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# Aural Textiles. Hybrid practices for data-driven design.

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**Abstract:** This paper explores the developing co-creative relationships that arise through integrating digital making and data-driven processes as inspiration within collaborative distributed networks of design and making. It draws upon a year-long case study of landscape sound digital pattern design with a group of textile practitioners from across Scotland. The aim is to understand how these collective 'hybrid ways of making' between digital data-driven design and analogue maker impacts the overall democratisation of textile design and manufacturing and influences the makers' practice.

Keywords: Co-Design, Data-driven design, textile patterns, distributed making

## 1. Introduction

The ongoing conversations around digital technologies, machine learning, and the question of authorship continue to raise debates as to future ways of making (Gunkel 2017, Atkinson 2010). In many of these conversations, there is a sense of fear and trepidation that machines and data will replace the skilled artisan, as has been the case in many instances during the Industrial Revolution where machinery replaced skilled workpeople (Sennett 2009). In textile manufacturing, these developments include historic punch card jacquard weaving looms and nineteenth century knitting machines. Recently, algorithm-designed patterns integrated with these machines have been developed that require input only from data sources, including song data (Ricketts 2017) and DNA sequence information (Tucker 2015). In this respect, the question of automating textile *design* comes into play, where the role of the designer-creator shifts towards algorithm development that is based on their knowledge of available data combined with their experience of textile manufacturing processes.

This paper covers the developing co-creative relationships that arise through integrating digital making and data-driven processes as inspiration within collaborative distributed networks of textile design and making, and builds on a case study developed by the authors (Mennie and Jaramillo, in press 2018). The aim is to understand whether 'hybrid ways of making' between digital and analogue sources can democratise textile design and manufacturing. The *Aural Textiles* research project was a year-long project of collaborative exploration between practitioners and researchers, using landscape sound as a digital/analogue approach to designing textile patterns. Beginning as an exploration of the aural landscape (including awareness of and attunement to soundscape) it would

become a collaborative distributed project where six textile practitioners from different disciplines took part in a “sound-to-pattern making” process to create contemporary patterns based on landscape sound, thereby promoting an embedded-landscape approach to pattern making and developing a collaborative digital process.

In this paper, we first explore existing ways of textile making including a brief exploration of automation and machine-replacement processes of the Industrial Revolution. We relate it with the implications of today’s digital technologies and bring up questions of digital agency and making. This is followed by describing the sound-to-pattern process using spectrograms, and discussion of the workshops and digital platform used as part of the project’s process. We then focus towards analysis and insights of the research looking at three key points in what is termed ‘hybrid ways of making’, concluding with some final reflections and next steps.

## 2. Existing ways of making

Textile design and making is a long human and animal tradition with the earliest evidence of human textile production dating from the Upper Paleolithic period (Soffer et al., 2000). Early or pre-industrial textile production processes continue to this day throughout the world, and are formed of a multi-step process in which fibres - whether plant or animal based - are spun into thread or yarn-like forms that are then interlocked to create flexible and multipurpose fabrics: weaving, knitting, crocheting and other hand-made processes all follow related processes of creating a web of interconnected threads to form fabric. Designs within the created fabric would typically follow specific patterns unique to the region of creation, and reflective of regional visual scenes (Day 2013). These fundamental processes of textile design and manufacture have persisted throughout history to present day, whether for handmade or machine-made fabrics.

### 2.1 From industrial production to data-driven design

The developments of automation in weaving particularly and, later on, in machine knitting spurred the developments of our contemporary textile manufacturing process. The machinations and experimentations from silk weavers in France (Sennett 2009) to the spinning mills of Derbyshire encouraged a transformation in our relationship with production, design and use of textiles. The emulation and eventual replication of human actions would affect a difficult and tenuous relationship with the means of creating artefacts, particularly with textile looms, while also enabling more complex designs to be produced and encoded within the machinery. The encoding of visual information for textile production, initially via punched cards, tread a path towards the age of computers; and this now comes full circle as computers encode data that can be used to inspire new textile designs.

General approaches to data-driven design can take two approaches: the first is where large sets of quantitative data (typically ‘big data’) feeds and informs the process of design, widely used across a variety of disciplines ranging from building information management and parametric design through to web design; the second is a more general understanding where qualitative data informs and most likely initiates a design process. Data-driven design is not so much dependent on the type of source data or code as in large datasets of information, rather it is about understanding existing conditions to help drive the way design is developed and created. In this sense, the data is the information used to either support a designer’s intuition or lead them towards better solutions. For our purposes, we consider a third approach, where the data themselves are used as the source of inspiration for visual design, in this case using sound data to inspire textile pattern design.

## 2.3 Co-creation and its understanding to making

Co-creation describes a process of producing items of mutual value, allowing the design aspect of production to sit between multiple stakeholders and creator (Pralhad and Ramaswamy 2004). A major step-change, enabling such a process, is the ability to link external design inspiration with pattern creation software linked to manufacturing equipment. One aspect of supporting such a process includes fashioning tractable methods to collect and manipulate “design inspiration” that are amenable to the application of computer-based production. Here we describe the outcomes from research exploring the use of “data-driven designs” that transform recorded environmental sounds into woven, knitted or printed textiles; and offer up opportunities for encouraging these hybrid digital-analogue design processes.

## 2.4 Questions of Authorship

Digital innovation and digital agency play a key role in the way that we understand the input of digital technologies. The agency of the machine and the practitioner make for contemporary debates on its impact of how we take into account these new non-human actors. It can be considered that the loom and the knitting needles play an important role in the making of the fabric and become extensions of the human body. It is these questions of experience (Leslie 1998, Suchman 1998) in craft in an age of mass production that begin to promote these relational notions between machine and human. Furthermore, there is discussion of the ‘post-automation’ of craft (O’Donovan et. al 2017) where moving beyond the agency of digital technologies creates new types of conversion encounters within non-industrial/bespoke fabrication processes.

This review opens up conversations about the way that technologies have and can alter the creation of textile artefacts and our relationship in that making, particularly in the context of solo practitioners. The nature of textile creation requires physical co-location of maker and equipment to produce items, with some equipment more portable than others: crochet hooks can be carried easily, but not a weaving loom or knitting machine. Designers can be located separately from the place of creation, but many solo practitioners are both designer and creator. The notion of the lone textile creator is a limiting concept for the modern practitioner, particularly in an age where remote geographies are digitally accessible.

Modern practitioners are mobile, diverse and interdisciplinary; they expect to access information, skills and knowledge digitally; and they need to compete more and more with larger commercial/industrial enterprises across the same media platforms. The need for new techniques and acknowledgement of cooperative approaches to textile making, whether between groups of designer-creators or co-creating designs with end consumers, are expected to develop in the next few years; and mechanisms that support these new interactions (with our environment, between designer-creators and with end users) are required (Kenning & Law 2018). The next section explores a new type of distributed yet collaborative digital/analogue approach, trialled with six textile practitioners from across Scotland: two weavers, two knitters and two screen printers.

## 3. Process

In order to demonstrate the concept of data-driven textile design, we have focused on data derived from sounds. The aural landscape is a significant, yet often ignored, component of the embodied multi-sensory landscape —from the buzz of fluorescent tube lights in an office to the intermittent roar of aircraft flying overhead, no space is ever silent. This attunement to the soundscape is key to developing awareness of the landscape as well as to the space of listening. For example, human

voices have internal overtones yet our brains and senses tend to cancel out these sounds. This project attempts to engage with a sonorous world that exists beyond our conscious, and asks us to listen to it and respond to it beyond the sound.

The first notation of music was developed in ancient societies (West 1994) representing an early attempt to sound visualisation. The rise of polyphony in early Medieval monastic societies throughout western Europe required the creation of musical notation allowing many people to understand and follow a series of sounds. Four hundred years later, these early visualisations would include devices such as Edison's phonograph. These systems allowed soundwaves to be visualised by physically carving the sound into grooves and able to be reproduced. The audio wave impressions would be the predecessors to today's digital visualisations, including oscillograms, wave displays, and spectrograms.

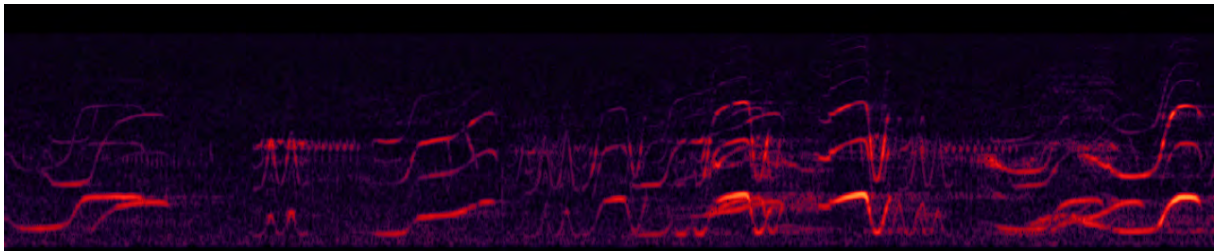


Figure 1: Spectrogram of lapwings from the RSPB site on North Uist, Scotland (Source: Jaramillo 2016)

A spectrogram (Figure 1) is a type of audio visualisation where, the intensity and spectrum of frequencies are displayed across time, rather than simply the amplitude (as is normally seen in a waveform visualisation). There are many applications for the use of spectrograms including recognising phonetic speech, in bioacoustics applications, and even the vibrations of the earth in seismology. The field of bioacoustics is especially useful in spectrogram use as different animals that normally cannot be tagged, like large underwater mammals or migrating birds, can be tracked by their specific call (like an audio voiceprint).

### 3.1 Transforming the Sound

In order to generate textile patterns from sound, the basic process was broken down into three main steps of capturing, transforming, and visualising (Figure 2). Participants spent time capturing their soundscape - recording sounds including lapwing and other bird calls, waves, the wind and man-made sounds such as machinery and airplanes overhead - in an attempt to better understand their local environment beyond that which was simply seen. Using smartphones and small audio recorders, we can capture the sounds around us.

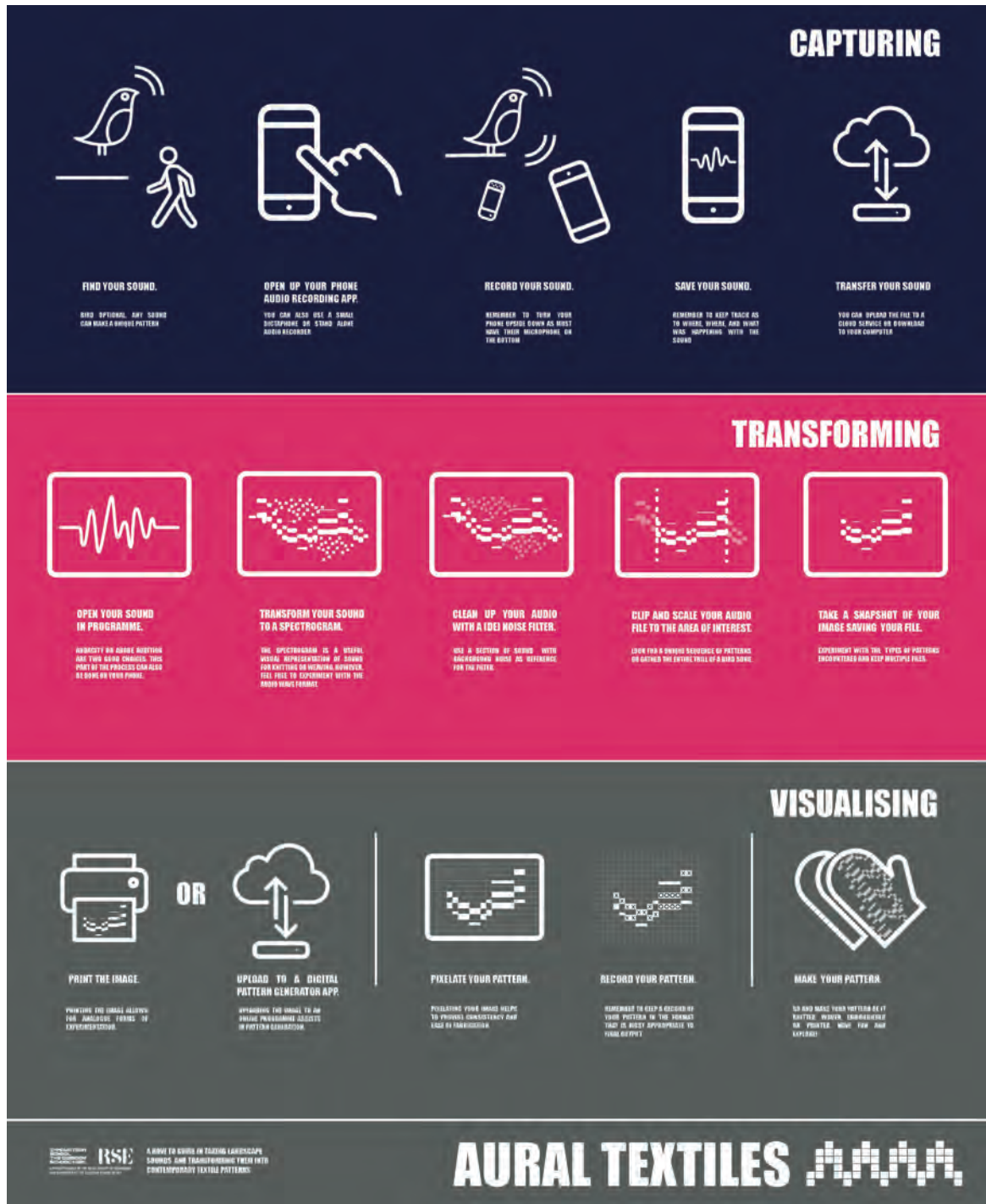


Figure 2: The sound to pattern process diagram showing the three main phases of capturing, transforming and visualising. (Source: Jaramillo 2018)

From this point, through the use of audio software, the sound can be transformed into a spectrogram that visually represents the entirety of the recorded sound, across time and audio spectrum. This image was then digitally manipulated by the designer/practitioner to reduce background noise and simplify the bio-acoustics pattern, and the manner in which this was done varied by designer according to the shapes visible within the spectrum and dependent upon their own design aesthetic. For example, some designers preferred to focus on very small and distinct segments of the spectrogram while others worked with more diffuse and extended segments. Having completed this transformation point, the practitioner can then manipulate the image further; for

example, segments can be abstracted, repeated, rotated, inverted, and recombined, as is typical for any design process. However, the textile designer must do all of this with reference to the constraints of their specific discipline (whether the number of shafts and treadles on a loom, punch card size on a knitting machine, or screen print dimensions) and the materials used.

From a single spectrogram, a huge variety of patterns and textiles can be visualised and created, within and across textile disciplines. This cycle from analogue  $\Rightarrow$  digital  $\Rightarrow$  analogue enabled the textile practitioners to work with the digital space in an iterative manner. The source data from the audio file and digital image manipulation is one aspect of the textile produced but the finished piece is also dependent upon the interaction between data and practitioner, which is, in turn, dependent upon the creative process and skill set of the practitioner. We see that different practitioners create completely different textiles from the same source spectrogram (sound).

## 3.2 Engagements

Through a participatory design approach (Bannon & Ehn 2012), we developed a series of collaborative workshops where the six textile practitioners worked together with researchers to develop new processes for inventing and generating textile designs using non-traditional approaches, with designs taking inspiration from the “heard” rather than “seen” environment. Residential workshops brought together a cohort of practising solo textile designer-creators working at various locations across Scotland, and from a variety of disciplines with very different technical considerations: hand-knitting, machine knitting, tapestry weaving, shaft loom weaving and screen printing. The workshops provided an opportunity for the practitioners to share skills and experiences with each other and with the researchers of their different textile disciplines, and to consider the challenges and opportunities of considering non-traditional textile design processes, with practitioners and researchers working on co-creation of data-driven “aural textile” designs.

### Workshop One

The first two day-one night workshop introduced the source data used as inspiration for sound-based textile design, allowing participants to understand and relate to the audio source and begin to build a cultural and design narrative around the “heard” environment stimulus. Meeting in the village hall of Newtonmore, the group spent time being introduced to the audio-spectrogram process, took part in an audio walk in the village to gather a set of sounds, and began working with these sounds to gain an understanding of the potential within the digital aspect of the transformation process. We also gathered a baseline of reflective material from each participant to understand their needs, desires and reasons for joining the project. Following this workshop, participants returned to their individual studios to explore the process further and develop a variety of textile samples.



Figure 3: A view during the pattern making workshop at our gathering in Plockton, June 2018 (Source: Fegan 2018)

## Workshop Two

The second workshop took place in Plockton, and supported the practitioners to share and reflect on their experiences of “heard” environment-based textile design and the collaborative design-production process. It also permitted further collection of qualitative data to support analysis of these outputs. The second workshop ran across two nights and three days, giving participants ample opportunity to easily share, reflect and think through the collective processes, and address any issues working with the digital process. Participants brought a variety of textile samples with them and, during an informal critique session, described the sounds used, explained the design process behind each sample and discussed modifications to the designs. Following this, the practitioners selected six sounds suitable for further pattern development (Figure 3), with each practitioner agreeing to work on two different sounds and all sounds represented across a variety of textile disciplines.

## Final exhibition

An exhibition of the textiles created was held at the end of the project. Each practitioner created one finished piece (whether a bolt of fabric or a finished product) for the public exhibition, as well as a range of samples for the two sounds that they had worked on. The final exhibition was held in



Forres, running for one week during September 2018, and was accompanied by an explanation of the design process and exhibition catalogue. A freely-accessible pattern book with details of the finished pieces will also be produced.

#### Digital Platform

Along with the in-person interactions at project workshops, we also developed digital platforms to support exchange and dissemination of information and experiences from this project. Images were shared on a project-specific Instagram account, and a project hashtag (#auraltextiles) was used by project participants when sharing their own work. A project website included public-facing as well as private areas, which the participants could use as a reflective tool, as well as to collaborate, identify and address issues with the design process, follow progress and simply get to know each other. This digital platform served to reinforce collaborative relationships throughout the project (and beyond), and enabled participants to further develop ideas that emerged during in-person workshops.

## 4. Analysis/Insights

The first aim of the Aural Textiles project was to see how a variety of practitioners would engage with and use the data-driven pattern-making process, the outcome being a series of patterns, design and forms that took inspiration not from what was seen but from what was heard. Secondly, we attempted an approach to collaboration wherein different practitioners, separated by geography, could continue to create, share, and inspire each other's practice at distance. In this sense, the sound-design process becomes a catalyst for distributed collaboration. These processes explore the entangled agency between humans and digital machines. Particularly, it continues conversations developed from Sennett (2009) where machines promote rather than command. It is this approach to working with machines and, in particular, the agency of digital data that we observed in our project as three key insights.



Figure 4: A collection of participant finished pattern samples put on final exhibition (Source: Fegan 2018)

## 4.1 Augmenting not replicating

The first was that the digital processes augmented but did not replace the designer-creators' abilities, with each having control over the final output as influenced by their pre-existing skills and own design aesthetic (Figure 4). This parallels work of Andrew & Diamond (2018) that sees a broadening acceptance of digital tools into textile craft. Sennett (2009) supports the notion (of Diederot) that the machine should not replace nor replicate but can suggest and enhance. Digital machines and their outputs have as much a 'digital aura' (Jeffrey 2015) in their making and thus are capable of maintaining the quality of design. For example, one participant stated that the digital/analogue process:

“has given [me] a new way of seeing. Now when I go out into the landscape... I'm aurally connected... I feel like I get some kind of weird aural synaesthesia. When I go out and hear birds... I see contrasts, and I know that this is informed through seeing spectrograms... It is a language and it's interesting to see how when I'm weaving, it's not visually inspired, it's actually aurally inspired.”

Here, this practitioner sees that linking the sound with digital visualisations has provided them with a unique ability to see/hear beyond the normal human capabilities. This provides a unique example where technologies have augmented the design process, but not completely replaced its making. It actually enhances the quality of the designing process and the experience of creating for this participant.

## 4.2 Enabling experimentation

The second insight was that the textile practitioners saw the digital and data-driven processes as opportunities to freely experiment and explore beyond standard practices, including the opportunity to evolve and innovate. In this instance, the creator is given an opportunity to 'try things out' without the market needs being fully thought through. One of the participants stated that stepping away from forced commercialisation had been essential to their enjoyment of the project, since this consideration would have “blocked [them] creatively”. In this case, the freedom to experiment with sounds, spectrograms and developing patterns from these without constraints superimposed by any computer algorithms was beneficial – here, digital technologies are enabling design thinking promoting a two-way approach to computation and design making (Fass & Walker 2015). Yet, this is not to say that there were not negative reflections, with one participant stating that the “computer has ... moved into the middle of things,”: the increase in an already heavy digital workload limited production of more work, and advancements that reduced the time required to work digitally would be preferred - “I just don't want to see any more screens”.

In this respect, the development of algorithms to take sounds, scan for regions of interest and auto-generate (eg) weaving or knitting patterns that are informed by the technical constraints of the discipline would be something to explore. This follows examples of algorithmic textile design (Koutsomichalis & Psarra 2015) that could be applied to this process to upload a favourite sound to an interface, select the manufacturing technology and generate a variety of patterns from a scan through the spectrogram. This would allow the practitioner to then select more quickly from a set of pre-created patterns that were ready to take directly to their equipment, while also maintaining control over aspects of the design process. Whilst an apparently simple concept, this would require considerable development around the technical constraints of textile-manufacturing equipment – in the case of weaving, this would include the type of loom, number of shafts, underlying weave structure, colours and type of yarns, to name but a few; knitting and screen printing have entirely separate considerations. In the two situations described here, control sits ultimately with the

practitioner, however, the agency of the digital translations and processes are enabled at different points by digital technology promoting a socio-materiality (Svahn et al. 2009) of innovation between the practitioner and digital encounters. This, in part, arises because the practitioners participating in this project create bespoke, one-of-a-kind or small batch textiles, and the site of control may change were the paradigm to shift towards mass production. The collaborative digital design model perhaps lends some resilience for solo practitioners in a changing marketplace (Lanz & Tuokko, 2017), supporting the retention of control with the domain of small-scale artisanal practitioners.

### 4.3 Promoting collaboration

The final insight from the project relates to the ability of the solo practitioners to collaborate on a shared project over distance. The digital platforms and ease of open source ways of processing and moving information allowed for the practitioners to share sounds between each other, as well as ask and answer questions or provide reflections on their own working practice within a private forum. As one practitioner states, ‘the shared nature of the Aural Textiles workshops has provided me with a community rich in its variety of makers, their approaches and textile processes.’ Beyond this, the digital platform for the Aural Textiles collaborative provided additional emotional support to practitioners who typically worked alone, and empowered them to push the boundaries of their creative practice. This digital catalyst also stimulated extended engagement between participants, subsequently fostering physical encounters and collaborations; for example, two of the participants met concurrently over a few weeks to create their pieces within shared studio space. This collaboration is supported within continued exploration of distributed digital spaces (Luckman 2013) where online platforms such as Etsy contribute to a self-actualising form of collaboration. Significantly, it illuminates the social relations of creativity prevalent in contemporary DIY and maker movements (Gauntlett 2011), one where the inherent solo practitioner is integrated into not just a collective of other practitioners, but where making together is key to overall success

While the findings from this project were generated in the context of working across Scotland, the principles apply equally across more distant geographies, with the only caveat being the requirement for (intermittent) access to IT equipment and the internet. The sound-inspired design process and digital platform could easily be used to bring together textile designers working across different continents and timezones, contributing to the democratisation of the design process across cultures and enabling the exploration of different cultural interpretations of sound-inspired textile design. In all, this work encourages the idea that technology can support and enhance the human element required for innovation in textile design. Using the supportive notions that we have discussed, we can think through the agency of machines as hybrid approaches to making, where iterative cycles between digital and analogue and the agency of the digital machine and person play a pivotal role in the design of patterns.

## 5. Towards hybrid ways of making

“A burn trickling over rocks; a wave lapping the shore; raindrops falling onto a shed roof: these all create sounds and images which are rich with design potential.”

As one of our participant’s states, the design potential is rich within the landscape—analogue or digital. It is this potential that we seek to move ahead. Overall, this study achieved two objectives: first, it promoted innovative multi-sensory approaches to traditional pattern creations; and second, it opened dialogues across the traditional textile disciplines, disrupting the textile manufacturing paradigm. The existing textile approach as discussed earlier maintains different manufacturing processes separate to each, as is utilised in a Fordist industrial manufacturing process. Each process

that was originally created by hand needed to be replicated into a mechanical automated system. This approach causes a stressor and detachment to the ways that production of material is made. It can be imagined that the future of digital design could also follow suit where algorithmic and artificial intelligence take out the agency of humans from the design of artefacts as well. In rethinking our relationships to the digital machines, our co-produced and co-designed patterns enable unique opportunities and perhaps a new direction in making as well as for participatory design (Bannon & Ehn, 2012) in a post-automated society (O'Donovan et al. 2017). Thus, we can begin to explore these hybrid ways of making as an interplay and translation between landscape, sound, machine, and person, rather than through a creator and machine dichotomy. The potential impact for novel pattern creation and contribution to the evolving field of textile design in contemporary Scottish manufacturing will not only show how we can innovate the process of pattern design but also, in the long term, push towards more open-distributed approaches of textile design and production.

## 5.1 Next Steps

There are many applicable possibilities that this process can lead towards from traditional commercialisation prospects to wider distributed participatory design actions. For example, birdsong collected from a regional RSPB (Royal Society for the Protection of Birds) site could be used to develop a series of site-specific textiles patterns (e.g. birdsong scarves) for that site. The client and designer would play a new role in the bespoke development of products. Furthermore, the role of end user in the participatory design process can be explored, where a consumer/customer/client may desire to create or commission textiles inspired by their own recorded sounds. This could take the form of introducing digital platforms to promote bespoke commissions. In this case, we expect the control would sit between end user and textile practitioner; however, further work is required to determine the extent to which this is the case, and it would likely depend on the role for algorithmic pattern creation within this relationship.

As identified previously, there is considerable scope beyond the initial stages of this project to explore the role for and development of algorithms for sound-inspired pattern creation that support practitioner and end user engagement with the process, as well as the impact of these on agency and location of control within the design process. The potential to use this process as a tool for wider public engagement with the soundscape and the design process, among adults and children, also exists. There is also scope to examine the democratisation of the design process across geographic, demographic and cultural barriers and it is this distributed and open nature of the process that can lead to exciting avenues of digital/analogue interactions.

Outside of the design process considerations, the concept of sound-inspired digital textile design described here offers a means to contribute to a personal narrative (for end users, practitioners and other groups) by capturing a moment in time, with all of the nostalgia and personalisation inherent within this, as well as the ability to visually represent change in sounds over time with changing landscapes (e.g. loss of habitat) or personal circumstances (e.g. hearing loss). Particularly, using the process can open up ways of working together in difficult geographical areas or influencing larger notions of migration tracking and mapping of aural landscapes across different regions. In this way, the hybrid ways of making can be used to support generation of a variety of new and unique artefacts by skilled practitioners for a range of purposes, while maintaining control of the process within the human realm.

Overall, this project has promoted a new awareness of the sound landscape and has given the participants a new appreciation of a normally shunted sense. It has also prompted new understanding of the participants' relationship to the landscape and generated new relationships

with a desire to evolve into a more formal structure, whilst maintaining a resilient and adaptable nature as required by the group. Most importantly, it provides new ways of understanding our human and machine relationship by not fearing nor simply embracing it, but by forging respectful and influential relations across the analogue and digital divide.

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