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Automating the black art: Creative places for artificial intelligence in audio mastering

Thomas Birtchnell
University of Wollongong, tbirtchn@uow.edu.au

Anthony Elliott
University of South Australia, Anthony.Elliott@unisa.edu.au

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Keywords: post-production, music, creativity, robots, sound, affect

1. Introduction

> You see, you found ways of breaking the rules and that's why they called it the black art because people would say, how do you get that level on that record with that length? And I'm going, you know, I'm not telling. But there were just things we did to overcome the system. And every genre of music was different.

> (Interview, M, 60s, Mastering Engineer, 2017)

In 2014 the Montreal-based company LANDR launched an automated system for audio mastering catering to musicians, sound producers and film score composers. With the provocative slogan 'A.I. From the heart' the company promotes its use of 'A.I. and machine learning (think self-driving cars and Shazam) to replicate the processes human engineers make when mastering a track' (LANDR, 2018: no pagination). The Head of Product Design at LANDR articulates how the company's system works:

> Machines that do 'deep learning'—like LANDR—are a form of advanced artificial intelligence (A.I.). They deal with large and complex sets of data. They're capable of high levels of abstract understanding. They adapt. They learn how to learn … The LANDR A.I. is a new form of life that's always seeking to understand sound and music better. It lives alongside us … The LANDR A.I. depends on a human's ability to arrange new sounds. If we all stopped making music tomorrow LANDR would die.

> (Thoreau, 2016: no pagination)

While the company is certainly not suggesting that their artificial intelligence (AI) is able to think about and have an experience of music and sound in the same way a human does, the provocation upsets long-standing ideals about the role of human expertise in the creative industries. AI here is projected as working alongside and with human experts in a new relationship that supports rather than substitutes for them. Such a viewpoint runs counter to mainstream notions in academic, industry and government foresight that AI will replace, through redundancy or cost-effectiveness, people's jobs.

In this article, we consider the spatial aspects of AI in the creative industry of audio post-production. Our central research question is how does AI transform the geographical aspects of audio mastering, namely the studio spaces humans labour in and the wider places they connect to as artists and suppliers of creative expertise? Before we start, it is necessary to define what audio mastering involves. It is easier to demonstrate what audio mastering is rather than explain the process in words. To listeners mastered sound recordings are loud, impressive, familiar and inspiring. To sound creators the difference between unmastered and mastered recordings is obvious to their ears. Moreover, there is an assurance a mastered recording will sound as originally intended regardless of the playback system.

The origins of the practice of audio mastering lie in the era prior to the spread of digital technologies into the music industry. Mastering arose in the era before mass-distributed sound was digitized when it was prone to unintended alterations due to the nature of the technologies and the variability of the skills of those entrusted with reproduction. So, what is it human audio mastering engineers do that is so difficult for machines to replicate? Nowadays, audio mastering engineers assist musicians and sound producers with bringing their productions to a wider audience and market according to set standards and conceptions of what is deemed normal in line with listeners' expectations and perceptions. In this sense, they are affective 'gate-keepers' who ensure the emotional content instilled in creative practice is as appreciable as possible. The term 'affect' is generally defined in human geography as referring 'to the wide range of registers—beyond sight, image, and word—in which humans interact with, make sense of, and experience the world' (Castree et al., 2013: 4).

A skill that appears to require the all-too-human attributes of critical listening, a socio-cultural awareness of musical taste and fashion, and a combination of scientific knowledge and gut instinct would presumably be immune from recent forays into AI. Yet, this is not the case. The recent emergence of AI in the music industry, a sector known for creativity and ingenuity, is both unsettling and beguiling for the audio mastering professionals who are the focus of the research in this paper. AI for audio production work is still in its infancy, yet already there are profound ramifications for creative spaces and places. AI in audio mastering is by its very nature challenging to human labour and the economic geographies of music and sound production since the algorithms draw on vast and growing databases of audio sourced from many origins in order to inform its decision-making, a feat no human expert could match.

AI then is spatially significant and of geographical interest. Over the term of its existence the occupation of the audio mastering engineer has been notably place-specific, grounded in studios and scenes, and embedded within the wider cultural infrastructures of the music industry. We argue that the geographical aspects of audio post-production are key to understanding how AI will become enmeshed in new assemblages of people and machines in creative endeavours rather than simply substituting directly for human expertise.

The paper's structure is as follows. The next section reviews the social science and geographical literature on AI, creativity and music. In the third section, we summarize the art of audio mastering and distinguish the skillsets required from related creative work. We pay particular attention in this discussion to the notion of affect in the work of professionals who uphold and regulate the qualities of mass distributed audio. In the fourth section, we then turn to assess the inroads AI is making into this creative work in the music industry and describe the gathering ubiquity of services acclaiming to offer more-than-human benefits. Throughout these sections of the article, we embellish the analysis with narrative extracts from semi-structured interviews with professionally listed and globally recognized audio mastering engineers, including a handful who have been in the industry for more than 30 years and are considered exemplars in professional circles. The empirical research also involved participant observation in nineteen studio spaces. We discuss two distinct types of place important to audio mastering engineers facing the emergence of AI: first, the studio; and second, the cultural infrastructures harbouring musical 'scenes', which provide clients and inspiration. We highlight how AI's affordances are discomfiting assumptions about place and its role in human skills. Shifts in the music industry more widely are also instrumental in providing windows of opportunity for AI to capture sections of the audio mastering sector. Through close attention to the skills involved in mastering and the places enfolded into the process, we contextualize AI's geographical aspects and question recent assumptions about the roboticization and computerization of jobs.

2. AI in the Creative Industries

The debate over what constitutes AI is complex and complicated, but we start by noting the definition used by the UK Government in its Industrial Strategy White Paper: 'Technologies with the ability to perform tasks that would otherwise require human intelligence, such as visual perception, speech recognition, and language translation' (UK Government, 2017: 37). AI systems, we would add, include technologies in which computer systems sense their environment, think, learn, and react in response to such data-sensing. AI-driven technologies include both robots and purely digital systems that employ learning methods such as deep learning, neural networks, pattern recognition (including machine vision and cognition), reinforcement learning, and machine decision-making. A key concern in the social scientific literature on AI's future is whether humans will be made redundant by automation. Many sense that a 'jobless future' is on the horizon (Ford, 2015).

The widespread predictions of AI transcending humans in future is critiqued in some quarters as being the product of Judeo-Christian apocalyptic beliefs informing popular science discourses, a get out of jail free card from a litany of human-centric challenges (Geraci, 2010). Yet, where popular commentators and scientists are in agreement is that creative tasks continue to represent a 'bottle-neck' for AI lending some sectors an apparent sense of immunity from automation (Kaplan, 2016: 118). Language, creativity and emotion are something of a holy grail for AI to achieve 'general' intelligence, the acme of human intelligence (Boden, 2016). In spite of this there are now incursions of AI into creative industries. Before summarizing one case in particular in audio mastering, we next review the literature in geography on the creative industries and then move on to consider the digitalization of human labour in these sectors of the economy.

2.1 The Creative Industries

Research on the creative industries is a hallmark of this journal (c.f., Banks et al., 2000; He, 2017; Luger, 2017) as is spatial politics within the music industry specifically (c.f., Brown et al., 2000; Fraser and Ettlinger, 2008; Wang and Chen, 2017). Discarnate modes of business

pose a conundrum since physical creative places—that is, the studio and scenes—are recognized by human geographers as 'relational spaces of creativity' where experts share knowledge and interact with peers and clients (Gibson, 2005). Descriptions of craft learning show imitation and routine is the remit of apprentices who having gained access to the workshop—that is, of the medieval gold-smith (Sennett, 2008) or, more recently, American cowboy boot-maker (Gibson, 2016)—learn skills osmotically and often in a way that is indistinguishable from other menial tasks. In audio mastering studios have traditionally functioned in a similar way to craft workshops as spaces for learning and succession.

Early on geographers became aware of the flexible structure of the creative industries, for instance film-making, which is made up of specialists across pre- and post-production services. Spatially concentrations of creativity in major cities, for instance Los Angeles, dispersed to suburbs nearby in the metropolitan fringe where property was more affordable and superior amenities available, for instance Hollywood (Christopherson and Storper, 1986). The fragmentation of large firms to clusters set apart from urban cores provided surplus employees for design, freelance writing, film, photography, new media and music. In countries such as Sweden creative industries experienced rapid growth in market size due to this fragmentation in the late twentieth century (Power, 2002). Geographical awareness of the music industry in particular broke it up into three main types of companies: major 'label' corporations, large to medium size companies with many interconnections to major labels, and small 'independent' companies. Creative labourers span global networks connecting 'alpha world media cities', London and New York, with small specialist producers and service providers distributed according to preferences based on property affordability, socio-cultural amenities or lifestyle choices (Watson, 2008).

Beyond the industrial and spatial structure of creative industries, individualized creativity in relation to place is another viewpoint in human geography. Individuals draw profit from proximity to cultural infrastructures through utilizing them as a resource for inspiration and to procure new clients. Place as an associative 'brand', harbouring both reputation and tradition, is another facet of geographical import wherein individuals belong to communities of creative workers all tied to a place: Seattle, Nashville, Brooklyn, Berlin and so on (Drake, 2003).

Another line of inquiry in human geography pertinent to this paper is the spatiality of creative endeavour. Craft conveyance—that is, learning the ropes of a creative endeavour—over time and in specific places is an emergent topic in human geography and studies show how momentum rather than stability defines the succession of practices and collaborative learning between elites and apprentices (Patchett, 2017). With the emergence of 'net locality', professionals are able to interact with creative places from great distances or infrequently according to alternative spatial logics (de Souza e Silva and Frith, 2010). For creative workers to assemble social networks they must draw on both formal and informal modes of labour and methods of promoting their expertise. Notwithstanding reputation, the knowledge of social movements and fashions is a strategy open to creatives able to immerse themselves in scenes deterritorialized, yet irrevocably rooted in, place (Connell and Gibson, 2004). What manifests is a diversification of places to be creative in as Internet-based services spawn viable scenes in rural areas allowing some professionals to earn a living away from urban cores, yet to stay in proximity (virtual and physical) to other creatives and clients (Gibson and Gordon, 2016). Notwithstanding the proliferation of rural creative scenes, moving away from the dense cultural infrastructures found in urban cores does carry risks, with the rising

precariousness of work and the 'gig economy' upsetting business models entirely oriented around online services (Zwick, 2017).

Nevertheless, the high cost of property in urban cores of the twenty-first century means creative labourers are compelled to substitute some physical proximity for net locality to stay in their relevant 'scenes'. Once client bases exist, established experts are able to reside in more geographically isolated places, and this has been a spatial phenomenon across different creative industries with the advent of the Internet. Interestingly, geographically isolated creative scenes, in Australia cities such as Perth (Ballico, 2017) or Tamworth (Gibson and Davidson, 2004), combine the intensity of isolated proximity with the benefits of online access to industry standard audio mastering, ensuring their products are on par with networked scenes remotely. For instance, the celebrity mastering engineer Chris Athens in the United States relocating from Sterling Sound, New York to Austin, Texas to freelance due to the emergent underground scene there offering access to rural cultural resourcefulness (Gibson and Gordon, 2016). Next, we move to the geographical consequences of the digitalization of the creative industries.

2.2 The Digitalization of Creativity

Since the digital revolution, creative labourers have invariably moved to become transnational freelancers utilizing networking technologies—file transfer protocol (FTP) servers and cloud connectivity— to liaise directly with their clients, at times at a considerable distance (Watson and Beaverstock, 2016). As the Internet has altered the way data are stored and transmitted the places where creatives work and relate in have transitioned in line with similar professions (Watson, 2013).

AI and bot-technologies are a timely topic for human geographers interested in the creative industries since they are able to view them 'as actors in networks and assemblages of sociospatial relations' (Del Casino, 2016: 847). The emergence in the last few years of 'cloud geographies' and complex algorithms brings creative skills within reach of the competence of AI (Amoore, 2016). Innovations in neural networks and deep learning, which uses many layers of artificial neurons to solve more difficult problems, increased significantly during the early 2000s, and lies at the core of the expansion of AI today. Neural networks are often used to classify information from images or text, but also sound. This has been key to transformations in the creative industries.

AI indeed looks set to exacerbate the transformation of the creative industries centred on core places to work—that is, studios—and proximate scenes due to the ubiquity of digital networks and code for artistic production, distribution and consumption (Leyshon, 2014). Since the mid-twentieth century predictions about the demise of 'blue-collar' manufacturing and services jobs imperilled by robotic automation has shifted to debates about 'creativity' as a working response to such automation (Warren and Gibson, 2011). AI's inclusion in multiple 'white-collar' professions—that is, doctors, lawyers, accountants, architects, journalists and management consultants—is causing consternation and heady predictions of change (Susskind and Susskind, 2015). There is now speculation about AI's place in 'no-collar' jobs in creative industries.

In pursuit of this line of inquiry a definition and understanding of creativity is imperative. In light of recent advances in AI human creativity is far from straightforward. People enact creativity through a blend of their own competence and ideas gleaned from copying others. A part of this is emotional labour and the 'right vibe' emanating from the nexus of place, people, practices and technologies (Watson and Ward, 2013). Creative practice then involves

the transposition of creativity to new creations from other people either directly, such as in the co-presence of musicians in a band, or indirectly via inspiration drawn from a recording, performance, or via information captured in other mediums including textual and oral traditions. Just as 'digital spatialities' from robotics and AI are disturbing notions of proximity and place in sexuality so too are they affecting audio mastering as a human endeavour (Cockayne et al., 2017).

3. The Creative Industry of Audio Mastering

The orthodoxy of audio mastering is that it is analogous to picture 'framing' rather than painting; engineers are objective listeners who 'maximize' affect and are generally understood to have no creative license, control or input over the artistic content; rather, they act as 'creative brokers', translating artistic vision into a marketable showcase (Pinch et al., 2010). This being said, the processes involved in audio mastering also include improvisation, intuition, performance and other affective skills. In this section, we summarize the chief aspects of audio mastering.

The etymology of the term 'master' in the music industry is unclear but appears to stem from the era of gramophone record production in the early twentieth century. An early record label's logo, His Master's Voice (HMV), sported the image of a dog convinced it was hearing its owner's commands emanating from the gramophone's horn, testament to the quality of the machine and the clarity of the label's product. A disc master, also 'master matrix', was the ancestral negative copy made originally in copper or soft alloy from the direct transfer of sound into the diaphragm of the gramophone's recording horn and a cutting head on a rotating cylinder. The master would be used to press a 'mother' positive copy in wax, which would in turn produce multiple lacquer copies for distribution and sale in bulk to listeners.

A number of distinct professional roles arose from the changes in musical instruments, music recording technology, audiences, radio programming and music styles in the mid-twentieth century. The production, distribution and consumption of music underwent a transition at this time as instrument and equipment makers, performers, songwriters and publishers all took advantage of the advent of ubiquitous phonographs and radios to form a musical socio-technical system.

After Geels, 'magnetic tape recording completely altered music recording, as more was learned about functionalities and complementary technologies became available … the recording studio became an instrument itself and music engineers became artists' (2007: 1429). The innovation of magnetic tape in the mid-twentieth century generated the distinct occupational role of the mastering engineer. With magnetic tape the quality improved dramatically and masters could be made separately in time and space from the recording process. Industrial tools, such as lathes, were no longer required in recording studios and the skills attributed now to audio mastering diverged from recording and mixing engineers, who would continue to work directly with artists. The latter engineers began to work solely with tape, editing the recording by cutting or splicing and gluing the ends back together. The former would continue to work with records. The minutiae of tape, transducers, electroplating, stamping, lacquer blanks, styli, lathes, presses, and vinyl production generally is out of the scope of this paper; however, expert guides on the mechanics of mastering offer indepth information on these legacy techniques and revivals of some of them (c.f., Owsinski, 2007).

Standards in audio capture and duplication steadily became computerized with the innovation of digital instruments, recording and processing systems, and media over the 1990s until the global ubiquity of compact disc (CD) players in the early 2000s. Another important event for audio mastering was the spread in the 2000s of mastering software, chiefly products by the companies Waves and Ozone, to artists and laypeople who either purchased competitively priced copies outright or accessed file-sharing or pirated versions. The do-it-yourself 'democratized' movement that arose is considered a key historical industry challenge to the experts interviewed in this paper as income rates plummeted and competition stiffened since the cost of the technology was no longer a barrier of entry in the profession: the 'software slump' (Leyshon, 2009). The subsumption of the studio into the repertoire of sound creators is the next step in the transition as the technology is made more portable and software enabled a more democratic approach to recording, mixing and processing. With AI, mastering appears to be a logical progression in this process towards artists' cradle-to-grave relationship with their sound creations.

Nowadays how do audio mastering engineers do their work? Following a diagnosis of the recording, interventions the mastering engineer makes include increasing the recording's volume, making it more energetic in frequency range, balancing the mix across the stereo spectrum, ensuring compliance with format standards (vinyl, cassette, CD, MP3, WAV) and guaranteeing it is free of errors introduced during the previous phases, such as clicks, noise, distortion and other blemishes deleterious to the overall transmission of the recording. Although sound, once converted to digital information, is capable of being replicated perfectly as carbon copies innumerable times without human intervention in each instance, inconsistencies emerge as different file formats are introduced (WAV, AIFF) and compression is applied to reduce the size of the file (MP3, OGG); audio mastering engineers will often need to take these other formats into account in their work on the ancestral 'master' copy. Yet, managing the conversion between physical and digital media formats is only a fraction of the occupation.

The mastery over multiple technologies, musical theory, the science of sound, and the various standards involved makes this role one that garners much respect in the music industry. There are three services audio mastering engineers perform routinely in their roles in the twenty-first century.

First, just as their predecessors did, they inspect the recording for defects in the form of clicks, pops, noise, glitches, distortion and other unwanted elements. Since a majority of recordings are made nowadays in the digital realm errors appear both in the performance of the music (unless composed entirely in a Desktop Audio Workstation (DAW) on a computer) or in the mixdown of different tracks and in the application of creative effects by artists and recording or mixing engineers: reverb, delay, chorus, flange, phase, and other more esoteric ones (Order, 2016). As a rule, mastering engineers do not work with individual instrument or recording tracks or 'stems' of audio, although there are indications this trade practice is changing as artists take on board recording and mixing duties themselves (Watson, 2015: 24).

Second, the audio mastering engineer applies treatments to the recording in order for it to conform to various standards predefined by the mediums for bulk distribution: the analogue media of vinyl and cassette tape in the past and, nowadays, the digital media of DATs, CDs and various file formats for computers, smart phones and file players (Leyshon, 2001). Engineers utilize what they term a signal or tool chain of mastering processors, which the audio flows through as it progresses towards the final master. Each audio mastering engineer has a unique blend of different technologies across a range of brands in their toolchain.

Examples include multi-band compressors and limiters; parametric equalizers; exciters, maximizers and finalizers; and audio to digital convertors, amplifiers and listening monitors.

Third, a task nowadays for the audio mastering engineer is to make the recording 'louder', denoting not only the volume, but also how energetic and 'hot', or impressive, it sounds. A key factor here is the total harmonic distortion (THD) and the regulation of the root, mean, square (RMS) power (roughly the average volume throughout the recording) in order to overdrive the signal without causing noticeable distortion and an unpleasant or fatiguing effect for the listener. It is in this third aspect wherein creativity plays a role since audio mastering engineers are able to use the different elements within their toolchains to create overdrive as they process the signal depending on the nature of the recording and the genre of music or, to a lesser extent, intended audience of the sound recording. Certain genres such as heavy metal or dance music demand more loudness than other more dynamic ones: jazz or classical. Since the loudness of a master depends upon comparison to other recordings a result is the 'loudness wars' wherein there is competitive pressure for audio mastering engineers to achieve loudness at the expense of dynamic range and clarity to attract and satisfy clients (Devine, 2013).

Currently, loudness is difficult to replicate through AI and other software since it requires human ears to listen to the recording in its entirety and apply variations to harmonic distortion, frequency and volume in response to the RMS spontaneously. Overdrive requires the continuously variable physical quantities of audio provided by circuit or valve equipment (so-called analogue), which has components better suited to providing palatable effects in comparison to digital ones where the signal is first converted into bits of data to be processed and then reconverted back into audio. If done incorrectly, loudness leads to signal degradation resulting in perceivable distortion and reduced dynamic range ultimately resulting in listener disinterest or fatigue. Another side effect is for audio quality to be diminished in broadcast since radio stations often feed mastered sound through their own signal processing toolchains causing a confluence of degradation and a reduction in fidelity.

'Mastering is something of a black art' (Marshall, 2003: 37). Despite the mystery around audio mastering, progress in machine learning, big data analytics and algorithms has inspired efforts to scientifically and methodically plot the skills and practices involved and replicate them in software. In 2014 research at the Centre for Digital Music (C4DM) at Queen Mary University of London culminated in a Montreal-based startup company, Mixgenius, launching a product offering AI-enabled audio mastering. An interview with the founder Justin Evans details the workflow:

> You take your stereo output from your recording, and drag and drop it onto our website, which uploads it to our cloud server. Our server then analyses it, understands what the appropriate mastering is for the track, and applies a bunch of processors. Which processors depends on the frequency of the music, and some genre and style elements. The system automatically does what a human mastering engineer would do.

> (Cooke, 2014: no pagination)

Of import is the enlisting of technologies able to purportedly 'learn' from humans in order to automate their routines and assist with menial tasks. The technologies that simulate human skills in order to master creative works offer profound reflection upon the convolutions inherent in the entrustment of labour to non-living entities. Efforts to simulate and even replace human skills with AI unwittingly create distortions in those very same skills that

create repercussions for human practitioners as they cascade into sensory expectations amongst listeners and warp the demand for professional standards.

4. Studio Spaces and Sound Scenes

From the mid-twentieth century, as the occupation of the audio mastering engineer solidified, relational spaces of creativity also diversified to cater to the distinct roles that emerged. A demand of recording technologies was for sound creators to share proximity to recording engineers who would capture the audio and then splice and overdub it into discrete track 'stems'. A separate expert, the mixing engineer, would then record these stems, 'summing'[1] the waveforms into a single final mix; once these had been transported to them via hand, courier, or mail. The final mix tape would then be distributed again to the mastering engineer to prepare for factory bulk production. As sound creators availed themselves of more portable and affordable technologies for recording and mixing, creative scenes changed to accommodate 'global urban networks of recording' and the 'networked studio', with the divisions between rehearsal and recording spaces blending and even merging (Leyshon, 2014).

The mastering professionals interviewed in this paper do not create music per se, rather they ensure that the copies of musical works sent out to audiences through mass distribution systems (nowadays as much online as instore) remain as similar as possible to the original regardless of the playback technology the listener uses and the spaces they listen in. Before reaching the ears of listeners the music and sound interweaving through the lives of twenty-first century citizens throughout the world moves through various phases of composition, rehearsal, recording and mixing before final 'mastering' takes place. Mastering involves the close scrutiny of the penultimate version usually by a direct comparison to similar works by other artists, through visual aids such as spectrum analysers, and repeat playback in carefully prepared spaces and on 'acoustically transparent' audio speakers (monitors) that offer the most accurate sound possible.

4.1 Studios

Audio mastering is a set of human skills and a distinct occupation. Arising in the mid-twentieth century the creative place where mastering happens has undergone a number of profound shifts. The mastering studio began as a relational space where audio mastering engineers commingled with artists and other technical experts in a recording studio environment close to music industry professionals. As the occupation became more technical over time demand grew for a different kind of creative place and recording and mixing studios took over as relational spaces of creativity while mastering studios withdrew to being the sole preserve of a handful of technical 'post-production' roles. A model where studios are inhabited by and created for individuals according to their own sensorial and occupational capabilities is now the norm. In what follows next, the studio's origins as a place where professionals 'learn the ropes' through occupying the space alongside mentors.

4.1.1 Learning the Ropes

Many of today's most lauded mastering studios arose in the late 1980s and early 1990s as expert engineers left the large label houses and subcontracted out their expertise freelance.

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[1] The summing of waveforms is a scientific process involving calculation of the RMS. Many audio mixing and mastering engineers achieve this through intuitive listening and visual aids, such as spectral analysers.

Exemplars would then attract talent and train them in-house. Assistants would start with menial tasks and learning the ropes through observation in an apprenticeship fashion. What has perhaps not been adequately encompassed by geographical analysis is the degree to which certain occupations rely upon such mentorship in proximity in order for skills to be reproduced through time and in distinct places. In the early days of mastering, craft conveyance was serendipitous and a facet of co-location, with conveyance often taking place after shifts and through socializing:

> I mean there was something about… in the eighties when I worked at [major recording label], being in a studio environment that was very valuable because I was interfacing with a lot of artists and a lot of musicians. And we were talking and just having a chat, traditionally every Friday afternoon would be gin and tonics for example, being an English company. And you'd sit around and you'd chat, but it was brainstorming.

<div align="right">(Interview, M, 60s, Mastering Engineer, 2017)</div>

As with craft workshops recording studios are worlds of their own with important rites of passage and social practices for incumbents that afford occupational progress, loosely termed 'studio etiquette', within which technical and sensorial learning are enmeshed (Thompson and Lashua, 2014). Mundane tasks are indistinguishable from important learning opportunities. Moreover, sharing proximity with exemplary peers affords a degree of attainment impossible to achieve through programs of study undertaken during formal qualifications. One of the few female mastering engineers in the industry we spoke to highlighted the rites of passage necessary in the past to gain access to the technology of the recording studio, the in-house talent, and the base of clients:

> So, my history started as a recording engineer, or I suppose assistant engineer to begin, as you do; you make the coffee, you make the tea, you roll the leaves, you get the pizza at two in the morning, and then you get your chance to play with the technology and see what you don't know. So, the period that I'm talking about is in recording studios.

<div align="right">(Interview, F, 50s, Mastering Engineer, 2017)</div>

These are features of creative places insurmountable to AI, regardless of how 'intelligent' these innovations become in future, barring actual physical co-presence and experience in the space itself. Mundane and routine tasks were a primary feature of the early experiences of the interviewees who undertook their apprenticeships prior to the digital revolution:

> Then from there I moved actually into the cassette mastering room. And that's a very basic and simplified version of what CD mastering is. It was still very much incorporated into the manufacturing process. I had managers coming in with the clipboard wanting masters to be churned out. It was very simple; get it in, get it out. Maybe fix it up if there's a few little sonic things. You didn't labour over it. So that was my introduction to mastering.

<div align="right">(Interview, M, 40s, Mastering Engineer, 2017)</div>

Co-presence is a stock component of the interviewees' reflections on apprenticeship duties in studios with even some early career mastering engineers flagging the merits of mentorship

from established talent; indeed, some made use of their pedigrees in their promotional material. Just as physical, corporeal travel is difficult to replicate through online or virtual 'telepresence' (Urry, 2003) so too is the intermingling of information that takes place through face-to-face conversation and the simpler proximities of working alongside another human and gaining their trust and learning their habits:

> So as humans we have a good ability of absorbing that subconsciously in the presence of someone. So, in terms of how I think it's going to impact things I think a few things will happen. I think, first of all, the learning process just takes longer because we've kind of got to learn a new way. So, in the past, you would get an apprenticeship as a recording engineer, as a mixer, as a mastering engineer and your learning could be accelerated because you could learn this person's 20 years of experience who learnt from there and it just gets passed down. Whereas, now, it becomes self-taught so it takes longer to get to that stage.

> (Interview, M, 30s, Mastering Engineer, 2017)

Audio mastering began as a making culture (Carr and Gibson, 2016) with various artisanal practices of a routine and humdrum nature culminating in the ability and passion to generate a paragon of the trade ready for mass production. As mastering mediums and production technologies became automated the routine aspects of the role did diminish. Machines did substitute for human lathe operators. As audience listening mediums became digital, with the CD and MP3 player arising as ubiquitous, mastering engineers upscaled from routine workers in quality control to their present role where they command respect as creative professionals. So, the turn to digital and the shift away from manual and menial labour did substitute for some skills, but also underpinned others:

> It was a very exciting time. People were really excited about digital technology, and what it was doing. I didn't see it as a risk. Setting up a mastering business was certainly something that was a bit risky in the sense that no one really knew what it was. I mean they knew it had to be done, but at the time most records were made by labels who had budgets, and they would usually get the stuff done at [lists major Australian mastering houses] or they'd take it overseas. As far as independent guys were concerned, there really was very little or no one around, really. It was a very, very new thing.

> (Interview, M, 50s, Mastering Engineer, 2017)

In the late 1960s specialist studios arose dedicated to mastering and these were until recently the market dominators, such as Sterling Sound in New York, Gateway Studios in Portland, Maine, and Abbey Road studios in London (Leyshon, 2009: 1318). As the technology changed over the 1980s and various technical skills became industry standards, independents began to dominate the market. In the 1990s the term 'mastering' entered popular awareness with a spate of digital remasters on CD, partly as a response to the bootlegging industry: the sale of unmastered poor quality live recordings on CD, a trend consequently quashed by Internet filesharing of MP3s (Melton, 2014). The trend for 'remastering' in the 1990s arose from the lack of a definitive version globally and proved to be a rich seam of business for major mastering houses—Abby Road and competitors (Bennett, 2016). Since each mastering engineer would master the same songs slightly differently each country would hear a unique version depending upon where it had been mastered and by whom. Over time, the masters each factory would use would deteriorate until re-release became unfeasible due to quality

control issues:

> So, someone says why is the English one better than the Australian one? Some bright spark says well, let's remaster them, let's go back to the original one with the original things, let's put it on, let's play that, let's EQ that. You do that the first time, aren't we clever, except for the guy that transferred it first time wasn't the A-level mastering guy, he was the B guy that did the archive stuff.

> (Interview, M, 50s, Mastering Engineer, 2017)

With the digital era, public awareness of the role of mastering and remastering in shaping sound recordings provided demand for this profession amongst independent artists. As audio tape recording consoles became more and more portable recording and mixing engineers no longer needed to share the same spaces as mastering engineers. The rise of the mastering engineer as an elite practitioner in the 2000s saw a trend for freelancing and the formation of studios designed for individual needs around their own repertoires and collections of technologies. In the next section, I examine the creative place of the studio in its refashioning of purpose from relationality to functionality and finally to somewhere in between.

4.1.2 Learning the Space

Audio mastering engineers take time to learn how a space sounds and this process involves investments of both time and money since any spatial eccentricities must be altered through treatment, for instance insulation or rearrangement of equipment. In the early days of sound recording, studios were chosen for their physical merits to performers with little regard for sonic precision for recording or mastering. So, for instance, Columbia's seminal 30th Street Studio in New York was a repurposed church—it came to be nicknamed as such—to capture the acoustics and ambience of the space's sound for musicians including Miles Davis and Charles Mingus. As expertise progressed, and recording technology gained higher degrees of fidelity, controlled spaces were sought that did not colour the sound so that greater control was given to the engineers to manipulate the recording and apply artificial and creative 'effects' such as reverb, delay, chorus and other sound innovations:

> Well, the theory originally was that a mastering room should sound like a control room. And the room at [a major recording label] when I first went to [the major recording label] in 1980, was just that: it was acoustically designed by somebody from the BBC and it was an incredibly dead room. You'd walk in and you could feel the sound being sucked out of your head, it was that dead. And they had big speakers in there and it was just unreal, it just didn't make sense to me.

> (Interview, M, 60s, Mastering Engineer, 2017)

Different processes occurred in uniquely treated rooms so that the sound of the machinery and activities of the personnel did not interfere with the recording. So, the original studios would house cutting rooms, recording rooms, rehearsal rooms and mastering rooms with the recordings being transported between them by hand, courier or mail. Some of these spaces would not just deal with local recordings, but international ones too; these belonged to the overarching company that ran the record label's production, distribution and promotion functions. In far flung destinations neither the master plates nor the bulk final records would

be transported due to the cost and risk of damage. Instead, local mastering engineers would be tasked with mastering from the magnetic audio tape onto their own master plate that would then be sent to the factory for mass production. Rooms in these mastering houses were not designed for recording but solely mastering and would feature distinct spaces for each engineer's preferred toolchain as well as the expensive industry standard disc cutting lathes (for instance, the Neumann VMS70).

A feature of technological progress was to make the equipment more portable and smaller thereby allowing a more efficient use of space and consequently supporting expert engineers to freelance and design their own creative place. Creative places became more relaxed and homely:

> And it was my philosophy—and it still is, I think–that a mastering room should sound like a nice lounge room, it should not be a recording studio. And the speakers that I'm using are hi-fi speakers, they're not studio speakers. They're big honest speakers so you hear everything that's going on but they're the same as what people with a lot of money might have in their lounge room. That's what people were listening to, they'd compare. And you have to have that for a mastering room and you have to have full range, accurate monitoring.

> (Interview, M, 60s, Mastering Engineer, 2017)

The critical listening environment is a human requirement AI does without; however, for humans this creative place has become an essential feature of their workflow. The complex procedures of equalization, compression, peak limiting, and so on, demand an ability to comprehend the sound's performance qualities across many different playback systems and environments from car stereos to supermarket radios. In the spaces within recording studios engineers were able to shape the room according to their own listening requirements and any shortfalls or inconsistencies could be learned and adjusted to over time through repetitious listening:

> The way I work, it's every song has its own custom setting that can be achieved on either analogue or digital equipment, and it's always about what serves the song best. And because every song is different, every recording is different, every mastering setting ends up kind of being different. And I guess to a degree you might find that a certain mastering engineer falls into a similar problem, where all their mixes have the same problem. Which could be a function of the acoustics of the room that they're mixing in.

> (Interview, M, 30s, Mastering Engineer, 2017)

As the original generation of mastering engineers who worked on cutting lathes and audio tape reach retirement age, a trend is for them to move elsewhere and continue to offer their services remotely thereby affording them the capacity to design their own creative place to work. Combining their existing professional networks with the digital affordances of email correspondence, Internet advertising, online file uploading and cloud storage they are able to offer combinations of both traditional techniques and services and contemporary ones:

> The room acoustics, obviously if you've got a nasty reflection you've got to get rid of it. I've done this myself, this is a garage basically, but I just fiddle around. The first thing I did when we moved up here from the city was to just plug the speakers in with nothing

happening and listen to it and we went: it doesn't sound too bad. It's not good, but it just needs something. So, then I started buying things and adjusting things and putting treatment in there and treatment up there and down the sides a little bit and then it came together without much bother and I'm still tweaking.

<div align="right">(Interview, M, 60s, Mastering Engineer, 2017)</div>

The trend for audio mastering engineers to design their own listening spaces and move away from major mastering houses has been in some cases deleterious to the trade's standards since it encouraged amateurs to enter the market without support of a mastering house and its mentors. When those with a limited budget or experience attempt to make a creative place to work in, they seldom notice the shortfalls:

So, if you're attempting to master on headphones or in a square room with no bass trapping on $2,000 monitors you're probably going to put too much bass in or not enough bass or too much treble, add it to the harshness and then you've got this big issue. And especially if you've composed it and mixed it in that same room. So, in that case, LANDR—I have no idea what their algorithm does, but I'm sure that it has frequency analysis and they will probably do a better job at compensating for the room frequency problems.

<div align="right">(Interview, M, 30s, Mastering Engineer, 2017)</div>

The affordability and accessibility of digital audio mastering software and hardware created a wave of amateurs in the late 2000s offering budget audio mastering services. AI competes with this bottom end of the audio mastering market since it has an advantage over many amateurs unable to create an effective listening space. Indeed, the major mastering houses now operate more as cooperatives with tenant engineers sculpting their own rooms and utilizing the mastering house for its brand to set them apart from amateur competitors. So even the major studio houses offer engineers' room customization options:

A mastering engineer's ability is a function of how well they know the acoustic environment in which they work in. Like for instance, if I was to go into [a colleague's] room, or [another colleague's] room, even though the rooms are the same size, just the different furniture, the different temperature, different humidity, all that changes the way the room sounds. If I went into [another colleague's] room and hit play, I wouldn't really know what I'm hearing.

<div align="right">(Interview, M, 30s, Mastering Engineer, 2017)</div>

A response to the competition at the budget end of the market composed of amateurs and AI is for elites to use AI systems themselves. The signature sounds of freelance mastering engineers are being hybridized through combinations of analogue, digital and AI technologies where quality control is maintained by industry exemplars. For instance, celebrity American mastering engineer Colin Leonard recently launched ARIA, a fully automated system based on an algorithm, which processes sound through his studio's signature toolchain, returning the master to clients within minutes and featuring no human intervention or listening.

4.2 Scenes

The second major creative place for audio mastering engineers is not so obvious since the space is not directly proximate: namely, the wider cultural infrastructure from which they glean clients, contacts, inspiration and amenities. The shift of the music industry from recording sales to performance and the gig economy is a progression from the 'demo'-ization of mastering in the 1990s ('demos' are promotional recordings, often in the past unmastered, distributed to attract listeners and music labels to music artists). The role of AI in facilitating to promotion rather than record sales is a further shift in the creative industry as LANDR and other competitors have a role to play in supporting new, or unrecognized, artists and performers within the wider 'scene'.

4.2.1   Word of Mouth

Informal, non-textual—that is, word of mouth—forms of communication are intrinsic to the persistence of musicians, music scenes and the professional facilitating services to them. 'New musical forms and innovations have to be experienced and evaluated "live" and thus proximity to audience as well as gatekeepers and taste-makers is central' (Florida and Jackson, 2010: 312). The tradition for informal endorsement by peers continues in this creative industry and this applies to audio mastering as well:

> Well, you know it's word-of-mouth, it's people telling other people about the experience, or ultimately, not necessarily the experience, but "Here, have a listen to this." You know that's what people do, they go…and you know, that, I think carries more weight than any sort of blurb on Facebook or whatever. So, I often get things from other people.

> (Interview, F, 50s, Mastering Engineer, 2017)

Amongst the most prestigious interviewees a nexus applies of engagement with cultural infrastructures, embeddedness within musical scenes, and ability to master according to current tastes. The link between relational spaces of creativity and wider social networks is difficult to formalize yet remains a chief method for professionals to gain clients on a case-by-case basis. The ability to survive in this 'gig economy' involves professionals accumulating enough capital—that is, social and financial—to mitigate lulls in work:

> But the phone rings and the person on the other end of the phone wants to give me money. That's the relationship I've had with my clients since the mobile phones were invented in 1992. Every now and then the phone stops ringing and it might stop for three weeks and you're like, what's going on? And the bills start to stack up and you go and talk to an accountant and he says, well, where's your client list, where's this, where's that, where's all your sources of income? I'm like – from the magic phone.

> (Interview, M, 50s, Mastering Engineer, 2017)

There is a marked dependence on wider relational spaces of creativity in scenes outside of recording studios for ongoing work that involves professionals marketing themselves online and offline. Notwithstanding the ubiquity of portable and home recording equipment, some human expertise remains a premium service, with exemplary engineers able to weather the instability of the gig economy and market their advantages. The interviewees drawn from this cohort were unanimous that AI is impacting the bottom end of the market that grew through the 2000s through the ubiquity of affordable (or pirated) mastering software and other home

recording equipment. Certainly, sub-standard operators unable to compete in the gig economy with either established professionals or online AI services are facing diminishing clients and instability. However, the human element is becoming a marketable attribute in and of itself with exemplary engineers offering consultation as an advantage over their competitors:

> And over the last sort of 10 years it's become incredibly normal for no one to come to mastering, someone will just send it over the internet. And most of the time I'm here by myself. And I didn't sign up to work by myself in this business. I don't like it. I tend to talk a lot and have an experience with my clients that keeps me working.

> (Interview, M, 50s, Mastering Engineer, 2017)

Indeed, the human touch is something AI systems are cognizant of emulating. Those who utilize AI mastering services such as LANDR receive regular emails from 'Angela', 'Jace', and other personalities keen to draw client attention to the people (real or not) behind the software.

4.2.2 Working Remotely

The centrality of mastering studios to cultural infrastructure is not obviously connectable to the realities of how engineers enact their skills with cases of artists visiting them in person for consultation being the exception rather than the norm:

> Everyone's gone home. So, if you take this business and you put it in my basement and you charge what I charge it's a pretty good business. If you take my business and put it in a 450-square metre warehouse this close to the city it's a shit business.

> (Interview, M, 50s, Mastering Engineer, 2017)

Yet, it is irregular communication with clients that is crucial for those deciding to work remotely from cultural infrastructures. The interviewee above goes on to describe the 'flytrap' of moving studios away from cultural infrastructure to remote locations. Since the 'gig economy' requires the constant renewal of client bases then immersion in creative scenes continues to be vital for survival. One factor here is the solitary nature of the practices of audio mastering and the balance between client liaison and critical listening:

> Yeah, I think mastering guys tend to be a bit more of the loners of the audio world. Because if you're recording with a band, if you're a tracking engineer, you're with bands, you're with other people, producers and stuff. It's very collaborative. With mastering, you come in and it's just you, speakers and that's it. Sometimes clients come in, but it's better if they don't a lot of the time, in a funny kind of way.

> (Interview, M, 20s, Mastering Engineer, 2017)

Working remotely from cultural infrastructures is really only feasible for those with prestige from careers spanning decades or for those with the capacity to bear the risks of the gig economy. Interaction with scenes in creative clusters, and usually in urban cores, continues to be a notable advantage of human audio mastering engineers that insulates them from the vagaries of the online, solely digital, post-production market with its mixture of AI, amateurs and hybrids of automation and signature mastering equipment (e.g., ARIA).

5. Conclusions

Through examining the mutability of human skills in audio mastering as engineers face the introduction of AI into their studios and scenes, we reflected on the implications for creative industries more broadly, so-called 'no-collar' jobs, alongside trends in automation within blue-collar (manufacturing and services) and white-collar (knowledge workers) ones. Many critics have argued that the creative occupations are the last bastion against AI and robotics, but our research on audio mastering offers unsettling findings. According to the standpoint we developed, it is not just labour and economic geography that must contend with the rise of the robots and AI, but social and cultural geography more generally–as digital transformation begins to bite ever more deeply into creative practice and new experiments in living (Bissell and Del Casino, 2017).

In future, deep neural networks appear set to replicate the dynamic operations of audio mastering engineers (Mimilakis et al., 2016). However, at the moment AI audio mastering services are not competing with human ones per se but are instead targeting niches in the market. A primary niche is that of artists and amateurs using home—termed 'bedroom'—studios, or portable recording and mixing technologies for ad hoc creative spaces (Watson et al., 2009). There are a number of different avenues into the music industry currently being explored by start-ups such as LANDR and Cloud-Bounce. A key factor is that AI audio mastering services offer lower quality 'MP3' mastering for no to low cost that undercuts human mastering engineers to some extent in a market where humans must charge for their time and manage overheads such as studio space rental, equipment insurance, and so on. In response to the criticisms of AI's capacity to compete against human skills, pioneering companies and freelancers point to the alternative business models they are capable of invoking. First, is the affordance for artists to 'test' their mixes before sending them to human audio mastering engineers. Nowadays artists are tending towards recording both as a group and independently in different spaces and times on their own equipment. With the advent of ubiquitous recording through DAWs, recordings are often sent back to artists for remixing, since human mastering engineers do not work with stems. There are limits to the scope of their interventions when the mix or recording is deemed incorrect.

Second, AI audio mastering is beneficial for the shift in the music industry to the 'gig economy' wherein purchases of music recordings are at an historic low due to ubiquitous audio streaming over Internet services so artists are now earning incomes nearly entirely from live performance and merchandise. In order to attract gigs, musicians distribute 'demo' recordings, and if these can be mastered by AI cost-effectively at prices lower than human mastering engineers are willing to charge, then this is potentially a large market to capture.

Third, there is a relatively untapped market of commercial music for short films, elevators, shopping malls, advertisements and so on. What many human mastering engineers might consider as 'sub-optimal' standards of mastering are tolerable in many contexts where the intention is not to release a song or album but instead to promote a product or service via a 'jingle'.

Fourth, human mastering engineers themselves are also availing themselves of AI audio mastering services to provide a comparison to their own work for prospective clients—that is, to demonstrate the worth of human mastering. As the founder of LANDR, Justin Evans, describes: 'One of the most exciting things for me was when Bob Weir from Grateful Dead and his TRI Studios found us, and loved us, and they are now using LANDR to prepare

tracks for streaming services' (Cooke, 2014: no pagination). Audio mastering engineers could also recommend artists utilize AI services to gain a sense of the kind of product they envisage from human mastering engineers. In order to compete with free mastering, human mastering engineers could surreptitiously use AI services and then simply provide an additional level of expert scrutiny that is unavailable to the majority of artists.

Across all of the interviews there was a general sense that mastering engineers were again interacting face-to-face with creative clients in the studio, although not all mastering engineers offered this service regularly, since the Internet is also a source for clients at varying degrees of distance that makes physical co-presence undesirable or unfeasible. Yet, as AI becomes more pronounced in this occupational role, the mastering studio is shifting again to become a place where sound creators are able to meet with mastering engineers. Since sound creators now more commonly record and mix recordings themselves there is a willingness to engage in the mastering process too. Moreover, AI is not yet able to compete with human relationality within scenes and this makes physical co-presence in studios a premium form of service. The construction of the creative places around human individuals' needs became the norm as the technical aspects grew more pronounced into the twenty-first century. A balance is now apparent between mastering studios as relational spaces of creativity and as individualized ones tailored solely for the engineer's needs.

In the instance of audio mastering these relations are crucial since the AI in question depends upon vast databases of human-mastered music in order to compile templates of workflows of signal processing in order to replicate human decision-making in pre-mastered music. Instead of falling into a hackneyed appraisal of the consequences of AI on jobs—that is, either lauding the benefits to industry or prophesizing imminent retrenchments to humans—we utilized a critical, geographical viewpoint to explore the ramifications of AI for place in the construction of this specific niche of human skills. In reviewing the literature on creative places, we contributed the thesis that human skills and sensory products are enmeshed in, and typified by, certain spatial parameters and restraints that influence creative places, which in turn determine social practices and networks of reproduction. We subsequently showed how the introduction of AI into audio mastering and the pursuit of the most affective 'master' version possible neither necessarily reduces human skills to quantifiable and mechanical processes as might be presumed nor reconstructs humans and machines as ideal 'cyborg' assemblages. Instead, we advocated a more nuanced stance through exploring the crucial role audio mastering engineers fulfil in the mutability of the affective atmospheres of sound. The paper thus progressed recent critical writing on affect in human geography and elsewhere and previous questionings of the rigid conceptual divisions between affect and emotion. By paying heed to the audio mastering engineer's role in correcting, standardizing and enhancing the affective qualities of sound productions, we discussed how audible conventions are grounded in particular contexts, practices, technologies and histories and are far from definitive, quantifiable and precognitive.

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