3) Musicians with a larger budget are more likely to hire more people for their productions compared to musicians with lower budgets (there is an expected correlation between budget and accessibility to mixing and mastering engineers).

The survey helped gain an insight into the views of musicians and with 300 responses, provided a sufficiently large pool of people to acquire a broad view on the use of A.I. in the production of music. The following data results show the correlations that were observed between the different questions asked. These correlations were discovered with the help of a data analyst who inputted the survey results into a data analysis software to determine the correlations between variables.

	Yes	Significant variables
Use of A.I. music production services (Question 8)	14.3 % (43)	**Genre (Question 3)** [Chi-Square p. value= *0.0021*; ANOVA p. value= *0.0014*]

	Neutral	Likely	Significant variables
Likelihood of the loss of business being a deterrent to the use of A.I. in music production (Question 14)	13.3 % (40)	50.5 % (152)	**Budget for the production of one song (Question 4)** [ANOVA p. value= *0.0331*]

	Less than 100 €	100-500 €	500-1000 €	1000-5000 €	More than 5000 €	Significant variables
Budget for the production of one song (Question 4)	51.3 % (154)	31 % (93)	12.3 % (37)	5 % (15)	0.3 % (1)	**People involved with production of music (Question 5)** [Chi-Square p. value= <*.0001*; ANOVA p. value= <*.0001*] **Likelihood of the loss of business being a deterrent to the use of A.I. in music production (Question 14)** [ANOVA p. value= *0.0331*] **Occupational level of musician (Question 2)** [Chi-Square p. value= <*.0001*; ANOVA p. value= <*.0001*]

	Amateur	Semi-professional	Professional	Significant variables
Occupational level of musician (Question 2)	30.3 % (91)	46.3 % (139)	23.3 % (70)	**Budget for the production of one song (Question 4)** [Chi-Square p. value= <*.0001*; ANOVA p. value= <*.0001*]

	No	Composer, songwriter	Music producer	Session musicians	Recording engineer	Mixing engineer	Mastering engineer	Band member(s)	Significant variable
People involved with the production of music (Question 5)	30.5 % (145)	8 % (38)	5.9 % (28)	15.1 % (72)	12.4 % (59)	12 % (57)	14.7 % (70)	1.5 % (7)	**Budget for the production of one song (Question 4)** [Chi-Square p. value= *<.0001*; ANOVA p. value= *<.0001*]

	Rock	Classical	Electronic	Jazz	Folk	Alternative	Pop	Other	Significant variable
Genre (Question 3)	21.7 % (65)	16.7 % (50)	31.3 % (94)	4.7 % (14)	3.7 % (11)	6.7 % (20)	3.7 % (11)	11.7 % (35)	**Use of A.I. music production services (Question 8)** [Chi-Square p. value= *0.0021*; ANOVA p. value= *0.0014*]

We can observe a correlation between the budget of musicians for the production of one song and the number of people involved with the production of their music. This can be proven by the probability value of the correlation between those questions being less than 0.05 (Chi-Square p. value= <.0001; ANOVA p. value= <.0001).

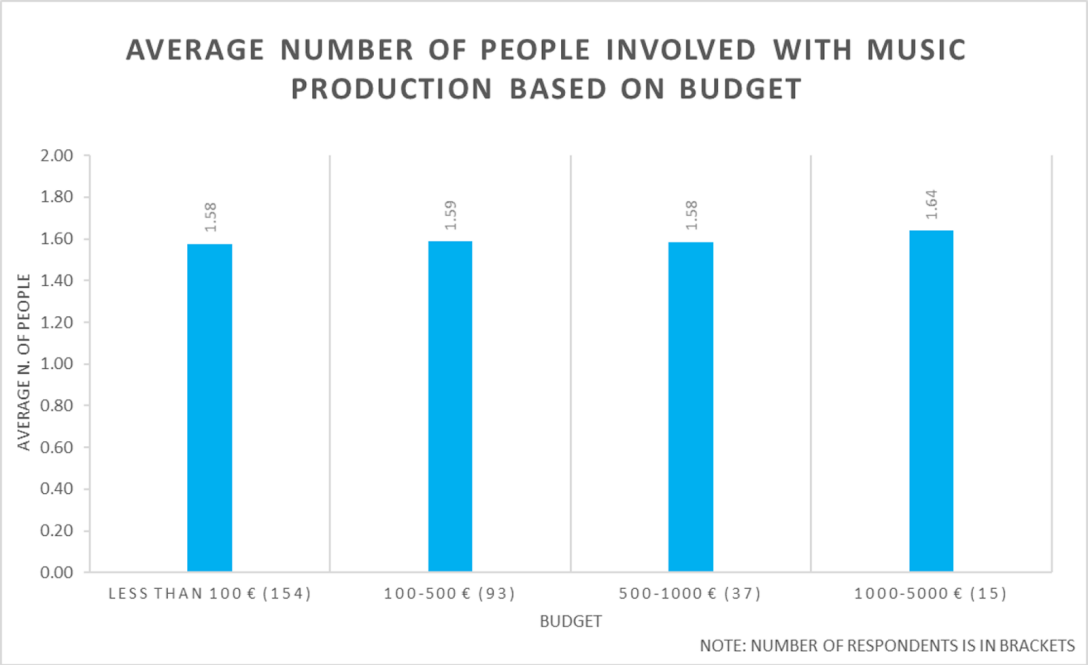

Figure 6: Representation of the correlation of musicians' budgets and the average number of people involved with their music productions.

As we can see in figure 6, on average there appears to be a higher number of people involved with the production of music for musicians that have a budget of 1000-5000 €.

We can also observe a correlation between the use of A.I. software to produce music and the genre of music the musician plays. This can be proven by the probability value of the correlation between those questions being less than 0.05 (Chi-Square p. value= 0.0021; ANOVA p. value= 0.0014).

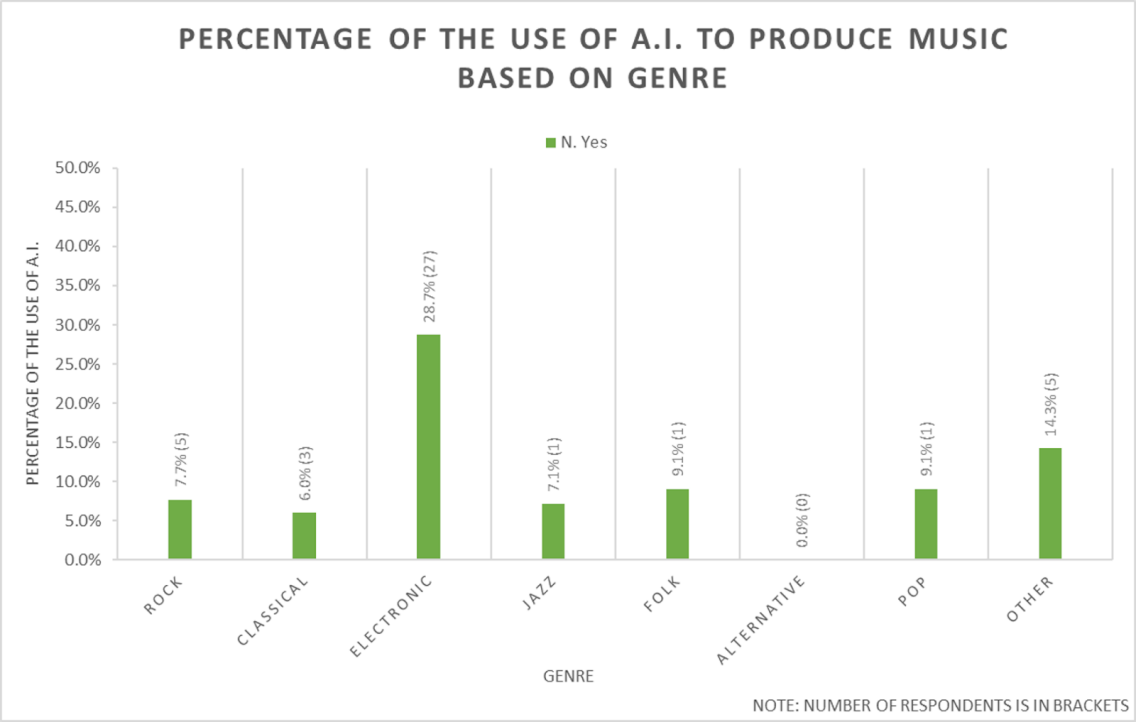

Figure 7: Representation of the correlation between the use of A.I. software to produce music and the genre of music the musician plays

As we can observe in figure 7, there seems to be a higher rate of usage of A.I. software to produce music by musicians who make electronic music.

We can observe a correlation between the budget of musicians for the production of one song and the likelihood of a potential loss of business to people in the music industry being a deterrent to the use of A.I. in music production. This can be proven by the probability value of the correlation between those questions being less than 0.05 (ANOVA p. value= *0.0331*).

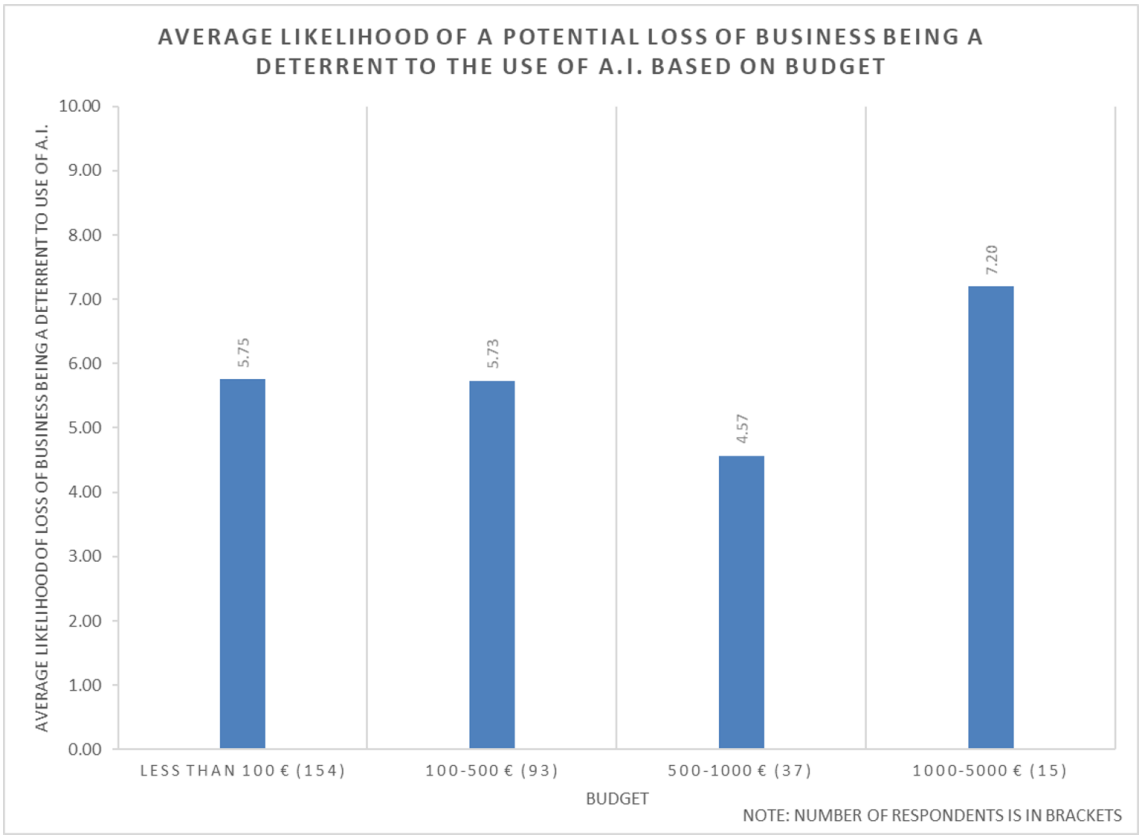

Figure 8: Representation of the correlation between musicians' budgets and the likelihood of a potential loss of business to people in the music industry being a deterrent to the use of A.I. in music production.

As we can observe in figure 8, there seems to be a significant difference between the average likelihood of a potential loss of business to music professionals being a deterrent to the use of A.I. for musicians with a budget of 500-1000 € and 1000-5000 €.

Lastly, we can observe a correlation between the budget of musicians for the production of one song and the occupational level of musicians. This can be proven by the probability value of the correlation between those questions being less than 0.05 (Chi-Square p. value= <.0001; ANOVA p. value= <.0001).

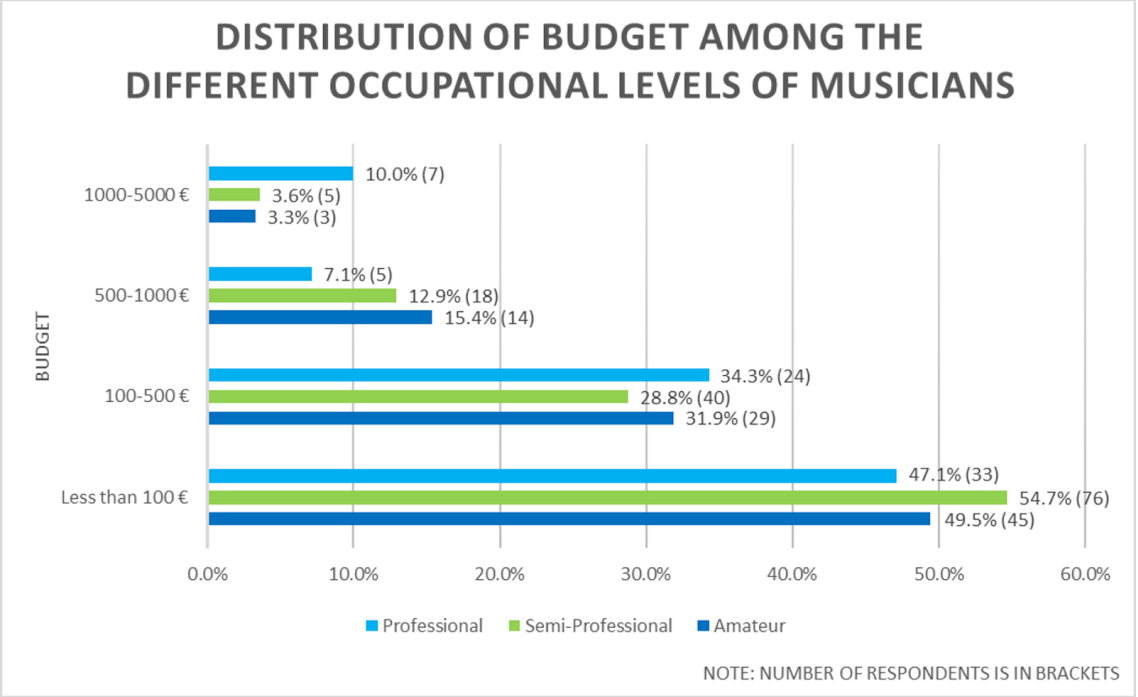

Figure 9: Representation of the correlation between musicians' budgets and the occupational level of musicians.

As we can observe in figure 9, professional musicians seem to have a higher budget compared to amateur musicians.

The first hypothesis can be confirmed. Amateur musicians are more likely to have a lower music production budget compared to professional musicians as there seems to be a correlation between the budget and the occupational level of musicians. This can be proven by the probability value of the correlation between those questions being less than 0.05 (Chi-Square p. value= <.0001; ANOVA p. value= <.0001).

The second hypothesis cannot be confirmed. Musicians younger than 35 are not more likely to use A.I. software to produce their music as there seems to be no correlation between age and feelings on the use of technology. This can be proven by the probability value of the correlation between those questions being more than 0.05 (Chi-Square p. value= 0.3812; ANOVA p. value= 0.7738)[1].

The third hypothesis can be confirmed. Musicians with a larger budget are more likely to hire more people for their productions compared to musicians with lower budgets as there seems to be a correlation between budget and accessibility to mixing and mastering engineers (number of people involved in the production of music). This

[1] See the appendix for more details on these results.

can be proven by the probability value of the correlation between those questions being less than 0.05 (Chi-Square p. value= <.0001; ANOVA p. value= <.0001).

5) Discussion

a) Answering the Research Questions

How do musicians feel about the use of technology?

To determine how musicians feel about the use of technology, musicians were asked in the online survey how they feel about the use of technology in day to day life on a scale of one to ten. Most musicians have a positive feeling towards the use of technology, with 82.3 % giving a positive response and 12.3 % giving a neutral response. This suggests that musicians are open to the use of technology and may potentially also be open to the use of A.I. technology.

When musicians were asked what some of their concerns were for the use of technology, here is what some of them said:

- Lack of privacy and security
- Excessive automation
- Negative impact of social media on people and society
- Less creativity
- Excessive use of technology, dependency, and addiction
- Distraction from real life, less productive
- Potential for misuse
- Not always reliable
- Loss of control
- Lack of humanity, human communication and connection
- Overly reliant on technology
- Risk to jobs

Here are some of the positive aspects that musicians highlighted about technology:

- Technology is a sign of advancement of our species

- Technology helps humans, makes life easier
- It adds to the creative process

As we can see, there are a lot of concerns related to the use of technology that need to be addressed by A.I. companies if they want to successfully implement their services into the music industry and convince more musicians to use them.

How do amateur and low-budget musicians feel about these technologies?

Answering the same question on the feelings of technology on a scale of one to ten, amateur musicians gave an average answer of 7.56, semi-professional musicians gave an average answer of 7.67, and professional musicians gave an average answer of 7.5. As we can see, there's not much difference in the average answers based on the occupational level of the musicians, which suggests that the overall feeling on the use of technology is unaffected by occupational level.

Looking at the average feelings on the use of technology based on the budget of musicians to produce one song, we can see that lower budget musicians have an average answer of 7.51 for musicians with a budget of less than 100 € and 7.43 for a budget of 100-500€. For higher budget musicians, the average answer is 8.22 for musicians with a budget of 500-1000 € and 7.87 for a budget of 1000-5000 €. We can see that there's a slight difference between lower and higher budget musicians with there being a slightly higher score for higher budget musicians. However, overall the answers are positive for both lower and higher budget musicians, which suggests that the overall feeling on the use of technology is unaffected by budget.

What is the likelihood of professional or amateur musicians using these technologies?

In the online survey, musicians were asked if they have already used A.I. services to produce music or not, and 14.3 % said yes. When asked which ones, 72.7 % of musicians said that they had used LANDR. As we can see in figure 10, this makes LANDR the most popular A.I. music production service among musicians, followed by iZotope Ozone, and iZotope Neutron.

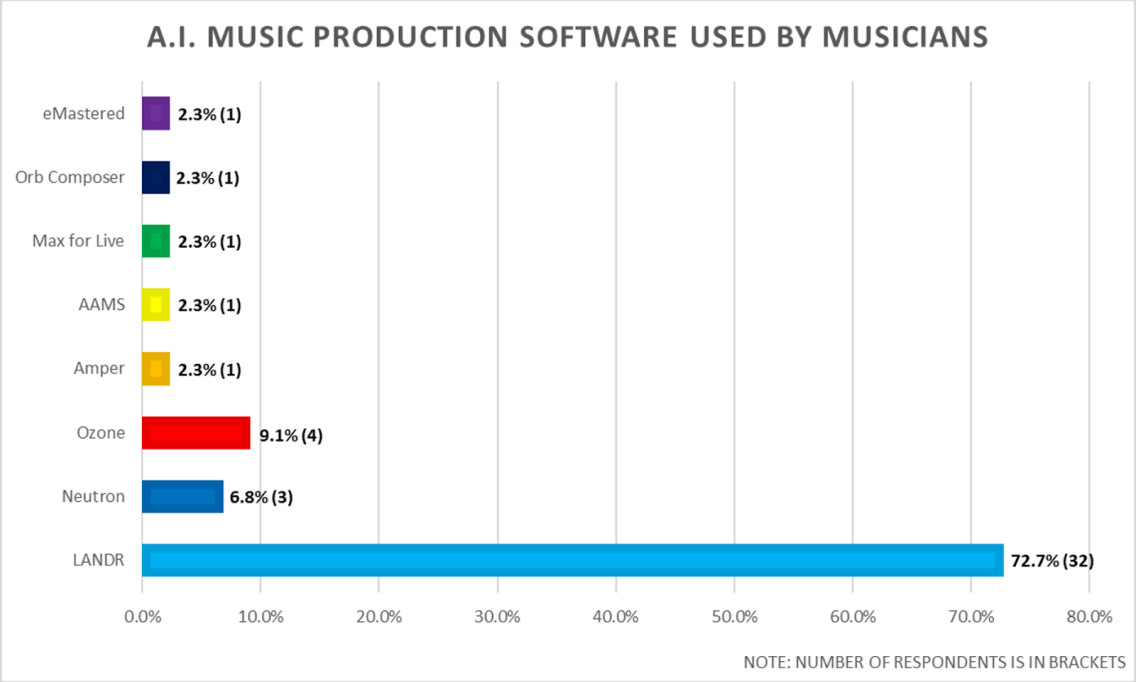

Figure 10: The most used A.I. music production software among musicians who answered yes to the question of whether or not they use A.I. software to produce their music.

While the average feeling towards the use of technology among musicians is mostly positive, the majority of musicians don't use A.I. technology to produce their music. When musicians were asked how likely they are to use A.I. services if they could be used to replace music production professionals (such as mixing and mastering engineers) for a significantly lower price while maintaining similar results, the majority (45.9%) of musicians said that they were unlikely to use these services. For the rest of musicians, 11.7 % gave a neutral result and 42.3 % said that they were likely to use these services. As we can see, even though the majority of musicians said that they are unlikely to use these services, there is also a large amount that said that they are likely to use them. When asked to clarify their responses, here are some of the reasons given by musicians to not use A.I. music production services:

- Lack of trust in the technology
- Dislike of results, generic results
- Lack of human control
- Not comparable to music professionals
- No emotion, music is about feeling
- No human contact and communication
- Unwillingness to put music professionals out of business
- Difficulty to emulate humans in music production
- A.I. can't replace an engineer with "good ears"

- Willingness to support local music scene
- Every song is different and requires a different approach
- A.I. doesn't take into account the infinite possibilities in mixing and mastering
- It feels good to be part of a creative group of people
- Human imperfection is unique and gives character to music

Here are some of the reasons given by musicians to use A.I. music production services:

- It's affordable
- Useful if it can be used in a creative and unpredictable way
- Useful for musicians who need help, "beggars can't be choosers"
- Willing to use if it does a better job [than music professional]
- Helpful when you can't find a professional
- It doesn't matter if the end result is the same as an engineer
- Saves time and speeds up the process
- Improves the process, makes it easier and more approachable
- If the end result is the same then it doesn't matter for the listener
- Useful for mastering as it requires less personal artistic views
- Machines do what you want, when you want
- It eliminates human errors

These results suggest that some musicians are willing to use A.I. services to produce their music if they can get similar results to other music production engineers, but there are still a lot of constraints that are discouraging musicians from fully embracing these technologies.

How do mixing and mastering engineers feel about these technologies?

An interview was conducted with Pieter de Wagter, mastering engineer at EQuuS studio in Brussels, Belgium, to gain an insight into the use of A.I. in music mastering[2]. Speaking about the use of A.I. technology in his own projects, he stated that he sometimes uses Izotope's Ozone mastering assistant to give himself a fresh perspective when he's unsure of which direction to go in with the mastering. "It can give me a starting point," he says. "After that I usually change all the presets and there's

[2] See the appendix for the full interview

nothing left of the original AI settings. So it's sometimes usefull (*sic*) but you still need a professional ear to asses (*sic*) the quality of the processing."

When asked how he feels about the use of A.I. technology in the music industry, he said the following: "Today these services as mostly used by labels releasing a lot of music, or amateur producers. They can't afford a professionel (*sic*) mastering, and then turn to A.I. services. But when they release an important album, they always use a professional mastering studio" (de Wagter, 2018).

It seems that the use of A.I. technology as an aid to mixing or mastering can be useful to engineers, but that same technology can't yet fully produce the same quality of results as those professional engineers.

Will mixing and mastering engineers consider collaborating with these technologies?

During the same interview, when de Wagter was asked if he'd consider collaborating with A.I. technology if it became fully integrated into the music industry, he said the following: "I would continue using my current workflow. In my experience it's mostly a waste of time. I hear the result, compare it with what I've done, and 9 times out of 10 I prefer my own version. But as I said before I use it as a starting point when the mix is really bad" (de Wagter, 2018).

As previously mentioned, A.I. technology can be a useful tool that mixing and mastering engineers can use to aid them in their work. It appears that a collaboration between A.I. and mixing and mastering engineers is already a possibility.

b) What the Results Suggest for the Future of the Music Industry

i) According to the Survey Results

The survey results suggest that amateur musicians have a lower music production budget compared to professional musicians. This information can be useful to A.I. services so that they can take advantage of amateur musicians' lower budgets to market their low-cost software to them. This information can also be useful to mixing and mastering engineers, whose services usually cost more than A.I. services such as LANDR which can cost from four to 25 dollars a month (LANDR, n.d.). If they know that

professional musicians have a higher budget, mastering engineers can market themselves to them and maintain the current costs of their services.

The results also suggest that musicians with a larger budget are more likely to hire more people for their music productions. This could be useful information for A.I. services, as they can then fill the roles of the people that musicians with a smaller budget aren't able to hire. It would also be useful for mixing and mastering engineers to market themselves to musicians with higher budgets in this case.

Additionally, the results show that the largest group of musicians that use A.I. software use it to produce electronic music. This could be useful information for A.I. software companies as they can market themselves to fans and musicians of electronic music. This is also useful for mixing and mastering engineers, as they can aim to work with musicians of other styles of music.

Lastly, the results show that musicians with a budget of less than 1000 € are less likely to be deterred from using A.I. software to produce their music if it's a risk of loss of business to people in the music industry, compared to musicians with a budget of 1000-5000 €. This suggests that musicians with a budget larger than 1000 € are concerned with the risk of loss of business to professionals in the music industry, possibly because musicians with a larger music production budget are more likely to hire music professionals. This is useful information for mixing and mastering engineers as they can work to maintain good professional relationships with musicians with large budgets, so as to ensure their loyalty and business in the future. This is also useful information for A.I. software companies as they can use this information to reach more lower budget musicians as they seem to be less concerned with the potential loss of business to music professionals as a result to their use of A.I. technology.

ii) <u>According to the Interviews</u>

Discussing his predictions for the future of his industry, Pieter de Wagter said the following during his interview: "I think there will not be a big change in the coming years. LANDR will be a (*sic*) alternative for people who cannot afford a professional mastering, or who just want to test a production. But you'll always need human, experienced ears to confirm the quality of the mastering." When asked if he felt threatened by the use of A.I. in the music industry, he continued with: "I really don't think my job could be threatened by LANDR & co. There are so many other factors that

I have to take into account while mastering besides just frequency balance and loudness (such as editing, changing the order of the tracks on an album, thinking outside the box for certain genres of music, …). [...] To me mastering is above all a final stage of listening and quality control. It involves a lot of psychology, and a bit of technology" (de Wagter, 2018).

An interview was also conducted with Christophe Winters, an A.I. researcher from imec in Leuven, Belgium, to gain insight into the current situation of A.I., and what his predictions are for the future[3]. When asked if he thinks it's possible that in the future we will have a society where almost every job has been taken over by A.I., he said the following: "No don't think so. However some parts will indeed be taken over by A.I I'm convinced other still need human interaction to perform some tasks". When asked if he thinks that there's a risk of ending up with a low-employment society, he said that there is a risk of this happening. He continued with the following: "Personally It (*sic*) think we should prevent it as it will discourage people to be creative. [...] People will probably enjoy life much more as they will have less stress but on the other hand there will be less stimuli to entrepreneurship and creativity which I think finds mostly its base in companies / work-environment" (Winters, 2018).

Another A.I. researcher from imec, Bram Verhoef, was also interviewed about the future of A.I. in society[4]. When asked what he thinks of the possibility of an A.I. run society, he said the following: "In the near future, i.e. five to ten years, I strongly doubt this will happen. [...] However, if AI keeps on progressing like it does right now (and that's not completely certain, because AI has had its up and downs in the past, with people being very optimistic about AI's capabilities and then noticing that the time wasn't ripe yet.), then in the more distant future I see no reason why AI shouldn't be able to perform any job (better than humans). This will also include the arts". Speaking on being prepared for the future of A.I., he said the following: "If AI keeps its promises, the applications will be myriad but the dangers as well. [...] If AI will assists (*sic*) people in their jobs, then people will need new technical skills, in addition to conventional computer skills. Furthermore, if AI starts to replace jobs, we need to thinks (*sic*) about replacement jobs for those people who lose their jobs". He continued with the following: "So I don't think it's useless to worry at this stage, in fact we should prepare ourselves, because strong progress in AI will happen, whether in the near or the far future" (Verhoef, 2018).

[3] See the appendix for the full interview
[4] See the appendix for the full interview

When asked about the likelihood of A.I. replacing human workers, he said the following: “In the beginning, AI will assist workers to do their jobs better. But once, AI starts to outperform humans or when AI becomes cheaper than human workers, there is little doubt that companies will favor (*sic*) AI over human workers. Such changes have happened in the past (e.g. industrial revolution) and will happen again. We should adapt to those new circumstances”. Speaking on how this could impact society, he said the following: “In theory, a low-employment society doesn’t have to be bad: if we all have our robots that work for us, our quality of life can increase significantly. However in practice, i.e. in our current capitalistic society, I believe this will not work well because it has the potential to increase inequality dramatically: those who possess AI, can make more AI and will have all power and financial means”. When asked what steps we can take to ensure a positive impact from A.I., here is what he proposed: “What we can do, is make governments aware of the progress and capabilities of AI (e.g. an advisory board consisting of specialists), change our education (e.g. more math (*sic*) and computer sciences) so that more people understand what’s happening and can participate in AI, some regulations (in response to issues raised by the advisory board) to protect the rights of human workers, more work on ethics in AI, etc” (Verhoef, 2018).

As we can see, there are varying opinions in the A.I. community surrounding the predictions for its future. But both Christophe Winters and Bram Verhoef agree that a low-employment society is possible in the future if A.I. becomes widespread and that this could have negative repercussions such as lower creativity and productivity, and a rise in wealth inequality. However, they both raise some positive sides to it such as less stress and a rise in quality of life.

Pieter de Wagter was sceptical of the possibility of A.I. taking over his job as a mastering engineer, stating that he doesn’t expect to see a big change in the music industry in the coming years, something that Bram Verhoef echoed by stating that he doubts that A.I. will be able to take over society in 5-10 years. Pieter went on to say that he thinks that you’ll always need human ears to master and that A.I. can’t replace a mastering engineer. Bram countered this point by stating that if A.I. continues to progress as it has been doing in recent years, then there would be no reason why A.I. shouldn’t be able to do any job, and that would include jobs in the music industry such as mastering.

6) Summary and Conclusion

To summarise, we can observe a lot of research and development in artificial intelligence over the last few decades, and this includes its use in music production applications. Throughout the advancement of A.I. technology, many questions have arisen surrounding the practical and ethical consequences of its uses now and in the future. There are many different answers to these questions, and many differing opinions on the predictions for A.I.'s future, making it difficult to come to a conclusion about what the impact of A.I. will be in the coming years and whether it will be positive or negative. Due to the uncertain future of A.I., it is wise to be prepared for any possible outcome within all industries including music. Understanding the consumer behaviours of musicians and what their views are can be helpful to be better prepared for the outcomes that A.I. could possibly have on the music industry. By better understanding the relationship between musicians and A.I., we are able to predict how the future of the music industry may change which is useful for mixing and mastering engineers, as well as A.I. software developers that are interested in creating or already have created music production services for musicians.

Based on the research conducted in this paper, we can conclude that amateur musicians seem to have a lower music production budget compared to professional musicians. We can observe that musicians with a larger budget are seemingly more likely to hire more people in their productions compared to musicians with a lower budget. We can also see that most musicians seem to have a positive opinion on the use of technology in day to day life but that not many musicians seem to have used A.I. software in their productions. However, when asked if they'd consider using A.I. software if it could provide them with the same results as music production professionals for a lower cost, almost half of the musicians said that they would be likely to use the software. This could suggest that if the technology improves to be at the same level as music production professionals, then this could be a risk to mixing and mastering engineers. However, at this point in time there are still a lot of constraints that musicians highlighted against using A.I. software, so if the latter were to happen, then it is not likely to happen in the coming years as it would probably take a while to fully convince all musicians of the level of quality that A.I. may be able to reach one day.

It may also take music production professionals some time to also be convinced of the possibilities of A.I. taking over jobs in the music industry, should it advance that far. Pieter de Wagter stated that he is unconvinced of the possibility of this and believes that humans will always be required in music mastering. However, he does state that A.I. can be a useful tool to music production professionals and that he uses these tools himself. It seems that a relationship between A.I. and mixing and mastering engineers has already been established and there's no reason why this relationship can't be maintained in the coming years, so long as the A.I. technology doesn't become too powerful and take over the jobs of those engineers. Some A.I. researchers see this as a possibility one day, as Bram Verhoef stated that if developments into the technology continue to advance as they have been doing recently, then, in theory, there would be no job that A.I. couldn't do including jobs in the music industry. However, in practice, this may not be the case, as technology hasn't always kept its promises for its abilities and has had disappointing results in the past, so we should carefully consider both possible outcomes and be prepared for both of them. One of the best ways for mixing and mastering engineers to do this is to maintain their current professional relationships, as we have observed that musicians that have a larger budget and have more access to such music professionals are less likely to use A.I. software if it results in a loss of business to the people they work with to produce their music.

The results from the survey and interviews conducted were able to answer the research questions of this paper, but this only scratches the surface of the questions relating to the future of the use of A.I. in the music industry. Further research should be conducted with a larger pool of musicians to gain a more accurate perspective on the use of A.I. to produce music, and there should be further research into the risks involved with the widespread use of A.I. in all areas including music, such as the risk of a low-employment society and growing wealth inequality. We will likely see a rising number of A.I. music production services in the future, so it's important that we gain a better insight into the use of these services by musicians now so that we can continue to ensure employment to the people that these technologies have the risk of replacing. As musicians are the main clients of music production professionals, their use of mixing and mastering engineers' services ensures the survival of their profession so it's important that those relationships are maintained for this purpose.

It may be possible for the A.I. music production services to prosper while maintaining the clientele base for mixing and mastering engineers if A.I. software companies market themselves to amateur low-budget musicians who are less likely to

hire those engineers in the first place. Arguably, the ideal outcome for the future of the music industry would be a coexistence of A.I. and human mixing and mastering services, both with a specific demographic. There is no way to ensure this future, however, so while there are still uncertainties, musicians and music production professionals should be conscious of the possible outcomes of A.I. in the music industry. Further research should be conducted and more questions should be posed to acquire a clearer view of the future of the music industry. It may be argued that A.I. can be a powerful tool but needs to be used wisely by both musicians and companies alike, and the best way to do so may be with further research, education, and government regulation.

7) Acknowledgements

I would like to thank my parents, my sister, and my friends for their continuing support throughout my university studies. I would like to thank the SAE Brussels staff for their continued guidance throughout my studies. I would like to thank Gert Van Hoof for his mentorship throughout the writing of my major project. I would like to thank the 300 musicians who took part in my online survey. I would like to thank Guy Vanden Boer for helping with the statistical analysis of the data from my survey. I would like to thank Pieter de Wagter, Christophe Winters, and Bram Verhoef for their contributions to my research in the form of interviews. Lastly, I would like to thank the reader for taking the time to read my work.

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