RTD2015

21ST CENTURY MAKERS AND MATERIALITIES

Proceedings of the 2nd Biennial Research Through Design Conference | RTD 2015

Parkinson, A., Cameron, D., and Tanaka, A. 2015. HapticWave: presenting the multiple voices, artefacts and materials of a design research project. In: Proceedings of the 2nd Biennial Research Through Design Conference, 25-27 March 2015, Cambridge, UK, Article 9. DOI: 10.6084/m9.figshare.1327979.

HapticWave: Presenting the Multiple Voices, Artefacts and Materials of a Design Research Project

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Abstract: The HapticWave is a haptic audio waveform display device that has been developed in collaboration with a group of audio engineers and producers with visual impairments for use in real world recording studio environments. This was not a project led by a designer or driven by a design brief: rather, the genesis of the HapticWave emerged from exchange and interaction between actors who brought to the table different practices, experiences, expertise and needs. By presenting the voices involved in this practice based research project, we offer a comprehensive report to retrace step by step the development and deployment of a research prototype.

Keywords: NIME; Haptics; Accessibility; Design workbook.

HapticWave: presenting the multiple voices, artefacts and materials of a design research project.

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Abstract
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Introduction
The HapticWave is a haptic audio waveform display device designed and elaborated working with a group of audio engineers and producers with visual impairments for use in professional recording studio environments. The interface takes the visual waveform display of standard audio production tools, and transposes it to the haptic domain. The prototype demonstrates the cross-modal translation of media information and its potential for opening up access of sophisticated media editing to new types of users, as well as assisting existing users by improving their workflows.

This was not a project led by a designer or a design brief. Rather, the genesis of the HapticWave emerged from collaboration and interaction between different actors, bringing different practices, experiences, expertise and needs to the table. We present the different voices involved in the project to retrace, step-by-step, the development and deployment of a the prototype. We believe this reflects the intertwined and interconnected relationships inherent in practice-lead design research. We hope to capture the changing dynamics, multiple voices, emerging design ideas and serendipitous encounters in the design process.

We follow the iterative design trajectory of the HapticWave through the interactions of the 'actors' involved. A Design Workbook [Gaver, 2011] documents the user-centred design workshops, engineering developments, related research and technologies, and design and material choices made in the elaboration of a functioning prototype. The development of the project will be presented to conference delegates by laying bare the artefacts and materials from various stages in the development of the HapticWave. This collection includes hardware development, prototypes, sketchbooks, design workbooks, photographs and video footage of workshops and the documentation of user studies. For the conference exhibition we present a working demo of the HapticWave for conference attendees to experience. This multifaceted presentation encourages an open discussion, inviting visitors to reflect upon, question and discuss the artefacts and different accounts of the project.

We present three 'actors' involved in the genesis of the HapticWave. We use the term 'actor' as a neutral yet powerful term to describe the stakeholders involved. Each of these actors represents a diverse, heterogeneous assemblage, containing combinations of practitioners, users, designers and researchers, with some individuals embodying all of these roles to different degrees. Distinct categories of 'artist', 'user' or 'engineer' become problematic, as we have end users who hack and modify products, and artist / engineers who build their own instruments and interactive systems.

The HapticWave

Actor 1: DePIC Researchers

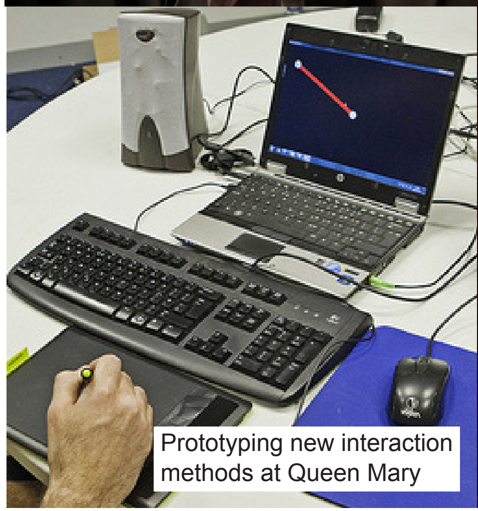
DePIC (Design Patterns for Inclusive Collaboration) is an Engineering and Physical Science Research Council (EPSRC) funded project carried out across Queen Mary, Goldsmiths and Bath University. It brings together researchers from the fields of Human Computer Interaction, Accessibility, Participatory Design and Psychology. The project carries out research on how different sensory mappings can open up space for collaboration amongst people with different senses available to them.

The DePIC team at Queen Mary, University of London consists of HCI researchers and programmers focused on cross-modal mapping and design patterns. Their previous work involved sonification and translation into the haptic domain of UML Class diagrams, working with engineers and professionals with visual impairments [Metlata et al, 2012].

Two of the present authors are DePIC researchers based in the Embodied Audio Visual Interaction (EAVI) research group at Goldsmiths. EAVI explores embodied interaction and new interfaces for performing music, creating novel musical instruments drawing on technologies such as biosensors, microcontrollers and single board computers, with a focus on practice-lead research. They are performing musicians, taking their interactive systems on stage. As such, EAVI represent technologically aware practitioners operating in a close field to the expert users, with an awareness of performance practices, music interaction technologies, and workshopping methods [Jo et al, 2013].

As practitioners working with similar tools to the audio engineers with visual impairments, Atau and Adam also possess an awareness of the types of tasks involved in audio production, and the hardware and software used. In addition to this, they bring an awareness of emerging musical technologies that are on the fringes of commercially available products, circulating through conferences, DIY communities and research centres.

Atau and Adam performing using smartphones



Prototyping new interaction methods at Queen Mary

DAW developed at Queen Mary

Actor 2: Audio Engineers with Visual Impairments

Central to the development of the HapticWave was the 'end user' group of audio engineers with visual impairments. They are experts in their field, working professionally and using accessibility tools such as screen readers to operate otherwise highly visual audio production tools designed for sighted users. While 'end user' implies that the product development ends with the group, these individuals were actively involved in the design research process, and should be able to modify or make, as well as use, a HapticWave.

This group shares commonalities with DIY / hacking communities: many are not just users of off-the-shelf products, instead modifying software and hardware they used and sharing this with others. DIY hacking communities have become a source of interest to the CHI community [Buechley et al, 2009, Wang and Kaye, 2011]. Unlike conventionally imagined 'leisure' hackers, the hacking undertaken by this community emerges out of professional necessity, and informs how the outcome of our design and research will be used by them.

These audio engineers have diverse skill sets and work with audio in different ways, including a session drummer who is sent recordings which he adds his own drums to, a radio producer who creates podcasts on her laptop, and a metal guitarist who records, mixes and masters tracks and albums by bands. Some have only ever used computers for audio production whilst others have experience with physical mixing desks and other tools of traditional studios, which are in many ways far more tactile and accessible.

This group brought to the project an expert understanding of the tasks involved in audio production and were able to identify where cross-modal interfaces could make a palpable improvement in their ability to work.

A typical recoring studio

Sherie Grifiths recording a podcast

Scott Chesworth playing bass

Actor 3: Designers and Makers

The third actor is a group of designers and makers. These individuals engaged with the project at different times and for varying durations, and are introduced in chronological order of their collaboration in the project.

Leafcutter John is a musician known for building his own instruments, using tools such as Arduino and Max MSP, with a background in the DIY / hacking community [1]. John built and programmed the first prototype in the project. The fact that John was not a traditional designer or hardware engineer gave rise to a very distinct first prototype that re-appropriated and recombined existing hardware (such as a disused scanner) into something new.

Martin Klang is a professional electrical engineer and a key individual in London's Music Hackspace community, and involved in 'The OWL' programmable DSP guitar pedal, funded through Kickstarter [2]. Martin acted as engineer on electronic and mechanical components at later stages in the development, as well as manufacturing PCBs for the final prototype.

David Cameron, an industrial designer and design researcher, joined the project in the design and manufacture of the final prototype. He brought his skills as a designer maker to develop the HapticWave from an early iteration to the final prototype. David's experience as a maker enabled him to build iterative and exploratory prototypes to develop the physical form and internal mechanism of the device. His industrial design experience offered a knowledge of materials and manufacturing processes, with an ability to produce CAD and technical drawings to outsource the fabrication of the device.

Working at the Interaction Research Studio at Goldsmiths [3], David also brought his experience as a practice-based researcher within HCI. This half of his practice offered design-led research methods, such as Design Workbooks [Gaver, 2006], as well as the experience of designing and deploying interactive research prototypes with research participants [Jarvis et al., 2012]. The combination of these two practices enabled David to engage with research materials from earlier engagements with the 'end user' group, and to use these insights to shape design of the research prototype.

Leafcutter John performing

Photostroller's controller

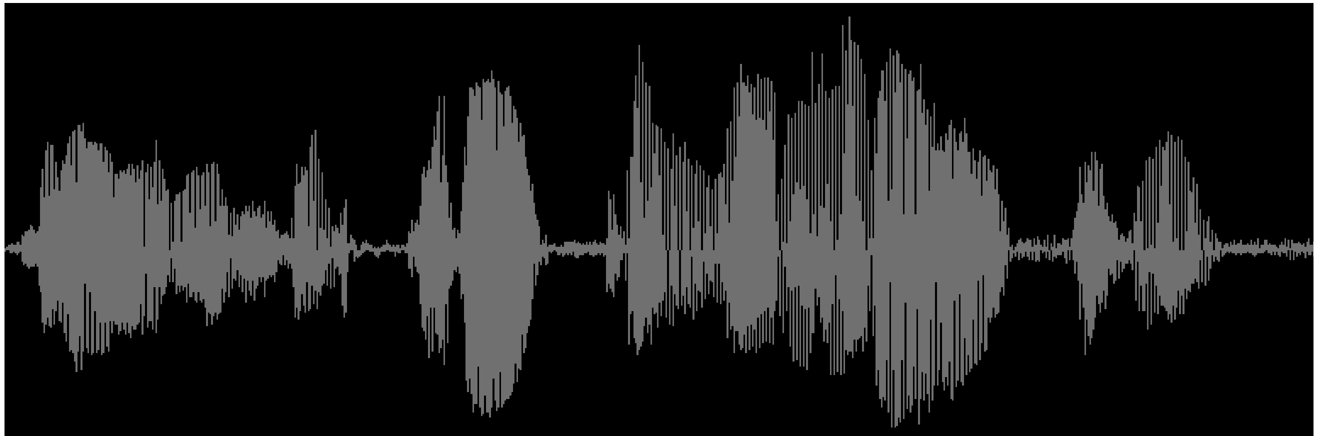
The OWL Pedal

First stages: Scoping workshop to understand users' practice

The first workshop brought together the first two actors: DePIC and the audio engineers with visual impairments. We organised it as a participatory design workshop, drawing on techniques outlined in Svanæs and Seland [2004] amongst others. Over the course of one day, participants discussed day-to-day problems experienced in their work, were introduced to technologies (eg haptics, sonification), and asked to speculatively design a 'dream box' which would overcome some of these problems. The intention of this structure was that the participants would critically think about the specifics of their workflow, be inspired by new modes of interaction that new technologies could offer, and then suggest ways in which novel interaction could be helpful to them.
We identified the following problems with existing DAW environments for audio engineers with visual impairments through studying footage from the workshop and drawing on the thematic analysis described by Braun and Clarke [2006]:

1. Difficulty in getting an overview and context of a project
2. Problems with unintuitive, non-musical feedback from DAW when interacting with screen reader: the screenreader is using the same modality (audio) as the medium being edited
3. Inter-DAW incompatibility of file types + longer turnaround time for visually impaired engineers created barriers to collaboration
4. Lack of long term support for products made maintaining accessibility after software updates problematic
5. Lots of keystrokes needed to complete tasks when interacting via keyboard + screenreader
6. Problems with solutions that introduce more layers of technology

There was also a discussion about audio waveforms, and being able to identify salient points (such as silences, or specific words when editing podcasts or audiobooks), and the possibility of using haptics to perceive the waveform:



The Digital Audio Workstation, or DAW, is at the heart of modern music making and production. DAW describes a combination of software and hardware: the hardware is likely to consist of a laptop or desktop, and any combination of controllers, and audio interfaces, synthesisers and effects.Modern DAWs are very visual environments. A great deal of the information about a recording or a song is provided visually. The recordings themselves are shown as waveforms on a timeline. Information about a recording can be obtained from this visual waveform, such as:

- the overall dynamic range (how much the volume varies)
- the presence of any silences (which could be useful to identify the end of a chapter in the recording of an audio-book, for instance)
- the presence of large peaks in the volume salient features, such as a kick drum or a snare, often have distinctive images and some audio editing can be done entirely visually

The waveform can provide this very quickly, and one can find out lots of information about by glancing at the screen.

The DAW

TM: I've got a task that I need to be able to do, and that's be able to scan a waveform and find gaps in it, and find - when I import books from another audio company, and we have to chapterise it, and sighted people can see big gaps coming up, and they can see the waveform saying chapter one, chapter too, uh, and so they move the cursor to that point, so for me to be able to --- all I'd do would, I'd

SC: Haptic would be really good for that, wouldn't it

SC: Some sort of haptic feedback would be epic

TM: Yeah

PB: That's what the Moose would be able to do

[several] the Moose?

PB: The Moose is something which is a haptic feedback device, and the demonstration I had was, someone called Sile O'Modhrain who some of you might know, she's at MIT in Ireland, and she had - the haptic feedback was something you hold in your hand, and it was tracing waveforms in real time, and so you could actually, you could move the device, and when you move it you get a real time representation of the waveform, so all you would need is for the waveform to be zoomed to the right level, and you could then explore it quickly, so you're actually, you're touching the waveform in effect

JR: wow

SC: That's cool

Trasncript form the workshop, referencing O'Modhrain [2006]

HapticWave 01: The First Prototype

Haptic Serendipity

From the workshop, it emerged that much could be From the workshop, it emerged that much could be gained from being able to 'feel' the waveform, and that haptic technologies could enable this. Simultaneously, a serendipitous encounter at the TEI (Tangible, Embedded and Embodied Interactive Conference) in Barcelona introduced the EAVI group to the possibilities of cheap, lo-fi haptics using the Arduino platform. A workshop at TEI by the Copenhagen Institute of Interaction Design (CIID) presented modified Arduino boards built with Bill Verplank, with libraries enabling control of motors [4]. CIID demonstrated devices using repurposed motorised faders (found on mixing desks) and linear motors from hard disk drives. These boards allowed rapid haptic prototyping, and an inexpensive and open way to explore haptics for audio. A workshop with CIID researcher David Gauthier at Goldsmiths followed, investigating further the libraries they had created for sophisticated control of motors. The Queen Mary group used haptic devices such as the Phantom Omni. For our purpose, devices such as the Omni are powerful, but have too many degrees of freedom, are relatively expensive, and do not have the community of users that platforms such as Arduino has. In the design session at the end of the first workshop, participants suggested providing a haptic overview through using a haptic overlay on an iPad, but the technologies to achieve this are not yet widely available, nor are they proven to have the resolution and accuracy necessary to be useful. In this technological context, the CIID platform offered the best possibility for exploring haptics.

Drawing on the practice, community and knowledge base of EAVI, along with the needs identified in the practice of the audio engineers with visual impairments, the first HapticWave was developed.

EAVI worked with Leafcutter John to create a first working prototype of the HapticWave, repurposing an old flatbed scanner and mounting motorised faders, controlled by the CIID board, on the moving scanner bed. Software was written in the Arduino environment to run on the board. Moving the scanner bed from left to right moves through the waveform, and the motorised faders are then used to represent the volume of the waveform. EAVI worked with the DePIC team at Queen Mary to integrate the device with accessible DAW software being developed by the team.

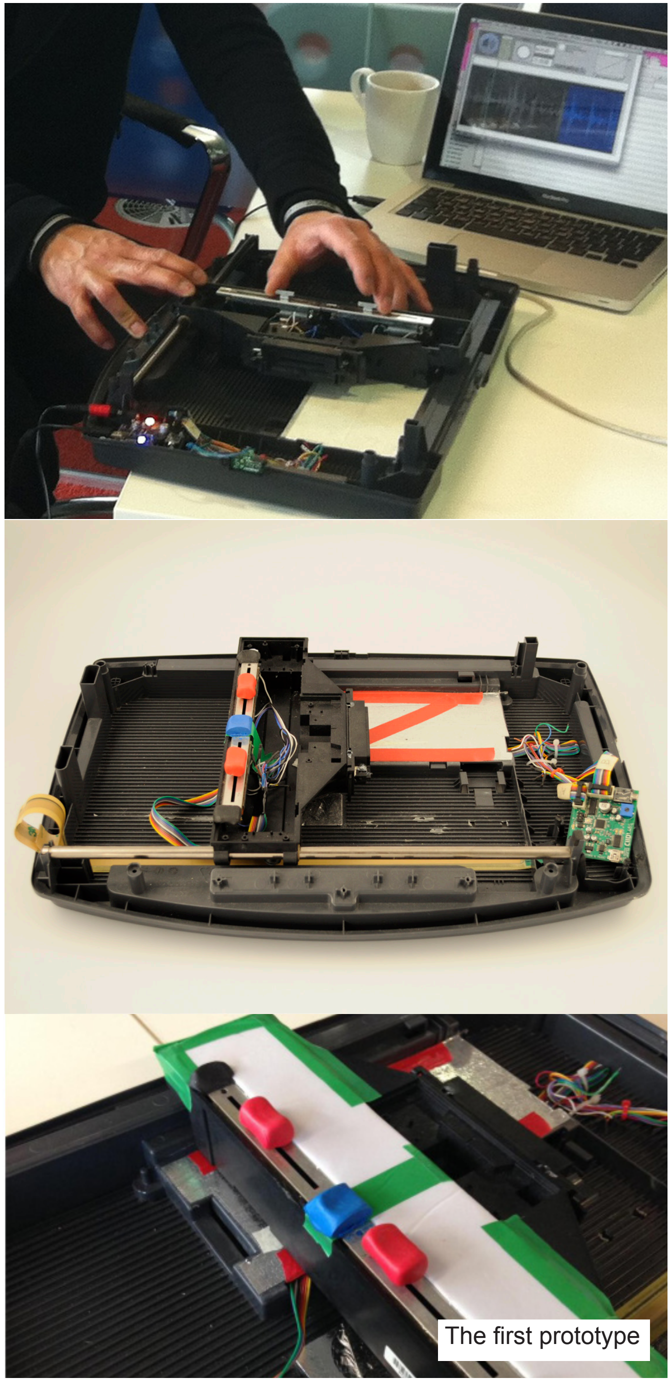
A visual representation of a sound wave has a positive and negative component, which are both shown in a waveform display. However, the top (positive) is normally effectively mirrored in the bottom part of a waveform display. Nonetheless, conventional DAW software uses valuable screen space to display both positive and negative components of the wave. In the first prototype, this convention was carried over from the visual to the haptic domain, using two motorised faders to represent the top (positive) and bottom of the waveform.

The HapticWave addressed problems (1) and (2), identified in the workshop:

1. It provides an overview of a waveform (though interacting via the medium of touch, and scanning physically from left to right, might not be as quick as a visual interaction.
2. It provides that overview via a different medium to the one they were working with.

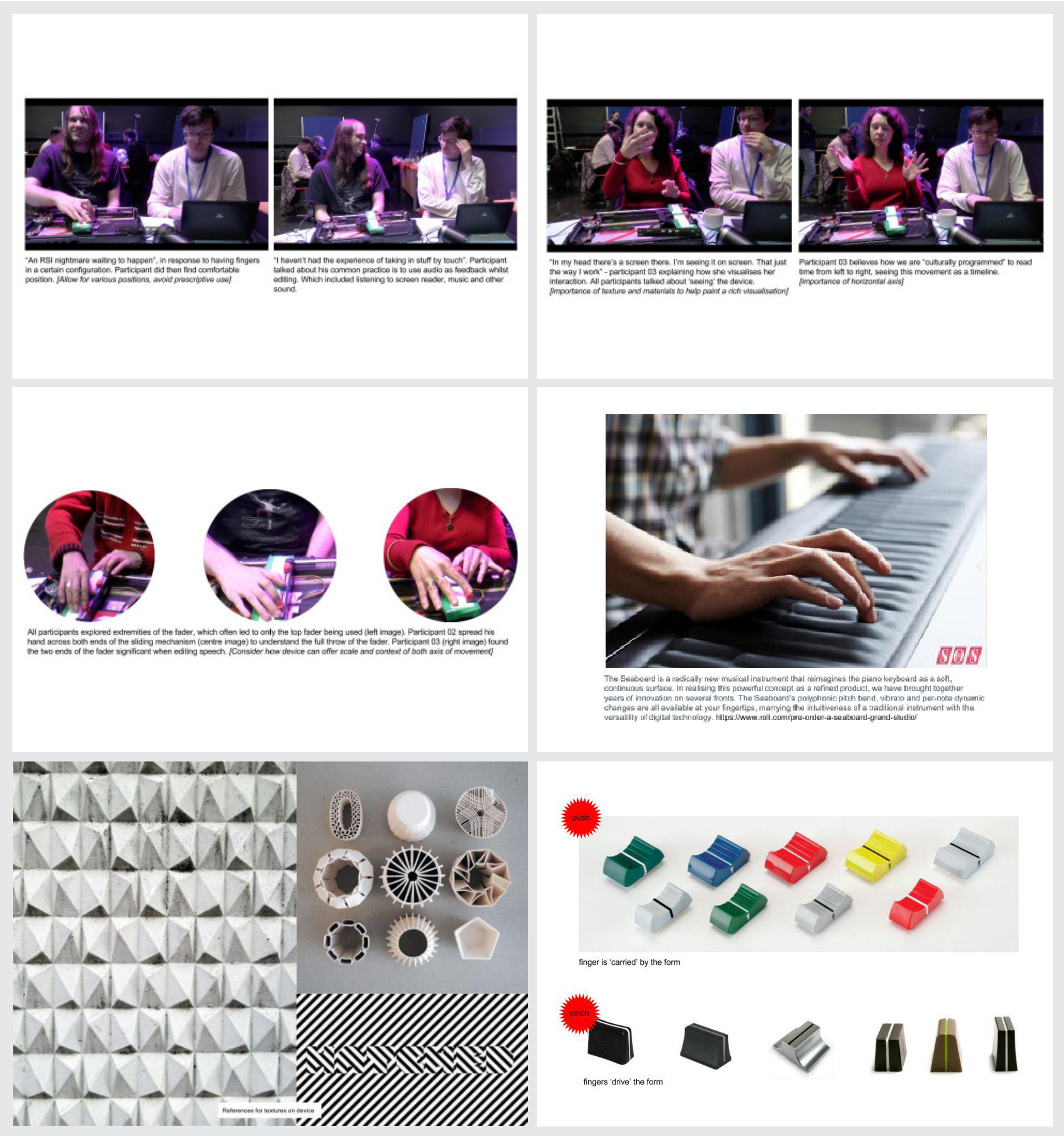
Testing the first prototype

Over the course of the next several months, further workshops were conducted with some of the original participants, introducing them to the first HapticWave. With audio samples loaded into the DAW environment, participants were encouraged to navigate through the sound using the HapticWave, feeling the volume, and identifying salient points. Participants were recorded using the HapticWave and discussing their thoughts towards it.



The first prototype

Design Workbook: Gathering voices in the project



It was after the first workshop that the hardware engineer (Martin Klang) and the industrial designer (David Cameron) joined the project. It was also at this stage that a Design Workbook was introduced. Workbooks "are collections of design proposals and other materials drawn together during projects to investigate options for design" [Gaver, 2013]. With a working prototype already established earlier in the project, design proposals in this workbook focused on a second generation of the scanner bed prototype, including fader configuration, form and materials. The workbook served as a space to collectively develop the project whilst working independently across different locations. This shared document was used by the researchers to synthesise research materials, share ideas and communicate hardware and design developments.

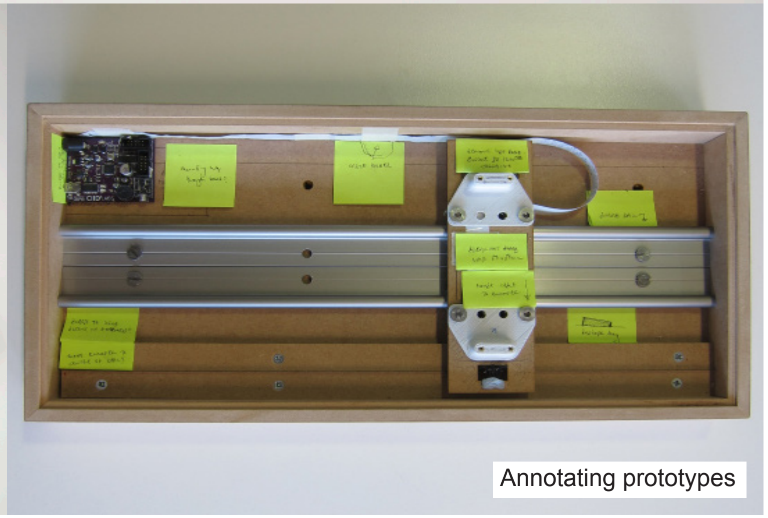
David and EAVI worked together to study the way in which participants had used the HapticWave during the first workshop. Several hours of video footage were distilled into a number of workbook pages, presenting images and quotes from the participants. These helped to draw out and articulate insights from the workshops, three of which have been presented here. The first was a greater understanding into the various practices of the audio engineers, some of whom worked with sound and needed to perceive small changes of a waveform, whilst others edited speech and expressed the importance to locate the extreme points of a waveform. A second insight emerged when an experienced audio engineer revealed he had not encountered a waveform represented with top and bottom, and was surprised they were represented this way. This led to reconsidering the configuration of the double fader that was used on this first prototype. Finally, a third significant learning from the workshop was a participant's description of 'seeing' the device on an imaginary screen, an image that was created through touch. This description prompted a consideration of how the form of the device could create a clear and rich picture.

The workbook also enabled researchers to share examples of related work and technologies relating to their practice, to develop design concepts such as graphical textures, and to explore the language of form in existing audio related devices.

Workbook pages, clockwise from the top left:
Stills taken from videos of the first workshop; images zooming in on participant gestures; reflections on existing work; exploring patterns and textures; observations on existing audio faders.

3D printed iterations

Testing rail mechanisms



Annotating prototypes

HapticWave 02: Communicating design developments

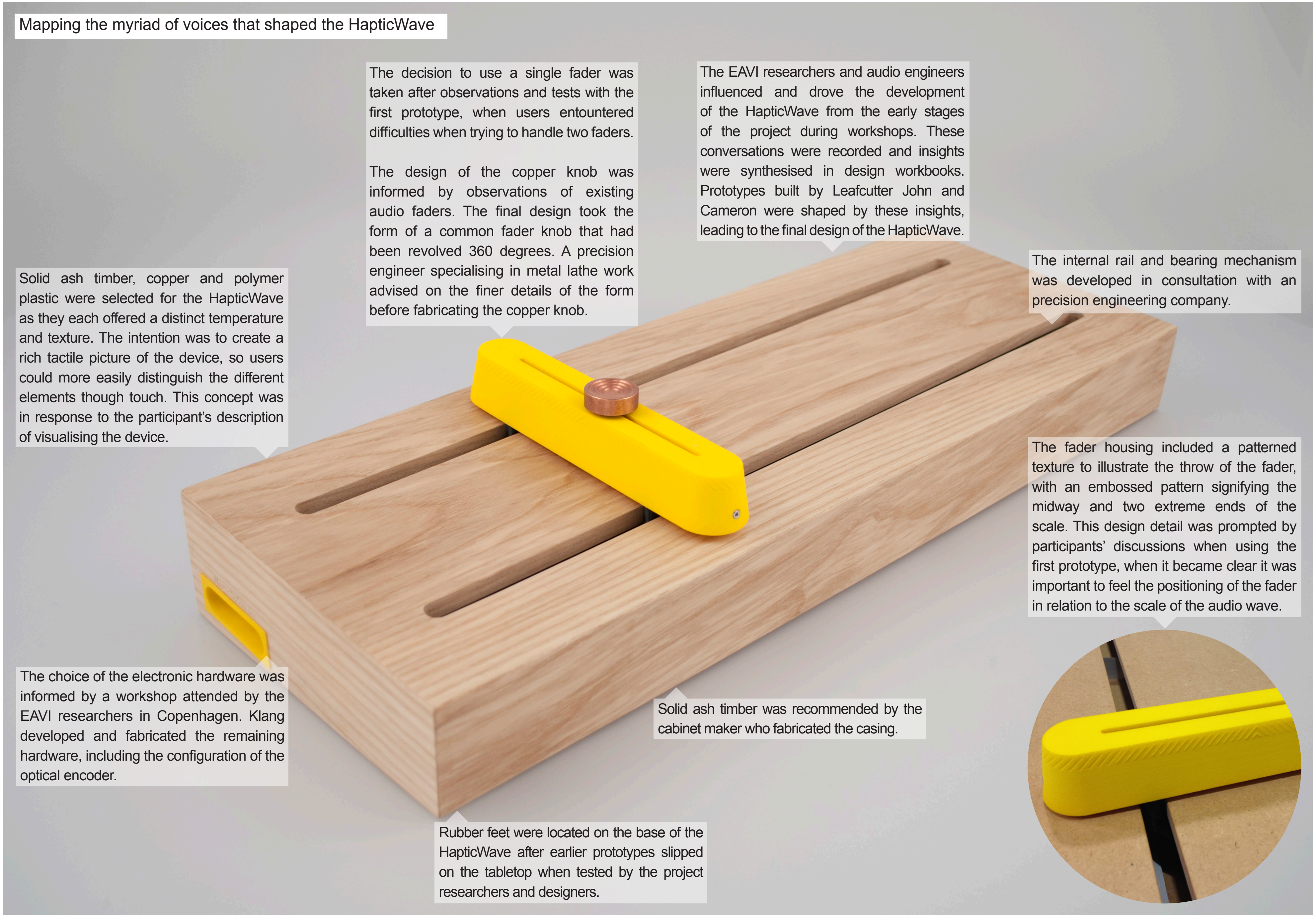
The design and hardware development of the second prototype was led by Martin and David, and involved a wider collaboration with other designers and makers who offered specialist knowledge. This knowledge helped shape the design of the HapticWave, informing a variety of elements from engineering details to materials. The designers and makers communicated their specialist knowledge through a variety of artefacts, including written reports, technical drawings, annotated prototypes and material samples.

The HapticWave required precision engineering solutions for the linear movement of the yellow fader housing. A supplier of specialist bearings and rail mechanisms was consulted on a number of potential solutions which were built into prototypes by David for hands-on testing. This collaboration offered specialist advice on load bearing restrictions and accurate bearing configurations.

Tests were carried out to evaluate a variety of linear position sensor technologies by Martin, who specified an optical encoder to measure the linear movement of the HapticWave. These findings were communicated in a report before the recommended components were ordered for production.

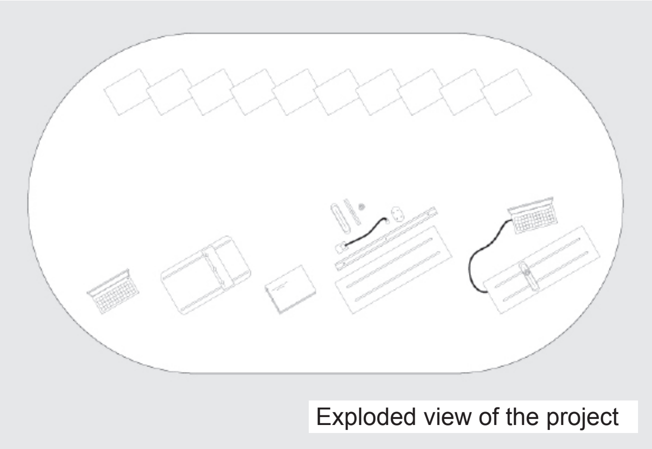
A solid timber casing for the HapticWave was fabricated by a cabinet maker local to the EAVI studio. This craftsperson offered specialist knowledge of materials, specifying ash timber with a lacquered finish to offer a structurally sound and durable material suitable for precision machining.

A prototype of the second HapticWave was annotated during a project meeting, embedding discussions between researchers, designers and makers. These notes provided pointers for further design and engineering iterations. Many of the internal components were 3D printed, which enabled the design of these parts to respond to electronic hardware changes throughout the development phase, without a concern of longer lead times demanded by other manufacturing processes.


Mapping the myriad of voices that shaped the HapticWave
The decision to use a single fader was taken after observations and tests with the first prototype, when users entountered difficulties when trying to handle two faders.
The design of the copper knob was informed by observations of existing audio faders. The final design took the form of a common fader knob that had been revolved 360 degrees. A precision engineer specialising in metal lathe work advised on the finer details of the form before fabricating the copper knob.
The EAVI researchers and audio engineers influenced and drove the development of the HapticWave from the early stages of the project during workshops. These conversations were recorded and insights were synthesised in design workbooks. Prototypes built by Leafcutter John and Cameron were shaped by these insights, leading to the final design of the HapticWave.
Solid ash timber, copper and polymer plastic were selected for the HapticWave as they each offered a distinct temperature and texture. The intention was to create a rich tactile picture of the device, so users could more easily distinguish the different elements though touch. This concept was in response to the participant's description of visualising the device.
The internal rail and bearing mechanism was developed in consultation with an precision engineering company.
The fader housing included a patterned texture to illustrate the throw of the fader, with an embossed pattern signifying the midway and two extreme ends of the scale. This design detail was prompted by participants' discussions when using the first prototype, when it became clear it was important to feel the positioning of the fader in relation to the scale of the audio wave.
The choice of the electronic hardware was informed by a workshop attended by the EAVI researchers in Copenhagen. Klang developed and fabricated the remaining hardware, including the configuration of the optical encoder.
Solid ash timber was recommended by the cabinet maker who fabricated the casing.
Rubber feet were located on the base of the HapticWave after earlier prototypes slipped on the tabletop when tested by the project researchers and designers.

The HapticWave at RTD2015

We present an exploded view of the project at RTD 2015, enabling participants to handle project materials and interact with devices. Project artefacts map the chronological development of the HapticWave, including (from left to right) videos of workshops, a working version of the first prototype, design workbook, iterations and prototypes of the device, a fully functional HapticWave.



Exploded view of the project

Presenting materials and prototypes

Conclusion

We have described a design process which, through multiple iterations, brought together diverse and heterogeneous actors. Communities of practitioners exchanged knowledge which became embodied in the HapticWave.

Nieters and Bollman [2011] note that the "collaborative design workshops" they developed at Yahoo function through bringing together the skills, knowledge and needs of different groups:

"experts in different disciplines (engineering, product management, and user experience) all view the world differently. We think differently. We all perceive different opportunities, and more importantly, different constraints. ….Collaborative Design Workshops,…. help leverage the different insights of each discipline, and integrate these insights into our thinking."

Whilst Nieters and Bollman discuss this method in reference to potential conflict management between these different groups, and getting the best out of different 'experts' who all think they are right, we can also see this as a more general comment on how the design process, in order to be successful, must integrate these diverse voices. Our design process tried to bring together the different areas of expertise of different groups, in a process that was never lead by a specific design brief but rather relied on a design emerging through the communication between these different groups.

Acknowledgements

The authors would like to thank research particicpants Sherie Griffiths, Scott Chesworth, Steve Burge, Peter Bosher, Thuy Mallalieu, John Ramm and Steve Holtz. The DePIC team at Queen Mary, including Nick Bryan-kinns, Fiore Martin, Oussama Metlata and Tony Stockman. And finally project partners CIID, Leafcutter John, Martin Klang and Anton Strilchuk.

References

Braun, V., Clarke, V. 2006. Using thematic analysis in psychology. In 2006; Qualitative Research in Psychology (3). London, Edward Arnold Publishers, 77-101.

Buechley, L., Rosner, D., Paulos, E., and Williams, A. 2009. In: DIY and CHI: Methods, communities, and values of reuse and customization. Ext. Abs. CHI 2009. New York, ACM Press, 4823-4826.

Nadine Jarvis, David Cameron, and Andy Boucher. 2012. Attention to detail: annotations of a design process. NordiCHI '12. ACM, New York, NY, USA, 11-20.

William Gaver. 2011. Making spaces: how design workbooks work. CHI '11. ACM, New York, NY, USA, 1551-1560.

William Gaver, Andy Boucher, John Bowers, Mark Blythe, Nadine Jarvis, David Cameron, Tobie Kerridge, Alex Wilkie, Robert Phillips, and Peter Wright. 2011. The photostroller: supporting diverse care home residents in engaging with the world. CHI '11. ACM, New York, NY, USA, 1757-1766.

Jo, K., Parkinson, A., Tanaka, A. 2013. Workshopping Participation in Music. in Organised Sound 18(3), Cambridge, Cambridge University Press, 282 - 291.

Metatla, O., Bryan-Kinns, N., Stockman, T., Martin, F. Cross-modal collaborative interaction between visually-impaired and sighted users in the workplace. 2012. In Proc 18th International Conference on Auditory Display ICAD2012. Georgia, Georgia Institute of Technology Press, 164 - 171

Nieters, J., and Bollman, E. 2011. Leading change with collaborative design workshops. Ext. Abs. CHI 2011. New York, ACM Press, 729-739.

O'Modhrain, M. S., Gillespie, R. B. 1996. The Moose: A Haptic User Interface for Blind Persons. In Proc of the Third WWW6 Conference.

Svanæs, D., Seland, G. 2004. Putting the users center stage: Role playing and low-fi prototyping enable end users to design mobile systems. In Proceedings of ACM CHI 2004. New York, ACM Press, 479-486.

Wang, T., Kaye, J. 2011. Inventive leisure practices: understanding hacking communities as sites of sharing and innovation. In Ext. Abs. CHI 2011. ACM Press, 263-272.

[1] www.leafcutterjohn.com/, www.cycling74.com/ and www.arduino.cc/

[2] https://london.hackspace.org.uk/ and http://hoxtonowl.com/

[3] http://www.gold.ac.uk/interaction/

[4] http://ciid.dk/