Running to Your Own Beat: An Ecological and Embodied Approach to Auditory Interface Design for Runners

Stuart Duncan Haffenden Cornejo

MRes. Digital Innovation, HighWire CDT, Lancaster University, UK

MA Music by Research, Lancaster University, UK

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HighWire CDT, Lancaster University, UK

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Abstract

Personal fitness trackers represent a multi-billion-dollar industry, predicated on devices for assisting users in achieving their health goals. However, most current products only offer activity tracking and measurement of performance metrics, which do not ultimately address the need for technique related assistive feedback in a cost-effective way. Addressing this gap in the design space for assistive run training interfaces is also crucial in combating the negative effects of Forward Head Position, a condition resulting from mobile device use, with a rapid growth of incidence in the population. As such, Auditory Displays (AD) offer an innovative set of tools for creating such a device for runners. ADs present the opportunity to design interfaces which allow natural unencumbered motion, detached from the mobile or smartwatch screen, thus making them ideal for providing real-time assistive feedback for correcting head posture during running. However, issues with AD design have centred around overall usability and user-experience, therefore, in this thesis an ecological and embodied approach to AD design is presented as a vehicle for designing an assistive auditory interface for runners, which integrates seamlessly into their everyday environments.

Table of Contents

List of Figures

List of Tables

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Declaration

This thesis is a presentation of the author's original research. No part of this work has been submitted for any other degree or qualification. All the work is the author's own unless otherwise stated.

The author of this thesis was the lead researcher on all the chapters.
Stuart D. Haffenden Cornejo Author
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1 Introduction

1.1 Motivation

With the increasing miniaturization and power of sensing and processing technology now included as standard on most smartphones, new tools such as augmented/virtual reality, wearable technology and location-based applications are now feasible with many functional and commercially successful products now available. These advanced processing capabilities mean data intensive applications like computer vision and real-time multi-channel signal processing, can be used to increasingly interface our digital technologies with the physical world allowing us to better measure, record and understand phenomena around us through data analysis.

As such, data has become an asset and driving force in many aspects of our daily lives. The reliance of our global society on connected devices has spearheaded rapid development in many sectors of industry and society, bringing both radical innovations, as well as disruption in the form of new and complex problems. With this ever-growing need to efficiently use and process the vast amounts of data we interact with, technologies like auditory interfaces have presented innovative opportunities for assisting with the analysis and practical use of the vast range of data types that are now possible to collect. However, despite their promise in a number of applications, auditory displays still face issues around usability that have stifled their path towards ubiquity in our everyday environments (Ballora, 2014; Hermann et al., 2011).

The struggle of auditory display research to address user-experience has been well documented by an ever-growing list of publications concerned with the discussion of the role of aesthetics, design and usability as key areas for development, as well as in meta-analyses of the field itself (Katz and Marentakis, 2016). In this body of research, it has been suggested by Mark Ballora and other prominent AD researchers, that the prevalence of cognitivist and utilitarian approaches has led to applications that although functional, are limited in scope and ignore critical issues in design such as the aesthetic, environmental and emotional sensibilities of end-users (Ballora, 2014). This has resulted in auditory displays, that yield positive results in short-lived and controlled settings, but do not translate well to real-world scenarios due to poor usability (Barras and Vickers, 2011; Clarke, 2005).

Despite the importance of usability in auditory display design the field has yet to form a consensus on how to address these issues (Berry and Osaka, 2002). The disparity between scientific and artistic approaches to sonification has seen the research community struggle to formalise sonification design into congruent and replicable theories of sonification (Hermann et al., 2011). Furthermore, due to the interdisciplinary nature of auditory display the prospect of developing an all-encompassing set of guidelines that are applicable to all possible contexts of auditory display applications is unrealistic (Goudarzi, 2016). As a result, the field is at a crucial point of its existence, as it aims to transition from a nascent, loosely defined practice into a formalised theory of research. Thus to address these concerns, studies have turned their focus towards methodologies and techniques such as user-centric design, more commonly associated with Human-Computer Interaction and Design Research (Barrass, 2015, 2012). These recent developments have the potential of providing researchers with better tools for informing auditory interface design by enabling a better understanding of users' environments and experiences (Grond and Hermann, 2014). Thus, within this thesis exists a motivation to further explore the potential impact of design-thinking approaches to sonification through the synthesis of a flexible design framework that will aid and inform future research in the development of usable user-centric auditory interfaces. Furthermore, through the development of a design framework, this project seeks to aid in the formalisation of design practice in AD through the creation of a sustained, adaptable, and replicable set of tools for aiding in the design of new interfaces.

To test the research questions guiding this project we will explore the role of auditory interfaces for wearable technology, specifically run training interfaces, of which many commercially available examples already make use of sound on some level to communicate information. Furthermore, technological developments in the ever-growing fitness tracker market have opened the possibility to explore new methods of data representation to aid runners in improving their running technique. As such, new approaches to interface design present an innovative design space for exploring the use of auditory display design as a tool for creating more effective assistive interfaces.

1.2 Research Questions

Given the outlook laid out by the previous discussion it is thus the prerogative of this thesis to explore the following research questions:

> *RQ1. What is the user experience of listening to auditory biofeedback while running?*

Rationale - RQ1 experience is conceived as the physical, emotional, and cognitive reactions produced by the user when attempting to derive meaning from data codified in sound within a particular environment. Through the lens of ecological and embodied design, this project explores the user's physical, affective, and cultural environment to inform user-centric designs and facilitate user testing, a focus characteristically lacking in sonification research.

> *RQ2. What sound designs/interactions influence positive behaviour change (improved kinematics) in the user?*

Rationale - This project will investigate how sonification might guide behaviour change for improving running kinematics. Through a survey study, cultural probe, participatory workshop discussion, auditory perceptual tests, and prototype sonification testing; specific sonic design requirements will be identified to produce optimum display efficiency. This research question also aims to address key issues of 'design process' in sonification research through a detailed and transparent user-centric sonic interaction design process. This relates to RQ1 as influence of user experience on behaviour change is intrinsic.

> *RQ3. What are the key incentives for users to adopt auditory interfaces within the context of run training interfaces?*

Rationale - While RQ1 and RQ2 relate to the actualisation of sonification design goals, it is crucial the project also identifies why sonification is a valid and potentially more efficient tool for improving motor skill training over other alternatives such as haptic feedback or current screen-based solutions. This is a key issue in sonification research, where novel designs are proposed for applications without evaluating if sonification is even worth pursuing in that area if it is less efficient and unable to outperform other interface designs.

RQ4. What are the contributions to the auditory display research field resulting from adopting an ecological and embodied cognition approach to the design of an auditory interface?

Rationale - As the sonification research community moves towards a more formalised definition of design theory, we have observed a recontextualization of auditory display research as a branch of design theory and human-computer interaction. As such, it is important to explore the application of established design tools and methods within AD research to identify any potential lessons or direct transference of theory that may be applied to future sonification design. This project is novel in applying and adapting specific tools developed within the design and HCI communities to guide the process of development of a sonification system for run training, in order to inform better design practice by querying processes employed in a specific application that has historically been explored by the field.

1.3 Ethics

Given the user-centric nature of this research project, several elements of each study required careful ethical considerations. Of particular concern were the use of methods which would result in data that could be used to identify users and their identities or locations, compromising their anonymity. Such methods as photographs, hand-written text, video and audio recordings posed a particular threat to privacy. Therefore, mechanisms to ensure data protection were employed, such as, quick transcription and digitisation of data, and destruction of identifiable original material. Participant consent was necessary for each stage and documentation was formulated and provided to each participant ensuring full transparency on the expectations placed on their contributions to this project.

Additional ethical concerns revolved around the use of body-worn sensors for altering users' running kinematics and listening to music whilst running in public places. This posed important health and safety questions, as injury to participants was of great concern; either as a direct result of the technology being tested, or because of users' shifted attention and focus whilst running in transited street settings. As such, each study which required participant interaction with technology, music or exercising, was constructed so that users were not asked to carry out activities that deviated far from their normal exercise routines. This ensured no additional pressure was placed on participants in

prioritising the data collection over their personal safety, and where participants carried out activities in public spaces, they were notified of potential risks in the consent documents, ensuring participants were fully aware of the hazards involved in undertaking these activities. Each of the methods employed and the ethical requirements around them were reviewed by Lancaster University's ethics panel on two separate occasions, giving their recommendations and consequently full approval for the implementation of the research methods described throughout this thesis.

2 Background Research

2.1 Introduction

Over the course of the existence of auditory displays, considerable effort has gone into classifying different sonification strategies into categories and techniques, such as: audification, parameter-based, and model-based sonification, with the aim of converging and standardising knowledge in the field (Grond and Hermann, 2012). However, a similar classification of design strategies has not been possible to standardise due to the ambiguous and complex nature of this interdisciplinary paradigm. Therefore, AD designers continue to face great challenges in designing sound palettes to represent data within structured theory driven designs. Nees (2019) suggests that 'In part, sonification theory has languished, because the requirements of a theory of sonification have not been clearly articulated. As a design science, sonification deals with artifacts—artificially created sounds and the tools for creating the sounds. Design fields require theoretical approaches that are different from theory-building in natural sciences.' This conceptualisation of sonification as a design field is important, in that it provides a more structured path towards the development of a theory of sonification through the well-established lens of design practice.

Thus, to address the challenge of producing auditory displays that tackle the issues of usability they have long suffered from, it has become necessary to adopt design approaches that place greater emphasis on the user and their experience. Consequently, there has been a rise in 'design-thinking' strategies, which have been suggested as possible means for improving usability and user experience in technology design applications (Wolf et al., 2015). These approaches may help break away from the polarising and hierarchical dichotomy of scientific versus artistic representation and instead frame AD design as a dynamic and adaptive interdisciplinary design exercise, requiring active engagement with end-users on a more human and ecological level (Dubus, 2012).

In the following sections the background research underpinning this thesis is presented; delineating design spaces in which such user-centric methodologies could be employed to further contribute to the building of design theory and tools for auditory display research. By enacting this design approach in the development of an auditory display for runners, a participatory user-centric study is proposed, which focuses on leveraging ecological and embodied design approaches towards exploring the physical and cultural environments of this group of end-users. This thesis is presented in the hope of addressing key design gaps in auditory display research by exemplifying the rich outcomes that can

be expounded from this type of approach and encourage future multidisciplinary user-centric research in the field.

2.2 Wearable Technology and The Quantified Self: The State of the Art

Alongside the technological advances of connected devices, we have seen a rapid expansion in the development of wearable technology and lifelogging applications, alongside its corresponding cultural movement commonly known as the 'quantified-self' (Reece, 2013). Quantified-self technologies integrate tracking for diverse activities such as exercise, health and nutrition, sleep patterns, mood, daily tasks, and social interactions among others. By quantifying a user's activities, these technologies aspire to provide users with insights into their lives, helping to identify trends and patterns in behaviour that could be modified to improve their health and well-being.

Until recently, this level of personalised data collection had only been accessible to specialists in fields such as professional sport, medical rehabilitation, and scientific research, however, as these technologies have become cheaper, smaller, and more powerful, they have permeated the mainstream consumer market. Statistics published by leading market research firms on the number of health and fitness tracker users showed an expected increase from 15 million users in 2013, to almost 100 million by 2018 (GfK, 2015) and global revenues from fitness trackers to increase from over $2 billion in 2014 to $5.4 billion by 2019 (Sprague, 2015). The astounding exponential growth of wearables has been in part influenced by a greater consumer awareness of health and well-being, which has resulted in fads around new technologies, food, and lifestyle choices. As a result, we have also seen the popularity of running as a competitive and recreational sport surge in recent years, as shown by the growing number of marathon runners per year (Andersen, 2015; Fox, 2015; Harshbarger and Jacobsen, 2015) and the increased popularity of health and fitness tracking software and wearable devices currently on the market (Siddique, 2015).

The current field of wearables can be broken down into three loose categories, although the boundaries blur with each new generation of devices:

- Smartwatches – These wearables form an extension to the mobile communication device ecosystem. As such, they offer functions primarily related to communications and social

media, with a lesser emphasis on general fitness tracking. Examples include Apple Watch, Samsung Gear, Huawei GT.

- Fitness trackers (for amateur/casual use)– These devices are often smaller, with simple displays and offer reduced commodity features. Primary focus is on basic fitness tracking such as steps, calories, and sleep patterns. Examples include the FitBit
- Specialised Sport watches/sensors – Professional level fitness tracking, through multiple body-worn sensors for a wider range and accuracy of metrics in activities such as running, cycling, swimming. Examples include Garmin Forerunner 620, Polar Vantage V.

This study will place some focus on the third of the categories of wearables due to their advanced sensing capabilities. Run training technologies have become increasingly popular with runners of all skill levels, generating millions of downloads and sales in the last few years. However, the majority of these run training technologies, and consequently those with the largest number of users, have so far been designed with the intention of motivating non-runners to run through designs centred around extrinsic gamified motivators such as, reward systems (goals, achievements, milestones, badges and points) (Deterding, 2012; McGonigal, 2011). Likewise, companies employ targeted marketing and features to touch on the health concerns of potential users' to ultimately lead them to buy into the wearable and fitness software market (Siddique, 2015). In addition, these designs have often sacrificed sensor accuracy and concrete data representation in favour of providing the user with a simpler and 'user-friendly' experience.

An example of the vague data representation common in commercial applications is the Nike+ Fuel points/reward system (part of the Nike+ Running app suite), whereby everyday activities are monitored by either a wearable device or a smartphone, and using a proprietary algorithm, the activity data recorded is translated into Nike+ Fuel, an abstract concept used by Nike to quantify activity (Nike, 2016). This type of run training system has been criticised for inaccuracies in data logging and its outcome of unintentionally rewarding users for inconsequential activity, such as jostling about while sat down, that does not substitute the benefits of a regular exercise regime (Feehan et al., 2018; Fuller et al., 2020; Siddique, 2015). Extensive user reviews of Nike+ Running and FitBit have even reported that vibrations from a car journey or flailing their arms in the air can count towards their daily activity measurements and ultimately skew the accuracy of the data (Reddit, 2015; Reece, 2013). Additionally, studies have shown that for people already motivated and committed to

running, such as advanced runners and professionals, these extrinsic motivation designs have proven ultimately ineffective, and new designs for this particular target audience must take into consideration the different levels of motivation for this type of user group (Knaving et al., 2015). Conversely, those applications that are far more accurate and more suited to advanced runners, on top of higher price points, offer a much more technical and less user-friendly interface design, with detailed graphs and statistics, focussed on tracking detailed performance metrics that can be overwhelming or difficult to understand for an inexperienced user (Hutchison, 2016).

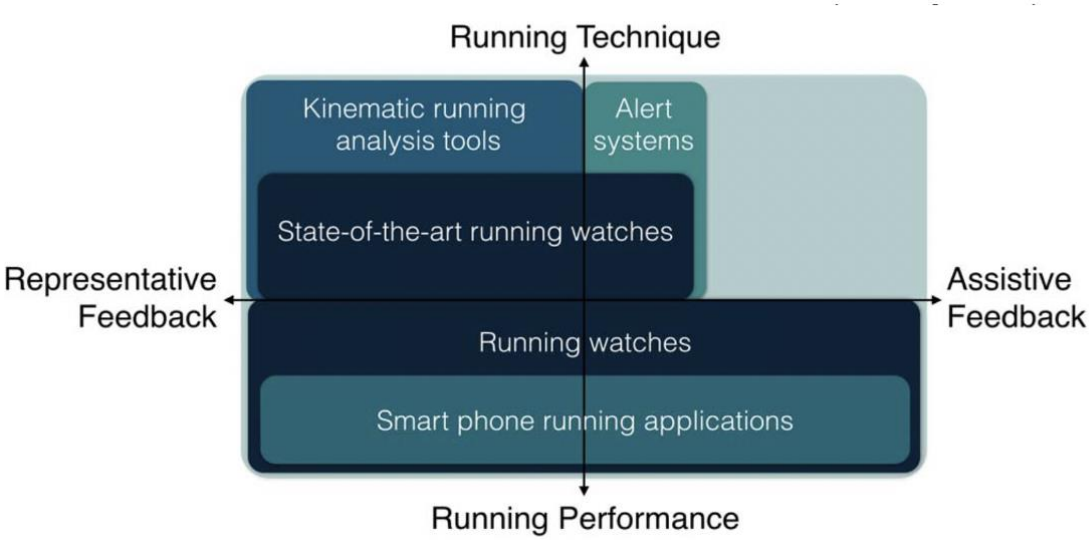

Figure 1 - Run training technology design-space (Jensen and Mueller, 2014)

Yet another insight on the current state of the art in run training interfaces can be found in M. M. Jensen and F. Mueller's comprehensive study of the design space for fitness trackers and other run training technology (Figure 1) (Jensen and Mueller, 2014). The study highlights how the focus of run training technologies has up until recently been solely on tracking pace, distance, route, heart rate and calories burned, which are metrics used to assess the overall performance of a run. Performance metrics are particularly useful for more experienced runners who, for example, know what their target pace or heart rate should be and how to maintain it during a particular type of run; but they do not provide insight into specific actions a runner can take during an activity to improve their performance. This paradigm is covered by the continuum of the y-axis in the graphic shown in Figure 1. To address this issue, state-of-the-art devices have started to incorporate running technique metrics into their interfaces to varying degrees, such as: vertical oscillation, cadence, stride length, foot strike and ground contact time. Running technique (which is described by the kinematics of

running) indicates the overall efficiency of a run and by tracking this data, a user can feasibly identify opportunities for improving their overall run performance and even prevent injury. These devices have so far been limited to advanced running watches and complex and expensive in situ camera systems for kinematic motion analysis.

Another issue presented by Jensen and Mueller relates to how the data measured by fitness trackers and wearable devices is fed back to the runner, this is plotted along the x-axis of Figure1. In this case representative feedback refers to data presented to the runner post-run, in the form of comparative analysis graphs and visualizations used for identifying trends and inferring correlations in the patterns of the measured data, so that the user may gain insight into areas of improvement. Assistive feedback refers to in-run feedback designed to update the user of the current progress of an activity. This type of feedback is usually presented as metrics and statistics displayed on the screen of the wearable device or smartphone and can sometimes include periodic verbal feedback informing the user of the progress after a given set of time or distance covered.

In the design space plotted out by Jensen and Mueller we can see that there is a gap pertaining to running technique metrics represented through assistive feedback. So far, most technique training technologies have been limited to displaying their data as complex kinematic analysis graphs presented to the runner after the exercise activity. A recent example, and one of the most comprehensive devices for measuring running kinematics is the RunScribe – Wearable Gait Analysis System which is composed of two 'pods' that attach to each of the runner's shoes via a clip and house accelerometers that can measure a complex set of running kinematics data such as foot strike, impact angles and cadence. This data is recorded during a run and is made available to users either as in-run metrics on a smartwatch using Garmin's Connect IQ development platform, or in more detail as post-run kinematic analysis graphs on a PC (Figure 2). This presents a communicative challenge for run training interface design in that, to effectively use running technique data a user must be able to adjust their technique intuitively and in real-time, something that is not possible with post-run information. Of those technologies that do include in-run assistive feedback for technique related data, such as the Garmin Forerunner 620 which makes use of accelerometers and interfacing with other sensors to give it the ability to measure a large set of kinematic data, the problem is further exacerbated as the number of data streams to be displayed increases. Screen-based displays suffer from a limited amount of 'screen real-estate', making it difficult to read a screen overloaded with

information. This is particularly an issue when the information is required in a dynamic and attention demanding context such as running, where screen-based displays have the effect of distracting focus away from the activity at hand and require the user to constantly break form to glance at the device screen.

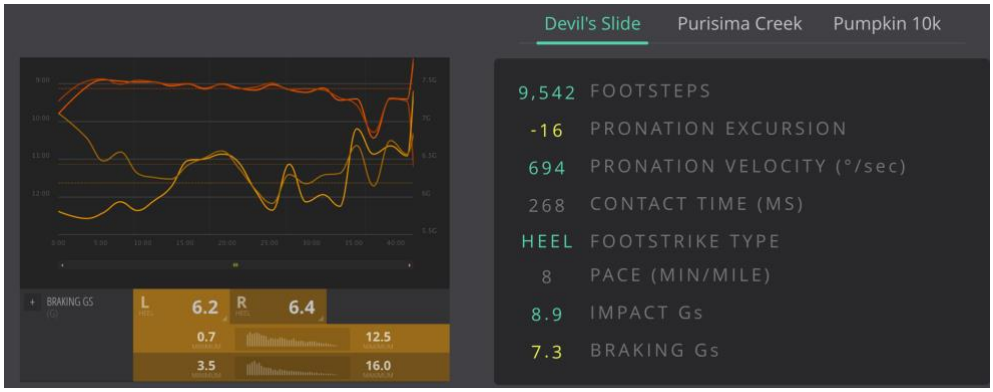

Figure 2 - Example of post-run kinematics analysis graph (RunScribe, 2016)

Jensen and Mueller therefore state that: 'To meet the communicative challenges of displaying this information during the dynamic context of running, there is a need to investigate alternative feedback methods and mechanisms that differ from conventional screen-based information interfaces' (Jensen and Mueller, 2014). This can be understood as a problem of data representation, where current interfaces assume that by simply providing the runner with the information on the current state of a particular metric the runner will know how to modify their behaviour to correct their movements. It is therefore important to consider alternative modes of feedback that allow for the representation of discrete multimodal data, in a way that can assist a runner in modifying their technique. Of particular interest as potential alternatives to screen-based feedback; haptic, auditory and a combination of different feedback modalities are proposed as viable alternatives that have shown evidence in supporting the learning of complex and discrete body movements (Sigrist et al., 2012).

With recent advancements in sensing technology, the latest generation of run training wearables are beginning to include capabilities for measuring and recording running kinematics. This is a positive development in the field in order to address the important issue of running technique, which is essential for improving overall running performance and for the prevention of injuries related to the sport (Dallam et al., 2005; Mechelen, 2012). However, to effectively utilise these types of data, runners must be able to monitor and react to them effectively in real time. This presents several

communicative challenges for the primarily screen-based interfaces that currently dominate the product sphere. The problem stems from the dynamic visually demanding context of running and the limited screen space available to a body-worn device for displaying the increasingly multimodal streams of running data.

We have seen therefore that the limitations of screen-based interfaces have called for the investigation of alternative feedback methods, such as sound-based interfaces known as auditory displays. Auditory displays exploit the human ear's capability of simultaneously tracking discrete changes of multiple individual sound sources over time (Hermann et al., 2011), and have shown great promise in areas such as rehabilitation and in applications for learning discrete body movements (Basta et al., 2008; Large, 2000; Lee et al., 2012; Sigrist et al., 2012; Yoo and Park, 2015). These features make auditory displays a suitable candidate for relaying running kinematics data to a user in real time. In the following sections we will give a background to auditory displays and explore the state-of-the-art of auditory interfaces designed specifically for running.

2.3 On Auditory Displays and Data Sonification

The field of Auditory Display is concerned with examining how the human auditory system can be used as the primary interface channel for communicating and transmitting information (Hermann et al., 2011). Auditory displays were developed to represent data or information by mapping it to sound parameters by process of filtering and scaling it into useable values for sound manipulation; the purpose of which is to display and highlight relationships, discrete temporal changes and interactions in a system or data set. Of particular interest in this field is the concept of Data Sonification. Sonification is a branch of Auditory Displays that specifically refers to the systematic, objective and reproducible method of mapping data to sound generation parameters (Hermann, 2010). Despite the concept of sonification and simple applications of auditory displays existing as far back as 1908, with devices such as the Geiger counter, or more recently SONAR and heart rate monitors (Kramer, 1994); international research efforts to understand all aspects of auditory display only began relatively recently, with the foundation of the International Community for Auditory Display (ICAD) in 1992. Auditory Displays have been largely unexplored as an alternative to visual displays, which is symptomatic of how society favours visual feedback and how there 'is a history in perceptual research

of greater research efforts toward vision than audition, and a concentration on a single modality rather than on how vision and audition interact' (Hermann et al., 2011, pp.71).

The motivation to use auditory feedback to represent and understand data can be found in the ability of the human auditory system to understand far more complex and detailed temporal and multidimensional information than our eyes. The human auditory system counts with exceptional pattern recognition abilities that allow it to identify and differentiate between discrete sound sources and complex timbral transformations over time, even under noisy conditions (Hermann et al., 2011). Likewise, Auditory Displays are designed to reduce the information load for screen-based interfaces and other forms of visual feedback, this allows auditory displays to work in conjunction with the visual faculties in activities that require high levels of visual attention. Given the flexibilities of the auditory system in reinforcing visual information, auditory displays designs have encompassed a vast range of applications across the spectrum of human-computer interfaces (see Table 1). This has led to the fruition of an intricate and furtive research field; however, the broadness of applications has led to difficulties in formalising theories and methodologies with replicable results in auditory display design (Barras and Vickers, 2011; Barrass, 2015).

Categories	Entries
Analysis	Multivariate time series Seismic data EEG data High dimension scientific data Statistics Data mining Data analysis Data perceptualisation Simulations Human physiological functions
Professional	Internet Medical Transport systems Air traffic control Control engineering Broadcasting
Mobile	Orientation Mobile computing Usability Information displays for blind and visually impaired users
Public	Exhibition Museum Fair Entertainment
Domestic	Furniture Household machines Telephone Home
Design	Interaction design Product design Industrial design Architecture
Alarms	Warnings Alarms

Table 1 - Auditory Display application design space (Frauenberger and Barrass, 2009)

One of the biggest concerns in auditory display design is the extent to which listeners can derive information from the sounds and codification choices made by designers, as this ultimately impacts on both the level of user engagement and efficacy of a particular system. This in turn is affected by the aesthetic and design choices embedded into auditory display designs (Walker and Kramer, 2005). If an auditory display is too akin to a musical experience, the information and meaning embedded in the sounds can become too abstract or unclear for the listener to interpret correctly (Hogg and Vickers, 2006). This vagueness can arise from the way humans engage with listening to music as opposed to engaging in critical listening, which is a substantially different state of consciousness. Critical listening is a specialised skill that must be refined through extensive training and listening and is not often easy for everyday listeners to employ. Secondly, in the cognitively complex and emotive nature of music, codified data can be obscured if it is not systematically and accurately represented. This also means listeners must receive some form of training in order to know what they are listening for in the sonification (Winters and Wanderley, 2014). In contrast auditory displays can also suffer from a lack of musicality and result in the phenomenon known as display fatigue, commonly associated with monotonous, repetitive or displeasing sounds, leading to disengagement from the auditory experience (Henkelmann, 2007). This is of particular interest to this study given the design implementations of leveraging the ergogenic effects of preferred music to create a sonic interaction that is musically pleasing to participants. Ensuring users are engaged with the application whilst being immersed in their environment without obstruction, is paramount for a successful design implementation. In the following sections we describe key design issues in the field of AD research, and how the development of design thinking as a practice is of interest to recent AD research trends.

2.4 Key issues of Auditory Display Design: Aesthetics and User-experience

Auditory displays have their origin in scientific and engineering disciplines such as, computing, medicine and aviation (Barras and Vickers, 2011). Early AD research consisted mostly of experiments exploring sound as a medium for codifying and communicating information for utilitarian purposes (i.e., medical applications, sonar, etc.). The results of these early experiments and applications in AD are characterised by very functional sonifications of little or poor aesthetic quality (for example, the Geiger counter). These sound signals, albeit informative and appropriate within their given context,

are monotonous and induce display fatigue over long periods of exposure rendering them inadequate for long period monitoring (Carlile et al., 2011).

However, as the concepts of sonification and AD have become more widely known in other fields, experimentation with these data analysis techniques outside traditional scientific disciplines has flourished. This is particularly the case with the sonic arts. Sonic artists and sound designers began experimenting very early on with data driven audio for producing innovative artistic works (Barras and Vickers, 2011). Data driven sonic art presented an opportunity to affect and captivate listeners by presenting novel, tangible and engaging experiences of data (Akiyama, 2014). This experimentation, alongside a desire to improve the poor user-experience in early sonification applications, brought about the consideration of aesthetics and interdisciplinarity to the forefront of the discussion on auditory interfaces, as seen at the 2002 edition of the ICAD conference (Berry and Osaka, 2002).

The interest in AD by disciplines grounded in the arts and humanities, gave rise to tensions within this historically scientific field, where practitioners have struggled to value or incorporate the contributions of aesthetic approaches to AD research (Filimowicz, 2014). The dichotomous discussion of science vs. aesthetics in auditory display has been the dominating approach, mainly centred around the ambiguity introduced to data streams when codified using a heavily aesthetic approach. In contrast, the more functional and unambiguous signals produced for scientific-oriented sonifications, have been valued due to a preference in the field for quantifiable unambiguous data (Ballora, 2014). With the emergence of this discussion, some insights into the role aesthetics plays in the user-experience of auditory displays have been gained. However, Barras and Vickers (2011) argued that this also presented a barrier slowing progression in the field by preventing the true interdisciplinary collaboration which is needed for addressing the critical issues of usability and user-experience in AD design. Despite this stagnation, it is clear the important role aesthetics play in the design of a successful auditory interface, from how it impacts the communication of the codified data, to the overall experience of the user. But what are ‘good’ AD designs? Or appropriate aesthetics? And how does a designer achieve usability?

Over time, considerable effort has gone into classifying different strategies in AD into categories and techniques, such as: audification, parameter-based, and model-based sonification, with the aim of

converging and standardizing knowledge in the field (Grond and Hermann, 2012). However, a similar classification of design strategies and techniques has not been possible to standardise due to the ambiguous and complex nature of this paradigm, and therefore AD designers continue to face a great challenge when choosing a sound palette suitable for the dataset they wish to sonify. Nees suggests that '*In part, sonification theory has languished, because the requirements of a theory of sonification have not been clearly articulated. As a design science, sonification deals with artifacts—artificially created sounds and the tools for creating the sounds. Design fields require theoretical approaches that are different from theory-building in natural sciences'* (Nees, 2019). This conceptualisation of sonification and auditory display as design fields is important, in that it provides a more structured path towards a theory of sonification through the well-established lens of design practice.

Thus, to address the challenge of producing auditory displays that tackle the issues of usability highlighted above, it has become necessary to adopt approaches that place greater emphasis on the user and their experience. Consequently, there has been a rise in 'design-thinking' approaches, which have been suggested as possible means for improving usability and user experience in technology design (Wolf et al., 2015). These approaches break away from the polarising and hierarchical dichotomy of scientific versus artistic representation and instead frame AD design as a dynamic and adaptive interdisciplinary design exercise, requiring active engagement with end-users on a more human and ecological level (Dubus, 2012). In the following section historical examples of auditory interfaces for run training are presented and key areas of interest identified to delineate the design space for this project.

2.5 Auditory Interfaces for Run Training - The State of the Art

Most current run training technologies incorporate some level of auditory feedback into their designs. Run training apps like Underarmor's RunKeeper and Nike's - Nike+ Running include verbal updates on stats and metrics such as pace, distance, heart rate, etc., at periodic intervals (Nield, 2015). These updates serve the purpose of notifying the user of progress and act as a reference to what stage of their work out they are in. Smartwatches incorporate haptic vibrations and beeps as a means of communicating to the user in a crude and low-level manner when some metric has changed. Far from providing any sort of corrective or assistive feedback of high-level multimodal data, these forms of auditory feedback are merely used to communicate information on the screen of the device to the

runner without requiring the runner's visual attention. Research into the use of auditory displays within the field of run training interfaces is not uncommon, however there is a clear gap pertaining to assistive auditory feedback in running technique-based interfaces as will be discussed in the following passages.

Like most current run training technology, as discussed so far, applications of auditory displays that provide assistive feedback in this area have primarily focused on using sound and music as a means of motivation, and for providing assistive feedback of running performance metrics, particularly of pace and heart rate. Examples of this can be seen in Fortmann et al., (2012) Hao et al.'s (2015) RunBuddy smartphone system for running rhythm monitoring, which use rhythmic auditory impulses to guide the user towards a consistent running rhythm and cadence for maintaining pace. Other examples can be found in T.W.G. Schuurmans' work on adaptive music feedback for maintaining target pace. This project involved an interactive system that provides rhythmic stimuli, derived from the beat of a song, and adapts to the user's pace to provide a constant guideline for maintaining it. The system can also suggest different paces for the user to adapt to and provides a stepped increase or decrease towards the new tempo to act as a guide for the runner (Schuurmans, 2006). In a similar fashion the iGrooving project by D. Lepervanche explores a sonification system, whereby the user's steps are tracked and used as sound triggers for atmospheric drum samples. The premise of the project is that by providing biofeedback of the runner's cadence, using atmospheric music to provide a meditative state, the individual can internalise and 'visualise' their cadence and familiarise themselves with the feeling of that pace. This project however falls short of testing an implementation of the system design and instead only provides a theoretical and conceptual backdrop to potential sonification biofeedback designs (Lepervanche, 2013). The iGrooving project builds upon interesting concepts of motivation in runners, that address the issues of current run training interfaces that focus on extrinsic motivators as outlined by Knaving et al. (2015), however, does not address technique biofeedback.

So far, we have discussed the prevalence of auditory feedback interfaces with a focus on running performance, however, there are a few more recent examples that address the area of running technique training as outlined by the design space mapped out by (Jensen and Mueller, 2014) seen in Figure 1. M. Eriksson and R. Bresin's project for improving running mechanics by use of interactive sonification involves a system for improving running posture based on auditory feedback, provided

by accelerometer data of a sensor placed around the waist. The system used pre-recorded audio files stored on a smartphone, made to trigger in response to sensor data thresholds being crossed. Due to limited processing power available at the time, real-time sound synthesis was not possible and therefore the system made use of audio files. The auditory feedback was provided in the modality of an alarm system, aimed at warning the user if posture was incorrect for more than a certain period of time, the researchers acknowledge however that while the system is able to feedback that running technique is incorrect, it is incapable of suggesting to the user how to adapt to correct it, and that this proves an important area of research (Eriksson and Bresin, 2010). The results for this project were derived from a single user case study as a proof of concept for the prototype system. The study showed that one test person was found to successfully adapt their running technique based on a simple sound model. However, the authors proceed to acknowledge that *'From one test person it is of course impossible to draw any conclusion about the behaviour of the population at large. However, we have laid the foundation for further studies in this area.'* (Eriksson and Bresin, 2010). More recently, in response to successful studies for reducing tibial peak positive acceleration in runners with visual biofeedback, the work by Wood and Kipp (2014) explores the use of auditory biofeedback to provide real-time information to runners in the field as opposed to an in-situ treadmill-based system typically used in other studies thus far. Results for their studies suggested that *'Subjects were able to significantly reduce Peak Positive Amplitudes (PPAs) during exposure to audio biofeedback. In addition, two rounds of biofeedback were sufficient for subjects to retain a reduction in PPAs without biofeedback. PPA-generated audio biofeedback therefore appears to be a feasible method of gait retraining to reduce PPAs in runners.'* (Wood and Kipp, 2014)

Auditory displays are a very useful tool for addressing the issues of representing multimodal data streams. They exploit the human auditory system's ability of tracking multiple sound events simultaneously and detecting discrete changes in auditory signals over time. The studies discussed in this section underline the importance of further investigation into auditory displays as running technique training aids and have mapped the design space for new technologies, modes of feedback and sonic interaction models. In the following section we introduce the focus defined for the assistive interface developed for this thesis by explaining the effects of 'forward head posture', a common misalignment of the neck and head resulting from prolonged incorrect posture in common contemporary scenarios such as sitting at an office desk and using mobile phones. Forward head posture is also present in poor running technique and has been demonstrated to impact efficiency of

movement and injury development of several musculoskeletal components (Jong et al., 2020; Koseki et al., 2019)

2.5.1 Background on Forward Head Posture Research

With the advent and growth of the service industry and rapid global urbanisation, the physiological effects of office work and technology use have become of greater concern. Prolonged sedentary periods, inadequate furniture, and bad technology use habits, have contributed to the development of chronic fatigue, mental health issues, and exacerbation of musculoskeletal and respiratory conditions in the workforce (Jacukowicz and Merecz-Kot, 2020; Koseki et al., 2019; Sui et al., 2019). As such, a growing body of work has focussed on probing this environment and exploring design applications to improve worker experience. In addition to the workspace, the widespread use of smartphones has led to users spending long periods in unhealthy postures, leading to chronic straining of neck and back muscles that can lead to diseases such as cervical myalgia (Lee et al., 2013). In conjunction, these two areas represent the bulk of research into issues causing incorrect posture in everyday technology focussed environments.

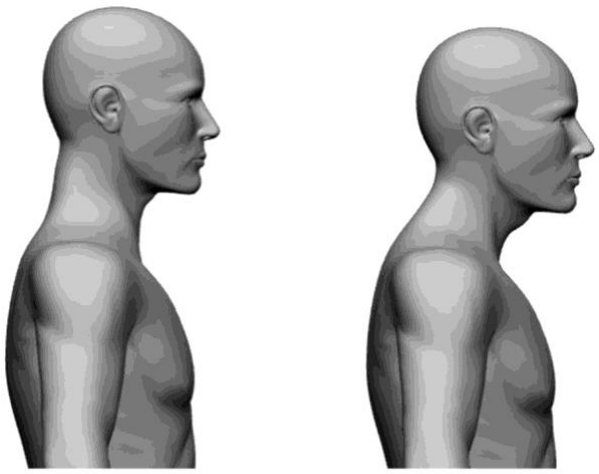

Figure 3 - Example of Forward Head Posture(Koseki et al., 2019)

One such issue of prominent concern is Forward Head Posture (FHP). FHP is defined by the hyperextension of the upper cervical vertebrae and forward translation of the cervical vertebrae, which results in a posture combination of slouched-forward shoulders and rounded upper back (see Figure 3) (Koseki et al., 2019). FHP can ultimately lead to a painful shortening of the muscles of the back of the neck, as well as compression of the uppermost portion of the spine that supports the

head and protects the spinal cord, as well as causing issues with respiratory efficiency and mental-health and anxiety (Ansari and Kondamudi, 2020). FHP incidence has rapidly increased in the decades leading up to 2016, with this attributed to the fast-paced adoption of laptops, mobile phones, and tablets. This has led the condition to be colloquially referred to as the iHunch, in reference to Apple products like the iPhone (Cuddy, 2015). Hence, FHP is of significant concern for a large portion of the global population as global sales estimates for 2021-2026 are expected to range from 6.4 – 7.5 billion units (Figure 4) (O'Dea, 2021).

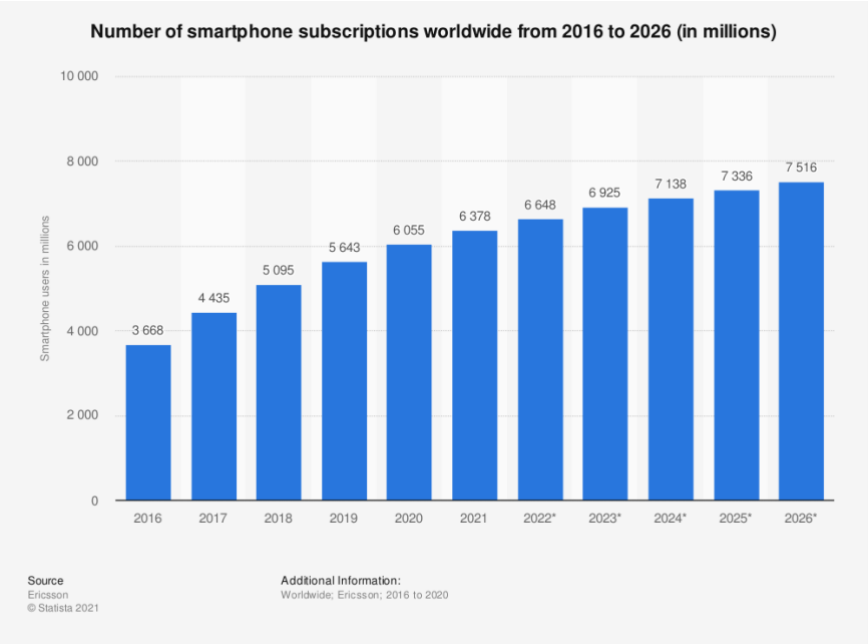

Figure 4 - Worldwide Smartphone Subscriptions Projection 2016-2026 – Ericsson (O'Dea, 2021)

FHP is of particular interest to this study as A) FHP impacts mobility and kinematic efficiency, resulting in inefficient locomotion and increased strain to the musculoskeletal structures that support the head (Dallam et al., 2005; Strohrmann et al., 2012) B) A gap exists in the design space for run training interfaces related to assistive technique interventions (Jensen and Mueller, 2014; Yoo and Park, 2015), this is further reflected by participants' concerns for injury prevention and improved performance. C) A solid foundation of research exists relating to the physiological effects of FHP to inform the design process for this project.

Key studies relating to auditory assistive feedback for FHP prevention can be found in the work of Lee et al., (2013). Here, the authors propose using 3-axis accelerometers for monitoring of users' head and neck tilt angle during smartphone use. The user is warned via haptic vibration and alarms if the

incorrect posture has been maintained for an abnormal range and needs correcting (Lee et al., 2013). This study presents a useful insight into the use of IMUs for FHP prevention, however, the feedback only alerts the user of incorrect posture, but does not assist with information on how much adjustment must be made to correct it. Similarly, the work by Yoo and Park (2015), presents an FHP intervention using surface electromyography sensors to detect contraction of the spinal and neck muscles, and prompt the user at intervals of 300 seconds if posture is incorrect. Like the study by Lee et al., (2013) auditory feedback is basic and does not provide assistive information. Thus, a motivation to further explore mechanisms for FHP mitigation using low-cost solutions is evident (Kim et al., 2011). In the following section a background on FHP research relating to running kinematics is presented to further explore the design space for an assistive run training interface for FHP mitigation.

2.5.2 Forward Head Posture and Running Kinematics

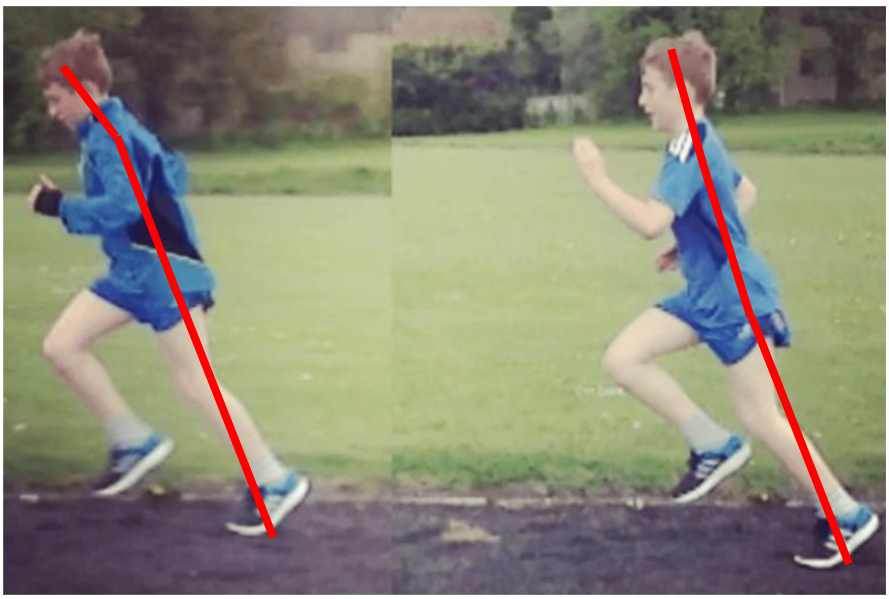

Figure 5 - Example of Forward Head Posture while running (Dunne, 2015)

Running is an intrinsic form of locomotion for humans, as well as an increasingly popular form of recreation, and most ubiquitous movement across sports disciplines. Furthermore, running is a high impact full-body activity, making use of many of the body's musculoskeletal structures; this results in running being a high injury risk activity, due to the vast range of motion involved (Daoud et al., 2012). These complex full body motions make achieving optimum running technique difficult, particularly if there are any pre-existing conditions (Folland et al., 2017), thus a motivation for designing assistive interfaces for running technique improvement exists in the research and private sectors.

As discussed in the previous section, FHP is an increasingly common issue amongst smartphone users, and as such, its effects are present during exercise activities. FHP during running can be observed in the angle tilt of the head and neck while running (Figure 5) and as such its effects can be exacerbated by high impact resulting from poor running technique. Whilst much of the body of work relating to FHP has focussed on sedentary correction of posture (Ansari and Kondamudi, 2020; Kim et al., 2011; Lee et al., 2017; Triangto et al., 2020), there is little evidence of FHP assistive feedback for running. Furthermore, as discussed in the opening sections of this chapter, current auditory display research has focussed on applications that target running performance, leaving a clear gap for creating an assistive run training interface for FHP mitigation.

2.6 Design Thinking

Design thinking is characterised as the consideration of cognitive processes that lead to design action and arise from the use of ethnographic tools to understand users and their environments in their natural state (Cross et al., 1992; Tim Brown, 2008). The evolution of the philosophical aspects of design thinking between the 19060's through to the 1980s and onwards, maps out a process by which the role of the designer shifted from that of an 'all-knowing expert' to that of the reflective practitioner (Schön, 2017). The positioning of the designer in a state of 'reflection in action' moved away from the characterisation of the designer as a practitioner relying solely on their training, and consequently their preconceived knowledge of theory and technique to produce designs. This new conceptualisation of the role of the designer embraces uncertainty, serendipity and dialogue with users, to construct ad hoc theories and methodologies that target specific design scenarios (Sas and Dix, 2009). Thus, the information-processing conceptualisation of the 'problem-solution' framework for design was rejected in favour of the concept of the 'design-situation' or 'design space'. This ideation of the design space opened up sensitivities to human and environmental factors more commonly associated with the social sciences (Bousbaci, 2008). In this new design paradigm, qualities designers must embrace are experimentalism, collaboration, empathy and self-reflection to better understand the complex and nuanced interactions between users, their environments and the designs produced to respond to specific scenarios (Sas and Zhang, 2010).

Design thinking spurred the proliferation of user-centric methodologies aiming to improve usability through empathic design conscious of user environments, experiences and sensibilities. As such user-

centred design has become a central tenet of disciplines concerned with technology design such as HCI, which have recognised the potential in engaging users to produce more meaningful and impactful designs. HCI practitioners have been successful in spearheading the adoption of design thinking in a field previously guided by rigorous 'scientism', by opening up the possibilities to better explore and understand the ambiguous nature of data produced by design-based research in the field, ultimately enabling actionable paths for design (Gaver, 2012; Koskinen et al., 2011).

A key focus of incorporating design thinking into HCI has been to embrace innovative frameworks and methods, while consistently aiming to produce stable and transferable tools formalised into the body of research. This ability to formalise experimental tools has been central to the success of user-centred design adoption within HCI and has spurred a shift away from positivist frameworks towards user-centric approaches in related fields which employ design-based approaches for the generation of new knowledge. A recent example of a field that has begun a transition from positivist and information-processing philosophies is auditory display research. As explored in the previous chapter, traditionally the field of auditory display research has struggled with adopting ambiguous qualitative data and favoured quantitative scientific methods, whilst the argument over scientific sonifications over aesthetic approaches has dominated the majority of discussion in the field (Ballora, 2014; Filimowicz, 2014). This has resulted in a difficulty in formalising design theory of auditory displays as the nature of this field of research encompasses a vast range of disciplines, much like HCI, and thus new approaches to critiquing evaluating design methodologies in auditory display research has pushed the field towards more user-centric philosophies.

2.6.1 Towards a formalization of AD theory

Despite its close relation to HCI research, auditory display research has been slower in adopting user-centric methods, however as of recent publications user-centric methodologies have begun to become more prominent (Landry and Jeon, 2017; Metatla et al., 2015). In these recent examples a clear shift in vocabulary and techniques has become evident, reflecting the influence of design thinking by showcasing theories and approaches to design more common in HCI and the social sciences. This convergence between the fields of AD and HCI research present an opportunity to homogenise the approaches employed in AD research and produce a more formalised theory for sonification and auditory display design.

Clear examples of this shift in philosophy amongst the auditory display community can be seen in the work of prominent AD researcher Stephen Barras, where he describes the introduction of aesthetic considerations to the field of AD research as a consequence of the explosion in popularity of what he terms the 'aesthetic turn in visualisation' (Barrass, 2012). This aesthetic turn in visualisation is understood as the revolution of data visualisation through the skills and perspectives of artists and designers, who were able to open the field to innovative ways of experiencing the nuances of complex data sets. Barrass describes sonification and auditory display as the auditory counterpart to data visualisation and envisaged that '*the extension of the aesthetic turn to sonification could transform this field from a scientific curiosity and engineering instrument into a popular mass medium*.' (Barrass, 2012). Further examples of the vision proposed by Barrass, can be seen in the work of Wolf et al. where a decentralised approach to AD design is presented. In their paper, users are given control over a semi-autonomous sonification system that implements established sonification techniques, to produce a soundscape which users are able to affect and modify the mapping parameters to suit their preferences (Wolf et al., 2015). The authors of this study expressly use techniques adapted from HCI to develop a user-centred approach to AD design and test the applications of this techniques within this field, as such, the researchers acknowledge further investigation of this methodologies is needed.

As observed in key examples from prominent researched in AD design, an amalgamation of design thinking activities and tools has begun to appear in AD research, as such, the motivation to further explore these techniques present an opportunity for the field to produce more cohesive tools and theories of sonification, leading to a more sustainable ecology which pushes knowledge in the field forward. Of particular interest to this project are two approaches well established in HCI research which have found their way into more recent sonification research, ecological and embodied design. These two notions, grounded in psychology and cognitive science, offer fresh perspectives on how to better understand user experience, perception, and behaviour by focussing the user-centric lens on the relationships users have with their environments, their consciousness and their mental states. In the following section an account and background of ecological and embodied design to frame current UCD approaches within HCI research and how they relate to current approaches in AD design and research.

2.6.2 Ecological and embodied approaches to AD Design

During the 1960's a shift in the conceptualisation of cognition began to occur, whereby the dominant cognitivist information-processing philosophy began to be rejected in favour of more human-centric interpretations to cognition. One such theory was proposed by James Gibson in 1966, known as the ecological perceptual theory, which moved away from an interpretation of the world as a chaotic source of random sensory stimuli, onto which organisms capable of perceiving superimpose structures of meaning, derived from mental representations of the world stored in their cognitive apparatus (Gibson, 1966). Gibson's theory proposed a radical and innovative interpretation of perception for the cognitive sciences at the time. Here cognition was understood to be derived from the situatedness of the perceiver in a naturally structured environment controlled by the laws of physics, in which ambient information permeates and allows the perceiver to act (Wilson and Foglia, 2017). In this framework, perception is an active and exploratory state which the perceiver uses to orient itself through actions within its environment. Perception is considered as a self-adapting process of decoding ambient information by the sensory organs, which then in turn reinforce and optimise the perceptual system, allowing it to become more sensitive to the subtle invariance of an evolving yet stable environment (Clarke, 2005).

One of the most important takeaways from Gibson's theory of ecological perception for understanding the synergies between the environment and perceiver is the concept of *Affordances.* Affordances are used to explain how the invariant and inherent properties of objects 'afford' the perceiver with cues on how to regulate its behaviour in response to a particular context of events within the environment. These affordances are what permit an organism to react appropriately to what occurs without any prior knowledge or cognitive process (Hirose, 2002). Furthermore, it is important to note that the ecological theory of perception does not distinguish between the physical natural environment, and the more abstract cultural environment of human experience. Thus, perception is not limited to physical objects and interactions, allowing the extraction of actionable meaning from abstract phenomena like language, emotional expression, sound and graphical symbols (Clarke, 2005). This new understanding of cognition as a perception-action cycle stemming from the situatedness of the perceiver in a sensory-rich environment, not only revealed the intrinsic relationship to the environment, but cast the spotlight on the perceiver as a primary actor, which ultimately fostered the notion of 'embodiment'. Traditionally the cognitive sciences had positioned the body of a perceiving organism as peripheral to cognition, however, the notion of embodiment

recontextualised this perception (Hirose, 2002). Cognition was now viewed as intrinsically tied to aspects of the perceiver's body other than the brain, as a consequence of an individual organism's ability to sense and decode the affordances which exist in the environment it inhabits (Wilson and Foglia, 2017). In the current scope of technology design, the body has become of central concern for design as we seek to expand its capabilities. Thus, embodied design aims to leverage the situatedness of the body within the ecologies it inhabits to inform design (Wilde et al., 2017). The affordances designers are presented through embodied design have allowed the development of user-centric frameworks, particularly useful in perceptual research disciplines like auditory display design, by providing tools to adequately scrutinise the relationship between users, environment, body and product (Sas and Chopra, 2015).

While the specific language and theory of embodied design is relatively new to AD research, notions of ecological and embodied perspectives to auditory perception are present throughout related historical sources contemporary with Gibson's theory of ecological perception. One clear example comes from the 'listening modes' developed by Pierre Schaeffer and built upon by Michel Chion. In their work Schaeffer and consequently Chion, aimed to formalise ideas on the situatedness of the listener and the listening state of mind experienced in varying contexts, by creating a taxonomy of the different modes of listening (Chion and Murch, 1994; Schaeffer, 1966). The categorisations presented in these taxonomies laid the groundwork for an embodied approach to musicological research into the listening and perception of 'organised sound' and have continuously been adapted to fit more modern perspectives on music perception (Tuuri and Eerola, 2012). As the philosophy of AD research has shifted to employing techniques for better understanding users' experiences of listening, the effect on perception of the different listening modes has become of great relevance to the field and used a source for defining design parameters (Grond and Hermann, 2014). Similarly, other ecological approaches have come from the application of Gestalt Theory, used for describing processes for designing auditory displays that integrate discreetly into their intended ecologies and are designed by considering the environment they sit in as a whole (Rönnberg et al., 2016). More recently, the work of Dermot Furlong and Steven Roddy has been exemplary in championing the application of embodied design in AD research and presents the most comprehensive and explicit use of embodied design in the field. In their work, Furlong and Roddy isolate 'realism and cognitivist thinking' as key barriers to development of AD research and propose ecological and embodied design

as a framework to address the key issues in theory formalisation and lack of cognitive research in auditory display design (Furlong and Roddy, 2020)

From these instances and throughout the discussion in this thesis, it can be observed that the AD community has been shifting towards more user-centric approaches in recent times. However, while much attention has been given to understanding the listener in the domain of music and organized sound, the same cannot be said of AD and HCI research (Vickers, 2012). This is of particular importance as greater emphasis on user-experience has become paramount to current AD design. Given this, it is a key priority of this project to explore the application of ecological and embodied design as a tool for producing rich and innovative studies within the field of AD research, thus in the following the cultural probe methodology is analysed as a valuable tool for developing an auditory interface in line with the discussion presented in this chapter.

2.7 The Cultural Probe Method

Cultural Probes are a design-led approach, which emerged from the work carried out by Bill Gaver, Tony Dunne, and Elena Pacenti, as part of the *EU Presence Project*. Their research aimed to explore how to better integrate elderly people into their communities, the results of which, were outlined in the article *Cultural Probes* published in *Interactions* magazine (Gaver et al., 1999). In this article Gaver and his team discussed how they developed cultural probes as a method to provoke inspirational responses from their participants, with the intention to better understand the communities they would be designing for and to open possibilities for new design spaces.

> *'The probes …address a common dilemma in developing projects for unfamiliar groups. Understanding the local cultures was necessary so that our designs wouldn't seem irrelevant or arrogant…' (Gaver et al., 1999)*

Taking an artist-designer perspective as opposed to a scientist (or engineer)-designer approach, Gaver et al. (1999), envisaged the cultural probes as a tool, not for gathering user requirements, but for uncovering and developing new spaces for design in user experience, pleasure, and sociability. As such, Gaver et al. (1999), did not prioritize precise analysis or controlled methodologies as in

traditional ethnographic studies, but instead attempted to create a dialogue between researchers and subjects for the consideration of the cultural implications their designs could potentially have. Inspired by the Situationist, Dada and Surrealist movements, the probes were designed as a set of fun, abstract and open-ended tasks that would provide inspirational information to stimulate the designers' imaginations, rather than provide data for defining user requirements.

'*Trying to establish a role as provocateurs, we shaped the probes as interventions that would affect the elders while eliciting informative responses from them' (Gaver et al., 1999).* This approach allowed for the consideration of broader information such as beliefs, desires, emotions, aesthetic preferences and the cultural concerns of the participants.

In the work of Gaver et al. (1999), as well as in the majority of other cultural probe examples that have followed, the probes take the form of physical packets or 'kits' containing the materials needed for completing a set of open-ended, provocative and abstract tasks set by the designers (Boehner et al., 2007). The materials provided traditionally consist of maps, disposable cameras, journals or sketchbooks, media diaries, postcards and basic craft materials (Gaver et al., 1999; McDougall and Fels, 2010).

The contents of these probe kits were designed and chosen in response to a variety of perceived obstacles the researchers had to overcome to initiate a conversation with the elderly communities they would be designing for. The playful nature of the probes aimed to mediate the tensions created between the researcher/subject dichotomy, and the 'official' nature of research from the participants' perspectives.

> *'Using official looking questionnaires or formal meetings seemed likely to cast us in the role of doctors, diagnosing user problems and prescribing technological cures' (Gaver et al., 1999).*

> *Secondly, their compact form allowed for geographical barriers to be overcome, allowing participants to post their probes back to the researchers. The largely visual nature of the probe materials likewise served to mediate problems relating to language barriers (Gaver et al., 1999).*

In recent years, research in HCI has shifted its focus towards trying to better understand the user and the influence design has on everyday life. Consequently, this has led to user-centred methods such as cultural probes to be explored as alternative means of engagement with target user groups. This wide adoption of the use of cultural probes, however, has attracted some criticism within the HCI community, largely stemming from tendencies to replace traditional ethnographic studies with the probe method and trying to analyse the results from a scientific standpoint. In the following sections we will detail how the probe method has been adapted and interpreted in HCI in order to shed light on the issues mentioned previously.

2.7.1 Cultural Probes in HCI

In the work carried out by Boehner et al., (2007), a review of approximately 90 papers into the uptake of cultural probes within HCI, revealed a diverse 'microcosm' of adaptations of the probe method. In order to characterize this diversity Boehner uses the umbrella term 'x' probes (Boehner et al., 2007). The term 'x' probes encompass a wide range of probe inspired methods that include Technology Probes, Urban Probes, Empathy Probes, among other variations of the original probe method.

By comparing the literature concerning these 'x' probes, Boehner et al. (2007), trace several key attributes of the original probe method that have been incorporated, adapted, and discarded by different research groups, and comments on the implications of these decisions.

Probes as Data Collection:

Boehner et al., identify that the most prominent feature found in the papers reviewed, is the approach of using probes as a form of data collection. This method sees the original probe method being used for user requirements gathering, as well as a supplement to, or in some cases a replacement for ethnographic studies. Likewise, some approaches suggest following up probe studies with ethnographic methods, such as interviews, to help validate the probe results. This has been criticized for adapting the probe method into a form of 'discount' or rapid ethnography, which fails to capture what true ethnographic studies capture due to a lack of analytic and methodological concerns (Dourish, 2006).

Probes as Packet:

Another prominent feature amongst the literature has been the adoption of the original form of the 'probe kit', with some studies however, only using one or two elements such as open-ended postcards, or the photo diary, instead of the whole package. It appears that in many cases this approach has been adopted as a form of ready-made kit to quickly gather data without the need for in-depth analysis, particularly useful within industry where design periods are short due to budgetary concerns (Boehner et al., 2007; Gaver et al., 2004).

Probes as Participatory:

A less prominent, but still commonly cited attribute is the participatory nature of cultural probes. Participants often cite the level of participation afforded by the probes as more enjoyable than traditional approaches such as interviews. They allow participants to control the information they provide and are therefore favourable when dealing with participants in sensitive contexts, where privacy is necessary. Similarly, probes are associated with emotional aspects of design and HCI, due to the playful, creative and abstract nature of the tasks involved, this has become an increasing motivation for probe use in recent years (Bernhaupt et al., 2007; Vetere et al., 2009).

Probes as Sensibility:

Far less common in the literature are works that cite the provocative nature of probes as inspiration for the development of new methods. These works usually abandon the traditional probe kit, and instead appropriate the attitude behind the cultural probe method. That is, the designed artifacts, applications or installations serve as a form of 'probe', which provokes reactions and feelings to a new technology or device (Boehner et al., 2007; Lundberg et al., 2002).

The work provided by Boehner et al. (2007), highlights the trends observed in HCI literature regarding cultural probe uptake. It is of note that the original form of the 'probe kit' has largely remained intact, along with their use to stimulate design conversations with end-users through play and participation. Meanwhile it is less common to find approaches that have been inspired by the provocative and subversive nature of probes.

A review of literature published after Boehner's et al., research reveals a continuation of the trends highlighted in their work, where the probe kit and probe for data collection approaches still prevail. Examples of this can be observed in *Discovering Madeira: A Case for Cultural Probes* (Leeuwen, 2011),

where the authors advocate validation of their results obtained from their probe study through subsequent supporting interviews with participants. Likewise the *iAWN* project (Jeng et al., 2011), takes the form of a probes as method for data collection, with a strong emphasis on trying to rationalize results. Further examples can be found in (Hutchinson et al., 2003; McDougall and Fels, 2010; Thoring et al., 2014).

2.7.2 Evaluating the Cultural Probe Method

The way in which cultural probes have been incorporated into HCI studies, as outlined in the previous sections, has created tensions within the HCI community, attracting several criticisms over this method's validity in generating design knowledge. This has led on from a deviation from the original intentions behind cultural probe studies that the original authors foresaw.

In a follow-up article to their original cultural probe study, Gaver et al., caution against the continuing tendency in research, to rationalize and summarize probe results, in an attempt to produce user requirements analyses from the data they collect (Gaver et al., 2004).

By appropriating the probe method into this 'scientific' approach, researchers are at risk of sacrificing the true insights cultural probe studies can provide. Throughout the literature reviewed, many researchers acknowledge that despite the cultural probes being designed for inspiration, they were adapted in some way to provide information that could be used to validate and rationalize the results (Boehner et al., 2007). These approaches commonly place less emphasis on the provocative aspects of cultural probes, in fear that the data returned might be too abstract or unclear.

Gaver et al., 2004, point out this ultimately has the consequence of leading to probe studies which:

- Ask unambiguous questions that lead to predictable and unsurprising results, only reinforcing what the researcher already knows.
- Due to the abstract nature of the method, this may lead to poor interpretations of individual subjects when trying to rationalize and summarize the results.
- Constrain the imaginative element for storytelling that can inform design and is a key aspect of the cultural probe method.

The cultural probe method has also been likened to a 'discount' ethnography (Boehner et al., 2007; Dourish, 2006). This comparison stems from the similar emphasis the cultural probe method and

ethnographic studies place on the interaction between researchers and research subjects. Likewise, both approaches focus on the similar domains of inquiry of everyday life. However, due to the scientific perspective pervasive in HCI, these research methods have been adapted to elicit information that can then be used to produce user-requirements. Where ethnography is a valuable method for generating this type of data through interpretative analysis, cultural probes were never intended to generate any data at all. To attempt to interpret them as such distances them from being meaningful conversations between designers and participants, to an impersonal analysis independent of both (Boehner et al., 2007; Gaver et al., 2004).

> *Our Probe results are impossible to analyse or even interpret clearly because they reflect too many layers of influence and constraint… They produce a dialectic between the volunteers and ourselves: On the one hand, the returns are inescapably the products of people different from us, constantly confronting us with other physical, conceptual, and emotional realities (Gaver et al., 2004).*

The continuing prevalence of using probes as data collection methods is evidence of a larger and systematic misunderstanding of the probe method, resulting from the tensions created by scientific oriented perspectives in HCI, rather than an attribute of the method itself. Similarly, the pervasiveness of the 'probe as packet' method echoes the tensions Gaver et al., foresaw would arise from their original work; where they acknowledge the potential to adapt the probe method to different areas, but state that *'a generic approach to the probes produce materials that seem insincere, like official forms with a veneer of marketing'* (Gaver et al., 1999). This probe packet or kit, consisting of a camera, postcards, diary, maps, and tasks are often enough for a research paper to cite probes as central to their research methods. In cases such as these, what is adopted is the probe method but not the methodology (Boehner et al., 2007). Without this methodological approach the probes merely become the packets of objects that they are made up of, 'without the epistemic grounding that make their results truly meaningful' (Boehner et al., 2007).

2.7.3 Probology

Arising from the previous sections, a fundamental issue that attracts criticism of the cultural probe method is the appropriation of the method without the corresponding methodology. Gaver et al. acknowledge this, in their distinction between the concept of 'probe as method' and 'Probology'. The probological approach uses Probes to encourage subjective engagement, empathetic interpretation,

and a pervasive sense of uncertainty as positive values for design (Gaver et al., 2004). While the authors proceed to acknowledge the probe technique may be adapted towards different needs, Gaver et al., encourage the adoption of a methodological approach and place emphasis on the design process of cultural probes.

> *The real strength of the method was that we had designed and produced the materials specifically for this project, for those people, and for their environments. The probes were our personal communication to the elders, and prompted the elders to communicate personally in return (Gaver et al., 1999).*

A key aspect of the original probes that has been overlooked and usually omitted, as outlined in the work by Boehner et al., is the detailing of the process by which the probes are designed, as well as the acknowledgement of the subjective nuances and biases of the designers throughout the design process (Boehner et al., 2007). In the original cultural probe study, a substantial amount of consideration went into the design of the probes, focused through the lens of functional aesthetics (Gaver et al., 1999). This consisted of viewing aesthetic and conceptual pleasure as an integral part of functionality, thus allowing the probes to be designed so as to be delightful, but not childish or condescending, designed but not intimidating and personally reflective for both the participants and the designers (Boehner et al., 2007; Gaver et al., 2004). Ultimately the success and appeal of the probe method lies not only in its potential for yielding unexpected insights, but also in promoting active engagement of participants with the research tool through embedded and designed playfulness. Through play participants interact more honestly and with greater disregard for the scrutinizing academic eye, allowing us to pear into the unconscious emotional and personal environments of users in their everyday lives (Bernhaupt et al., 2007).

This chapter has thus far detailed the development and evaluation of the cultural probe method in relevant fields of research to the scope of this project. In the following section an adaptation of the cultural probe method employed to generate valuable design knowledge and understanding of the emotional connection between runners, running technology and their everyday environments is described. As the initial aim of the project is to focus on user-centred design and the emotional context of user experience of runners, the cultural probe framework that has seen widespread use in design and HCI-led practices presented an interesting way to understand the research context and

create a dialogue between the researcher and the rational/emotional actors within it. Furthermore, cultural probes have seen previous and successful application in the research and design of assistive technologies (Brown et al., 2014), such as the one this project is concerned with. To address the tensions and limitations of this method within the HCI realm, careful attention was paid to the design of all the features of the probes. As a result, a few interesting points arose concerning the value and effectiveness of adapting the cultural probe method as a tool for generating design knowledge for creating auditory displays for runners. In the following section, a background on participatory design methods is presented to underpin the value of cultural probes in iteratively designed technical solutions.

2.8 Participatory Design

Participatory Design (PD) is an innovative approach to computer systems design in which the users ultimately destined to use a particular system play a crucial role in the design of it (Schuler and Namioka, 2017). Any technology system development process faces the problem of defining parameters of design. This has traditionally taken the form of user requirements gathering, whereby methods are employed to elicit from users what it is they want the technology being designed to do for them. Such methods include paid focus groups, model users and operability tests, which are used as 'stand ins' for the actual users who will ultimately use the technology (Lane et al., 2016). The issue with traditional methods of requirement gathering is the displaced context in which they occur, where design decisions and implementations are made away from the specific site or environment in which the technology will ultimately be used. Issues that PD researchers are particularly faced with in conducting design activities through this framework, are influenced by the relations between researchers and users, and ultimately the power dynamics that the role of the expert and the layman are usually associated with. Researchers hold power over research design, resources and specific skills for mediating, influencing and decision making in any given project, and traditionally users were seen as unable to contribute to the design process due to their lack of formal training. Given the goals of PD, researchers and designers must find a balanced approach in diversifying and decentralising these power dynamics through appropriate PD methods, in order to leverage the knowledge inherently and intrinsically available in users experiences of their own environment (Maguire, 1987; Vio Grossi, 1981).

Participatory design stands in contrast to the 'all-knowing' infallible design specialist who relies on training and expertise to formulate answers to 'design problems. This theme in user-centric approaches has been previously discussed in chapter 2 as the rejection of positivist information-processing perspectives, and is an integral feature of PD and other similar methodologies (Coleman et al., 2007; Norman and Draper, 1987; Vredenburg et al., 2002). As such, PD does not reject or disparage the value of formalised training and expertise, but rather aims to leverage it in conjunction with knowledge derived by the stakeholders ultimately affected by any design application. Thus, PD demands active participation and engagement between users and expert designers to generate parameters for design. Participatory Design's aims are underpinned by the design thinking ideology and can be understood as a shift in perspective of the role of the designer in three meaningful ways (Bjögvinsson et al., 2012; Tim Brown, 2008):

1. Designers should move away from the 'cult' of the product and instead be more involved in socially innovative design that transcends capitalist motivations.
2. Design should be a collaborative process giving voice to participating stakeholders
3. Ideas and designs should be prototyped, tested, and refined in a hands-on way, early in the design process, with a distinct human-centric, empathic, and optimistic lens.

TOOLS AND TECHNIQUES	PROBE	PRIME	UNDERSTAND	GENERATE
MAKING TANGIBLE THINGS				
2-D collages using visual and verbal triggers on backgrounds with timelines, circles, etc.	X	X	X	X
2-D mappings using visual and verbal components on patterned backgrounds		X	X	X
3-D mock-ups using e.g. foam, clay, Legos or Velcro-modeling			X	X
TALKING, TELLING AND EXPLAINING				
Diaries and daily logs through writing, drawing, blogs, photos, video, etc.	X	X	X	
Cards to organize, categorize and prioritize ideas. The cards may contain video snippets, incidents, signs, traces, moments, photos, domains, technologies, templates and *what if* provocations.			X	X
ACTING, ENACTING AND PLAYING				
Game boards and **game pieces and rules** for playing		X	X	X
Props and **black boxes**			X	X
Participatory envisioning and enactment by setting users in future situations				X
Improvisation				X
Acting out, skits and **play acting**			X	X

Table 2 – Table of example PD methods (Choudhary, 2019)

PD presents designers with a set of tools to probe, communicate and collaborate with stakeholders. Such examples of current methods employed in PD studies can be found in Table 2. While this table of methods is not exhaustive, it is also important to bear in mind that PD methods should be constructed and tailored accordingly to the specific design space looking to be explored (Ahn and Park, 2007; Choudhary, 2019). As such, PD presents opportunities to produce experimental and innovative mixed methods approaches to design by targeting the situatedness of users within their environment, and thus is a useful tool for achieving the goals of ecological design presented throughout this thesis thus far. In the following section, the specific application of PD principles in AD research is presented as a background to contextualise the use of participatory workshops for the further development of prototypes for assistive sound-based run training interfaces.

2.8.1 Participatory Design in Auditory Display

In the previous chapters of this thesis, the development of user-centric principles in AD research has been expounded, capturing a broad view of the current philosophical perspective, use of research methods and applications in contemporary and historical AD studies. In this section a focussed analysis of explicit use of PD methods in AD research is presented, culminating in the research design decision to make use of participatory workshops for the next stage of technology development presented in this project.

The development of UCD and design thinking in AD research has presented opportunities to homogenise and formalise tools for AD design in the field. However, user-centric methodologies and frameworks encompass a great range of tools and techniques generated through the foci of different approaches to human-centric design, examples of which include Participatory Design, Contextual Design, Participatory Action Research. Methodologies derived from these different approaches have begun to permeate AD research in an attempt to resolve the issues brought about by the cognitivist mentality that dominates the field (Barrass, 2016). As such, in the interest of this project, exploring these developments is important to informing tools and techniques that enable ecological and embodied approaches to design. Participatory Design presents a particularly interesting methodology in that research is focussed on empowering users to influence design through action and dialogue and makes use of tools that probe and emphasis the situatedness of the user and their embodied experience of their environment. Examples of PD are present in contemporary AD literature in the work of Visda Goudarzi. In their paper, the author employs the HCI derived method of the participatory workshop to create a dynamic interaction between users and designers to create user-centric sonifications (Goudarzi, 2016). These dialogues were used to bring to light common threads and barriers between designers and users and provide a basis for the creation of a synergetic relationship with overall onus lying with users. Despite the challenges in communication and interpretation presented by attempting to form dialogue between ‘experts’ and users, the authors suggest the participatory workshop method provided a useful tool for mediation and for fostering an appreciation for each other’s perspectives and motivations.

Further convergence between the tools and techniques developed in participatory design disciplines with AD research can be observed in the work of prominent AD and sonification researchers Steven Landry and Myounghoon Jeon. In their paper authors employ a PD methodology to place direct

emphasis on users' needs and situated physical experience of the users' body within its environment as a source of design knowledge (Landry and Jeon, 2017). In this work, the authors aim to address issues with previous methodologies employed in developing sonifications of dancer movements. Namely, the lack of clear and stated methods for identifying, selecting and testing the most appropriate movement-sound mappings for dancer sonifications. The authors propose PD as a mechanism to eliminate top-down designs whereby designers' user their expertise to influence all decision making and instead focus on the embodied experience of dancers to guide the project. The authors highlight the complexity and unfamiliarity of employing such methods in the quest for designing an auditory interface but encourage further study of the methodology due to its ability to generate rich source data in collaboration with end-users. Thus, a clear motivation for employing participatory methods in AD research is present, and as such a crucial tool for the development of this thesis. In the following section, a critical reflection of the background research is presented in order to join the narrative that has guided this thesis project.

2.9 Reflection and Outcomes

With the body of work outlined by the background research of Chapter 2, a defined path to this thesis was synthesised. Looking to further explore the yet untapped potential of auditory displays, identifying key developments of design practice in the field informed the research design process. In line with the shift towards HCI derived processes and methods for design within AD research, a design philosophy rooted in ecological and embodied design was embraced for this thesis. This design perspective laid the groundwork for enabling research decisions to be derived directly from end-users' input by focussing directly on their environments and consequently on their emotional and embodied experiences. In order to explore said experiences, it was determined experimental methods such as Cultural Probes (Chapter 4) and Participatory Workshops (Chapter 5) could be leveraged to provide rich qualitative and abstract data often overlooked in the AD field. A good example of the benefits of such approaches can be observed in the tensions in AD research created by information processing perspectives with a resistance to ambiguous data and the need to embrace abstract emotional data in order to better understand user experiences; thus, the Cultural Probe method, which embraces ambiguity in data, presented an interesting opportunity to query these tensions in the field. Additionally, these more experimental approaches were employed to build upon preliminary data captured by a survey study, which allowed a far greater reach of users with the

limited resources available to a PhD project. Thus, drawing knowledge directly from users at each stage of this thesis presented an opportunity to approach AD design from an innovative perspective for the field.

In order to test out a participatory approach to AD research, it was imperative identifying an application in which a historical body of research in the field already existed, in which traditional methods of AD design have been employed. Furthermore, this application required to have users enthusiastic about using the technology and benefit from exploring AD as an innovative mechanism to address user experience. As such, run training interfaces were identified as an interesting area for design as they presented interesting design challenges both from the AD design perspective as well as from the wearable/quantified-self design space. As identified in section 2.5, run training interfaces have long been of interest to AD research and a broad body of work exists exploring their application, however, within this research few examples have approached design from purely user-centric design approaches and have often targeted similar areas to traditional wearable technology that don't address the gap for assistive interfaces illustrated in Figure 1 and expounded in section 2.2. Thus, a clear focus of developing an assistive run training auditory interface via a user-centric methodology became the primary focus of this thesis. With a further exploration of potential assistive feedback streams, Forward Head Posture was identified as a viable application as no commercial applications have yet incorporated such a metric into run training interfaces. Additionally, the prevalence of FHP in the overall population provided further motivation to explore design solutions to address this issue. Given the mechanisms for measuring FHP using Inertial Measurement Units (IMUs), this additionally presented design opportunities as such units can be inbuilt into head mounted gear such as headbands or headphones, which runners already often use in their day-to-day activities.

In the following sections, the design process and implementation of an assistive interface employing the methodologies outlined so far is presented; beginning with a preliminary survey for gathering a broad range of data relating to runners' experiences, followed by a targeted cultural probe study and series of participatory workshops for outlining key design personas to inspire further design ideas, and concluding with a prototype implementation derived from the outcomes of the preceding studies.

3 Preliminary Study

3.1 Abstract

As an initial approach to employing the philosophies, theories and associated techniques developed in design-thinking disciplines as tools for auditory display design, as explored in the previous chapter, the targeted design space of run training products and users' experience of music was identified as a viable medium to apply these methodologies. As such, a survey study was deployed as an interactive form to capture initial data of the environment for which this project aims to design an auditory interface for and served as the basis to begin envisioning potential strategies for design of a concrete application of an assistive auditory interface for run training.

3.2 Introduction and Research Design

From the literature analysed in the previous chapter, the aim of fostering a user-centric design strategy for this project has been established as essential to evaluate the effect of this approach on developing a more usable sonification system. While there have been many examples of sonification studies looking at auditory feedback for runners, these have been characterised by top-down design approaches that seldom explore their theories and applications outside controlled testing conditions. Thus, with these aims in mind a three-part study was developed that would incorporate methods and techniques for generating initial data, which have been adapted from well-established user-centric design ideation and requirements gathering approaches developed within design and HCI fields.

As the particular focus of this study is to understand the user within the context of their environment, a definition or understanding of the 'environment' must be established. In the case of ecological and embodied design, the environment is understood as an interrelation between the physical world and the inner spiritual/cultural world of the user. The aim of the initial stage of the project is to specifically understand how runners interact with a given technology within their specific environment, so that any ideas developed are intrinsically related to user's direct experiences. Thus, the first method employed was a survey study aimed at reaching a large audience to gather a broad picture of the potential users this project would be designing for. This survey study focussed on providing qualitative data of users' experiences, emotions and self-perceptions relating to their exercise routines, use of running technology and experience with music.

The second phase of this thesis (Chapter 4) employed the use of a cultural probe in the form of a set of open-ended activities to explore user's environments in-depth through their perspective and build on the broader overview provided by the survey results. The cultural probe approach has been widely employed in HCI as a tool for exploring user's environments with a focus on emotion, experience, and reflection. The choice of this tool to explore this context stems from its ability to provide insight into the aspects of user experience users may not elicit consciously or willingly due to the personal nature of a research tool being used to scrutinise their behaviour. Cultural probes are not intended to gather hard data to action directly into design, but rather as an ethnographic tool used by researchers to get to know the environment they wish to design for. Finally, the third phase (Chapter 5) comprises two stages of data capture. Firstly, two participant-led workshops were held to elicit discussion between users and designers about their experiences of the technologies that exist already within the desired design space. Through listening activities, open ended questions, discussion, body storming and prototype testing, these workshops further expand knowledge about runners' environments and aims to generate qualitative data upon which to reflect when designing the initial prototype. Once the design queues were identified from the workshop data, the development of a user-centric prototype was made possible, allowing for a deployment cycle to test the derived design decisions in an active setting. Thus, through the methods described above, an overarching participatory design methodology was employed from initial data gathering, to the final deployment of a working prototype, providing insight into targeted HCI design principles in the design of an auditory display.

3.3 Survey Deployment

The first study deployed was a survey study with the aim at establishing an initial idea of users' motivations for running, interaction with current technology and their relationship to music for exercising. The survey's focus was to obtain a broad picture of the users this project would be designing for and served as a way of reaching many users with minimal resources. The survey was designed with a qualitative focus on user experience and emotion, as such some questions are more open ended and reflective. Some results are presented via traditionally quantitative data visualisation formats; however, these data were used for gauging users' self-perceptions of their abilities and proficiency, and therefore are not used for any quantitative analysis. Additionally, word clouds were employed for more open-ended questions to identify frequency of concepts. The final deployed survey can be viewed in Appendix 1.

The survey was deployed across running forums such as Runnersworld.com and several running enthusiast clubs and pages on social media sites, as well as to students at Lancaster and Manchester University and received 114 responses, of which a few were invalid due to duplicate or nonsense entries from non-serious responders. The survey was open to any participant with no requirements of regularly engaging with running technology or music while exercising.

3.4 Survey Results

Presented below are the results to each individual question of the survey. Quantifiable data is presented as pie charts and bar graphs displaying distribution of answers across multiple choice and Likert scale style questions; while results to open-ended questions are presented as word clouds showcasing frequency of terms used by participants to respond. Each question is accompanied by a summary and analysis on the insights gathered.

1. What is your age?

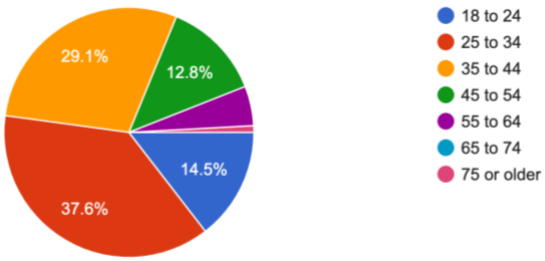

Figure 6 - Survey participant age distribution

A total of 117 responses were received, comprised of participants aged 18-24 (14.5%), 25-34 (37.6%), 35-44 (29.1%), 45-54 (12.8%), 55 – 64 (5.1%) and 75+ (0.9%) (Figure 6). Given the method of participant recruitment via social media and online forums for students, technology enthusiasts and runners, it was expected most participants would represent a middle-aged demographic as observed above. While an effort was made to include participants of upper and lower bands of age demographics, it is out of the scope of this study to explore the differentiation between engagement and interest with the topic of research amongst the different age groups.

2. What is your Gender?

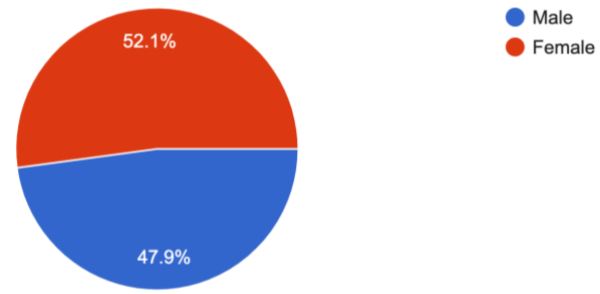

Figure 7 - Survey participant gender distribution

While gender was of no bearing to the outcome of the project, the question of what gender participants identified with, was poised to ensure a balanced perspective across participants' identities and to minimise any gender bias as shown in Figure 7.

3. In a typical week, how many days do you exercise?

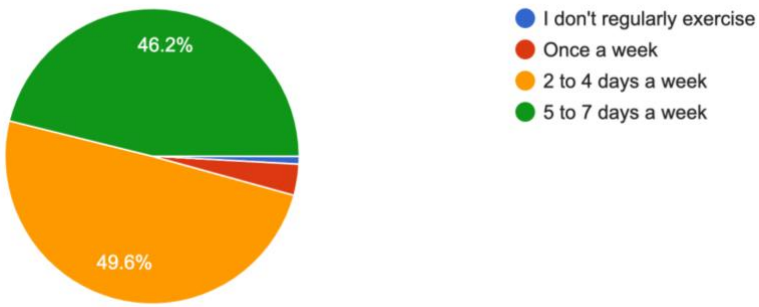

Figure 8 - Survey participant frequency of exercise

Of the 114 responses collected, approximately half stated they exercised a moderate amount between 1-4 days whereas the other half identified as exercising regularly from 5-7 days a week (See Figure 8). The media of online running forums, Facebook groups and University societies by which

participants were recruited, provided a good means of obtaining individuals with a broad range of skillsets, that would have had exposure to running and the technology associated with it.

4. What do you feel is your level of experience with exercise?

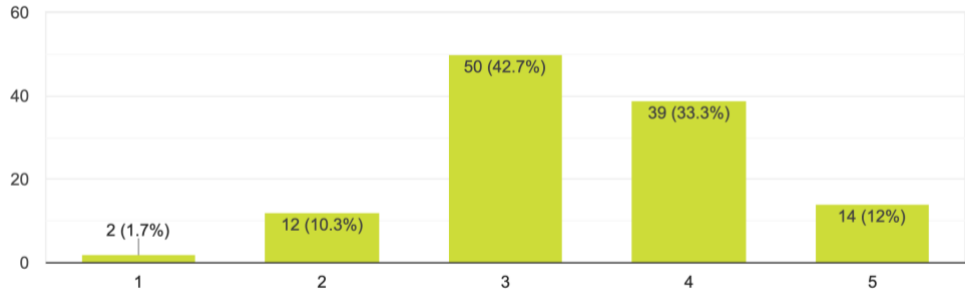

Figure 9 - Survey participant perceived level of expertise

Participants were asked to rate their perceived level of expertise with running/exercise on a Likert scale with data shown in Figure 9. 78% of participants rated themselves across the 3-4 level indicating a moderate to high experience with exercise. Likewise given the targeted audience of amateur runners and use of running forums to collect it was anticipated most responses would come from more experienced individuals. It is important to note that cognitive biases by which people evaluate their skill levels may result in embellished evaluations as described by theorems like Dunning-Kruger effect or illusory superiority bias (Dunning, 2011; Hornsey, 2003). However, given the targeted audience and sources where they were recruited from these results reflect an expected level of engagement with exercise activities.

5. What is your main goal or motivation for exercising?

Figure 10 - Survey participant motivation for exercise word cloud

Participants were asked to describe their main motivation for exercising, with no limit on word count. Results are presented in the world cloud above, with the large font words in blue representing the most common answers.

It can be observed in the world cloud in Figure 10 that the most common words are indeed the concepts mostly associated with motivation for exercising, such as health, weight loss and fitness (Teixeira et al., 2012). Of note however, was the number of times competitive running (marathons, triathlons etc.) appeared, for both 'experienced' and 'inexperienced' participants. This reflects the consistently increasing popularity of marathon events as social gatherings, activism, and fundraising, that have attracted non-runners into the sport for reasons beyond personal health (Fox, 2015).

Of further interest, mental health/wellbeing appeared as another major category in the word cloud. This is of particular interest to this study, as an ecological approach to design by definition, must take into consideration the users external and internal environments as inter-related and crucial to harnessing embodied intrinsic motivation(Hirose, 2002; Wilson and Foglia, 2017).

6. Is there anything specific about exercising that prevents you from feeling motivated?

Figure 11 - Survey participant demotivator for exercise word cloud

Participants where asked which specific factors interfere with their willingness or motivation to exercise. Motivation is a key issue in designing run training technology as the mechanism by which a user engages with an application is crucial to its long term use and adoption (Knaving et al., 2015; Teixeira et al., 2012). The main comments highlighted by the survey and represented in Figure 11, indicate a general perceived lack of time due to family/work/life commitments, which is reflective of data suggesting the average income earner experiences barriers to entry such as cost, childcare, lack of time and low awareness and highlight the need for support to build confidence and competence in exercising technique to achieve sustained engagement (Withall et al., 2011).

Monotony of exercise routines and overall self-determination were also presented as highly contributing factors affecting sustained engagement with exercise. This is of particular interest of this study given the large number of participants who stated they have actively engaged with running technology. This particular insight is reflective of the particular design aspects of run training technology that have been criticised for being unable to generate intrinsic motivation in their users (Knaving et al., 2015; Siddique, 2015). This is of significant interest to this study as it is reflective of the need to further explore new techniques for creating more impactful user-experience for run training technologies.

Additionally, as participants were recruited in the United Kingdom, volatile and cold weather features as a major determining factor in people's motivation, this has commonly been found to be a determining factor in not only the type of exercise people engage in, but also how motivated they are to sustain their engagement (Chan and Ryan, 2009; Dhahbi et al., 2018; Wagner et al., 2016).

7. Have you ever used a fitness app or wearable device to track your activities?

Figure 12 - Survey participant run training interface preference word cloud

Participants were asked to name the technologies they have used for running, to gain an idea of the type of product that is most prevalent amongst amateur runners. Given the targeted audience, Garmin devices alongside Nike, Runkeeper, Strava and MapMyRun apps were the most popular, as seen in Figure 12. Of particular interest is the prevalence of Garmin devices, as these are specialised run training wearables, of which some models are capable of specialised data such as vertical oscillation and cadence tracking. In relation to the previous survey question about motivation, the data may suggest these devices continue to lack the necessary mechanisms for a perceived intrinsic motivation to engage with exercise and the wearable technology on a long-term basis.

8. How do you feel about fitness apps and trackers? Do they help you maintain your motivation or achieve your aims? Or are they just not for you?

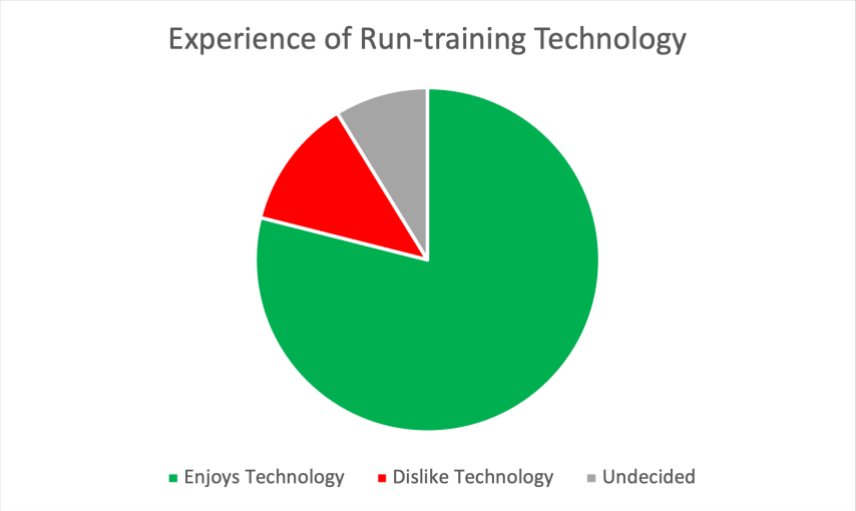

Figure 13 - Survey participant experience of run training technology

Out of 114 responses represented in Figure 13, 88 participants (78.9%) stated they enjoyed using run-training technology in a wide range of devices and wearables. Out of this group 36 Participants described their enjoyment for tracking running metrics and visualising their statistics as tools for improving their running, whilst not necessarily affecting their level of motivation as captured from this quote. This group of participants describe themselves as 'serious' amateur runners and are part of the group of users who engage in regular training amateur marathons and races.

'They're just useful for a more in-depth tracking of my activities. Don't find them less or more motivational'

Equally, there were 36 mentions of enjoying the use of run-training technology for motivation and encouraging adherence to exercise routine. Motivation was stated to be inspired by several different variables. Key motivators included: the availability of training plans that allow users to track progress in a systematic fashion, notifications, and reminders to do exercise, being able to track benchmarks and beat records, often through gamified elements such as badges and tiers.

'Love them I wear my watch every run, it allows me to programme my training and monitor my progress. Strava is great for comparing runs, it's gives you trophys [sic] when you've beating previous times for segments which is great motivation. "If it's not on Strava, it didn't happen' you're running community know if you have it haven't been for a run!' – Participant 79

7 participants who enjoyed the use of run-training apps mentioned their enjoyment of social aspects of run training interfaces such as Strava and sharing runs on social media. Participants particularly enjoy encouraging each other and feeling part of a community of people with aligned goals.

'I love them they help keep me on track I love being part of a community also that can challenge each other, and I love improving and seeing this on the App'

Additionally, 4 participants expressed that they would always exercise with some form of tracking device, in some cases some who expressly would not exercise without technology at all.

'I love my Tom Tom runner. I don't exercise without it' - Participant 83

'Maintain I'd be lost without it' – Participant 79

Of the Participant interviewed 14 stated they dislike or did not use run-training technology. Participants who did not use technology when exercising were primarily experienced runners, 7 of which felt technology does not add any additional value to their exercise routines and motivation. This group of participants was not reserved for those of greater age and represented a group of runners who have cultivated embodied intrinsic motivators and derive pleasure from running.

'Not for me. I find that the more bells and whistles I add to exercise, the less I actually do it. I need just to dive right in without planning it too much or setting goals… I hate that apps ask for your weight and stuff like that. I don't know how much I weigh, so I almost never get past that screen on fitness apps. I just delete the damn thing'. – Participant 30

'They are good but after 34 years of running it's not for me' – Participant 105

6 mentions were also made regarding dissatisfaction with UI elements such as notifications and the perceived effort of inputting and tracking data on a regular basis. Participants who were not overly technology oriented in their daily lives will be more susceptible to user interactions that require dedicated attention and learning to incorporate into their daily routines.

'If they worked properly and were hassle free, I would feel very motivated by them' – Participant 74

'They're fine, the idea is good, but the app is horrible and difficult to understand' – Participant 1

Finally, 9 participants mentioned they were unsure on their stance regarding the effectiveness of run-training technologies. Participants stated reservations regarding the accuracy of devices, perceived barriers to entry such as learning an interface and inability to concentrate on purely running when exercising with a device.

'At first, yes. But after a while I realised that I was focusing too much on times and distance parameters instead of focusing on the run/exercise and my bodies response. I felt it clouded my experience and stopped me appreciating the activity. since reducing the use of tracking, I am paying more attention to what my body can do and have reduced injury occurrences as a result' – Participant 35

'I enjoy looking at the statistics of my exercises, however I feel the apps do not track my progress or metrics with 100% accuracy, so I only rely on them to maintain a structured routine every week and know what I've done.'

– Participant 6

9. How often do you exercise with a partner or group of people?

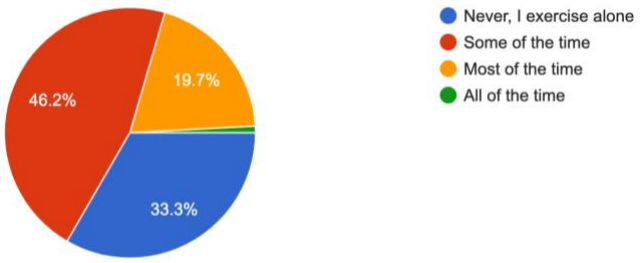

Figure 14 - Survey participant frequency of exercise

Participants rated their level of social running on a Likert Scale, stating they exercised with a partner 'All of the time', 'Most of the time', 'Some of the time' and 'Never, I exercise alone' as seen in Figure 14. The 46.2% who responded that they exercised socially some of the time, alongside the 33.3% who never run socially, indicate running is primarily done as a solitary practice most of the time. This reflects similar statistics captured in National running surveys in the USA (Running USA, 2017), where runners primarily rated themselves as exercising alone the majority of the time (Figure 15).

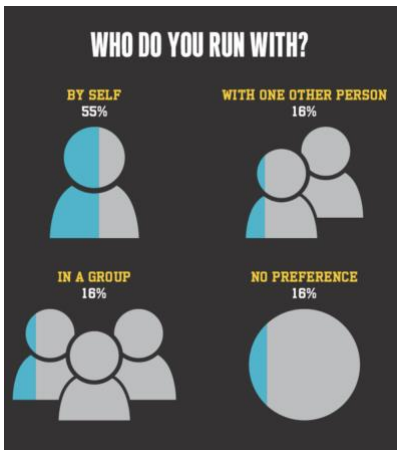

Figure 15 - Social running graphic National Running Survey 2017 (Editors and Seligman, 2017)

10. When exercising, how often do you listen to music?

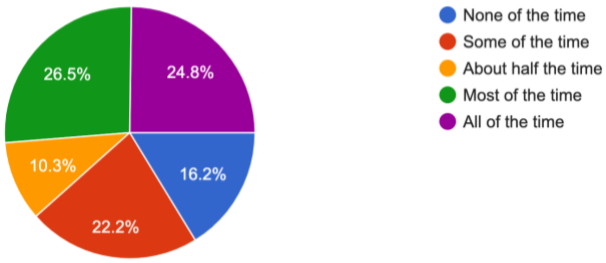

Figure 16 - Survey participant frequency of exercise with music

To assess listening habits during exercise, participants were asked to rate the frequency with which they exercise whilst listening to music as observed in Figure 16. 51.3% of participants estimated they listen to music from most to all the time. Whereas 10.3% estimated to listen to music for approximately half of their exercise routines. Participants who listened to music sporadically to not at all made up a total of 38.8% of responses.

This survey question demonstrated the prevalence of music during exercise whereby 83.8% of runners surveyed stated they listened to music in some or all circumstances. This aligns with the known use of music by both skilled and amateur runners for its ergogenic effects on endurance and resistance based exercise, by modulating physiological responses such as heart rate, and muscle activation, through to psychological effects on mood and motivation (Ballmann, 2021). Those who didn't listen to music in any circumstance were primarily composed of those who do not use running technology either.

11. What are the main features you look for in a song for it to be included in your exercise/walking playlist?

Participants were asked to identify musical features they enjoyed and used to select music for their exercise routines. Responses were categorised into a set of codes that encapsulate general themes relating to musical features participants were responsive to. The coding used is as follows:

- Energetic Beat
- Happy/Upbeat
- Motivational/Inspirational
- Meditative
- Songs from Personal Library
- Music with lyrics
- BPM that matches target pace
- Specific Genres

22 participants stated they chose exercise music based on its perceived level of intensity, to feel energised. Responses in this category were classified by use of language relating to concepts of 'energy, power and fast tempo'.

'Bouncy sounding or angry' – Participant 7

'The sort of track that would fit well dubbed over the training montage scene in any of the Rocky films. Or over any fast-paced fight scene…' – Participant 61

'I look for a continuous beat in the music, not the calm type but the ones that will make you want to raise your performance. The faster the beat the bigger the effort' – Participant 11

For the category of 'Happy/Upbeat' features, 26 responses were codified by their use of language that implies an emotional response of happiness or elation to a piece of music. This response was often described to be elicited by 'upbeat' songs with positive lyrics. This category shared some overlap with the energetic beat category, in that participants described deriving motivation from songs with a high tempo and choice of instrumentation/lyrical content that creates a sense of purpose.

'Recognisable tune, motivational uplifting lyrics' – Participant 14

'Life affirming – uplifting' – Participant 91

'Steady rhythm is very important but emotional moments are also nice (especially during a race) …' Participant 36

17 participants stated that they looked for music they felt was motivational to them. This category classifies abstract responses in which participants did not provide context as to what it is that makes a piece of music motivational to them. This particular question elucidates the complexity of capturing data relating to participants' affective experience of sound and music and the difficulty non-audio professionals encounter when expressing their experiences of sonic and musical phenomena (Droumeva and McGregor, 2014a)

'Sound motivational' – Participant 17

'I need something that inspires me' - Participant 41

'A beat I can exercise to. Really upbeat songs that make me wanna keep going.' - Participant 4

4 Participants stated they looked for music that helped them enter a meditative state of relaxation or concentration. Similarly, to the 'Motivational' category, little context was provided as to what music facilitated participants to achieve this state during exercise.

'Cheerful, relaxing, and that can help me clear my mind' - Participant 25

'Easy for me to get lost in and focus on my breathing and running rhythm …' - Participant 6

13 participants stated they did not look for any specific feature in music other than it being in their personal library or playlist. This category of responses gives insight into the importance placed on the ergogenic effect of music runners' have a connection to. There is a marked difference on the impact of the ergogenic effect on exercise performance between preferred vs non-preferred music (Ballmann et al., 2018), thus the tendency for people to select music from their personal libraries regardless of genre is common.

Likewise, 8 participants stated they preferred music which contained lyrics they connect to. In conjunction with the previous group of responses, the ergogenic effect of lyric driven music is of great importance due to the personal connection the listener may have to a particular song. Participants

stated they often enjoyed singing whilst running, which exemplifies the embodied experience of music and the physiological and psychological effects it has on exercise performance (Bigliassi et al., 2018).

Additionally, there were 17 mentions of participants actively selecting music by its tempo to match their run pace to the rhythm of the music. Whilst there is some similarity to the group of participants who expressed their preference for high intensity music for their exercise routines, this group of responses differs in the expressed active process of attempting to match the pace of their run to the tempo of the music. Studies suggest there is an influence of music tempo on walking/running pace either through spontaneous or active synchronisation or through ergogenic motivation (Franěk et al., 2014; Hamish G MacDougall, 2005), the extent to which runners achieve this synchronisation during the run is largely dependent on several variables such as, ability to accurately identify the bpm of music and the ability to maintain concentration during active listening whilst running.

Finally, 9 participants responded with specific genres they listened to. These genres correlated with previous responses in the survey, which include high intensity music like punk rock and heavy metal, through to dance music for steady constant beats and hip-hop for its lyrical content and narrative. These genres encompass the features outlined by the previous categories but help gain an insight into the type of contemporary music genres amateur runners enjoy listening to.

12. How musical do you consider yourself to be?

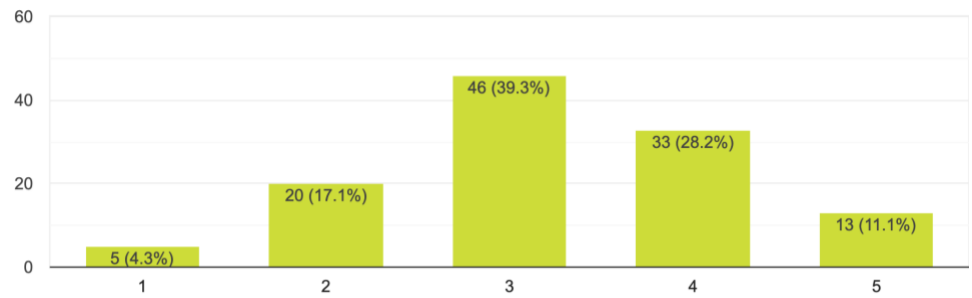

Figure 17 - Survey participant perceived level of musicality

To conclude the survey, participants were asked to rate their level of musicality. The concept of 'Musicality' was left up to the respondents' interpretation to assess the level of confidence participants feel when thinking and discussing their musical experience. As seen in Figure 17, 39.3% of responses provided show that participants evaluated themselves to be somewhat musical, whilst

39.3% evaluated themselves on the higher scales of musicality. This division in responses is surprising as participants rated themselves to be overall quite musical. This may stem from a connection between participants enjoyment of music whilst running and the attachment they have to the benefits it brings to their routines and serves to highlight the potential impact of harnessing those effects for technology design.

3.5 Insights and Further Work

The survey study provided a valuable initial exploration of the environment of amateur and experienced runners, by detailing their barriers to exercise adherence, motivations, technology use, levels of social engagement with other runners, musical preference and listening habits. The data capture in this survey was used to provide a qualitative overview of runners' experiences, despite the use of quantitative methods like the Likert scale. These quantitative methods were used to interpret how runners perceived their personal traits, such as musical ability or athletic proficiency and thus no quantitative analysis was applied to these results. Of particular interest to this project, was the prevalence of run-training technologies with advanced features. This shows an active interest and engagement with wearables and apps aimed at improving running performance, highlighting an active user-base in the design space this project aims to explore and is suggestive of users' willingness to engage with relatively complex technology. Additionally, participants highlighted interesting key issues they have with current technologies, namely usability and interaction, which suggest the design space identified in Figure 1 has not been addressed by current technologies people are using, thus providing potential design queues for the latter stages of this project.

Furthermore, the relationship between runners and their listening habits was elucidated in detail by the participants descriptions of their personal listening habits when exercising and preferred musical features. This set of data likewise serve as valuable design-space insights, as they describe mechanisms by which participants overcome barriers to motivation and adherence and signify the level of importance participants put on using music as a tool for improving their performance and overall experience of exercise.

Having captured an initial snapshot of the design-space this project aims to explore; the next stage of the project was designed to build on this preliminary consideration of the environment and ecology

of amateur and experienced runners. Maintaining a strict user-centred focus, a cultural probe study was developed to capture more serendipitous, ephemeral, and personal data in the wild. The results of the survey study in conjunction with those of the cultural probe study would then be used as basis to develop design ideas and prototypes for the latter stages of this project.

4 Cultural Probe Study

4.1 Abstract

The Cultural Probe method is evaluated and presented as a key tool for exploring end-users' ecologies and environments. It's unobtrusive and creative nature makes it suitable to capture serendipitous moments and insights in users' experience that more formal methods which produce more considered answers do not capture. A background of the original method is presented, followed by a review of its adoption into technology design disciplines such as HCI and the impact it has had on design methodologies. A methodological approach to cultural probe design is presented as a blueprint on how to incorporate it into new disciplines and based on this approach a probe study is created as part of a user-centric approach to the design of an auditory display for run training. The results of the probes and subsequent interviews are analysed and presented as a set of personas and scenarios that capture amateur runners' environments and experiences of running and run-training technology and serve to inform the implementation of initial prototypes.

4.2 Introduction

As a response for the need to further engage with the users that are ultimately influenced by the designs and interventions that result from HCI research, the adoption of user-centred approaches has seen proliferation in this field. User-centred design provides a framework of processes, which aim to engage with end users and consider the implications design decisions may have on them throughout every stage of the design process (Norman and Draper, 1987). As such, user-centred methods of inquiry have been amalgamated into HCI research, of which the cultural probe method has seen extensive use. These approaches have historically created tensions amongst the HCI community relating to the adoption of design-based approaches within the typically scientific framework of traditional HCI (Gulliksen et al., 1999; Karat and Karat, 2003; Vredenburg et al., 2002). However, despite these tensions, user-centred approaches continue to be an important and developing area of discussion due to their ability to create dialogues between end users, designers, and researchers.

Auditory display research is in itself a branch of HCI and in recent years user-centric approaches to design have begun to be used in the field of auditory display (Droumeva and McGregor, 2014b; Furlong and Roddy, 2020). As such, exploring the tools developed and formalised in the more established HCI community, as tools for design in auditory display research, is a motivation of this

project and tested through the development of a cultural probe study focussed on developing an auditory interface for runners. In addition, Personas, another tool developed in the design-thinking philosophy is employed to make sense of the complex qualitative data user-centric methods usually produce. Personas are idealised characters representing the user-types that form a particular environment / ecology and are used to understand the context into which designs created fit (Chang et al., 2008; Miaskiewicz and Kozar, 2011). In the following sections the development and deployment of a cultural probe study, followed by the creation of personas derived from the probe data is presented. Finally, the data captured is used to identify a set of design implementations and the process by which these designs are created based on the probe data is expounded.

4.3 Cultural Probe Study

4.3.1 Study Design

Having identified the cultural probe as a valuable method for exploring users' cultures, environments, and emotions, it was determined it would suit the preliminary phases of this project, as a means for the researcher to familiarise himself with the design space from the perspective of users. Taking heed of the tensions and shortcomings that the cultural probe method presents, a 'probological' approach was employed to the probe design. That is, instead of adopting the traditional probe packet of the camera, postcards, diary, etc. as a given, a dedicated probe would be devised for this study by carefully considering the environment and context in which participants would be using the probe.

Thus, the following three design goals were proposed to guide the development and execution of these cultural probes:

- **Portability -** As the focus of the project is to explore the environment of runners, it was identified as an initial design point the need to create a probe with components that would be portable, for capturing data in the field.
- **Immediacy -** Probes should capture emotions, thoughts, and moments in real-time, so as not to let memory, or over-thinking colour participants' answers. Thus, any activity required by the probe should be easily executed with minimal materials and thought from the user.
- **Playfulness –** The cultural probe, by definition, should encourage and promote user participation, thus through embedded playfulness the probe should stimulate the user's

curiosity, creativity and imagination. This outcome is important for providing serendipitous and honest results as well as ensuring a better completion rate amongst the sampled population.

Having clearly defined the design intentions behind the probe, several key elements and decisions were framed. Firstly, through the parameter of portability the traditional probe packet was ruled out due to its composition of many separate elements such as, the camera, diary, postcards, making it less appropriate for the context of running. Secondly, the immediacy of the traditional probe packet activities is not always suitable for the context of running if participants are required to write thoughts in a diary or postcard activity. Finally, the paradigm of playfulness is always a factor in cultural probes, so the traditional probe packet had some useful teachings in this area. The concept of open-ended activities often framed in surrealist or Dadaist perspectives was a key element the researcher wished to retain.

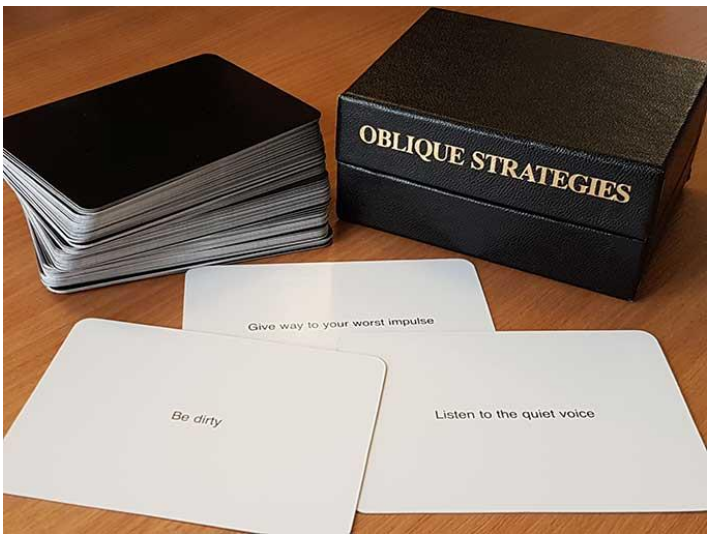

Figure 18 - Example Deck of Brain Eno's Oblique Strategies (Taylor, 1997)

Through the above considerations and taking inspiration from Brian Eno's 'Oblique Strategies', a card-based method for promoting creativity in music (Figure 18), whereby users draw a card to reveal a printed set of instructions that are often absurd, surreal and open to interpretation. The aim of such interactions is to stimulate user's creativity through lateral and abstract thinking.

Thus, for this project a set of oblique strategies for runners would be developed into the form of a deck of twenty individual cards with the following set of rules.

1. Participants are encouraged to draw a card just before any running session they are to carry out and complete the task on it. Completion will occur pre, post or during run depending on task.
2. Participants are allowed to compete as many activities as they wish/can in the timeframe specified by the researcher.
3. Each activity on the card is designed to be brief, entertaining, and able to be recorded either directly onto the card itself or as a video on the user's mobile phone if necessary.

Through this ad hoc methodological redesign of the cultural probe packet, a successful implementation of the three design goals of portability, immediacy and playfulness was achieved. Additionally, many elements of the original cultural probe method such as the open-ended activities, cards, camera, and diary entries, were readapted to explore the ecology of run-training technologies. The minimised packet of a single set of card activities with space to capture written responses in conjunction with the mobile phone as the recording media for any activities that required capturing images or sound, enabled the capture of rich data for actioning design ideas. The 30 activity cards developed can be found in the following section under Figures 19, 20 and 21.

4.3.2 Probe Cards

Figure 19 – Probe activity card set 1

Figure 20 – Probe activity card set 2

Figure 21 – Probe activity card set 3

4.3.3 Deployment

Participants were recruited via posts on the online running forum runnersworld.com, Facebook running enthusiast groups, University societies and through word of mouth. Additionally, 3 participants who completed the initial survey study volunteered to participate in the probe study, completing a total of seven participants for this phase of the design and research process.

To proceed, volunteers were supplied with a participant pack containing information about the project, contact details, terms and the required consent forms required to comply with ethical regulations of the study. Once participants returned their consent to take part in the study, the probe packet was either posted out or delivered in person to the participants. The design of the probe packet as a set of cards and its incorporation of the users' mobile phones meant participants with a broad geographical distribution across the UK were able to complete and return the study.

Participants were asked to complete the probe study at their leisure across a period of maximum 4 weeks, with no prescriptive number of activities to complete. This allowed for participants to feel at ease and no pressure on behalf of the researchers to complete the study by modifying their behaviour outside of their usual activities. Participants were told to complete one probe card activity per exercise, giving an estimated range total of 8-28 activity cards completed per participant, based on the survey data indicating a large segment of participants in the running enthusiast demographic exercised between 2 – 7 days a week.

Once the probe study was completed, participants returned the completed activity cards via post or as photographs via email alongside any relevant images or video captured by the participants. The probe study was followed up by an in-depth interview to capture musings and reflections by participants regarding their answers and overall experience. These interviews were carried out via online conference call.

4.4 Probe Results

4.4.1 Transcription

Once all seven participants returned their probes and interviews completed, the text on the activity cards, alongside the interview recording data were transcribed and input into Atlast.ti qualitative analysis tool. Upon transcription all physical data that could identify participants was destroyed to protect confidentiality. Qualitative text data was then grouped into participant profiles and codified in order to capture key words, concepts and nuances across all data collected, these codes are presented in the following sections. Each participant profile was then used to create a persona capturing the key takeaway of users' environments and experiences. These personas were then used to motivate a design perspective and instantiate design decisions into 'soft prototypes' for the next phase of the project.

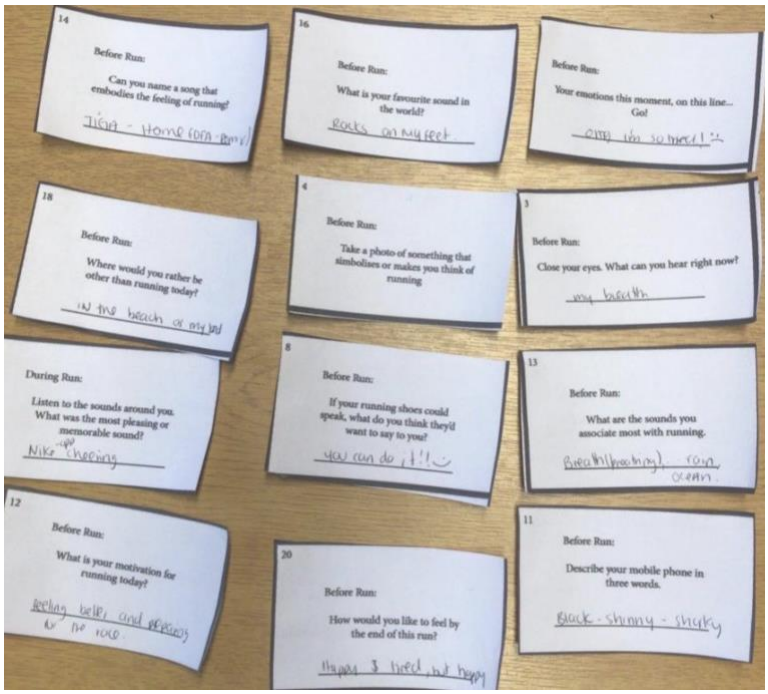

Figure 22 – Example of completed probe activity cards

In the following sections the coding structure used to codify the transcribed probe activity data is presented. The completed probe activities showcasing participants' responses to the random cards drawn throughout the length of their participation (example in Figure 22), alongside the conversations captured at the post-probe interviews are presented as transcribed scripts from the original audio/video recordings of each participant interview in Appendix 2.

4.4.2 Interview and Probe Study Code Structure

In this section the code structure developed to categorise and classify the data collected from the probes and interviews is presented. 5 overarching codes with relevant subcodes were derived by using the background literature for this project to answer the research question: *What are users' experiences of run training technology and music/auditory feedback during exercise?* This research question is then framed through the embodiment and ecological framework to develop the subcodes into categories that probe the data for queues used to identify key environmental and ecological facets of runners' experiences of running, technology, and sound. Relevant sources that informed the construction of each branch of the code structure can be found under the relevant code categories.

4.4.2.1 Code Structure

1. **Environmental/ecological factors of exercise**
    a. Auditory perception during exercise
    b. Running as a social practice
    c. Running outdoors vs. indoors
    d. Salient features of the environment

Sources:

Hirose, N., 2002. An ecological approach to embodiment and cognition. Cognitive Systems Research, Situated and Embodied Cognition 3, 289–299. https://doi.org/10.1016/S1389-0417(02)00044-X

Droumeva, M., McGregor, I., 2014. A Method for Comparative Evaluation of Listening to Auditory Displays by Designers and Users [WWW Document]. URL https://smartech.gatech.edu/handle/1853/52062 (accessed 1.24.16).

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Rosli, M.H.W., Cabrera, A., 2015. Gestalt Principles in Multimodal Data Representation. IEEE Computer Graphics and Applications 35, 80–87. https://doi.org/10.1109/MCG.2015.29

Tuuri, K., Eerola, T., 2012. Formulating a Revised Taxonomy for Modes of Listening. Journal of New Music Research 41, 137–152. https://doi.org/10.1080/09298215.2011.614951

Vickers, P., 2012. Ways of listening and modes of being: electroacoustic auditory display. Journal of Sonic Studies 2, 1–23.

2. **Experience of Auditory feedback in run training technologies**
    a. Auditory feedback as a motivator
    b. Effectiveness of auditory feedback
    c. issues with auditory feedback

Sources:

Dallam, G.M., Wilber, R.L., Jadelis, K., Fletcher, G., Romanov, N., 2005. Effect of a global alteration of running technique on kinematics and economy. Journal of Sports Sciences 23, 757–764. https://doi.org/10.1080/02640410400022003

Eriksson, M., Bresin, R., 2010. Improving Running Mechanics by Use of Interactive Sonification, in: Proceedings of Ison 2010, 3rd Interactive Sonification Workshop. Presented at the Ison 2010 Interactive Sonification Workshop, KTH, Stockholm, Sweden.

Messier, S.P., Cirillo, K.J., 1989. Effects of a verbal and visual feedback system on running technique, perceived exertion and running economy in female novice runners. Journal of Sports Sciences 7, 113–126. https://doi.org/10.1080/02640418908729830

Schuurmans, T.W.G., 2006. Motivating joggers through adaptive music feedback. Eindhoven University of Technology, Eindhoven, Netherlands.

Sigrist, R., Rauter, G., Riener, R., Wolf, P., 2012. Augmented visual, auditory, haptic, and multimodal feedback in motor learning: A review. Psychon Bull Rev 20, 21–53. https://doi.org/10.3758/s13423-012-0333-8

3. **Experience of Run Training technology**
    a. Choice of running tech
    b. Technology / data as a motivator
    c. Technology as a tech fad
    d. Feelings/emotions regarding run training technology
    e. Issues with technology

Sources:

Consolvo, S., Everitt, K., Smith, I., Landay, J.A., 2006. Design requirements for technologies that encourage physical activity, in: Proceedings of the SIGCHI Conference on Human

Factors in Computing Systems, CHI '06. Association for Computing Machinery, Montréal, Québec, Canada, pp. 457–466. https://doi.org/10.1145/1124772.1124840

Hutchison, A., 2016. Do all those stats matter? [WWW Document]. Runner's World. URL http://www.runnersworld.co.uk/training/do-all-those-stats-matter/14474.html (accessed 1.25.16).

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4. Experience, Feelings and Adherence to Exercise

a. Detractor for adherence
b. Exercise Preference
c. Motivator for adherence
d. Perspective of personal experience with exercise

Sources:

Strike and Injury Rates in Endurance Runners: A Retrospective Study. Med. Sci. Sports Exerc. 44, 1325–1334. https://doi.org/10.1249/MSS.0b013e3182465115

Kluitenberg, B., van Der Worp, H., 2014. RISK FACTORS FOR RUNNING RELATED INJURIES IN NOVICE RUNNERS PARTICIPATING IN A 6-WEEK RUNNING PROGRAM. Br. J. Sports Med. 48, 620. https://doi.org/10.1136/bjsports-2014-093494.164

Knaving, K., Woźniak, P., Fjeld, M., Björk, S., 2015. Flow is Not Enough: Understanding the Needs of Advanced Amateur Runners to Design Motivation Technology, in: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, CHI '15. ACM, New York, NY, USA, pp. 2013–2022. https://doi.org/10.1145/2702123.2702542

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5. **Music as an ergogenic aid:**
    a. Music for Motivation / mood
    b. Music for dissociation
    c. Features of preferred exercise music
    d. Instances where music is not preferred

Sources:

Ballmann, C.G., McCullum, M.J., Rogers, R.R., Marshall, M.M., Williams, T.D., 2021. Effects of Preferred vs. Nonpreferred Music on Resistance Exercise Performance. Journal of Strength. https://doi.org/10.1519/JSC.0000000000002981

Campbell, C.R., White, K.R.G., 2015. Working It Out: Examining the Psychological Effects of Music on Moderate-Intensity Exercise. Psi Chi Journal of Psychological Research 20, 73–79. https://doi.org/10.24839/2164-8204.JN20.2.73

Ziv, G., Lidor, R., 2011. Music, Exercise Performance, and Adherence in Clinical Populations and in the Elderly: A Review. Journal of Clinical Sport Psychology 5, 1–23.

4.4.2.2 Code Analysis

The results from the interview and probe coding are presented in Appendix 3 as a comprehensive code report detailing the codification of the transcribed participant interviews. The codified data was subsequently used to isolate meaningful features of each participants' ecosystem in the form of quotations and used to synthesise user personas that embody the motivations, barriers, and desires of amateur runners.

The code structure presented in the previous section, maps out the process of classifying interview data to capture ecological/environmental features of running experience, use of run training technology, motivations and barriers to exercise, experience of auditory displays in contemporary run training technologies, and use of music as an ergogenic aid to improve overall exercise experience. This classification was then used to populate the different sections of the user personas. Following from the personas, the codified quotations were used to derive design cues to explore in the participatory workshops and further refined and implemented at the porotype design phase of this study.

4.4.3 Personas

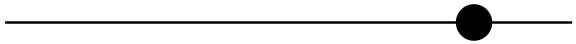
Persona 1:

Steve

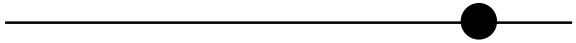
Casual runner passionate about music

Age	25-34
Sex	Male
Occupation	Student

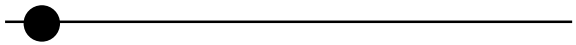
Weekly Exercise



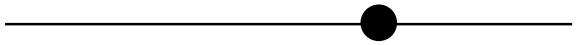
Tech Savviness



Social Runner



Musicality



"When I run without music, I feel like I'm wasting time and I find myself constantly thinking about how boring it is to exercise."

Motivations

- To live a longer life spending more time with the people I love.
- Having a manageable low-intensity routine
- Using apps to challenge myself to beat my previous run's stats.
- Reflecting and planning exercise to meet goals

Barriers

- The amount of dedication needed before reaping rewards.
- Running without music.
- Feelings of guilt of not exercising regularly enough.
- Difficulty scheduling exercise around work and social life

Running and Tech

- Experienced app user
- Uses a run focussed smartwatch
- Enjoys user-friendly apps that don't require too much to learn.
- Find detailed and customisable data metrics enjoyable and motivating.

Audio Feedback

- Dislikes ringtones, notifications and alarms.
- Prefers to wear headphones
- Thinks app sounds could be more enjoyable
- Uses app verbal feedback for warm-up and training exercises.

Music Preferences

- Music to distract from the monotony of running.
- I like music that has a sense of movement that drives you forward or upward.
- Music that inspires me, Like, when you hear a song a friend sent you.

My story

I grew up in a sporty family, my parents always signed me up for sports activities, it just never stuck in adult life ait is important to live healthier in order to spend more time with the people I love in the long run.

Over the past 5 years I have taught myself how to run using apps. I enjoy running apps because they help me motivate myself.

I prefer running on my own, to keep concentration on what I am doing, but also because I like listening to music to distract from the unpleasantness of running and feel motivated by the sounds.

I consider myself to be somewhat musical as I play keys and guitar, but I've always felt I struggle keeping a good rhythm and I think this shows when I'm dancing!

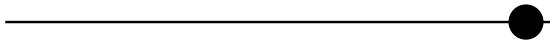
Persona 2:

Rhian

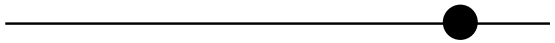
Beach-loving, gadget obsessed, on a recent health kick.

Age	25-34
Sex	Female
Occupation	Student

Weekly Exercise

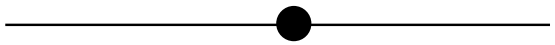


Tech Savviness



Social Runner

Musicality



"I love the feeling of being outside running. The feeling of the ocean breeze while you run is an incredible feeling"

Motivations for running

- To enjoy indulgent food and snacks but avoid diabetes and heart disease.
- To energise and lift mood throughout the day
- Tracking progress with smartwatch
- Smartwatch notifications and reminders
- Reciprocal encouragement when exercising with friends.
- Training for marathons and social races.

Barriers

- Feeling overwhelmed or tired from exercising too often.
- Social, family and academic responsibilities.
- Chatty friends at the gym.

Running and Tech

- Experienced app user
- Uses a variety apps for fitness and food intake tracking
- Hates in-app music playback, prefers using separate apps.
- Feels data is limited and would like features to help her improve her running technique.

Audio Feedback

- Loves encouraging vocal queues during run.
- Relies on time and distance updates for encouragement during run.
- Uses verbal feedback for training and warm-up exercises.

Music Preferences

- Happy upbeat music
- Hates melancholic music when exercising.
- Likes music that evokes happy nostalgic memories.
- Listens to music all the time except when doing yoga or exercising with friends.

My Story

I recently got back into exercising very seriously after having struggled maintaining my routine due to moving to another country! I am now comfortable in my new city and have fallen in love with tracking my exercise using my new smartwatch, since I am obsessed with gadgets and social media.

I love eating food with the people I love, but diabetes runs in my family, so I've decided to make more of an effort! I love exercising with my friends, we encourage each other, but I often prefer running on my own and lose myself listening to a happy beat that reminds me of being by the beach.

I would love if my gadgets could help me get even better at running as I have started training for 10k and marathon races and I want to go faster and farther!

Persona 3:

Jeff

Music obsessed, undiscplined, laidback

Age	35-44
Sex	Male
Occupation	Teacher

Weekly Exercise

Tech Savviness

Social Runner

Musicality

"I have had an on/off relationship with exercise there's been times where I have been good at keeping up with a routine, but I've never managed to make it stick."

Motivations for running

- Losing weight
- Feeling more energised
- Managing insomnia
- Intrinsically motivated after overcoming social stigmas of weight.

Barriers

- Feeling overwhelmed from setting too ambitious targets.
- Unhealthy body image.
- Societal and family pressures to exercise.
- Dislikes exercising with other people except partner.

Running and Tech

- Experienced technology user
- Enjoys tracking data, however, has become less dependent on that type of extrinsic motivation
- Enjoys training plans and exercise routines
- Hates social media.
- Loves technology.

Audio Feedback

- Uses verbal feedback for training and warm-up exercises.
- Hates verbal feedback during run due to interruption of music.
- Hates notifications and alarms.
- Dislikes 'cheesy' app gamification features like badges and tiers.

Music Preferences

- Loves running to new exciting songs.
- Enjoys channelling the energy of song into exercise intensity.
- Likes getting lost in a good song.
- Does not care about genre or tempo of music, could exercise to classical music.
- Dislikes gym music

My Story

I'm the most overweight I've ever been, so I have decided it's time to really get back into exercising. I recently found motivation by putting less pressure on myself by setting ambitious exercise targets, and I know enjoy doing what feels right for me, my body and my mind.

I used to be more obsessive about tracking my progress but having a smartwatch didn't make me more disciplined. I like the freedom of running without it, although I do find them a useful tool as I love technology and understand its potential.

I love the outdoors and I enjoy running by the river near my house and I find motivation in going to nice places and listening to music that inspires me to move.

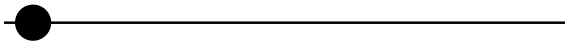
Persona 4:

Nora

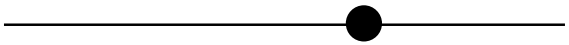
Hectic job, music fanatic, loves the outdoors, hates running.

Age	25-34
Sex	Female
Occupation	Producer

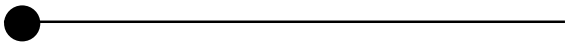
Weekly Exercise



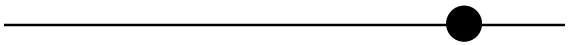
Tech Savviness



Social Runner



Musicality



"I have a trauma from school, where if you were good at something you would be rewarded and if you weren't you were made to feel a failure and I think that it influences my relationship with exercise"

Motivations

- Relieve stress
- Maintain fitness
- Improving focus at work
- Better mental health
- Friends

Barriers

- Bad weather
- Hectic work schedule
- Psychological triggers
- Lack of social support
- Difficulty maintaining discipline
- Self-conscious of appearance when running

Running and Tech

- Does not use fitness trackers
- Reluctant to invest in devices
- Enjoys social features of apps, but doesn't have enough peers to engage with

Music Preferences

- Listens to music of all genres
- Curates her own playlists to fit her mood
- Uses music as an ergogenic aid to overcome barriers to exercise.
- High-energy up-tempo music for exercising
- Dislikes commercial music and Spotify playlists

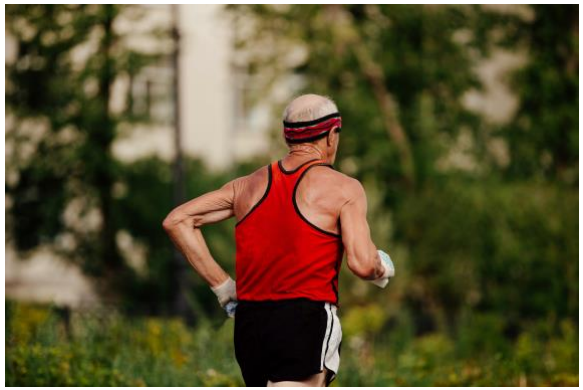
My Story

Running is something that I must really gear myself up to do, it's not something I do often because I associate many negative experiences and feelings towards it. I had a bad relationship with my PE teachers at school, which left me always feeling inadequate and bad at sport. To this day I still feel self-conscious about exercising, especially if there are other people around.

I have a very hectic schedule and often find myself away from home, making it difficult to maintain any sort of routine. I still try to do enough to maintain my level of fitness, improve my mental health and stave away the boredom and stress that piles up with work. This is also why I always prefer to run outside and have a connection with nature before going back and being chained to my desk for the rest of the day. I don't particularly use any running apps as my only goal is to maintain the level where I am, so I do what feels right for my body without having to track every activity or step.

I am passionate about music; I enjoy going to concerts and listening to all sorts of different things. I listen to radio and podcasts and therefore enjoy making my own playlists to fit whatever mood I'm in. I always use music to escape or help me push through the monotony of exercise.

Persona 5:

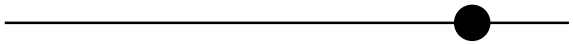


Charles

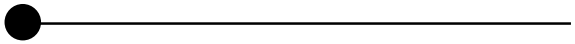
Expert runner, old school, can't live without music

Age	65-74
Sex	Male
Occupation	Retired

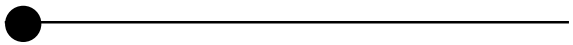
Weekly Exercise



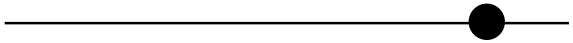
Tech Savviness



Social Runner



Musicality



"I spent my adolescence running several hundred miles a week and was successful in steeple chase competitions, so I have the background to know what I should be doing and what I shouldn't be doing with my body."

Motivations

- To maintain weight
- To live a longer life
- Pride in own appearance
- To be able to indulge in lots of food and snacks
- To feel free and elated
- Beautiful outdoor spaces
- Grey, damp and cool days

Barriers

- Price of running equipment/tech is too steep
- Geographical setting, outdoors over indoors, countryside over city.
- Highly intrinsically motivated

Running and Tech

- Has never used tech
- Due to expertise feels most features are too basic, while specialised equipment is too expensive.
- Feels most technology and gadgets are part of a tech fad and part of consumerist culture.
- Finds mobile phone and running technology frustrating as they are packed with features he does not need.

Auditory Feedback/Perception

- Hates the sound of HGV's as they signal danger on usual running route.
- Enjoys the sounds of the countryside and draws inspiration to run from them

Music Preferences

- Passionate for a wide range of genres.
- Music that evokes strong emotions
- Music for dissociation
- Prefers music with lyrics
- Has used music whilst exercising, but it's not part of regular routine.

My Story

I was lucky to grow up in the countryside running in cross-country races as a teenager and I have worked hard to carry on these efforts into my later years as I like challenging people's preconceptions of what someone my age can do.

I love listening to music, but I prefer to do this separately to my exercise. I need the sounds of nature to feel at home when I run, plus there's little space on narrow country lanes so I must listen out for oncoming traffic!

I am not interested in apps or running technology, I've been doing this for so long I am in tune with my body, and I know what I must do to maintain my fitness level. I also find technology frustrating as it is packed full of features, I have no interest for, and which seem designed to sell devices as part of the latest fad. Due to my age, I would consider using tech that helps me prevent injuries!

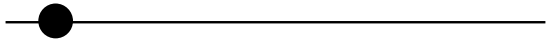
Persona 6:

Eleonore

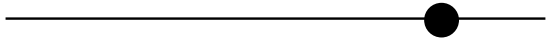
Age	25-34
Sex	Female
Occupation	Waitress

Weekly Exercise

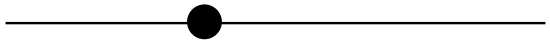
Tech Savviness



Social Runner



Musicality



"My dad was a sportsman played football my mom was always into yoga. I do think that influenced me a little bit in that I was brought up to do a lot of exercise."

Motivations for running

- Maintaining fitness level
- To feel uplifted
- To keep up with family traditions
- Intrinsically motivated
- Being connected to nature

Barriers

- Mood
- Weather

Running and Tech

- Laziness learning new technology
- Stuck in her old-school ways
- Could be interested in tracking progress to challenge herself.

Audio Feedback

- Lives near a busy road, hates all the traffic sounds.
- Likes the outdoors to connect with natural sounds

Music Preferences

- Music to push me to go faster
- Won't listen to music when she wants to connect with nature.
- High-energy, fast tempo for running
- Chilled out and relaxed for yoga
- Trance music for channelling that energy
- Uses Spotify playlists.

My Story

I work very long hours so and my job is quite physical. That means at the end of the day I can be very tired. I try to schedule my exercise around that, but luckily, I'm always quite motivated as I grew up in a very sporty family, so I've always been used to being very active.

I'm a little bit old-school so I don't ever use any apps, and I sometimes feel that could help challenge myself, however I am comfortable with what I do so no need to fix what's not broken!

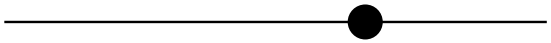
Persona 7:

Alberto

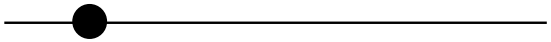
Ex-swimmer, ex-smoker, motivated runner

Age	25-34
Sex	Male
Occupation	Cook

Weekly Exercise



Tech Savviness



Social Runner

Musicality

"I prefer having a personal trainer and invest my money into that. There's something about the human connection that motivates you on those days when you're not quite up for it."

Motivations for running

- Combat effects of years of smoking
- Better respiratory health after operation
- Reciprocal motivation from exercising socially
- To lift mood and feel satisfied with achieving goals.

Barriers

- Work schedule
- Exercising alone
- Traffic and busy streets

Running and Tech

- Price of gadgets is too high.
- Prefers human contact
- Would buy a device which would help improve his running technique.
- Thinks assistive devices are too far in the future to think about.

Audio Feedback

- Does not use apps
- Enjoys connection to natural sounds
- Enjoys the sounds of other people having fun

Music Preferences

- Never listens to music when running.
- Only listens to music when doing strength straining.
- Creates personalised playlists on YouTube
- Fast paced upbeat electronic music, never pop music

My Story

I used to be a fanatic swimmer, exercising 5 or more days per week. I stopped swimming because I started smoking and partying a lot, and it sort of led to me stopping exercising altogether. I went through a few years of being unhealthy until I started noticing my breathing becoming very difficult, so I realised I didn't want that for my future, so I started exercising again.

I don't really use any apps or technology; I don't even really listen to music when I exercise. I find more enjoyment exercising with other people as this inspires me to push myself harder. I work very long hours, so I sometimes struggle to manage my work-social life balance.

4.5 Outcomes

The combination of the survey study, cultural probe and subsequent interviews for this research project yielded a rich spectrum of qualitative data, capturing musings and emotions felt within the environments of everyday amateur runners. The personas created from the codified data presented a mechanism to concretise the complex data into profiles that captured the serendipity, instantaneousness and embodiment of the human experience and ensured the individuality of each participant was faithfully expressed. Secondly, they provided a basis for deriving actionable design ideas by highlighting prominent features in the ecologies of amateur runners. The personas presented an opportunity to implement design thinking processes which retained an environmental/ecological focus whilst conjunctively being informed by secondary data in the literature and the researcher's own training and expertise. Presented below are the key insights resulting from the data analysis of the personas that would be used to implement initial prototypes in preparation for the participatory workshop phase of the study.

4.5.1 Emerging insights

Analysing the personas and interviews, prominent statements were used to identify potential design scenarios for creating outcomes that address key issues shared across the overall runner ecology encompassed by the personas. This iterative user-centric process was envisioned and deployed to create bottom-up designs that are flexible and able to satisfy a range of complex needs and fill gaps in the design space for run training technologies highlighted in Figure 1. The key takeaways from this process are presented below with the relevant quotations that informed them:

1. Users find some level of extrinsic motivation from activity tracking; however, this does not always translate to prolonged adherence to exercise or aid in improving running technique.
    - 'Using apps to challenge myself to beat my previous run's stats.'
    - Relies on time and distance updates for encouragement during run.
    - I would love if my gadgets could help me get even better at running as I have started training for 10k and marathon races and I want to go faster and farther!
    - I have fallen in love with tracking my exercise using my new smartwatch, since I am obsessed with gadgets and social media.

- I used to be more obsessive about tracking my progress but having a smartwatch didn't make me more disciplined. I like the freedom of running without it, although I do find them a useful tool as I love technology and understand its potential.
- Due to my age, I would consider using tech that helps me prevent injuries!

2. Feature-set and consequently price point of run training technology is an important factor influencing technology choice for amateur runners:
    - Reluctant to invest in devices
    - I don't particularly use any running apps as my only goal is to maintain the level where I am, so I do what feels right for my body without having to track every activity or step.
    - Price of running equipment/tech is too steep
    - It feels most technology and gadgets are part of a tech fad and part of consumerist culture
    - Due to expertise feels most features are too basic, while specialised equipment is too expensive.
    - *I enjoy tracking things accurately; I feel I wouldn't be satisfied with just knowing how long and far I have run. I like seeing how my average heart rate changes with the days, so those missing little details might make me a bit less motivated.*

3. Run training UI design is a key mechanism for engagement for both experienced and non-experienced users.
    - Enjoys user-friendly apps that don't require too much to learn.
    - Finds mobile phone and running tech frustrating as they are packed with features he does not need.
    - Dislikes ringtones, notifications, and alarms.
    - Hates notifications and alarms.
    - I have the motivation from my smartwatch which reminds me to do my activities so now I complete all my activities before 1pm because otherwise the watch sends me reminders after 1pm that I am being lazy.

- I chose Nike just because I like how easy it was to use and the exercise routines included has been very good and everything works for me, it connects to my apple watch, but I hate the feature of how it connects to Spotify.
- Thinks app sounds could be more enjoyable

4. Music selection as an ergogenic aid is an indispensable tool and key feature of amateur runners' ecologies and was discussed passionately and in detail by participants:
    - *"When I run without music, I feel like I'm wasting time and I find myself constantly thinking about how boring it is to exercise."*
    - Hates melancholic music when exercising.
    - Likes music that evokes happy nostalgic memories.
    - Listens to music all the time except when doing yoga or exercising with friends.
    - Hates verbal feedback during run due to interruption of music.
    - Loves running to exciting new songs.
    - Enjoys channelling the energy of song into exercise intensity.
    - Likes getting lost in a good song.
    - Uses music as an ergogenic aid to overcome barriers to exercise.
    - High-energy up-tempo music for exercising
    - Music that evokes strong emotions
    - Music for dissociation
    - Prefers music with lyrics
    - Music to distract from the monotony of running.
    - I like music that has a sense of movement that drives you forward or upward.
    - Music that inspires me, Like, when you hear a song a friend sent you.
    - Curates her own playlists to fit her mood
    - I love exercising with my friends, we encourage each other, but I often prefer running on my own and lose myself listening to a happy beat that reminds me of being by the beach.

5. The auditory and physical ecology of runners' environments influences mood motivation.
    - *I love the feeling of being outside running*
    - Hates the sound of HGV's as they signal danger on usual running route.
    - Enjoys the sounds of the countryside and draws inspiration to run from them
    - Because I love the feeling of being outside running especially in summer. I associate the beach with running because the feeling of the ocean breeze while you run is an incredible feeling.
    - *I like running in green areas, where you get more natural sounds like trees and birds or maybe also people walking, but I think people are not very good drivers and you often find yourself having to get distracted to see if a car is coming your way or sometimes some people just drive too fast, and the cars make such a loud sound.*

4.5.2 Design cues

Having classified participants' contributions into five key categories, a clear set of design areas were identified and used to synthesise preliminary ideas for a sonic interaction prototype to be tested during a set of participatory workshops. While these initial designs were influenced directly by participants responses, they were also informed by relevant auditory display and run training interface research to explore key design issues in the fields that have been highlighted throughout this project thus far. In the following sections, the process by which these insights were applied into design action is detailed by exploring the implications for design that each of the cues presented.

Design cues:

1. *'Users find some level of extrinsic motivation from activity tracking; however, this does not always translate to prolonged adherence to exercise or aid in improving running technique'.*

    This theme presented in participants' responses to the probe is of significance to this project in that it highlights the demand for interfaces that go beyond basic activity tracking, gamified motivators and social media interactions as the primary mechanisms for engagement. A certain desire for assistive interfaces which provide technique related data as opposed to

performance metrics as is commonplace in the majority of run training interfaces as highlighted in Figure 1 (Jensen and Mueller, 2014) seems to be present amongst a range of users.

Some participants who found a level of extrinsic motivation in using running technology felt that the common place feature-set of pace, distance, time and step count provided limited scope to improve beyond a certain point, however, they found motivation in the tracking of progress and felt this aided in adherence to exercise. On the other hand, participants who were not particularly interested in running technology, felt that assistive interfaces would be of more use to them for injury prevention and refining of technique to improve performance. Designs that

2. *Feature-set and consequently price point of run training technology is an important factor influencing technology choice for amateur runners*

In conjunction with the previous design cue, participants who were experienced with running stated they preferred or required more specialised interfaces to monitor and improve technique metrics (i.e., cadence, vertical oscillation, and foot-strike), while less experienced runners also stated a desire for devices to help improve their technique. However, despite the desire for these interfaces across a broad range of users, price point presented a barrier to those who wished to access these features. Participants felt that the level of investment to acquire such devices was too great and that they either had sufficient experience to know what to do to maintain the level of fitness they had, or that they could be better off spending the money on a personal trainer who could help them improve through face-to-face training. Less experienced participants were similarly dubious about investing on a device fearing the possibility they may not end up using in the long term.

These first two insights are of great significance to this project as they highlight a continued barrier to engagement with run training technology, based on available features and prices at which they are available in consumer level products. Thus, these design cues inform the design of this project by stimulating ideas to address the issues of creating an assistive interface to help runners improve their technique at an accessible price point.

3. *'Run training UI design is a key mechanism for engagement for both experienced and non-experienced users.'*

UI design is an influential force in driving engagement with run training technology for a broad range of users. Participants were particularly effusive about applications being obtrusive or not providing a seamless experience. This can be observed clearly in the below quotations:

> *I can't really see so many benefits of having so much data being collected, when I am so in tune with my body, and I feel having all that data will make me feel distracted if I have constant reminders of my bad posture or blood pressure or whatever.*

> *I started out with MapMyRun because a friend suggested it, but its free features were quite limited, and the app felt a bit boring. I switched to Nike+ because it felt simpler to use and a bit more friendly, but after a while it felt like it was a bit too gimmicky and not as informative as I would have liked, that's why I switched to Garmin.*

> *I don't like how the screen sometimes responds to touch and some of the button menus are weird. There was quite a lot of remembering to do when learning how to use it and I kept getting lost trying to find simple features like the stopwatch.*

These quotations highlight the desire for apps and technology to connect seamlessly to runners' everyday habits and routines, resulting in users switching applications in search for the optimum experience. This design cue is relevant to the design of an auditory display for run training in that one of the main goals of auditory display is to allow more natural activity and motion by reducing the need to interact with screen-based information. Furthermore, issues concerning ease of use are of great importance as with any auditory interface some level of user training is required. The impact and efficacy of auditory displays has been shown

to be affected by the ability of users to learn how to derive actionable information from the sonified data and thus a design approach that leads to applications with low barriers to entry is desired (Winters and Wanderley, 2014). As such, the environmental and ecological approach taken throughout this project has served to elucidate these issues with technology not fitting into runners' everyday ecologies.

4. *Music selection as an ergogenic aid is an indispensable tool and key feature of amateur runners' ecologies and was discussed passionately and in detail by participants.*

Music as an ergogenic aid has been well documented as an integral tool for both professional and amateur runners primarily by dampening the perceived rate of exertion during exercise (Ballmann, 2021; Barrett, 2015; Bigliassi et al., 2018; Sanchez et al., 2014). These studies suggest music provides a distraction from the physiological effects of strenuous exercise; this can be understood as the effect of 'losing oneself' as commonly described by participants relating their experiences of running with music. In addition, the ergogenic effects of music also extend to the modulation of states of emotion and mood in listeners, providing motivation through the embodied connection a person may have to their preferred music (Ballmann, 2021; Elliott et al., 2005; Hayakawa et al., 2000).

This particular design cue is of importance in designing an auditory display for runners as the choice of sonic interaction and sonic palette have great impact on the user experience of a given design (Barras and Vickers, 2011; Grond and Hermann, 2012; Weinberg and Thatcher, 2006). A successful application must see users feel engaged and able to modify their behaviour accurately in response to the sonic stimuli.

5. *The auditory and physical ecology of runners' environments influences mood and motivation.*

An understanding of the ecologies and environments of runners is a central tenet to the epistemology of this project. The lens of ecological and environmental cognition frames the situatedness and embodiment of the human experience as a crucial aspect of understanding behaviours and motivations of users that are shaped by the affordances in their individual environments (Gibson, 2014). The act of listening to sound and music is an embodied

experience generating physiological responses to physical stimuli from our surroundings, and as such, users' interactions with auditory stimuli do not occur in isolation from the environment (Roddy and Furlong, 2013; Wilde et al., 2017; Wilson and Foglia, 2017).

This embodiment is clearly expressed in participants' statements, whereby a level of extrinsic motivation was derived from the physical environment and sonic landscape they exercised in. Auditory cues stemming from natural sources were cited as a central feature of runners' environments that produced motivational responses in participants. The connection to nature through birdsong, water flowing and wind amongst others, gave participants some level of inspiration to adhere to exercise or overcome barriers they associate with running. Similarly, a connection to the built and industrialised environment was also cited as a prominent feature, however with more negative connotations attached to these auditory elements. Traffic noise was of prominence as a detractor from the sonic experience on two levels, first on the noise pollution aspect of motorised transport, and secondly the dangers vehicles present to runners exercising in proximity of roads. These affordances elucidated by participants' responses help understand the sonic environment into which any designs created will fit, and similarly to design cue 4, where understanding the embodied relationship to music, helps make design decisions on aesthetics and format of any auditory display designs.

4.5.3 Design Actions

Having identified 5 key areas for design, a process of actioning those insights into sonic interaction prototypes was initiated. In this section, each design decision implemented and to be tested in the participatory workshops is clearly outlined. The process of interpretation of each design cue is detailed and related back to the gaps identified in run training technology and auditory display design.

1. Design action 1 – Use of running technique targeted biofeedback

   Derived from design cue 1 and 2, This action was crucial for informing the design of an interface that provides continued extrinsic motivation to users by tangibly helping them

improve their technique and harnessing the pleasure and empowerment participants felt from completing their exercise goals. This design action responds to the gap in assistive run training interfaces that currently exists in commercial applications (Dobkin and Dorsch, 2011; Jensen and Mueller, 2014) and is clearly in demand by users as stated in the data captured thus far. This confirmed the design focus to be that of creating a system for capturing and displaying technique related data through sonic interactions for users to modify their behaviour. Coupled with the concern of price point of devices capable of measuring technique related data, this ultimately informed the selection of an accelerometer and gyroscope sensor.

Inertial motion sensing units (IMUs) have progressed rapidly in the last decade offering up to 9-axis of motion sensing from combined accelerometer, gyroscope, and magnetometer modules with low energy consumption. Most importantly costs have dramatically decreased with examples trading as low as £8.06 for a 6-axis MPU6050 module (Figure 23) at time of writing. These IMUs can be easily incorporated onto custom made chipboards and implemented into mass-produced devices at a relatively low cost.

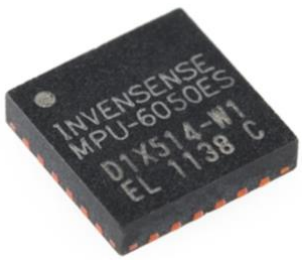


Figure 23 – 6-Axis Gyro/Accelerometer IC – MPU-6050 (SparkFun, 2021)

2. Design Action 2 – Creation of intuitive and unobtrusive sonic interactions that integrate into runners' ecologies seamlessly.

Derived from design cues 3 and 4, this design action aimed to address usability issues that runners have with the current ecosystem of run training interfaces. Firstly, runners stated that they looked for interfaces that were easy to use but were still informative enough to progress their technique and performance. Having confirmed the focus of creating an assistive

interface, this cue served to inform parameters for the type of sonic interactions to be used and the mechanism for sonification. Secondly, participants were effusive in expressing their relationship with music as an indispensable component and ergogenic aid to their running experience. This coupled with ease of use of technology being such integral components of runners' environments, a key decision was made to create a sonic interaction that would occur on top of users' preferred music, as a tool which modifies the audio output to the listeners headphones. This type of interaction was chosen as opposed to a sonification tool that generates real-time synthesised sounds, as has been commonplace in auditory display applications thus far (Bauer and Kratschmar, 2015; Biehl et al., 2006; Lepervanche, 2013).

Applications whereby data is sonified faithfully through real-time sound synthesis techniques may provide accurate data representations, however they often result in a sonic experience that is unlike music and thus everyday listeners may not derive a positive user experience from (Henkelmann, 2007; Walker and Kramer, 2005). In such an application where an auditory interface is being designed for an activity where users will habitually listen to a particular type of preferred music, this design cue suggests that a real-time synthesis sonification may not be best suited. Such an application could suffer from low long-term engagement from everyday users, as the ergogenic effects of music may not be engaged. Studies into the impact of preferred music versus non-preferred music on exercise performance have documented the overall importance preferred music plays on delivering the ergogenic benefits to individuals over non-preferred music (Ballmann et al., 2018; Lingham and Theorell, 2009; Nakamura et al., 2010). As such, the sonification system designed would be composed of adaptive music playback mapped to data relayed from a body mounted IMU sensor.

3. Design action 3 – Exploring bone-conduction headphone playback for safety and connection to environment.

Participants stated concerns with the safety of listening to music on busy city roads or narrow country lanes as a prime feature of the environment, therefore this concern informed the decision to explore methods of playback that enhanced user safety. Bone-conduction headphones (Figure 24) engage the auditory system through vibrations transmitted via the skull's bone structures via a vibrating transducer placed on the temples of the listener. This

type of playback mechanism allows the ear canal to remain unblocked and permit the perception of environmental sounds, resulting in increased awareness of surrounding for increased safety.

Figure 24 – AfterShokz Air bone-conduction headphones (AfterShokz, 2021)

Furthermore, bone-conduction headphones can be worn with earplugs to isolate environmental sounds and increase the bass-frequency response of the audio. This flexibility permits users to have the option to engage with the sonic landscape of their environments or to isolate themselves to focus purely on the music to engage its ergogenic effects. While it is out of the scope of this study to evaluate the performance of bone-conduction headphones over traditional in-ear mechanisms, it is important to assess if their relative performance allows for the accurate perception of the sonic interactions designed. Thus, in conjunction with design action 1 which determined the type of sensor to be used for sonifying data, the full hardware system of sensor-playback system to be tested was defined.

4.6 Further Work

Having extracted initial avenues for design from the probe into runners' environments, and implementing them into clear design actions and goals, the process of testing and refining the resulting ideations was necessary. Further retaining the ecological/environmental focus, a series of participatory workshops were envisioned to test the implementations. By presenting potential users with initial applications, an opportunity to take their considerations and reactions into account and integrate them into the design process was made possible. Participatory workshops enabled to retain a connection to runners' environments at a more advance stage of design, and ensuring any refinements and modifications were in response to real world user input. In the following sections the prototype architecture and sonic interaction types to be tested are detailed alongside a background into the theory and application of participatory workshops in human-computer interaction and auditory display research.

5 Participatory Workshops and Prototype Design

5.1 Abstract

The data from the Cultural Probe study presented opportunities to implement design ideas in the form of a basic sonic interaction prototype for testing potential implementations of an ecological auditory interface for runners. This prototype in turn was used to inform the design of a series of Participatory Design workshops where participants explored the different sonic interactions and scenarios developed from the design cues identified from the previous two studies. The following sections present the process by which the environments and ecologies brought to life by the personas created for the cultural probe study influenced prototype designs.

Having built a rigorous ecological and embodied design framework consisting of a survey study, cultural probe study and set of participatory workshops; the insight into participants experiences of running technology and prototypic sonic interactions have been carefully considered and mapped to further design actions.

In the following chapter the lessons learned from the previous studies, are implemented into a targeted auditory interface for the correction of Forward Head Posture (FHP). There is a significant body of work exploring assistive interfaces for posture correction, mainly from medical research, scientific studies of the behaviours in the workplace and use of mobile devices (Koseki et al., 2019; Lee et al., 2017; Sui et al., 2019). However, there is a distinct lack of applications for providing real-time posture corrective assistance in run training applications. FHP impacts running kinematics and respiratory efficiency and is therefore a key area for design. In these final studies, user-centric designs are implemented into a sonic interaction interface prototype and evaluated by participants through testing the system during running. Data for the participant experiences of the prototype were captured via reflective questionnaires and interviews. Participants reported a positive experience of the sensor system and sonic interaction algorithms, whilst also suggesting key areas for refinement and development. Key theoretical takeaways and contributions to the fields are presented within the overarching theme of ecological and embodied design presented in this project.

5.2 Introduction

By exploring the environment of amateur runners through the initial survey, cultural probe study and interviews, a user-centred design-space has been identified and used to stimulate design ideas in response to the qualitative data captured. The personas created were presented as an embodiment of the ecology of runners, their listening habits and technology use and enabled the researcher to transform the techniques stemming from design-thinking research into design-action. The resulting outcomes were the creation of the initial ‘soft’ prototypes to test out in a set of participatory workshops with a further set of participants. This was crucial to further reinforcing the ecological and embodied approach to design by making participants part of the technology design process and not just the ‘user requirements’ gathering stage of traditional projects with an information-processing focus instead of a user-centric approach.

Having instantiated preliminary designs derived from cues in the cultural probe study and further building the understanding of these design implications through the participatory workshops, section 5.7 of this chapter details the process of implementing a working prototype derived from an ecological and environmental user-centric design process. The sonic interaction strategies and designs derived through the workshops are further refined, focussed, and targeted into creating an auditory interface application to address the issues caused by 'forward head position' when running, which is a consequence of poor posture acquired through poor running technique, poor overall day-to-day posture or via pathological mechanism. This issue translates to inefficient running kinematics and can be exacerbated by intense physical exercise, causing injury to muscles in the neck. Running kinematics influence efficiency of motion, running performance and injury prevention/mitigation, therefore mastery and refinement of locomotion is a key target of professional athletes and of great benefit to everyday amateur runners. Modern run training technology has facilitated the monitoring of kinematic parameters such as vertical oscillation, gait analysis, cadence tracking, amongst other metrics useful for improving running technique. However, as highlighted by the goals of this project, assistive interfaces that can guide users, particularly novices, are still not commonplace and present a key design space for run training technologies.

In the following sections a methodology for the design of the participatory workshops carried out for this project is outlined, followed by an account of their deployment. Finally, the results captured from the workshops are presented and analysed in detail and with an evaluation on their influence on the prototype development and deployment of this project. The prototype development cycle is the presented and key outcomes are evaluated, exploring the impact of the participatory workshops and previous phases of the project on the ultimate outcome.

5.3 Participatory Workshops

5.3.1 Study Design

Having derived key design cues and subsequent design actions from the cultural probe and survey responses, a protype was developed in collaboration with a group of runners, to explore the design ideas inspired from the data. This allowed the researcher to obtain feedback derived from key stakeholders in the project to further refine the prototype whilst adhering to an ecological and embodied design framework.

In response to design cue 1 and 2, the first design action resulted in the decision to use running technique targeted biofeedback as the source of data to map. Based on this decision, the choice of using an Inertial Measurement Unit (IMU) as the primary sensor for the project was confirmed. The prototype IMU system (Figure 25) permitted the creation of a mock-up to present participants with an example of what a potential system could look like, and what type of sonic interactions could be attached to it. Furthermore, in exploring the embodiment and ecology of runners, these sensors allowed for 'bodystorming' whereby sensors could be placed on different parts of the body to understand participants feelings and perspectives on sensor location and consequently, what specific element of running technique they might want such a sensor to aid them with.

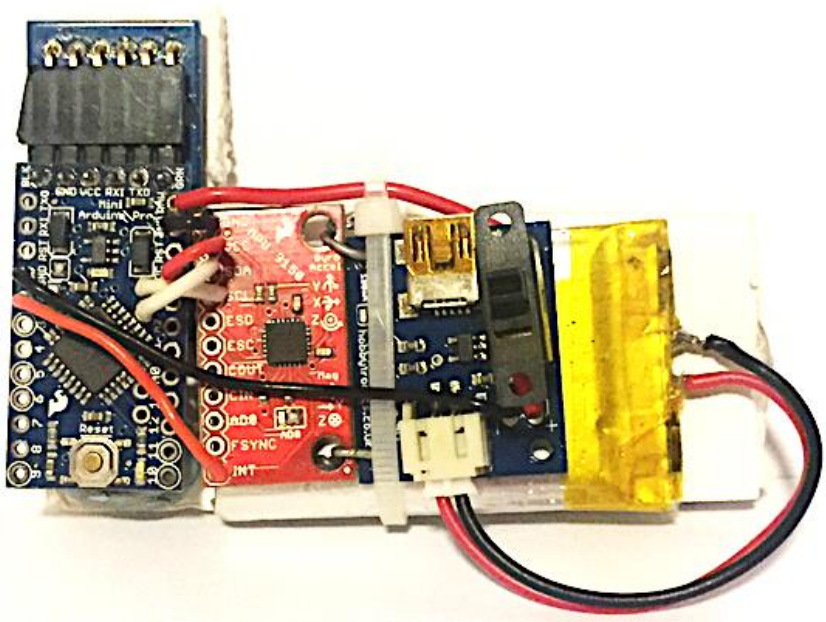


Figure 25 – Prototype sensor system for participatory workshops

In response to design cues 3 and 4, design action 2 determined the format for the sonic interactions to be tested. Having identified the importance of participants use of preferred music as an ergogenic aid, the key decision was made to not use real-time synthesis of sonifications. In order to retain the positive effects runners experience when listening to music they enjoyed, the decision was made to design a set of sonic interactions that permitted the manipulation of music that participants selected and normally listened to whilst running. Furthermore, this design action addresses issues participants raised regarding device prices. Costs of implementation of such a system are greatly reduced as it can run on a broader range of devices, and not just those with fast processing speeds. This openness and

accessibility thus align with the democratic nature of user-centric design. The resulting seven sonic interactions to be tested consist of:

- Hi-pass filter
- low-pass filter
- overdrive distortion
- frequency shifting
- pitch-shifting
- positive time-stretching
- negative time-stretching

These effects were chosen as potential mechanisms to modify the music playback and test participants reactions and perceptions to each type of sonic manipulation. The seven effects were chosen to test several qualities of the human auditory system as they operate across different spectrums of the audio signal. The first four: two filters, distortion, and frequency-shifting, modify the frequency spectrum of the audio signal, whereas the pitch-shifting and time-stretching effects operate on the temporal aspects of the audio signal. The perception of each effect is largely dependent on the sensitivity of the auditory system to different characteristics of sound signals, such as pitch or temporal shifts (Carlile et al., 2011), therefore it is important to test a range of signal manipulations that affect regions of auditory signals that have more or less sensitivity in different listening contexts.

These sonic interactions were the primary feature to be tested throughout the participatory workshops, with a particular focus on understanding the embodied experience of each of these interactions. A sample screengrab from the software created to test the seven interactions can be seen in Figure 26. The prototype was created using Max 8 for all the audio control and sensor data mapping, and Arduino for the IMU motion processing software loaded on the sensors system microprocessor.

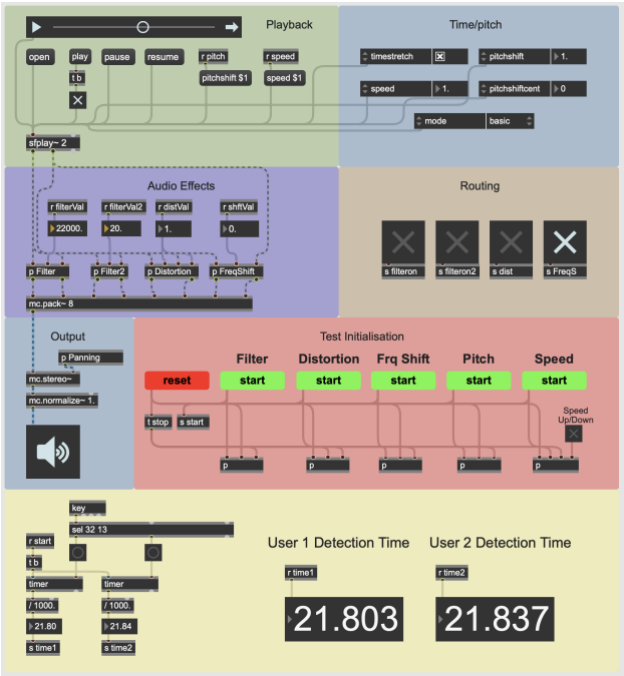


Figure 26 – Participatory Workshop Sonic Interaction Tester

The workshop format was designed to test each of the three design actions implemented from the probe data and consisted of four main activities:

1. An introductory discussion to get to know each participant and build rapport, this was intended as a relationship building exercise rather than for capturing actionable data.
2. A listening test, whereby participants were asked to listen to each of the seven interactions one by one and rate them using qualitative adjective pairs, assigning each sound a value between 0-2 for each adjective, 0 being the leftmost word, 2 the antonym on the right-hand column, and 1 being neutral (see Table 3 for adjective table). This method was chosen as it is a useful tool in perceptual research for assessing users perceptions and descriptions of sound qualities (Jurc and Jiricek, 2006) as well as other sensory stimuli (Okamoto et al., 2013).
3. A second listening test to capture the amount of time each participant took to notice each sonic interaction taking effect. Participants were given a remote-control button to click the moment they heard the interaction take place. This was done to evaluate which interactions were most notable and which parameters could be changed to make them more noticeable under different circumstances. Participants were shown how to modify parameters in the software for each effect, in order to tailor them to their liking.

4. A bodystorming exercise, whereby participants interact with the sensor mock-up system to get a feeling of how it might control the different sonic interactions and how those are translated into sound. Participants were asked to wear a rough prototype of the head mounted sensor system and asked to move around the space while paying attention to body-feel and emotions/feelings regarding the sensors on their head. Participants were then questioned on their experiences of the sensors to gauge their initial reactions to the rough prototype and overall concept of the technology. Bodystorming offers an opportunity to explore the embodied experience of the sensor system physically placed on the body, as well as the embodiment between the body movement and sonic interaction effect. This particular method has successfully been used across technology design disciplines like ubiquitous computing, HCI and design-based practices, as a tool for the consideration of physical, social, interactional, and psychological contextual factors crucial to design (Oulasvirta et al., 2003; Schleicher et al., 2010; Turmo Vidal et al., 2018).

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear								Unclear
Pleasant								Unpleasant
Positive								Negative
Airy								Solid
Smooth								Abrasive
Clean								Distorted
Motivating								Demotivating
Unobtrusive								Obtrusive
Calm								Energetic

Table 3 – Qualitative adjective table for participatory workshops

The resulting workshop schedule developed to guide the participants through the activities can be found in Appendix 4. The following sections detail the process of participant recruitment and deployment, followed by an in-depth analysis of the results captured across three participatory workshops.

5.3.2 Deployment

Participants were recruited via word of mouth, university, and social media message boards and at running clubs in Manchester. The participatory workshops were to be carried out in cohorts of two people, in a professional acoustically treated listening environment to ensure the integrity of listening tests and to faithfully capture participants contributions via audio recording. In order to maintain integrity amongst workshop results, the sonic interactions were set to modify a piece of music selected by the researcher based on qualities participants described their preferred exercise music to

contain in the previous studies for this project. The song was chosen for its broad frequency content instrumentation, upbeat tempo, combination of real and synthesised instrument and inclusion of vocals. This presented a useful backdrop to explore the frequency and temporal manipulations by allowing participants to experience changes across different parts of the auditory spectrum that encode information such as timbre, presence, spatialisation and pitch register amongst other sonic cues the auditory system can perceive.

Participants were then through the four main activities: initial open discussion, sonic interaction listening test, sonic interaction sensitivity test and sensor mock-up and bodystorming. The study concludes with a guided interview designed to stimulate a structured discussion on participants' experiences of the initial prototypes derived from the cultural probe phase of the study. Participants reactions to the technology presented, were captured, and codified to inform the further refinement of the prototype. Effect parameters that participants suggested were implemented and presented to the participants of subsequent workshops, each time repeating this process, to identify ideal parameters for the favoured sonic interactions to be deployed in the final prototype stage of this project. The results obtained from the participatory workshops and their implications for design are presented in the following sections.

5.4 Results

5.4.1 Transcription

The data collected for each participatory workshop is presented in the following sections. Activity 2 was completed by participants on printed handouts which were subsequently digitised and presented as the tables and comments in section 4.5.2. Timing data for the sonic interaction sensitivity test in Activity 3 were captured by the prototype software via remote-controlled button, the resulting data is presented in individual tables for each participant in section 4.5.3. Finally, the bodystorming session was captured in the form of guided questioning and captured via audio and video. Upon completion all recordings were transcribed, and original files destroyed to protect participant confidentiality. All textual data that captured embodied experience of the sonic interactions and sensor system are presented in section 4.5.4 as codified quotations captured in a custom-made code structure in Atlas.ti. Finally, the overall results are considered and evaluated for identifying further design cues and actions to implement in the final deployment of the sensor system.

5.4.2 Participatory Workshop Activity 1 Results

5.4.2.1 Participatory Workshop 1

Participant 1

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear	2	1	0	2	1	1	0	Unclear
Pleasant	1	0	2	2	2	1	1	Unpleasant
Positive	1	0	2	2	2	1	2	Negative
Airy	1	0	2	0	0	0	1	Solid
Smooth	1	2	1	2	1	0	2	Abrasive
Clean	1	1	2	2	1	0	2	Distorted
Motivating	0	2	2	2	2	1	2	Demotivating
Unobtrusive	1	2	2	2	2	2	2	Obtrusive
Calm	1	1	2	2	2	0	2	Energetic

Which of the 7 sound effects was your favourite why?
Second 2 because it keeps the melody in it, and it doesn't strip away or change the pacing or anything

Which was your least favourite and why?
3 because I stop recognizing at as the song I put on and its quite a disconcerting sound and feeling.

Participant 2

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear	2	0	2	0	0	0	0	Unclear
Pleasant	0	1	2	2	0	0	0	Unpleasant
Positive	2	0	2	2	0	1	0	Negative
Airy	2	0	2	2	0	2	0	Solid
Smooth	0	2	2	2	1	0	2	Abrasive
Clean	0	0	2	2	0	0	2	Distorted
Motivating	1	1	2	1	1	2	0	Demotivating
Unobtrusive	0	2	2	2	2	2	2	Obtrusive
Calm	0	2	2	2	2	0	2	Energetic

Which of the 7 sound effects was your favourite why?
Effect 2 was the easiest to understand and less dramatic of the lot. I enjoyed the ones that made the music speed up and slowed down but it kinda ruins the song a little bit and I don't think I would like to hear that all the time.

Which was your least favourite and why?
I didn't like sound 3 it made the music sound all distorted, and it sort of kills the mood a little bit, it also gets louder at some point so I don't think that would be nice with headphones.

Comments for next workshop:

Participants found the clarity of effect 1 very low and hard to perceive. With the low quotient setting of 0.2 for the filter curve and was also reflected in the sensitivity timing data of activity 3. On the other hand, the High-pass filter was more noticeable with the same quotient setting leading participants to adjust the quotient to a higher value after playing around with the settings of the filters. Thus, for workshop number 2 the participants were presented with the filter effects set to a quotient of 0.4. Likewise, the distortion effect was dialled back, and a level normalisation stage was added to the output of the distorted signal as participants stated they were concerned about such an effect played back through headphones.

5.4.2.2 Participatory Workshop 2

Participant 1

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear	0	0	0	2	2	0	0	Unclear
Pleasant	0	0	2	2	2	0	0	Unpleasant
Positive	0	0	2	2	2	0	0	Negative
Airy	2	0	2	0	2	0	2	Solid
Smooth	0	0	2	0	2	0	2	Abrasive
Clean	2	0	2	2	2	2	0	Distorted
Motivating	2	0	2	2	2	2	0	Demotivating
Unobtrusive	2	0	2	2	2	2	2	Obtrusive
Calm	0	0	2	2	2	0	2	Energetic

Which of the 7 sound effects was your favourite why?
Sound effect 2 was my favourite based on it giving me a very clear idea of what was going on and was not disconcerting to listen to.

Which was your least favourite and why?
Effect 4 and 5 were the worst, I didn't enjoy the way they made the music sound out of tune, it was very unpleasant.

Participant 2

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear	1	0	0	0	0	0	0	Unclear
Pleasant	1	1	2	2	1	0	2	Unpleasant
Positive	0	0	2	2	0	2	2	Negative
Airy	2	0	2	2	0	2	1	Solid
Smooth	0	2	2	2	1	0	2	Abrasive
Clean	0	0	2	2	0	0	2	Distorted
Motivating	1	0	2	2	1	1	2	Demotivating
Unobtrusive	0	2	2	2	2	2	2	Obtrusive

Calm	0	0	2	2	2	0	2	Energetic

Which of the 7 sound effects was your favourite why?
I preferred sound 1 and 2 they were the least dramatic or harsh of the lot, I suppose effect 6 was ok too, but I think it's the first two I prefer.

Which was your least favourite and why?
I disliked effect 3, the distortion was awful and not something I would like to listen to on a regular basis because it makes the music sound like it's from a bad quality recording.

Comments for next workshop:

The modifications implemented for the filter quotient value seemingly resulted in better intelligibility of the high-pass filter. This was demonstrated in the participants more positive reactions to the sound, as well as in the timing data of the sensitivity test, where participants were able to identify the effect faster. For the following workshop a higher quotient setting of 0.8 to further exaggerate the sonic interaction and test for further optimisation of this parameter.

Similarly, to workshop 1, participants derived the most displeasure from the distortion and frequency shifting algorithms. Stating the dissonance created by the frequency shifting inharmonic overtones gave them unpleasant experience. The pitch and time stretching algorithms were rated as more pleasant than effect 3 and 4, however, they were still rated as being obtrusive. Thus, for the next workshop the scaling and sensitivity of sonic interaction 5, 6 and 7 was modified to create a less dramatic change to the audio signal.

5.4.2.3 Participatory Workshop 3

Participant 1

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear	0	0	0	0	0	0	0	Unclear
Pleasant	1	2	2	1	0	1	0	Unpleasant
Positive	2	1	2	1	0	0	2	Negative
Airy	2	0	2	2	0	2	2	Solid
Smooth	0	2	2	2	2	1	0	Abrasive
Clean	0	0	2	2	0	2	0	Distorted
Motivating	1	1	2	1	1	1	1	Demotivating
Unobtrusive	2	2	2	2	2	2	2	Obtrusive
Calm	0	2	2	2	2	2	0	Energetic

Which of the 7 sound effects was your favourite why?
I kind of enjoyed number 5 it's just funny hearing the vocals go high pitched.

Which was your least favourite and why?
I think maybe 3 and 4, they're just too jarring and out of tune.

Participant 2

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear	0	0	1	1	0	0	0	Unclear
Pleasant	1	0	2	2	1	2	0	Unpleasant
Positive	0	0	2	2	1	1	1	Negative
Airy	2	0	1	0	0	1	2	Solid
Smooth	0	1	2	2	1	0	0	Abrasive
Clean	1	0	2	2	1	2	0	Distorted
Motivating	0	0	1	1	1	1	1	Demotivating
Unobtrusive	0	1	2	2	2	2	2	Obtrusive
Calm	0	0	1	1	2	2	0	Energetic

Which of the 7 sound effects was your favourite why?
I think maybe effect 2 and effect 1 because they didn't do too much to the sound, but you could still sort of hear what they do. Effect 1 has a metallic sound to it which I don't like so much so I think 1 overall.

Which was your least favourite and why?
Number 3 was a bit too distorted and made the music sound like cheap headphones.

Comments:

Participants were able to perceive the filter of effect 1 and 2 much more clearly, as captured in their ratings of clarity and timing data showing improved reaction time compared to previous participants. Despite the distortion effect being reduced to produce a milder effect, participants still equated it too poor-quality audio and disliked the overall experience of the sound. Finally, like in the previous workshops, temporal and pitch manipulations were variously rated as pleasant or unpleasant but were confirmed as obtrusive overall.

5.4.3 Participatory Workshop Activity 2 Results

Sound Effect	Time to notice effect (s)					
	Workshop 1		Workshop 2		Workshop 3	
	Participant 1	Participant 2	Participant 1	Participant 2	Participant 1	Participant 2
Low-Pass Filter	9.044	7.5	5.96	6.68	2.44	5.4

Hi-Pass Filter	2.23	0.7	1.37	0.53	0.95	0.44
Distortion	1.69	1.9	1.99	1.49	1.3	2.4
Frequency Shift	2.99	1.67	2.3	2.62	0.62	3.1
Pitch shift	0.8	1.01	1.04	0.71	1.12	0.78
Time shift (slow)	1.33	0.99	1.62	0.95	1.27	1.7
Time shift (fast)	1	1.81	1.26	1.47	0.48	1.31

Table 4 – Participatory workshop Activity 2 results

Table 4 above contains timing data for the sonic interaction sensitivity test, showing results for all 3 participatory workshops. Timings were captured using remote control MIDI buttons given to each participant to press the moment they noticed the effect take place from activation.

5.4.4 Participatory Workshop Activity 3 Results and Code Structure

The resulting guided discussions for activity 3 of the workshops were transcribed and codified using the code structure presented below. Each category served as a mechanism for classifying participant responses in order to consider potential design cues captured in the data. The code structure provided an opportunity for thematic analysis of the interviews by identifying responses that were repeated across the transcribed data that fit into the codes presented below. The relevant quotations captured in the thematic analysis are presented in Appendix 5 and are consequently evaluated in section 5.5.2 of this chapter.

Code Structure:

- Embodied Experience

Linked Codes:

← is a – ○ Feeling of Sensors on Body

← is a – ○ Integration into Runners' Ecologies

← is a – ○ Negative Emotional Experience

← is a – ○ Positive Emotional Experience

← is a – ○ Social Perception

- Experience of Running Technology

Linked Codes:

← is a – ○ Device Interactions

← is a – ○ Negative Experience of Running Tech

← is a – ○ Positive Experience of Running Tech

← is a – ○ Running Tech Features

- Experience of Sonic Interaction

Linked Codes:

← is a – ○ Interaction Mapping issues

← is a – ○ Sound – Action Perception

- Interface Design Cues

Linked Codes:

← is a – ○ Additional Feature Suggestion

← is a – ○ Sensor System Components

← is a – ○ System Reliability

5.5 Workshop Outcomes

5.5.1 Insights From Workshop Activities 1 and 2

Participants of Workshop 1 found the clarity of effect 1 very low and hard to perceive. With the low quotient setting of 0.2 for the filter curve, participants did not notice the effect until the 1-5k Hz region, this is also reflected in the sensitivity timing data of activity 3. This can arguably be attributed to the low-pass filter acting on the high-to-mid frequency range first, where frequency information related to presence and brightness is found. While the auditory system is most sensitive in this area, the ability for the brain to fill in and make up for frequency content information is well noted in this area, as exemplified in the narrow bandwidths of telephone auditory information and our ability to derive intelligible information from those signals. On the other hand, the high-pass filter was more noticeable with the same quotient setting, as it acts on the low frequency part of the spectrum, where the ear is least sensitive and more energy is needed in the signal for it to be perceived, as demonstrated by the equal-loudness curve in Figure 27. Any loss of energy is greatly perceived as a loss in the lack of body, fullness, and power of the sound; given modern popular music contains much

higher concentrations of low frequency information than music pre the year 2000, this could potentially influence the difference in performance of the two filters. Participants suggested adjusting the quotient to a higher value after playing around with the settings of the filters. Thus, for workshop number 2 the participants were presented with the filter effects set to a quotient of 0.4.

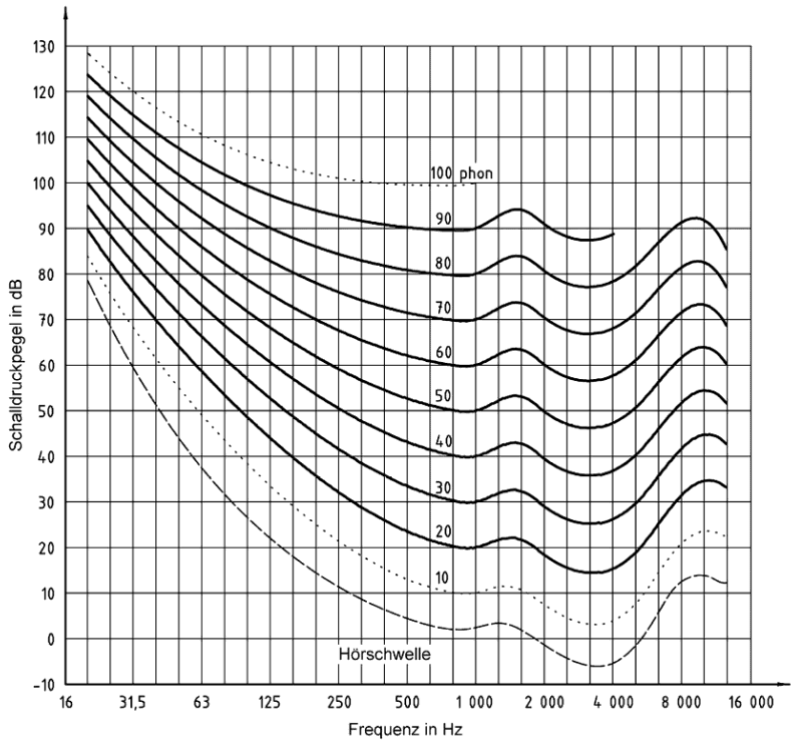


Figure 27 - Equal-loudness contour demonstrating sensitivity of human auditory system across frequency spectrum (Jordan, 2009)

Likewise, after feedback from workshop 1, the distortion effect was dialled back, and a level normalisation stage was added to the output of the distorted signal as participants stated they were concerned about such an effect played back through headphones. As the overdrive distortion effect increases, there is a gain increase resulting from the 'clipping' of the input audio signal. Clipping introduces new harmonic and inharmonic overtones in a signal through a non-linear process. Soft-clipping flattens the peak of the signal gradually, creating harmonic overtones, whereas, hard-clipping flattens the peaks of the input signal very abruptly, with the result of increased power output of higher harmonics through the effect of limiting and dynamic range compression (Figure 28). Hard clipping is achieved through increasing signal gain until the performance of circuit components is exceeded or 'overdriven'. The resulting squared-off waves produce sounds often described as harsh due to their inharmonic overtone content. Thus, as clipping is achieved through gain overloading, a normalisation stage to compensate for gain increase was introduced, likewise, to reduce harsh

inharmonic overtones the effect maximum gain increase was also added to address all participants' concerns about the effect.

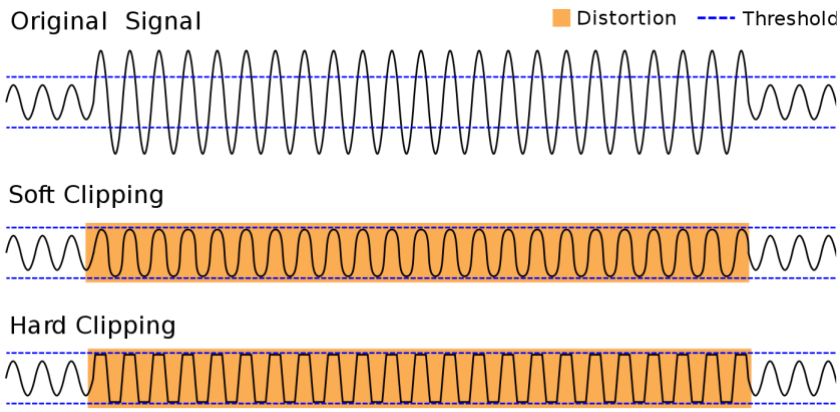


Figure 28 - Effects of distortion on signal amplitude (Iainf, 2007)

For Workshop 2, the modifications implemented for the filter quotient value, seemingly resulted in better intelligibility of the high-pass filter. This was demonstrated in the participants more positive reactions to the sound, describing the low pass filter as clearer, as well as in the timing data of the sensitivity test, where participants were able to identify the effect faster. This filter type however still did not outperform the low-pass filter in intelligibility or user preference. For the following workshop a higher quotient setting of 0.8 was used to further exaggerate the sonic interaction and test for further optimisation of this parameter. Similarly, to workshop 1, participants derived the most displeasure from the distortion and frequency shifting algorithms. Stating that the dissonance created by the frequency shifting inharmonic overtones gave them an unpleasant experience. The pitch and time stretching algorithms were rated as more pleasant than effect 3 and 4, throughout the first two workshops, however, they were still rated as being obtrusive. Thus, for the final workshop the scaling and sensitivity of sonic interaction 5, 6 and 7 was modified to create a less dramatic change to the audio signal. While this would make the effects more discreet, the overall manipulation results in fewer artifacts in the audio signal.

For the final workshop participants were able to perceive the filter of effect 1 and 2 much more clearly with the quotient setting of 1, as captured in their ratings of clarity and timing data, showing improved reaction time compared to previous participants. However, at this quotient setting the high-pass filter resonated a little bit and add a metallic timbre to the sound due to the ringing in the high-frequency

range; this was pointed out by one participant as unpleasant. Despite the distortion effect being reduced to produce a milder effect, participants equated it too poor-quality audio and disliked the overall experience of the sound. Finally, like the previous workshops, temporal and pitch manipulations were variously rated as pleasant or unpleasant but were confirmed as obtrusive overall.

5.5.2 Insights From Workshop Activity 3

The bodystorming activity yielded rich data about users' embodied experience of the prototypes tested for this phase of the study (Appendix 6). The resulting transcribed interviews were then encoded to classify the data into four broad areas of interest: embodied experience, previous experience of running technology, experience of sonic interaction and interface design cues. This categorisation allowed the integration of the data into actionable cues for design for the next phase of the project as well as future applications. The subcategories for each code helped isolate key quotations of interest to this study and of prominence across participants responses. These exemplary quotations are presented below with a rationale for the design cues derived from them.

- **Embodied Experience**

Linked Codes:

← is a – ○ **Feeling of Sensors on Body**

Given, the embodied approach to this project, this code served in identifying any concerns or issues regarding the physical placement of the sensors on the body. While some participants took some time adjusting to the sensation, for the most part this code suggests participants were able to accept the sensation quite easily.

- I would never wear a headband thing anyway but if it was like integrated into something a bit more covered like a hoodie or a or a hat? Yeah, I'd probably wear it.
- But I mean you can't really tell they're there because it's just like the pressure of the headband.
- you just get used to it don't you like everything you know if they're not heavy or whatever…

← is a – ○ **Integration into Runners' ecologies**

From the ecological perspective, it was important to understand the mechanisms and difficulty participants would find attempting to incorporate this device into their e3veryday ecology. Participants stated ease of integration with other devices as well as the need for use training to effectively use the system as main issues regarding integrating the device into their daily lives.

- You'd have to train yourself to like, you know, you're obviously the thing is, if you're wearing something like this, you're actively wearing it. So, you're actively deciding to use it as a device. So therefore, there's some kind of training that goes into calibrating yourself to it as well, like, but no,

- well, it should like to integrate with everything else obviously people use like smartwatches so I'm sure people wanted to connect to their other devices and just for it to be easy to set up you don't want to spend a lot of time before your run just trying to get it to work

- Yeah, I think it must be like tailored to different people, everyone will use it differently so maybe like have it with different pre-sets for different people or stuff like that.

← is a – ○ **Negative Emotional Experience**

It was important to capture emotive experiences runners have had with technology. Often, strong associations are made between negative experiences and adherence to exercise, thus, this quotation permitted a probing of these types of experiences.

- I feel really guilty when I don't complete training plans, and I get into this like rut or like habit of ignoring the notifications and reminders.

- I used to track my weight using my fitness pal, but I just kept getting depressed from not eating well and the app showing me all the crap I was eating

← is a – ○ **Positive Emotional Experience**

Similarly, capturing positive emotional associations was crucial to understanding runners' relationships to their habits and environment.

- I like things that look all techy like that, it's always fun to see how all those tiny things are connected.

- It's like the ultimate rave toy! I can control the music with my head bobbing up and down (laughs)

- It looks like something I was playing around with when I was 14, I used to love taking things apart and putting them back together.

← is a – ○ **Social Perception**

Social perception is key area of interest, as this forms an integral part to runners' ecologies. There is a certain sense of apprehension and lack of self-confidence, being exposed to other people whilst exercising. While some enjoy the social aspects of exercise, as per the quotes below and in other phases of this project, the embodied activity of running puts a spotlight on people's insecurities about their bodies and appearance, hence a desire for inconspicuousness.

- It looks sick. I'm sure there are some places where you could go where you'd fit right in but there aren't many of them

- yes, I'm sure they would notice something like this, I would like to avoid that

- yeah, I think that would make me feel self-conscious if I had wires sticking out all over me

- I think if it was more like compacted like it was kind of within the design of the actual material rather than it being an additional you know bolt-on then I don't think it wouldn't be like noticeable and I don't think anyone would think about it if you if you're out in running gear and when you are running it's like a different mentality because you see a lot of people with a million and one straps and things. I suppose it's not like I'm going to be popping to the pub with it on

● Experience of Running Technology

Linked Codes:

← is a – ○ **Device Interactions**

Key aspects of users' interactions with previous device use were of interest to this study in order to explore what kind of interaction participants have with technology in their normal settings. This aspect informed the type of interaction that might be expected with the system developed for this project:

- I look at my watch screen during exercise to see my pace and try to keep it up, I sometimes look at like the calories burned and heart rate graphs in my apple health app.

- So, I've got haptic on every kilometre. So yeah, pretty much every kilometre, I'm doing a look at it. Looking at the watch. Because it buzzes, not because I want to see it.

- I could quite happily live without it. I seem to use all that. But just because it's on all the time. But I think it's a bit obtrusive to have it buzz every five or six minutes.

← is a – ○ **Negative Experience of Running Tech**

Given the prerogative of this project of exploring embodied experience of technology, it was crucial to identify negative experiences with technology that may influence perception of new interventions in the ecology of runners.

- Just being obsessed with like weight and feeling bad for not doing exercise and having bought like fancy new gadget that you just don't end up using.

- also, it's just another thing to buy and to eventually turn into a landfill people have a lot of gadgets already.

- people just use gadgets and phones too much so it's not like we couldn't do exercise before it, so I don't know just it's another reason for people to use their phones

← is a – ○ **Positive Experience of Running Tech**

Like the previous point, positive interactions with technology were also important to capture,

- I have a smartwatch, which I do like using, I have it set to detect and begin tracking any sort of sustained activity like walking, so I capture all the bits of exercise I do throughout the day

- Definitely keeps me active, I love looking at my progress each week and like trying to beat records like my bike ride into work and things like that.

- So, I've got haptic on every kilometre. So yeah, pretty much every kilometre, I'm doing a look at it. Looking at the watch. Because it buzzes, not because I want to see it.

← is a – ○ **Running Tech Features**

- Just maybe for things to be cheaper so you can improve all your technique and get better without having to pay like two grand or something silly.

- Well, I'd like to remove the need for the devices. like I think we'll get to the point where you can probably put things inside yourself that give you information to your phone and stuff like that.

Experience of Sonic Interaction

Linked Codes:

← is a – ○ **Interaction Mapping issues**

Having identified key aspects of embodied experience, identifying key reactions to the prototypic sonic interactions was important to capture. Thus, this code aims to explore issues raised with data to sound mapping features of the system tested by participants.

- I think it needs like to have a thing that sets it to yourself because like everyone is different and like it could respond less abruptly so like when you just move your head to check where you are going it just doesn't cut out.

- Yeah, range is definitely too wide. I think maybe it's because it's your head it certainly seems like it's quite long-distance travel between each side. So definitely calibrate it to a smaller range of motion, but yeah you have quite a bit of control.

- You would have to calibrate because I feel it's fine if you're doing it slowly, if you do it quickly, I'm not so sure it's so easy.

← is a – ○ **Sound - Action Perception**

Having explored issues raised by participants with the previous code, this coding captured reflections of participants on the experience of perceiving the sound-action relationship of the sonic interaction algorithms.

- I mean yeah like you can see and feel how it works and I think you can practice getting used to it.

- I think you can tell what it's doing so is I suppose obtrusive cause like the music disappears

- That's so weird! It reacts pretty quick. definitely reacts very quickly It takes a bit to get used to, I think it definitely, like jolts you into in into noticing.

Interface Design Cues

Linked Codes:

← is a – ○ **Additional Feature Suggestion**

Features for further exploration suggested by participants were also captured to inform potential future designs or refinements to an auditory interface for runners.

- I mean maybe just something to help my posture like I'm always sitting down so maybe something to help out with that

- Yes, it seems like you could also use it in other applications as well as in running, that could maybe make it a very useful product

- just something that makes it a bit less noticeable I don't wanna have to always be thinking about having to track something.

← is a – ○ **Sensor System Components**

Comments made by participants on specific components of the system were captured to reflect on the experience of the physical device and its potential for incorporation in the ecology of a run training interface.

- I've seen those before and always thought they look really weird like they have a sort of minority report kind of sci-fi vibe, they remind me of the google glass. They sound ok, worse than normal headphones though.

- I mean yeah it would definitely have to be smaller and like hidden away

- well, it depends, if it was this size. I probably wouldn't wear it.

← is a – ○ **System Reliability**

Issues raised by participants regarding the reliability of the system in different scenarios was identified. This informed the study of concerns participants had raised with previous technology and in response to exploring the sensor system throughout the workshops.

- I think like with others its always the question if its accurate or not, like when you jiggle your arms and your Fitbit counts it as steps, you want these things to work especially if you pay for a nice gadget.

- I think it needs like to have a thing that sets it to yourself because like everyone is different and like it could respond less abruptly so like when you just move your head to check where you are going it just doesn't cut out.

- Definitely you would have to calibrate because I feel it's fine if you're doing it slowly, if you do it quickly, I'm not so sure it's so easy.

5.6 Further Work

Having implemented seven interaction types derived from design cues identified in the cultural probe study, the participatory workshops similarly afforded the project with cues for further refining designs. To simplify the system, a process of elimination was undertaken, whereby the sonic interactions mostly described as unpleasant were earmarked for removal from the final design whilst the most pleasant included for final modifications and implementation.

Design action 1:

Participants derived the most displeasure from effect 3 – overdrive distortion, associating it with adjectives such as 'obtrusive', 'demotivating', 'abrasive' and 'negative'. Likewise, it featured as the most disliked effect in the additional comment section of the handout completed by participants, being described as making the sound appear of low resolution and jarring. Thus, this was the first interaction to be discounted from the final designs. While different types of distortion could be used and tested due to it being very intelligible as an interaction, given the embodied experience of distortion as a 'negative' experience, it would make sense from an ecological standpoint that runners may not welcome such an interaction as a long-term feature of their environments.

Design action 2:

The sonic interactions derived from the filter presented the overall best experience for participants. These two effects were described as 'calm', 'unobtrusive' and 'pleasant' by most participants, with a slight inclination for the high-pass filter as the preferred interaction. Issues participants presented with the clarity and intelligibility of the low-pass filter were addressed through adjustment of the filter resonance or 'quotient' setting. This was evident in participants' ratings for clarity and perception timing improving with each consequent workshop. Given the positive experience of these effects the decision was made to include both filter types as the primary sonic interactions in the final implementation. The experiences described by participants suggest that from an ecological standpoint these interactions presented the most robust solution, as they impact the users' natural environments more minimally than the other effects presented. Additionally, given the issues with

intelligibility, a control for filter resonance could be added to allow users to make the effect more, or less pronounced to suit their level of perception and their environment.

Design Action 3:

Finally, effect 4 – frequency shifting, performed better than distortion. However, as the effect transposes frequencies of an input signal across the frequency spectrum, the harmonicity of the music is compromised, making it appear out of tune. Similarly, effect 5 – pitch shifting and effect 6 and 7 – positive/negative time-stretching, were cited as clear to understand and obtrusive yet less unpleasant than effect 3; this suggested the potential to include one of these interactions in the final stage of the project to test against the final selection, as despite their less welcomed effects, they were still ranked as highly intelligible overall. The decision was made to include the frequency shifting effect as the third mode of interaction to be implemented as the other three examples affect temporal aspects of the music. Given participant data reflecting the rhythm of the chosen music as a primary feature to trigger the ergogenic effects of music, these interactions were inappropriate as they affect the rhythm and tempo of the music, leading to a less natural and potentially unpleasant experience for the user. In the following sections the implementation of the design actions identified in the participatory workshop phase of the study are presented.

5.7 Prototype

5.7.1 Study Design

Having tested the seven prototype sonic interactions developed for the participatory workshops, the data collected was used to inform the development of a prototype auditory interface in the object-oriented programming Max 8. Two participants were recruited to test the prototype interface by completing three 5-minute outdoor runs to evaluate the three different pre-sets derived from the data of the previous study. During the three bouts of exercise, participants wore the sensor system and bone-conduction headphones, attempting to modify their posture in response to the auditory feedback. At the end of the exercise session, participants completed an interview to capture they're experiences (Appendix 6). This data was captured to evaluate user experience using the interface and inform the evaluation of the implemented designs from an ecological and embodied perspective. In the following sections, the design of the sensor system and sonic interaction algorithms is detailed, followed by a description of the deployment and the results obtained.

5.7.2 Sensor System Design

Having identified technique-related assistive biofeedback as the design space for this interface, and consequently selecting an Inertial Measurement Unit (IMU) as the sensor to capture technique related data based on positive results from the bodystorming sessions; a prototype sensor system consisting of an MPU9050 9-axis motion sensor, Arduino microprocessor, Bluetooth LTE module and LiPo battery was assembled. This system was refined from the initial architecture presented for the participatory workshops, by replacing power unit components to make the profile more discreet and the overall system much lighter. This was done in response to participants' embodied experience of the first system being too bulky and noticeable when attached to the body, particularly the head, resulting in participants feeling more self-conscious of their appearance with the device. The system was mounted on an elastic sports headband (Figure 29) and subsequently wrapped in waterproof fabric to hide the system components making it even more discreet, as well as to protect the device from sweat and moisture.

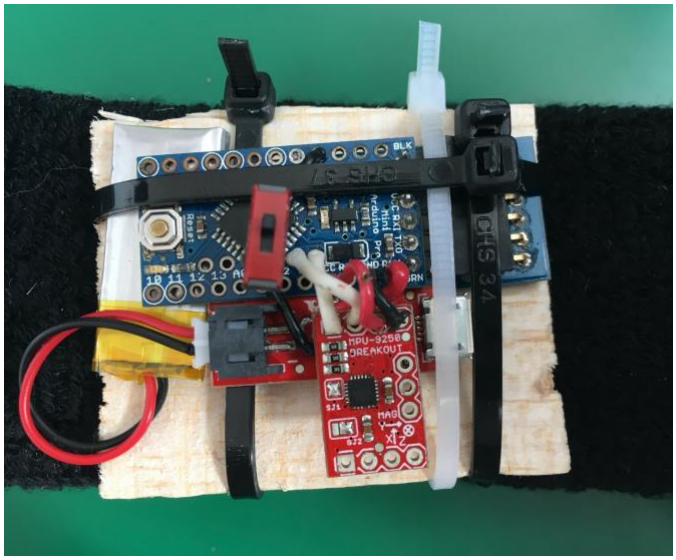


Figure 29 - Prototype sensor system, MPU9150 9-axis motion sensor, Arduino microprocessor, Bluetooth LTE module and LiPo battery pack mounted on sports headband.

The sensor system was programmed using the Arduino programming language, running on an ATMega 328 3.3V 8MHz microprocessor (microchip.com, 2021). This particular processor was chosen for its suitability and speed in processing continuous data streams from multiple sensors, in conjunction with reliable processing speeds for Bluetooth LTE serial data streaming (Arduino, 2021). Furthermore, it provided a very discreet profile to keep overall system weight down. Additionally, the MPU-9150 motion processing unit was chosen for its substantially small profile and in-built motion processing algorithms for fast motion-processing to capture accurate and discreet motion changes (InvenSense, 2013). Of these algorithms, the project made use of the gyroscope motion-processing features of the MP9150 to map head-neck tilt angle present in FHP (Lee et al., 2013). The data of the X-axis of the gyroscope was used to measure the principal deviation of the neck, as FHP only acts on one axis, it was not necessary to poll the other degrees of freedom available in the sensor; however, as a way of improving overall reliability and robustness of the sensor, a data fusion algorithm could be employed to incorporate the other degrees of freedom in the sensor to provide additional head posture data, although in the scope of this project this was not imperative. Additionally, the sensor was polled at a Baud rate of 9600 (or 9600 bits per second), this allowed sufficient resolution for the purpose for this type of device, whereby pinpoint accuracy was not required. This sampling rate was also determined by the Bluetooth module used, which due to its compact and low-cost nature works best at lower sampling rates. In a project less bound by budgetary constraints, a much more robust Bluetooth module could be used.

5.7.3 Sonic Interaction Design

The sonic interaction framework chosen for the prototype auditory interface was derived from the participatory data collected from the previous studies. Having implemented seven interaction types for the participatory workshops, participant responses afforded the researcher with cues for design action. The displeasure most participants derived from: effect 3 – overdrive distortion, effect 4 – frequency shifting, effect 5 – pitch shifting, effect 6, 7 – time stretching; indicated these interactions were obtrusive and, in many cases, participants stated the effect on the music made them feel uneasy. This insight led to the choice of testing the two filter types of effect 1 and 2 as the primary sonic interaction mechanisms, as they performed well in intelligibility and pleasantness ratings (see section 4.5.2). As the primary purpose of an ecological interface is to fit unobtrusively in an environment, these two interaction types offered the most efficient solutions. In addition, effect 5 – frequency shifting was included as an additional interaction type to test in the prototype. This choice served to contrast and compare performance of obtrusive versus unobtrusive interactions, both in their ability to inform the runner of their posture and in the embodied experience of the resulting interactions.

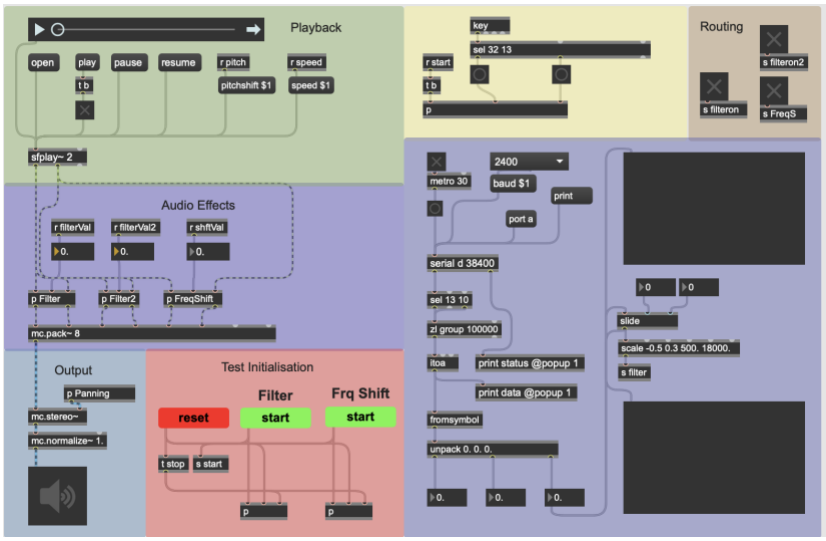


Figure 30 - Max/MSP Sonic Interaction Code

The auditory interface was created in the object—oriented programming language Max 8 for its audio processing capabilities and integration with sensor peripherals for audio manipulation. Furthermore, Max 8 offers rapid prototyping, allowing users and the research to easily implement and test modifications to parameters. The resulting interface can be viewed in Figure 30 and is

composed of the sonic interaction algorithm on the left-hand section, and the Bluetooth serial input processor for sensor data signal processing on the right-hand side.

$$y(n) = y(n-1) + ((x(n) - y(n-1))/slide)$$

Figure 31 - Low-pass filtering formula for sensor data taming (Cycling 74, 2018)

In order to filter noise from the gyroscope data, the formula in Figure 31 was applied via the slide object in Max 8. This filtering algorithm provides a useful mechanism for low-pass filtering, allowing to isolate meaningful or pronounced changes in motion. Furthermore, this allows more accurate envelope following of the incoming signal for mapping to the sonic interaction parameters. A given sample output from the slide object equates to the previous input value plus the difference between that value and the new input divided by the user-determined slide value. Thus, a slide value of 1 will always equal the input and provide instantaneous envelope following. In contrast, a slide value of 10 will change the output at 1/10th the rate of the input (Cycling 74, 2018). This feature was implemented in response to participant comments of the sensor reacting too quickly to meaningless motion, thus the slide algorithm allows the user to adjust the sensitivity of the sensor-to-audio interaction mapping to a comfortable level.

5.7.4 Deployment

Two participants were recruited from the group of previous participants who had completed the cultural probe and participatory workshops. Each participant was asked to complete a set of three runs, five minutes each, each time testing one of the three different sonic interactions whilst wearing the sensor system and modifying their head posture in response to the auditory feedback. Participants completed a post-run questionnaire at the end of each run to aid them in remembering their experiences during each bout of exercise for relating their thoughts later at the interview stage. Once the exercise sequence was completed, participants were interviewed to capture their immediate thoughts of the experiment and determine which of the sonic interactions best suited their experience. The results obtained are presented in the following sections, concluding with an evaluation of both the prototype system and sonic interaction algorithms, with considerations for future work presented.

5.8 Results

5.8.1 Transcription

The interview data collected for each participant in the final prototype study is presented in the following sections. Each interview was audio recorded and consequently digitised and original material destroyed upon completion to protect participant confidentiality. The interview schedule is presented in Appendix 7, while the transcribed interview text is presented in full in Appendix 8. The code structure in 5.8.2 (adapted from the code structure used in 5.4.4) is applied to classifying responses and presented in full in Appendix 9, this was used for consideration and identification of key features for further refinement of the prototype. This chapter concludes with an evaluation of outcomes, alongside closing remarks for future work and further prototype development.

5.8.2 Code Structure

- Embodied Experience

Linked Codes:

← is a – ○ Feeling of Sensors on Body

← is a – ○ Integration into Runners' Ecologies

← is a – ○ Negative Emotional Experience

← is a – ○ Positive Emotional Experience

← is a – ○ Social Perception

- Experience of Sonic Interaction

Linked Codes:

← is a – ○ Interaction Mapping issues

← is a – ○ Sound - Action Perception

- Interface Design Cues

Linked Codes:

← is a – ○ Additional Feature Suggestion

← is a – ○ Sensor System Components

← is a – ○ System Reliability

5.9 Outcomes

As in the Cultural Probe study of Chapter 4 and the participatory workshops of Chapter 5, the combination of techniques to elicit responses pertaining to the embodied experience of participants, yielded rich qualitative data for informing further refinement and development of the tested prototype. The code structure implemented in the previous section, maps out key insights taken from participants reactions to the implemented sonic interaction interface and physical protype, which are presented in the following sections.

5.9.1 Prototype Evaluation

On the physical components of the prototype, participants made key comments regarding the construction, mounting and body-feel of the device, reinforcing similar data gathered in previous phases of this study. Design outcome relating to the physical component are considered in this section.

Design Outcome 1:

Participants were overall comfortable wearing the head-mounted sensor, stating that previous experience with running equipment and technology meant they were used to exercising with elastic strap accessories around their body and limbs (see 'Feelings of Sensor on Body' coding). However, sensor casing was highlighted as a potential concern for system reliability and integrity, particularly in adverse weather (See 'system reliability' coding). This consideration, coupled with participants effusive thoughts on making the device discreet and integrated into garments captured in Chapter 4, suggests the desirability of an ecological interface that not only operates discreetly, but is physically discreet. Given technological advancements, such components could be printed on a custom-made circuit board with small footprint and integrated as a small bolt-on attachment, similar to cadence tracking pod sensors like the RunScribe system (Runscribe, 2016).

Design Outcome 2:

Participants were overall ambivalent about the use of bone-conduction headphones, however, a certain preference towards standard headphones was indicated. Whilst useful in achieving aims of greater environmental awareness, the desire to block out negatively associated sounds from the environment, namely traffic noise, seemed to be a priority. Whilst the goal of this study was not to

evaluate overall performance of bone-conduction headphones, further advancements to the technology may present interesting options for playback in other AD applications.

5.9.2 Sonic Interaction Evaluation

Regarding the sonic interactions, participants presented key insights into their experience of the systems' sensitivity to their movements and gave accounts of their thoughts on the specific perception of the movement to sound mappings. Design outcomes related to the sonic interaction algorithms are presented below.

Design Outcome 1:

A further issue presented was calibration, where participants stated the system was at times too sensitive and certain necessary head motions would trigger the interaction (see 'Sonic Interaction Mapping Issues' and 'Integration to Runners' Ecologies' codes). This suggests that the low-pass filtering applied to the sensor signal, although effective in smoothing the data-sound mapping gesture, could benefit from automated threshold detection, allowing users to exceed normal head posture limits briefly for reacting to the environment. Similarly, to the work by Lee et al, (2013), the sonic interaction could be triggered only when the user has exceeded normal head posture for more than a 'normal' period, with the added benefit in contrast to previous studies, of providing assistive feedback proportional to the modulation of the effect parameters.

Design Outcome 2:

Given the broad range of possible sonic interactions to test, coupled with the differences between different types of music a user might listen too; it is important to give the user control over a palette of interaction types, as different music may have different impact on intelligibility of effects in certain environments. The need for users to tweak parameters to perceive the effects is a key suggestion of this, and thus a system where participants could save their preferred settings would be desirable.

6 Conclusion

6.1 Key Insights and Contributions

This project set out to explore five key research questions that addressed key gaps in both the field of run training interfaces and auditory display research. By implementing an ecological and embodied approach to design, this thesis presented key methodological contributions to auditory display design theory by introducing related theory and techniques scantily applied in the field. The integration of these tools presents evidence of further convergence between HCI practices and AD design, and thus serves for aiding further formalisation of AD theory application. In addition, the contributions to the dialogue of run training interface design are tangible, having identified a clear design-space in commercial and research applications for technique assistive interfaces, thus further contributing to the design knowledge of this field of application. In the following segments, a discussion is presented on how each research question established at the beginning of the project was addressed.

> *RQ1. What is the user experience of listening to auditory biofeedback while running?*

RQ1 set out to explore the experience of auditory feedback in runners. Here experience was conceived through the lens of ecological and embodied design, defining it as the physical, emotional, and cognitive reactions produced by the user when attempting to derive meaning from sonic interactions. Thus, through an understanding of the user's physical, affective, and cultural environment, design ideas were facilitated to inform the creation of an auditory interface. Users' experience of auditory feedback was captured at each stage of the project, encompassing previous experience of feedback on commercial devices, through to the testing of the sonic interactions designed for this project.

The key insight stemming from the participatory data, relates participants find auditory feedback intrusive and obtrusive. This was gleaned from comments regarding commercial applications, whereby vocal feedback was deemed too robotic, and obstructive of the music playback, and thus not a desirable feature. Most participants either turned certain features off or used haptic feedback instead. The key mechanism of interaction presented for the prototype presented in chapter 5, however, aimed to address these issues by using participants preferred music as the feedback

mechanism. Participants reported pleasant and successful interactions with some of the sonic interactions designed, alluding to the possibility of further refining these unobtrusive feedback mechanisms for greater impact. This is of particular importance as the aim of an ecologically designed interfaces is to seamlessly integrate into a particular environment, and thus standard notifications and alarms do not fit this particular purpose.

RQ2. What sound designs/interactions influence positive behaviour change (improved kinematics) in the user?

This research question was posited to explore how an auditory display might guide behaviour change for improving running kinematics. Through a survey study, cultural probe, participatory workshop discussion, auditory perceptual tests, and prototype sonification testing; specific sound and interaction design requirements were identified to produce an ecologically efficient display. This research question also aimed to address key issues of 'design process' in sonification research through a detailed and transparent user-centric sonic interaction design process. This question is strongly related to RQ1, as the overall influence of user experience on behaviour change is intrinsic. Thus, the motivation to produce a positive user-experience via meaningful interactions that lead to positive behaviour change in runners was informed by this question.

The second layer program created to modify the output of users' headphones, permitting manipulation of preferred music, laid the initial groundwork for successful user experience. However, to further achieve the goals of an assistive interface, identifying what type of sonic interactions suited the modification of preferred music was imperative. Through the participatory workshops, seven interactions were presented to users, the results of which, indicated high and low pass filtering of the audio signal as the preferred modes of interaction. However, after having successfully identified interaction types that yielded a positive user -experience, one final issue was raised. Participants were vocal about the need for calibration of the sensor-interaction motion as it was too sensitive. This suggests potential applications in the future, should include controls for users to calibrate devices accurately, such as setting sensor sensitivity and threshold detection.

RQ3. What are the key incentives for users to adopt auditory interfaces within the context of run training interfaces?

While the first two research questions relate to the actualisation of auditory display research design goals, it was crucial the project also identified why auditory interfaces presented a potentially more efficient tool for improving motor skill training, over other alternatives such as haptic feedback or current screen-based solutions. As such an extensive literature review of auditory display research focussed on applications involving run training applications was carried out. From this secondary data, a key gap pertaining to assistive technique related applications was identified, since most successful applications focussed on improving or assisting performance metrics such as pace. Furthermore, background research on posture correction applications was also carried out, reinforcing the design space by identifying a key lack of auditory interfaces that provided assistive feedback over threshold crossing alarms. Thus, key motivations from medical research, auditory display research and sport science confirmed the validity of exploring auditory interfaces as mechanisms for assistive feedback. Additionally, participants were engaged by the unobtrusive design implemented, reinforcing the idea that appropriate design processes can lead to potential new applications that address user needs, in this case an assistive interface that is able to provide auditory feedback without disrupting the users' normal environment in a major way.

RQ4. What are the contributions to the auditory display research field resulting from adopting an ecological and embodied cognition approach to design of an auditory interface?

As covered in detail throughout this thesis, the AD research community has begun to move towards a more formalised definition of AD design theory. This has been reflected in the recontextualization of the field as a branch of design theory and human-computer interaction in recent publications (Barrass, 2015; Droumeva and McGregor, 2014a; Furlong and Roddy, 2020; Haffenden Cornejo, 2018). As such, it has been important to query the application of established design tools and methods and explore their use in AD research to identify any potential lessons or direct transference of theory that may be applied to future design. This project is novel in applying and adapting specific tools developed within the design and HCI communities to guide the process of development of an

auditory interface system for run training as proof of concept. The resulting application of survey studies, cultural probes, participatory workshops, and prototype testing, resulted in an intriguing collaboratively designed interface, that took careful consideration of how it would fit in a highly specified ecology. While the exact processes that enabled these outcomes to be achieved are not universally transferable to ecologies outside the one that framed this project, the true impact of this thesis comes from the methodological approach to design of an auditory display, as an example that builds on auditory display research by incorporating design-based processes in a novel way for the field. By identifying the trends in AD research and their confluence with HCI design practices, this thesis provides a thorough exploration of these principles in actions and lays groundwork for further study and application of these approaches in future AD work.

6.2 Limitations and Further Work

Given the cumulative knowledge acquired from the participation – design-action cycle presented throughout the different phases of this thesis, key areas for design and development for an auditory run training interface for FHP mitigation have been expounded. Despite largely positive tentative outcomes resulting from this process, due to the limitations of this project, a more robust set of data could have been produced by a second or third iteration of the prototype development cycle of Chapter 5, whereby the issues highlighted by participants could have been further addressed and the prototype refined to produce a more integrated experience. As such, future work would benefit from dedicating more resources to this section of the research, as well as the inclusion of more participants in order to map out common patterns amongst the experiences. Despite these limitations, the embodied and ecological design frameworks used to guide this study provided an iterative collaboration with users, aiding in the development of a conscientiously ecological interface tailored to their environments. Given the key gaps in AD research relating to user-centric design methodologies, this thesis presented a strong argument for further incorporation of design-thinking practices in the field. Future studies in this field can hopefully draw on the lessons learned through this process and adapt such methods as cultural probes, participatory workshops and bodystorming, as well as any of the vast range of other design-based methods in HCI research to future research projects in the field. Through these processes, certain biases in approaches to AD technology design can be mitigated, placing a greater onus on users in the development process of technologies that address their needs.

Key takeaways for the development of AD technology have been identified throughout this chapter and have laid the groundwork for future user-centric approaches to auditory run training interfaces for runners. A key theme running through the data captured in this thesis is the clear demand for assistive interfaces that aid users in improving their running technique. Such devices should be designed for discretion to minimise the psychological effects derived from sensor body-feel awareness, and ensure the device is more easily adopted. As such future studies will benefit from continuous advancement in the miniaturisation of new electronic components and testing the impact of more compact and discreet devices will likely yield more positive outcomes relating to technology adoption amongst users. Additionally, participants felt an initial sense of excitement to test new technologies, however, to create a more meaningful engagement that integrates efficiently into the runners' ecology, automatic calibration of the sensor and threshold detection should be included as features. This is necessary so that users in a dynamic environment where unpredictable motion is a likely possibility, don't feel penalised for temporary deviations from correct posture that have overall negligible impact on overall kinematics. Key areas for future work thus lie in the testing of different filtering algorithms such as Kalman Filters (Nagarajan et al., 2011; Srinivasan, 2018), which allow for multi-sensor data fusion processing for more accurate measurements of the other degrees of freedom available in the IMU used for this project. Likewise investigating mechanisms for sensor calibration would benefit the use of such systems in the wild, allowing for quick personalised calibration. The refinement of these features would benefit the prototype in engaging the user by providing better assistive feedback and seamless integration to their routines, which could translate to tangible results in improved technique and performance.

Participants did not report any negative comments regarding the choice of a second-layer sonic interaction implementation that acted on their preferred music. This is important as AD design has often suffered from usability issues relating to participants inability or inexperience of experiencing organised sound as something other than music. By retaining this prominent ecological feature of runners' environments and harnessing the use of music as an ergogenic aid, this implementation successfully integrates into the desired design space. Given this approach, future research would benefit from careful consideration of sonic interaction design decisions, moving away from the top-down approach commonly found in AD research. This has been exemplified by the plethora of sonification based projects that don't conform to users' ecologies and thus suffer from lack of overall usability despite their accuracy in sonifying data. In the final chapter, key theoretical takeaways for

both fields of run training and auditory display design are presented, alongside limitations of the project and areas for future work.

Given the above points left to be addressed to future work, it is important to bear in mind that this project was bound by the confines relating to the budget and manpower of a PhD research project, ultimately limiting the scope and reach of its aims. The amount of qualitative data generated at each stage of the project meant a significant portion of time was dedicated to capturing, transcribing, and codifying, in order to extract nuances and design cues for the researcher to act upon. Further work employing these methods on a broader scale with more participants, would ensure greater reliability in the assessment of the impact the methods presented could have. As such, further study of these processes and methodologies are a key incentive for the field of AD.

Further limitations stem from the components used for the prototype. A balance had to be struck between sensor reliability and costs, partly due to the philosophy of the project, but also due to equipment budget caps in the funding of this project. More reliable measurements and consequently more accurate sonic-interactions mappings are possible and should be tested in future projects les bound by budgetary constraints. While the overall purpose of the project was to contribute to the body of AD design theory, framing the applications of these methodologies through a proof of concept in a run training interface, meant the scope to test artifact mutability was restricted. As such, further exploration of the methodologies outlined in this thesis is encouraged across different applications of sport science, medical health, and recreation to further test the theoretical contributions outlined throughout the project.

6.3 Impact and Implications

The research in this project has ultimately had two major areas of impact. From the perspective of AD theory, current trends in the field were put to the test in a thorough iterative design process, evaluating theoretical contributions in the form of a successful implementation of an ecologically designed interface. These contributions to the AD field focus on building bridges between established design theory and emerging trends in AD research and as a consequence this thesis thus proposes a call to action to AD researchers to further amalgamate design-based tools and techniques, to help reinforce the innovative research already being produced by the community. Prominent researchers

in the field have begun advocating such practice and thus a continued interest to build on this body of research is a motivation for this researcher and future work related to this thesis. Secondly, from the perspective of the current trends in run training interfaces, an innovative application designed to improve runners' technique and prevent injuries was developed. The use of auditory feedback in contemporary running interfaces, presented a great opportunity to explore auditory displays as a vehicle for addressing the gap in assistive interfaces for runners. Furthermore, the contribution of embodied and ecological design to this aspect of the project was also tangible, as such processes have seldom been employed in the design of current applications and products. Additionally, this thesis presented an opportunity to explore assistive feedback for targeting issues relating to the impact of FHP in running kinematics, opening a new design space for run training interfaces.

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8 Publications and Contributions

Appointment as Technical Specialist – Manchester Metropolitan University, 2021

In collaboration with senior academic and professional services colleagues, I am responsible for the delivery and future direction of technical specialism in audio technology, AR/VR and UX at the School of Digital Arts (SODA). As acting Technical Services lead for SODA, I hold responsibility for development, adoption and embedding of these specialisms in education, research, and knowledge exchange activities, informed by the latest research in: Sound Design, User Experience Design and Human-computer Interaction.

WeatherSystems Data sonification - International Conference for Auditory Display, Newcastle, 2019

Generative composition driven by 30 hours of weather data collected in the Lake District. Designed with the application of aesthetic techniques to sonification, generating musical embodied metaphors of data. Arduino sensors and Max/MSP captured, processed, and quantised the data to trigger audio recordings and control different synthesis parameters. The resulting piece is a sonic analogy of a rainy day in the Lake District, where the sunrise and sunset can be experienced through sound.

Towards Ecological and Embodied Design of Auditory Display – International Conference for Auditory Display, Houghton, MI., 2018

An in-depth analysis on the emergence of design-based approaches in auditory display research by mapping out the progression of current research in the field. Through an ecological and embodied approach to perception and cognition, an evaluation of user-centric design strategies as tools for better understanding complex design spaces and improving usability is presented.

Speaker at the Get D #4 conference, Berlin, 2016

Guest speaker at Get D data decentralization conference, presenting on topics relating to the democratization of data through auditory display. A discussion on the potential of sonification and auditory interfaces to realize goals of decentralized computing by empowering users with user-friendly data analysis tools by leveraging the power for multimodal data interpretation of the human auditory system.

9 Appendices

9.1 Appendix 1 – Survey

1. What is your age?

- ◯ 18 to 24
- ◯ 25 to 34
- ◯ 35 to 44
- ◯ 45 to 54
- ◯ 55 to 64
- ◯ 65 to 74
- ◯ 75 or older

2. What is your gender?

- ◯ Female
- ◯ Male

* 3. In a typical week, how many days do you exercise?

- ◯ I don't regularly exercise
- ◯ Once a week
- ◯ 2 to 4 days a week
- ◯ 5 to 7 days a week

4. What do you feel is your level of expertise?

Beginner		Intermediate		Professional
◯	◯	◯	◯	◯

5. What is your main goal or motivation for exercising?

6. Is there anything specific about exercising that prevents you from feeling motivated?

7. Have you ever used a fitness app or wearable device to track your activities? If yes, please specify.

8. How do you feel fitness apps and trackers help you achieve your exercise routine and progress?

Negatively (They get in the way)		Neutral (I feel they do not make a difference)		Positively (They help me progress consistently)
○	○	○	○	○

9. How often do you exercise with a partner or group of people?

- ○ Never, I exercise alone
- ○ Some of the time
- ○ Most of the time
- ○ All the time

* 10. When exercising, about how often do you listen to music?

- ○ None of the time
- ○ Some of the time
- ○ About half the time
- ○ Most of the time
- ○ All the time

11. What are the main features you look for in a song for it to be included in your exercise/walking playlist?

* 12. List your top 5 workout/walking songs in descending order (include artist + track title).

1
2
3
4
5

13. How musical do you consider yourself to be?

Completely rhythm / tone deaf	Tone deaf, but I can keep a beat	Experienced musician/dancer
○	○	○

9.2 Appendix 2 – Transcribed Probe Data

9.2.1 Probe Cards

Participant 1

Card 2 Before Run: Your emotions this moment, on this line... Go! *Sleepy and tired, it's early!*	Card 3 Before Run: Close your eyes. What can you hear right now? *Wind rushing and washing machine*
Card 7 During Run: Listen to the sounds around you. What was the most displeasing sound? *Car engines*	Card 8 Before Run: If your running shoes could speak, what do you think they'd want to say to you? *Use me more often*
Card 13 Before Run: What are the sounds you associate most with running? *Car, Footsteps, Nylon*	Card 18 Before Run: Where would you rather be other than running today? *Indoors Reading*
Card 19 During Run: Record a sound along your running route for 30 seconds. *Participant recorded an outdoor run away from vehicles. Present sounds are rustling nylon, footsteps, and wind noise in tree canopy*	Card 20 Before Run: How would you like to feel by the end of this run? *Exhausted*

Participant 2

Card 1 After Run: If your run were a sound, what would it sound like? *OMG, YAY! (Is that a sound?)*	Card 2 Before Run: Your emotions this moment, on this line... Go! *OMG I'm so tired ☹*
Card 3 Before Run: Close your eyes. What can you hear right now? *My Breath*	Card 4 Before Run: Take a photo of something that symbolises or makes you think of running 
Card 7 During Run: Listen to the sounds around you. What was the most displeasing sound? *Nike App Cheering*	Card 8 Before Run: If your running shoes could speak, what do you think they'd want to say to you? *You can do it!!! ☺*
Card 11 Before Run: Describe your mobile phone in three words. *Black, shiny, sharky*	Card 12 Before Run: What is your motivation for running today? *Feeling better and preparing for a race*
Card 13 Before Run: What are the sounds you associate most with running?	Card 14 Before Run: Can you name a song that embodies the feeling of running?

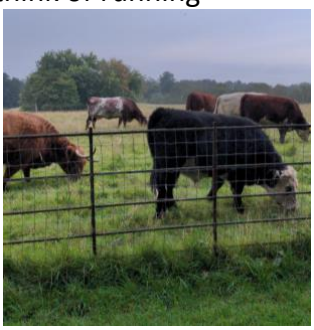
Breathing, rain, ocean	*Tiga – Home (DFA Remix)*
Card 16 Before Run: What is your favourite sound in the world? *Rocks under my feet*	Card 18 Before Run: Where would you rather be other than running today? *At the beach or in my bed*
Card 20 Before Run: How would you like to feel by the end of this run? *Happy and tired, but happy*	

Participant 3

Card 1 After Run: If your run were a sound, what would it sound like? *A big, long sigh of relief*	Card 5 During Run: Take a picture of the first thing that jumps out at you during your run. 
Card 9 During Run: Listen to the sounds around you. What was the most pleasing or memorable sound?	Card 11 Before Run: Describe your mobile phone in three words.

The sound of the river and the stones as I ran	*Slow, annoying, lifesaver*
Card 14 Before Run: Can you name a song that embodies the feeling of running? *Audion – Motormouth*	Card 17 During Run: Play a song you wouldn't normally play when exercising (if you I listen to music try playing some music this time). How did it make you feel? *Calm and relaxed I chose classical music*
Card 20 Before Run: How would you like to feel by the end of this run? *Less stressed*	Card 21 After Run: Describe your run as a colour *Green and electric blue*
Card 23 Before Run: how does the weather make you feel today? Happy! I love running after its rained, the freshness makes me feel alive	Card 26 after Run: what three words would you like to say to the weather today? Please sun leave!
Card 30 after Run: who do you dedicate this run to? My mum, I want her to know I'm working towards living a healthier life.	

Participant 4

Card 2 Before Run: Your emotions this moment, on this line... Go! Stress	Card 4 Before Run: Take a photo of something that symbolises or makes you think of running 
Card 7 During Run: Listen to the sounds around you. What was the most displeasing sound? Big trucks	Card 9 During Run: Listen to the sounds around you. What was the most pleasing or memorable sound? Birds
Card 11 Before Run: Describe your mobile phone in three words. Anxiety inducing Connected Enslaved	Card 12 Before Run: What is your motivation for running today? Boredom Too lift my mood To just move
Card 15 After Run: What was the most enjoyable moment of this run? I never find running particularly enjoyable!	Card 16 Before Run: What is your favourite sound in the world? The sound of when I put my keys in my door
Card 20 Before Run:	Card 24 After Run:

How would you like to feel by the end of this run? Happy That its finally over.	what do people see when they see you running past? Oh god! Like a really gangly idiot who doesn't know what they're doing
Card 27 Before Run: if you could go for a run anywhere in the world right now, where would you choose? Run around Lake Garda in Italy	

Participant 5

Card 4 Before Run: Take a photo of something that symbolises or makes you think of running 	Card 6 After Run: As soon as you get back, using your voice record a sound you feel captures the spirit of this run. Sound of 'aaaaaah! Glad it's over '
Card 7 During Run: Listen to the sounds around you. What was the most displeasing sound? Hgv's	Card 8 Before Run: If your running shoes could speak, what do you think they'd want to say to you? We were built for faster than this!
Card 11 Before Run: Describe your mobile phone in three words.	Card 13 Before Run:

Necessary confusing frustrating	What are the sounds you associate most with running? Birdsong the sound of wind in the trees and the sound of my feet on the tarmac
Card 15 After Run: What was the most enjoyable moment of this run? Reaching the top of the highest hill and turning round knowing I was halfway through and had gotten past the worst of it.	Card 18 Before Run: Where would you rather be other than running today? Just at the lake district climbing the hills.
Card 20 Before Run: How would you like to feel by the end of this run? That I did more than the last time! That my performance was superior.	Card 21 After Run: Describe your run as a colour Green
Card 22 After Run: Did you see anyone else running? What can you remember about them? One young lady who overtook me which was shameful, but she was way fitter than me, and younger! But I thought for a moment I could have beaten her!	Card 24 After Run: What do people see when they see you running past? Many of them probably don't want to admit that they think 'I wish I could do that' when they see me go past
Card 25 After Run: Take a photo of your running shoes	Card 26 After Run: What three words would you like to say to the weather today? I wish it could be like this every morning: grey damp cool

	
Card 27 Before Run: If you could go for a run anywhere in the world right now, where would you choose? In the forests north of Rovaniemi in Finland	Card 28 Before Run: If you could have any running partner dead or alive, who would you choose? Emmylou Harris or Mary Bignal Rand

Participant 6

Card 1 After Run: If your run were a sound, what would it sound like? Like a Yeah!!!!	Card 2 Before Run: Your emotions this moment, on this line... Go! *Ugh I'd rather stay in!*
Card 3 Before Run: Close your eyes. What can you hear right now? Traffic	Card 5 During Run: Take a picture of the first thing that jumps out at you during your run. River
Card 7 During Run: Listen to the sounds around you. What was the most displeasing sound? Car horns loud beeping sirens	Card 8 Before Run: If your running shoes could speak, what do you think they'd want to say to you? Speed up!!!
Card 19 During Run:	Card 20 Before Run:

Record a sound along your running route for 30 seconds. The water and birds	How would you like to feel by the end of this run? Relief.
Card 21 After Run: Describe your run as a colour Green	Card 24 After Run: What do people see when they see you running past? I always think, I should be doing more of that, like envy!
Card 26 After Run: What three words would you like to say to the weather today? Beautiful, crisp, fresh	Card 27 Before Run: if you could go for a run anywhere in the world right now, where would you choose? Somewhere with a forest! Thailand or Bali somewhere exotic.

Participant 7

Card 2 Before Run: Your emotions this moment, on this line... Go! At the beginning I feel motivation like go and get it, but I struggle to keep that feeling sometimes so sometimes like chore.	Card 4 Before Run: Take a photo of something that symbolises or makes you think of running
Card 7 During Run: Listen to the sounds around you. What was the most displeasing sound? Traffic, car horns.	Card 9 During Run: Listen to the sounds around you. What was the most pleasing or memorable sound? Birds and nature, dogs barking.
Card 12 Before Run: What is your motivation for running today?	Card 13 Before Run:

To lift my mood and personal satisfaction of having achieved this goal.	What are the sounds you associate most with running? My footsteps and breathing
Card 15 After Run: What was the most enjoyable moment of this run? Finishing the run and feeling that sense of completion. Finding the perfect route for running the amount that I need and being able to complete.	Card 16 Before Run: What is your favourite sound in the world? Bubble wrap is one of the most satisfying sounds in the world. And typing on the keyboard.
Card 24 After Run: what do people see when they see you running past? I often think this because I see people when they run and think do I run like that? Do I have a funny run? I feel like a giant	

9.2.2 Transcribed Interview Data

Participant 1

I. **Interview Body**
   a. **(Topic) Survey**:
      1. Exercise Routine
         1. In the questionnaire you have stated that your level of expertise was _____3____. Could you please elaborate why you have placed yourself in this category?

            I have a very sporty family and grew up with sport, my parents always signed me up for sports activities, but it just never really stuck in adult life. So, Wile I have lots of experience with sport I am not really an expert or a fan.

2. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show participant category list).

   I feel that nothing has changed much as I still follow my same routine.

3. You have also stated that you exercised with a frequency of ____ days per week. Can you please explain, what factors influenced you to choose this frequency?

   I once read a sportsperson who I respected say that you should never go more than 2 or 3 days without exercising and it seemed like a reasonable suggestion in terms of being able to find the time for it. I don't remember who it was, but I use that measure as a way of not letting too much time go past without exercise.

4. Can you also detail, what the specific activities constituted this exercise routine you were following?

   I normally start out with a 10-15-minute warm up using some routines I found on the internet, then I either cycle or run for 30-60 minutes. Occasionally I will also swim for 15 minutes if I feel energetic.

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   I think I have focussed more solely on running than my other activities like cycling.

2. **Motivation**
   1. You have stated your main motivation for exercising is 'Losing weight, living longer and looking better'. Can you elaborate why this is a motivating factor for you?

      I have never been completely skinny and at one point felt quite out of shape when I was smoking, so I felt it was time to start exercising. Especially as I've grown older, I've felt it is important to spend more time with the people you love in the long run.

   2. Is this still your current motivation for exercising or has this changed in any way since the start of the project?

      Yes this is still my current motivation.

3. You have stated 'I don't particularly enjoy the process as I'd rather be doing something else' prevents you from feeling motivated to exercise. How have you addressed this issue throughout the course of this project? Has it proven difficult to stay motivated?

   I have enjoyed reflecting about my relationship with exercise so that kept me quite motivated in a usual way. However, I feel like the process of exercising consumes so much time and attention I normally prefer investing in reading or learning or even socialising.

3. **Technology**
   1. In the survey you stated you have/haven't used fitness tracking technology before.
      a. If YES:
         i. Please can you state when you started using this device/app? (Ask for permission to view activity data in App to verify start date).

            I first started using exercise apps about 5 years ago but have gone through quite a few apps since the first one I used. I started out using MapMyRun then through to Nike+ and finally settled on Garmin.

         ii. Why did you choose this particular device/app over the other alternatives?

            I started out with MapMyRun because a friend suggested it, but its free features were quite limited, and the app felt a bit boring. I switched to Nike+ because it felt simpler to use and a bit more friendly, but after a while it felt like it was a bit too gimmicky and not as informative as I would have liked, that's why I switched to Garmin. I liked how Garmin can show you quite detailed information but gives you so many options of displaying it you can tailor it to what you want, so I enjoyed using that device more than just phone apps.

         iii. What are your favourite features of device/app?

            I like how the data displayed is customisable and can be presented in different formats from graphs to numbers on screen. I also like the phone app because it expands on what you see on the watch.

         iv. What are the features of device/app you do not find appealing?

I don't like how the screen sometimes responds to touch and some of the button menus are weird. There was quite a lot of remembering to do when learning how to use it and I kept getting lost trying to find simple features like the stopwatch.

v. Do you use any of the auditory feedback features of device/app, such as alarms or speech-based pace/time/distance updates?
    1. If NO –
        a. For what reasons do you not use this feature?

        I heavily dislike notifications and alarms so I always switch them off and only have the vibrations. It really annoys me when people use ringtones and notifications and don't turn them off in quiet public spaces. I feel they add to the noise pollution and are completely unnecessary as most of the time people can wait to answer their messages. They should only be allowed in emergencies!

        b. Is there anything you would change that would make this type of feedback useful to you?

        If there was some way that the sounds phones make were more pleasant or maybe have a way that only the owner can hear them would be good. It's ok if it's coming through headphones, it just shouldn't annoy other people.

vi. Please describe how your usage of device/app has changed throughout your time using it in this project. Do you use it now more than before? Have you stopped using it at some point? Or have you used it sometimes more than others?

Not much has changed since this project, except maybe I've been looking at the more detailed data on my phone rather than just recording it on my watch and forgetting about it.

vii. Now, please describe if you feel device/app has helped to keep you motivated in achieving your fitness goals? (Compare answer to answer to question 8 in survey).

I think it has helped but overall, it's not been a huge difference as I still exercise with roughly the same frequency I have always done. I have maybe challenged myself a little bit more as I've been locking at the numbers on the recorded data a bit more which always triggers the competitiveness inside me a little bit and I try to beat the numbers from the day before.

viii. Do you feel that you could maintain this level of motivation without device/app?

I might not as I enjoy tracking things accurately, I feel I wouldn't be satisfied with just knowing how long and far I have run. I like seeing how my average heart rate changes with the days, so those missing little details might make me a bit less motivated.

ix. Do you see yourself continuing to use device/app in the future beyond this research project?

Yes, I think I will continue using this app for a little while longer as I don't want to invest on another device for at least another year or two.

4. **Exercise habits**
    1. You have stated that you exercise with a partner or a group of people___None of the time___. Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

    I don't like running with other people as I sometimes feel awkward trying to match their pace, either I'm too slow or too fast and I just don't want to think about other people when running. As I've said before running seems to take too much attention for me to stay motivated and that sort of interferes with having someone running with me. I suppose it has also something to do with self-confidence and feeling a bit exposed. I've never really changed this habit and have only ever exercised with someone on two occasions that I can remember.

    2. In question 10 you said you listen to music whilst exercising Most of the time.
        a. If answer is some, half, most or all of the time:
            i. Can you please elaborate why you like listening to music while you exercise?

            I like listening to music because it helps me either be distracted from the unpleasantness of running or because I

may find some music that makes me want to dance and move. When I run without music, I feel like I'm wasting time and I find myself constantly thinking about how boring it is to exercise.

ii. On what exercise related instances do you not listen to music and why?

I don't listen to music while I'm warming up because I need to pay attention to my balance and counting when I'm holding a particular stretch. I find it easier to get through the warmup process if I focus on just that. I would listen to music while swimming if it were possible!

3. In question 11 you stated that a song must feature 'Something that makes me want to dance or distracts me, it can be anything though' for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

There is something about music that makes you want to dance that inherently fits with running, I don't know what it Is but sometimes you just have to move. I like music that has a sense of something moving and you feel it drives you forward or upward, like that feeling you get at a concert, or something that would fit well with a car chase. But I also like music that makes me feel quite emotional when I run because it makes me think of all the reasons I exercise, like if I hear something that reminds me of my mum or dad or a friend, I feel motivated to run because I know it is good for my health.

4. In question 12 you gave us a list of your top 5 songs for working out or walking outside. Can you please describe what each of these songs means to you and why you have chosen them to be in your top 5?

I don't have a top 5 because there is just so much different good music, and I don't always like listening to the same songs when I run.

5. In question 13 you stated you consider yourself to be ___4_____. Could you please elaborate as to why you feel this way?

I consider myself to be somewhat musical as I can play keys and guitar, but I've always felt I struggle keeping a good rhythm and I think this show when I'm dancing!

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**

1. Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

   Q. For card 2 you stated your emotions as sleepy, tired and its early! Do you often feel like this when you run?

   A. *Yes, I often feel like this because I run early before work or when I get back, which means I would much rather just rest!*

   Q. For card 3 you stated you could hear the wind rushing and the washing machine. Are these sounds common before your run?

   A. *We live in England, so I must say it is a definite yes on the wind noise! I do my washing early in the morning, so it coincides occasionally with me going out on a run.*

   Q. For card 7 you stated the most displeasing sounds you heard were car engines, what do you find most displeasing about this sound

   A. I *like running in green areas, where you get more natural sounds like trees and birds or maybe also people walking, but I think people are not very good drivers and you often find yourself having to get distracted to see if a car is coming your way or sometimes some people just drive too fast and the cars make such a loud sound*

   Q. For card 8 you stated if your shoes could speak, they would tell you to 'use them more often', Do you think you'll listen to them?

   A. *hahaha I should use them more; they are quite nice running shoes, so I even feel guilty I haven't worn them out yet! I think one can always do a bit more even if we feel it's impossible so I should try to use them more!*

   Q. For card 13 you stated the sounds you associate the most with running are 'cars, footsteps and nylon', aside from cars which you've mentioned you hate how do you feel about those two other sounds?

   A. I *really enjoy the sounds of footsteps, but only when it's on interesting material like grass or mud or leaves, the endless thwack against the pavement sometimes annoys me! In regard to nylon, I have a love/hate relationship with its sound, as it can actually be quite annoying and loud, but it also has a nostalgic effect on me because it reminds me of a time when my mother bought me a nylon tracksuit which I would make rustle for ages because I had never had one before. It also reminds me a lot of my dad because he enjoys running a lot, so we always buy*

him nylon sporty clothes for Christmas and birthdays.

Q. For card 18 you stated that on that day you would rather be indoors reading than out running, is this your favourite pastime?

A. *Yes, any activity that I feel is too distracting like I have said running is to me, always makes me think I would rather be sat at home reading something fun, interesting or informative.*

Q. For card 19 you recorded 30 seconds of audio during your run, how would you describe the sounds?

A. *Well I think it's a typical running sound as I described before with the footsteps and the rustling nylon, you can't hear any cars and you can hear the rustling trees in the wind, which is nice, so I would say its almost an ideal running session as there are no distracting unpleasant sounds!*

Q. For card 20 you stated that after that run you would like to feel exhausted. Is this a common feeling you want to have post-run?

A. *Yes! Of course, because if I came back from a run feeling perfect it would probably mean I didn't try too hard! I often want to feel this but its like what my shoes said to me, I should do it more often.*

II. **Interview Conclusion:**
   a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.
   b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

      I really enjoyed reflecting on my experiences whilst running and I feel like if I could keep the process of reflecting on how I feel I might be able to stay a bit more motivated.

   c. Thank you for all your help with the Running to Your Own Beat project!

Stop recording.

Participant 2

I. **Interview Body**
   a. **(Topic) Survey**:
      i. Exercise Routine
         1. In the questionnaire you have stated that your level of expertise was _____2____. Could you please elaborate why you have placed yourself in this category?

         2. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show

participant category list).
I would change it to a 3 or 4, I wouldn't say an expert, but at that time I was starting to exercise again because of my lifestyle and moving to another country and all that and getting used to a new city and things was a bit of a struggle.

3. You have also stated that you exercised with a frequency of _2-4 days per week. Can you please explain, what factors influenced you to choose this particular frequency?

   Because it was easier to do one day then have 2 free then another day to not feel overwhelmed and tired and then that could be also like a thing could make me not do it, so I chose not to do it every day and be very intense with it.

4. Can you also detail, what the specific activities constituted this particular exercise routine you were following?

   Running, gym routines, home routines

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   Now I exercise 7 days a week even if I feel really bad 7 days a week I exercise.

ii. **Motivation**

1. You have stated your main motivation for exercising is 'Healthy life. Can you elaborate why this is a motivating factor for you?

   Because I love food and snacks and all the delicious things that make you fat and not healthy so I need to balance that with exercise. Also, in my family there is diabetes and diseases thar result from bad habits, so I don't want to take that path and live many years, and my mental health benefits

2. Is this still your current motivation for exercising or has this changed in any way since the start of the project?

   Yeah and now I have the motivation from my smartwatch which reminds me to do my activities so now I complete all my activities before 1pm because otherwise the watch sends me reminders after 1pm that I am being lazy. It gives you rewards and medals which I find nice.

3. You have stated 'A proper routine' prevents you from feeling motivated to exercise. How have you addressed this issue throughout the course of this

project? Has it proven difficult to stay motivated?

no it has been actually really good, and in the past weeks when I struggled again, from physical things I can't control, I still pushed myself to do it because I knew it would make me feel better.

iii. **Technology**

1. In the survey you stated you have/haven't used fitness tracking technology before.
    a. If YES:
        i. Please can you state when you started using this device/app? (Ask for permission to view activity data in App to verify start date).

        Nike like 4 years and Nike running the same, adidas was too complicated so I stopped using it, and Underarmor I use to track what I eat and my weight.

        ii. Why did you choose this particular device/app over the other alternatives?

        I chose Nike just because I like how easy it was to use and the exercise routines included has been very good and everything works for me, it connects to my apple watch, but I hate the feature of how it connects to Spotify. Underarmor because I started tracking my food and from the different ones I tried, Underarmor was the best because I could scan my food and upload my data very easily keeping a record of what I eat everyday

        iii. What are your favourite features of device/app?

        the different exercises included like yoga or stretching or cooling down, or routines for doing in your house, it's quite friendly for everyone because the variety of exercises

        iv. What are the features of device/app you do not find appealing?

        the connection to my music is really annoying and I always just turn it off because it doesn't work well.

        Minute 25

        v. Do you use any of the auditory feedback features of device/app, such as alarms or speech-based pace/time/distance updates?
            1. If YES –

a. In what way do you feel this particular feature assists you while you exercise?
First, the time, I think time and distance are very important for me, because sometimes you're running, and it feels like it's been a long time and you're starting to get tired and then you check, and you've only been running for like 2 minutes. But sometimes you feel very well when you get feedback that says 5km completed or 20 minutes left which sometimes encourages me.
The connection between the app and my apple watch is not great so I sometimes turn it off

b. Is there anything you would change to make the feedback more useful?
Maybe a bit more detailed to have more data, because it's quite limited, but I feel it could be very annoying, but maybe they could find a way like for example your pace is below 7 it could tell you something or if you're being super slow some sort of prompt to run a bit faster, just a bit more information

vi. Please describe how your usage of device/app has changed throughout your time using it in this project. Do you use it now more than before? Have you stopped using it at some point? Or have you used it sometimes more than others?

I used it more because I started using it every day. I keep better track of my pace and distance and general progress. I keep track of my times to keep motivated.

vii. Now, please describe if you feel device/app has helped to keep you motivated in achieving your fitness goals? (Compare answer to answer to question 8 in survey).

I think the one that I was talking about was the adidas one because it wasn't very nice to use, but now I just love both of my apps,

viii. Do you feel that you could maintain this level of motivation without device/app?

probably not its weird but I really like tracking my data and keeping my record somewhere, I feel if I didn't do it, I am

missing something

ix. Do you see yourself continuing to use device/app in the future beyond this research project?

100%

iv. **Exercise habits**

1. You have stated that you exercise with a partner or a group of people___None of the time___. Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

I change it when I started going to the gym, but you get really distracted because you end up having a good time with your friends. But that's why I prefer to just be on my own with my music and just have that hour completely for myself so that's why I like it. But then running I usually do it by myself however I have now started running with friends, it's nice to have someone to go and explore, and it makes me feel safer like running at night or through areas I wouldn't otherwise but I really just like my time with my music.

2. In question 10 you said you listen to music whilst exercising All of the time.
    a. If answer is some, half, most or all of the time:
        i. Can you please elaborate why you like listening to music while you exercise?

because the music motivates me if its happy or brings me happy memories, but also if it's something like new music or I don't know the lyrics it makes me not think about anything else and I it makes me more focussed on just running.

        ii. On what exercise related instances do you not listen to music and why?
when I'm running with. Someone else or when I'm doing yoga.

3. In question 11 you stated that a song must feature 'Happy beats to keep me motivated for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

for me exercise is to keep me happy throughout the day. And I can't imagine waking up and listening to melancholic music, it would be so

depressing, so I run with happy music to overcome the feeling of the morning and I'm ready to start the day on a positive way

4. In question 12 you gave us a list of your top 5 songs for working out or walking outside. Can you please describe what each of these songs means to you and why you have chosen them to be in your top 5?

   They all sound happy to me,

5. In question 13 you stated you consider yourself to be __3__. Could you please elaborate as to why you feel this way?

   because I'm not an experienced musician but I lived with one, so I learnt enough to be a 3!

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**
   i. Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

   Q. for card 1 you stated if your run where a sound it would say the words 'OMG YAY!', can you please elaborate why you feel this is how your run sounds?

   A. because I want it to be a happy positive sound and that phrase makes me happy reminding me that I've done well.

   Q For card 2 when asked to state what were your emotions before your run you said, 'OMG I'm so tired', can you elaborate on what you felt that moment?

   A. This a day I was feeling lazy, so I had the option of staying in bed or going to exercise so that day I just felt the weight of wanting to skip the exercise routine.

   Q. For card 3 when you closed your eyes and were asked to identify what you heard, you said 'my breath', is this a sound you often associate with running?

   A. its because I've become more aware of my breathing because of exercise techniques and meditation so I listen out for it.

   Q. For card 4 you submitted a photo of your apple watch; can you explain why this object makes you think of running?

A. I use it all the time when I run to track my stats and its good for my motivation, so I think I'm better at exercise because of it in a way and so it is something I associate with running.

Q. For card 7 you stated that the most pleasing sound during your run was 'Nike Cheering'

A. because it's nice to finish something, it's a good feeling to achieve something despite feeling tired. Just getting up putting your shoes on and doing it, and I like that feeling at the end which makes me feel like 'you go girl'

Q. For card 8 you stated that if your running shoes could speak, what would they say to you? You stated, 'You can do it!' can you please elaborate on this answer?

A. Y. because my shoes know that every time I wake up I don't want to go running, and rather be in bed watching tv, so they should be by the door reminding me to go on and do it!

Q. For card 11 you described you phone as black shiny and sharky can you elaborate why these three words are connected to your mobile device?

A. I enjoy personalising my phone so much so I've personalised it with lots of shark stickers. I love customising my phone because it's a big part of what I do so it reflects my inner self!

Q. For card 12 you stated your motivation for running that day was 'feeling better and preparing for a race', could you elaborate about this race and why your motivation is to feel better?

A. feeling better because it really boosts my energy for my day, instead of drinking a coffee I do exercise. I've been preparing for a 10k race which is a big motivation for me to do it, because if I don't practice, I feel like I won't enjoy doing the race.

Q. For card 13 you state the sounds you associate the most with running are 'Breathing, rain and ocean', can you expand on why these share a connection to running for you?

A. Because I love the feeling of being outside running especially in summer. I associate the beach with running because the feeling of the ocean breeze while you run is an incredible feeling.

Q. For card 14 before you run can you name a song that embodies the feeling of running, why does this song embody the feeling of running for you?

A. because the video is about a guy running so I always connect it to that video which I really like, so it makes me feel like I am in the video, there's something about the rhythm as well that is pulsating and driving.

Q. For card 16 you stated your favourite sound in the world is 'Rocks under my feet' can you elaborate what this sound means to you and why

A. I because it's a natural sound found at the beach or forest or park and its 100% natural, and the feeling I get from hearing it is very nice, and I could run without music If that were the predominant sound because it is calming and peaceful.

Q. For card 18 where would you rather be other than running today and you said 'at the beach or in my bed'

A. Because I love the beach and whenever I go the beach I feel happy, so I like the idea of being at the beach maybe running as well!

Q. For card 20 you stated that by the end of that run you would like to feel 'happy and tired, but happy', why is this the feeling you want after a run?

A. because that kind of tiredness feels very good, that feeling of your body feeling the rewards of the effort and the feeling of getting stronger. Sometimes when I don't feel tired at the end of the run I feel like it wasn't a good run.

II. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.
b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

   I enjoyed this and think I would love answering more questions as I found it fun answering questions and reflecting on my exercise habits. I like to track things and see my improvement so I really enjoyed doing this a bit more thoroughly.

c. Thank you for all your help with the Running to Your Own Beat project!

Stop recording.

Participant 3

I. **Interview Body**

a. **(Topic) Survey**:
   i. **Exercise Routine**

1. In the questionnaire you have stated that your level of expertise was _____3____. Could you please elaborate why you have placed yourself in this category?

   I have had an on/off relationship with exercise umm, there's been times where I have been good at keeping up with a routine but have never managed to make it a permanent thing.
   So, I'm like no expert and definitely not sporty but I know how to run and have read about how to make routines, but I'm just not disciplined

2. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show participant category list).

   having to think about my exercise habits definitely helps to remind myself how bad I've been at keeping it up in my life. So maybe the guilt will make me exercise more from now on!

3. You have also stated that you exercised with a frequency of ____ days per week. Can you please explain, what factors influenced you to choose this particular frequency?

   before this I've been going through a period of little exercise really, not currently following a routine and I just enjoy going out for long walks at the moment, I've tried to push myself more for this project because it obvs gets you thinking what more you could be doing

4. Can you also detail, what the specific activities constituted this particular exercise routine you were following?

   my routine at the moment is to go out for a minimum of 30 minutes each day if possible, walking briskly and jogging

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   as I said before having to think about your habits has definitely made me want to exercise more than when I was only doing 1 day a week, I felt like having a small target like a minimum of 30 minutes a day, even if it's just a walk has helped me get back into things, I feel more accomplished than when I felt I had to do 2 hours of gym a day or something silly like that to feel rewarded and therefore never tried to adhere to that.

ii. **Motivation**

1. You have stated your main motivation for exercising is 'Losing weight, better mental health, feeling more energised and able. Can you elaborate why this is a motivating factor for you?

   I'm the fattest I have ever been and as I'm approaching middle age I just don't feel as energetic as I used. I feel tired and I don't sleep well and I've read that regular exercise improves mental health and sleep. So, I want to achieve that more than ever.

2. Is this still your current motivation for exercising, or has this changed in any way since the start of the project?

   I used to have a problem with my body image but I feel like I am now more motivated to do this for myself than for the sake of what people think of me,

3. You have stated 'I find it dull, so I struggle to dedicate the time it requires to achieve the goals I would like.' prevents you from feeling motivated to exercise. How have you addressed this issue throughout the course of this project? Has it proven difficult to stay motivated?

   Yes definitely, as I said before, I used to have an expectation that you had to be a big 'gym bro' to achieve a good physique and better health, but just realising I can be more active by walking and jogging regularly for small amounts of time makes me more motivated to do this.

iii. **Technology**

1. In the survey you stated you <u>have</u> used fitness tracking technology before.
   a. If YES:
      i. Please can you state when you started using this <u>device/app</u>? (Ask for permission to view activity data in App to verify start date).

         I've been using Nike for about 6 years on and off

      ii. Why did you choose this particular <u>device/app</u> over the other alternatives?

         out of the ones I tried I enjoyed Nike because it has an app called Nike training club that has lots of useful tutorials and video routines that are like having a personal trainer. I found that this app encouraged me to do proper warmups rather than being lazy and just exercising to get it out of the way

      iii. What are your favourite features of <u>device/app</u>?

I like the voice feedback and videos for the warm ups and strength routines in Nike training club. I also like the running app because it's very simple to use and you don't have to fiddle with too many settings.

iv. What are the features of device/app you do not find appealing?

I don't like the voice that updates you on your pace and distance, I always hate how long it takes to tell you the information when I just want to listen to my music and enjoy my walk/jog so I just turn it off.

v. Do you use any of the auditory feedback features of device/app, such as alarms or speech-based pace/time/distance updates?
   1. If NO –
      a. For what reasons do you not use this feature?

As I said before I really hate the voice feedback, and I also hate the cheesy congratulatory remarks that are played at the end of your run, I think it's like famous athletes or something, but I really don't care.

      b. Is there anything you would change that would make this type of feedback useful to you?

a more concise way to tell me my distance and pace that isn't a robotic voice that takes 5 minutes to tell me how I'm doing when I can just check faster on the screen

vi. Please describe how your usage of device/app has changed throughout your time using it in this project. Do you use it now more than before? Have you stopped using it at some point? Or have you used it sometimes more than others?

I've definitely gotten back into using my tracker because I do enjoy following my data and progress,

vii. Now, please describe if you feel device/app has helped to keep you motivated in achieving your fitness goals? (Compare answer to answer to question 8 in survey).

I feel it helps a little bit in being more disciplined however I've often tried to follow training plans and routines with my app and I've never managed to make it a regular thing

viii. Do you feel that you could maintain this level of motivation without device/app?

I think I am better now than before as I said I feel more motivated by having less ambitious targets and doing things for myself. If I didn't have an app, I would still be able to maintain my simple routine of 30 minutes a day

ix. Do you see yourself continuing to use device/app in the future beyond this research project?

Yes as I said I do enjoy using the app just to keep track of things but I hope it really sticks this time.

iv. **Exercise habits**

1. You have stated that you exercise with a partner or a group of people 'None of the time'. Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

I used to hate running with other people however I like walking and jogging with my partner now. Overall, I prefer to do it on my own because I like losing myself in my music and thinking of things

2. In question 10 you said you listen to music whilst exercising Most of the time.
    a. If answer is some, half, most or all of the time:
        i. Can you please elaborate why you like listening to music while you exercise?

I like listening to music all the time, I always feel excited about a new song I've discovered and I find that when I hear something that excites me I can use that energy and channel it to motivate myself during my runs.

        ii. On what exercise related instances do you not listen to music and why?

if I'm exercising with my partner I don't listen to music, and occasionally when I just want to clear my head and not

have any distractions and focus on the moment I won't listen to music

3. In question 11 you stated that a song must feature 'No preference other than I have a connection to the song, if I can get lost in the emotion of it or if it is an interesting beat I find it easier to get into my routine.' for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

   I like music I can get lost to, it doesn't matter if its rock, jazz, classical, dance, ambient music, I don't really need like a pumping beat to exercise to. I just like to have some connection to the music I listen to and if it moves me in some way then I like listening to it when I exercise

4. In question 12 you gave us a list of your top 5 songs for working out or walking outside. Can you please describe what each of these songs means to you and why you have chosen them to be in your top 5?

   as I said before any music I can connect to so I don't have a top 5. I really don't like cheesy trashy dance music you hear at the gym

5. In question 13 you stated you consider yourself to be ___4_____. Could you please elaborate as to why you feel this way?

   I play piano and guitar so I am musical in that way, I also enjoy listening to all sorts of music so in that way too I feel like I understand music.

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**

Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

Q. for card 1 you stated if your run where a sound it would say the words '*A big, long sigh of relief*!', can you please elaborate why you feel this is how your run sounds?

A. I just had a great run and I just love that feeling of being exhausted from pushing yourself, so I associate the end of a good run with a long sigh of relief which I usually let out when I'm done! It's like the last release of energy or

something ahaha.

Q. For card 5 you submitted an image of a river, can you explain why this stood out for you?

A. I love running near the river by my house, there's something about the openness and the colours of the surrounding nature that always inspires me to make an effort to go out.

Q. For card 9 you stated the most pleasing sounds you heard were 'The sound of the river and the stones as I ran', what did you find pleasing about this sound?

A. As I said previously the river really inspires me, maybe it's the sound of the flowing water and the feeling of movement it has. I also love the sounds of stones, the sound changes depending on the shape of the rocks so I always love hearing to the different textures of them.

Q. For card 11 you described you phone as slow, annoying and a lifesaver can you elaborate why these three words are connected to your mobile device?

A. my phone is a bit old so it's become really slow in recent times, I find this very annoying! Haha I also hate the number of emails and messages I receive these days, as well as the amount of time people spend on their phones, so that adds a bit to the annoyances. I also said it's a lifesaver because I kind of think its umm such an indispensable tool for everyday life that it helps you get out of sticky situations in unknown places!

Q. For card 14 you stated *Audion - Motormouth*, embodies the feeling of running for you, can you elaborate why?

A. this song is just pure energy, it has like a powerful driving beat that just pulses and its quite a long track that takes you on a ride, it feels like me like a machine or robot running and I sometimes put it on because it sort of invites me to run to its beat or something, its like kind of hypnotic.

Q. For card 17 you stated that on that particular day you felt *Calm and relaxed I chose classical music'* can you elaborate why you chose this type of music and the feeling it gave you?

A. I chose classical music because my dad often sends me classical pieces and I sort of put off and forget to listen to them so I always feel guilty that I have a backlog of music I should listen to. So, I chose a classical piece for this run because I normally wouldn't. I felt calm and relaxed because I got lost in listening to the music as I had never heard it before and I wanted to get a real impression of it while I ran. I think just concentrating on the music and ignoring the sensation

of running was quite pleasing because I just didn't think about it and before I knew it the time was up, and I felt good.

Q. For card 20 you stated that after that run you would like to feel *Less stressed*. Is this a common feeling you want to have post-run?

A. yeah recently I've been running to lower my stress levels as I know that mental health benefits from running so I've been trying to be better and get out just so I don't feel anxious all the time and sleep better as I often suffer from poor sleep.

Q. For card 21 you stated your run felt like '*Green and electric blue'* why do these colours represent this run?

A. I find those two colours so energizing; I even have an electric blue bike! Since it was quite a fun energetic run and the weather was nice to go out near the river those colours were present in the environment although maybe less electric? I think the feeling of running made everything feel more energised.

Q. For card 23 you stated the weather made you feel 'Happy! I love running after its rained, the freshness makes me feel alive' can you elaborate why you feel this way?

A. I love the feeling of going out just after it rains because the smell is just so delicious! The smells of the world change and if I'm out running it also makes me feel cool and gives me a little bit more stamina, because when I run in the heat, I get too tired and sweaty which I hate.

Q. For card 26 you said the three words you'd like to say to the weather were 'Please sun leave!' can you please elaborate why you want to say those words?

A. haha as I said in the previous question I really, really, really hate the heat, this was a mega summery day so I always feel a bit more exhausted and would honestly rather just be sat on a lounger with a fresh drink or something!

Q. Finally for card 30 you stated you would dedicate that particular run to 'My mum, I want her to know I'm working towards living a healthier life.' Can you elaborate why this motivates you?

A. I love my mum to bits for all the sacrifices she's made for me so I want to do my best to be healthy because as all mums do, she worries and is always nagging about my weight! So, I often think about her when I run to remind myself that there is also something else other than my physique to exercise for.

NB. Each participant will provide a varying amount and completion of cultural probe activities; therefore, this section of interview will develop naturally based on each individual datum.

II. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.

b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

It was definitely fun to think about all these things, and trying some different things out like listening to classical music. I hope I can keep this up because it makes me feel better when I keep up with my goals!

c. Thank you for all your help with the Running to Your Own Beat project!

Stop recording.

Participant 4

I. **Interview Body**

a. **(Topic) Survey**:

i. Exercise Routine

1. You have stated that you exercised with a frequency of __1__ days per week. Can you please explain, what factors influenced you to choose this particular frequency?

   Well it's not a given its more to do with workload and the weather

2. In the questionnaire you have stated that your level of expertise was _____1____. Could you please elaborate why you have placed yourself in this category?

   Well no one is particularly sporting in my family so it's not something I grew up with and I also found PE really stressful at school so its not something I continued into my adult life.

3. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show participant category list).

   No I still do what vie always done in terms of exercise so nothing has changed

4. Can you also detail, what the specific activities constituted this particular exercise routine you were following?

   Walking is the main one, yoga from time to time, strength training at home as well.

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   I was swimming up until recently, but I find it not as accessible, because of mental barrier to doing something as involved as swimming.

ii. **Motivation**

1. You have stated your main motivation for exercising is 'To maintain moderate fitness and to elevate mood'. Can you elaborate why this is a motivating factor for you?

   Well because I know it works and if I don't do it I feel worse, and its proven to work, it also helps me focus at my job.

2. Is this still your current motivation for exercising, or has this changed in any way since the start of the project?

   yes I have just always done things this way really

3. You have stated 'Having the right equipment or clothing to partake in different activities.' prevents you from feeling motivated to exercise. How have you addressed this issue throughout the course of this project? Has it proven difficult to stay motivated?

   I suppose knowing that I won't commit to something for a long period of time, I've caught myself out by paying for things in the past and then not continuing them and I don't want to repeat that, and I always say to myself, oh I'll pick it up once I get into a proper routine but I just never do.

iii. **Technology**

1. In the survey you stated you haven't used fitness tracking technology before.
   a. If NO:
      i. Before you started this project, what factors prevented you from using these products and technologies?

         It's just that I don't use fitness to progress, I just use it to maintain a level of fitness I feel good with mentally and physically, and they're the kind of thing that you have to invest some money into and I don't like all of that.

         I occasionally use a free pedometer on my phone but I don't check in on it with any regularity.

ii. In question 8 of the survey, you have stated you feel 'Concern that they would result in a 'marmite' effect on my mental health. i.e., positive when regularly exercising, negative when motivation is lacking' about the impact these technologies have on your progress. Please elaborate on why you feel this way.

Because I have a deep bred thing from school of things being either good or bad, and if you were good at something you would be rewarded and if you weren't you were made to feel a failure and I think that it's fed into how I view things in adult life.

iii. Has your opinion or perspective of this technology changed in any way since the start of the project?

I think if a group of close friends were actively using something like in those apps where you can share your progress and have competitions with your social circle, then maybe I would take part in it but I don't know anyone in my group of friends who does that so I don't engage with apps on that level.

iv. **Exercise habits**

1. You have stated that you exercise with a partner or a group of people 'None of the time' Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

   Because I don't want people to laugh at me! Its as simple as that. I will do group walks for like social wellbeing but anything like vigorous exercise I prefer to do on my own.

2. In question 10 you said you listen to music whilst exercising Most of the time.
   a. If answer is some, half, most or all of the time:
      i. Can you please elaborate why you like listening to music while you exercise?

      because I love listening to music all the time and I use it to

fit the mood I am in, or shift to a positive mindset if I'm down. If I do something more vigorous, I do put something more high tempo to channel that energy.

ii. On what exercise related instances do you not listen to music and why?

I wouldn't listen when I'm doing yoga or strength training, I often even just watch Netflix when I'm doing exercises at home.

3. In question 11 you stated that a song must feature 'Depends on my mood, but generally upbeat tempo. for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

It just keeps me going at a high pace and energy and helps me deal with the strenuous feeling of exercising.

4. In question 12 you gave us a list of your top 5 songs for working out or walking outside, you stated 'Dependent on different playlists available on my phone. I don't create specific exercise playlists.' Can you elaborate how you construct your playlists and what meaning they have to you?

I hate curated playlist because they have quite awful chart music, but I feel like I'm quite good at creating my own playlists that are full of tracks with a similar feeling and are an hour long and perfect to work out to.

5. In question 13 you stated you consider yourself to be ___3_____. Could you please elaborate as to why you feel this way?

Well not because I'm musically talented, but because I listen to a lot of music and love all sorts of genres and I don't close myself to new music.

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**

i. Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

Q. For card 2 you stated your emotions as stress! Do you often feel like this when you run?

A. Well it's something that I have to really gear myself up to do and its not something I do often and if I had a treadmill at home I would do it more often, and I worry what other people think of me.

Q. For card 4 you stated you provided an image of a park trail, can you explain why you provide this image?

A. I included this image because this is the place where I usually run, there are some lovely cows, donkeys, and other animals in the fields as you run past. So for me this is the thing I associate most with my exercise routine.

Q. For card 7 you stated the most displeasing sounds you heard were big trucks, what do you find most displeasing about this sound?

A. It's just horrible innit, its off putting, it makes you really aware of your surroundings and if you're on a main road it just reinforces that feeling that there are lots of people around.

Q. For card 9 you stated the most pleasing sounds you heard were 'birds', what do you find most enjoyable about this sound, what feelings does it evoke?

A. it's the opposite to the previous answer, it makes you feel more connected to nature and on your own. I love being in green spaces because it reminds me of being in the countryside

Q. For card 11 you described you phone as 'Anxiety inducing, connected, enslaved' can you elaborate why you associate these three words to your mobile device?

A. I predominantly use it for work and it often has alerts but I try to ignore them but I have to keep them on and they interfere all the time so its stressful.

Q. For card 12 you stated your motivation for running that day was 'boredom, to lift your mood, to just move', could you elaborate why these are your motivating factors?

A. A lot of the day I'm chained to the desk and in meetings, when I'm feeling bored or don't know what to do with myself it's a good way to let that energy out, I do try to go out most days just to move away from the screen.

Q. For card 15 you stated you 'never find running particularly enjoyable' can you elaborate why this is the case and what you do to overcome this?

A. again, it stems back to school from being forced to do cross country and certain things that were said by lovely P.E teachers. I've definitely gotten better at it and I do have friends who different types of exercise and I'm hoping to start doing things more regularly, and I think the encouragement of friends is very important to me in terms of exercising.

Q. For card 16 you stated your favourite sound in the world is 'the sound of my keys when I put them in my door' can you elaborate why you enjoy this particular sound?

A. Just because it makes me feel warm inside that I'm getting home and I can relax.

Q. For card 19 you recorded a sound which includes traffic noise, footsteps and sounds of other people, can you elaborate where this scene was captured and what features you would describe as pleasant and unpleasant?

A.

Q. For card 20 you stated that at the end of a run you like to feel 'happy that its finally over' do you often feel like this, is there ever a moment where this feeling differs?

A. Because I don't run with a particular time goal or pace or anything like that, but it's a sense of relief and accomplishment that I've gone out and done it regardless of anything.

Q. For card 24 you stated that when people see you running, they see 'a really gangly idiot who doesn't know what they're doing' what is it that makes you feel this emotion when you come across strangers. Does it affect how you run in any way?

A. I've been out with groups of friends and if someone has a weird run someone always comments about it and It just goes back to school the feeling of not wanting to standout for the wrong reasons.

Q. For card 27 you stated that if you could run anywhere in the world, you would 'Run around lake Garda in Italy' what significance does this place hold to you and why would you like to be there?

A. I went there when I was 17 with my mum and it was our first holiday together, but it was so beautiful and it was the first time I thought what an incredible place and again lots of birds and lots of greener and everything was still with no people around and a sense of freedom.

NB. Each participant will provide a varying amount and completion of cultural probe activities; therefore, this section of interview will develop naturally based on each individual datum.

II. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.

b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

nope!

c. Thank you for all your help with the Running to Your Own Beat project!

Stop recording.

Participant 5

I. **Interview Body**

a. **(Topic) Survey**:

i. Exercise Routine

1. You have stated that you exercised with a frequency of __2-4__ days per week. Can you please explain, what factors influenced you to choose this particular frequency?

Can be the weather, but usually it's from past history it's just what I know what I need to do to stay fit.

2. In the questionnaire you have stated that your level of expertise was _____5____. Could you please elaborate why you have placed yourself in this category?

I've spent most of my adolescence running several hundred miles a week, that gave me a good start, I also achieved the level of county champion in

steeple chase so I have the background to know what exercise I should be doing and what I shouldn't be doing with my body.

3. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show participant category list).

   I've learnt more about myself but I'm not up to date with everything to do with running nowadays, what I do know is my body and what I need to do to keep it in shape.

4. Can you also detail, what the specific activities constituted this particular exercise routine you were following?

   mainly jogging, sometimes, depends on the weather, I'll just do fast walking, which can turn into a run if I'm feeling really good.

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   no, it's almost exactly the same it's always been. However, When I was living at my previous address, and walking 10 miles a day to and from the supermarket I kept a daily record of the date temperature and the time it took me to travel the distance and I kept that record for 6 years, but I stopped when I moved home. I feel maybe I fell out of the habit because I was being so intense with the record keeping, it was a way of ensuring I was doing enough and being consistent

ii. **Motivation**

1. You have stated your main motivation for exercising is 'General health and weight control. Can you elaborate why this is a motivating factor for you?

   because its expensive to buy new clothes because my waistline is increasing, and pride in my own appearance, I don't like other people to see me and think fat. I love eating and I eat too much and the only way I can mitigate the bad effects of that is to jog every day.

2. Is this still your current motivation for exercising, or has this changed in any way since the start of the project?

I think since I started work everything changed, when I was young running was always done purely for pleasure, I loved running, but in my working life, with less time, it became more of a utilitarian thing for ensuring my health and fitness were maintained. I recently became fully retired so that has now changed back to running for a bit of pleasure again

3. You have stated 'Nothing.' prevents you from feeling motivated to exercise. Why do you feel so motivated?
   I have the need to do it, I have the need to know that I am looking after my body. When I'm out running, I get this feeling when things are going well this amazing feeling that the human body is a wonderful thing and that I want to be able to keep doing this for as long as possible, I don't want to stop ever. They said Ron hill in later life ran at least 1 mile a day until he died, it's that sort of thing.

iii. **Technology**

1. In the survey you stated you haven't used fitness tracking technology before.
   a. If NO:
      i. Before you started this project, what factors prevented you from using these products and technologies?

         Price is definitively one, everything I've seen that I would be interested in is far too expensive. As someone who is retired on a limited income, they are too expensive, and I'm not sure that I would be interested in the kind of information that they give me.

      ii. In question 8 of the survey, you have stated you feel 'Would use one if it gave me the information I required and was affordable. about the impact these technologies have on your progress. Please elaborate on why you feel this way.

         Strangely enough it's something that I don't think exists maybe. when I'm exercising, I'm perfectly aware of my heart rate, I know when my muscles are working properly, it's all obvious to me due to my experience, but due to my age I would like to know when I'm exercising am I damaging my hips, my ankles, it's that kind of injury from exercise that worries me and would be good to have something that helps me prevent that

iii. Has your opinion or perspective of this technology changed in any way since the start of the project?
Not so much, I can't really see so many benefits of having so much data being collected, when I am so in tune with my body, and I feel having all that data will make me feel distracted if I have constant reminders of my bad posture of blood pressure or whatever. Maybe for professional athletes they are much more useful.

I feel that most people buy one to show off that they have one or to be part of the fad.

iv. **Exercise habits**

1. You have stated that you exercise with a partner or a group of people 'None of the time' Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

It's just habit, it's what I have always done, since I was in school, I would just train on my own. When I was a kid and captain of school athletics then I used to exercise with other kids, but I never liked it, I always preferred on my own, cause someone I know told me once said during an intense exercise I'm done this is punishment and I said if you don't punish yourself, you don't get anywhere. So, I exercise for me to the fullest and that doesn't necessarily fit with what other people may want to do.

I see groups of people out running sometime and it annoys me to see them talking and I think, jeez if they can waste all that energy talking, they should be running fast

1. In question 10 you said you listen to music whilst exercising some of the time.
    a. If answer is some, half, most or all of the time:
        i. Can you please elaborate why you like listening to music while you exercise?

I don't specifically, I've done it periodically in part to test whether how it affected my exercising and one of my problems is that I love music so much and if I listen to music, I really like I lose myself too much into it and I lose concentration. It has its benefits if you're doing long distance running like a marathon, but just on average it doesn't work.

I tried using different tempos of music like rock, but that didn't work, and things I hear coming from gyms, I just don't like it, it's too rhythmic, it doesn't help my exercise in

any way.

ii. On what exercise related instances do you not listen to music and why?

I exercise on narrow country lanes where you don't know what's round the next corner, if you're listening to music completely lost in it you may not hear sounds you should be hearing to stay safe. Like HGVs coming down narrow country lanes.

2. In question 11 you stated that a song must feature 'I would want it to be mentally absorbing to take me to that higher plane where there is no physical pain. for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

Once everything is functioning perfectly what you need for long distance running is to accept it and forget it and ignore it, anything that helps you it's a bonus, for a lot of people that would be music because with the right music it can take you out of your body, your away, your e in that music. I've experienced it, but you can even achieve that without music, but it's not easy and it's a skill long distance runners have to master.

3. In question 12 you gave us a list of your top 5 songs for working out or walking outside, you stated 'Emmylou Harris - "Making Believe" - "Boulder to Birmingham" Jackson Browne - "The Dancer" Ken Boothe - "Everything I Own" Fairport Convention - "Meet on The Ledge".' Can you elaborate why you chose these songs?

they all have high emotional content, they are deeply emotional songs all of them, but they are intelligent songs, it's not pop music, this is a combination of music and lyrics, and it's what I use to escape in a sense, an escape which you choose you guide and you control, so it's the music I use when I need to get out my body for a while.

4. In question 13 you stated you consider your musicality to be ___4_____. Could you please elaborate as to why you feel this way?

I couldn't give a 5 because I'm not a musician but I classified myself like this because the amount of music I have dedicated myself to listen to over the years, my knowledge of different music genres, my love of music in

general, even opera if I'm in the right mood. It's a vital part of my life, I couldn't live without it.

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**
   i. Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

Q. For card 4 you provided an image of a plate of food and a glass full of an alcoholic beverage can you explain why you associated this image with running?

A. I love food so, so much that if I didn't run, I probably wouldn't have made it to my age! I have always tried my best to stay fit so that I can continue enjoying all the food I love without it taking years away from my life.

Q. For card 6 you recorded a sound that said 'aaaaaah! Glad it's over' with your voice that captured the spirit of the run, why did you choose to make this sound?

A. it's partly the satisfaction of making a sound that tells yourself that you are satisfied with what you have done.

Q. For card 7 you stated the most displeasing sounds you heard were HGVs, what do you find most displeasing about this sound?

A. Because its life threating not just because its loud, but it's a life threating sound, especially if it's coming from behind.

Q. For card 8 you stated your running shoes would say 'We were built for faster than this! Why did they say this to you?

A. I'm lucky in that I have found a make of shoe that is perfect for the kind of exercise that I do, which is walking jogging cross-country road, they're shoes I've proved will stand up to an incredible amount of punishment, and I can use them until they fall apart. So, I think my shoes are happy and I'm happy with my shoes. They said they would like to go faster, because like me they know I want to go faster, so they are there to encourage me, and achieve our goals together.

Q. For card 11 you described you phone as 'Necessary confusing frustrating' can you elaborate why you associate these three words with your mobile device?
A. I suppose because initially for me mobile phones were associated with work,

obviously I had mobiles when they were first invented, and the only ones who had them were companies who gave them to their executives, so initially they were 'work' and I've never liked using a phone of any kind for just chatting. I don't like speaking to people on the phone, so most of the stuff most use their mobiles for I'm not interested in, I don't use social media ever, so my phone is just an alarm clock, checking the weather, bus times or train times, news, occasionally use the camera, but I don't get any fun out of taking loads of pictures. In part due to my age they just have little value, yet I have become dependent on them since I no longer wear a watch and for ordering stuff online as its necessary to receive delivery updates.

Q. For card 13 you stated the sounds you associate most with running are 'Birdsong the sound of wind in the trees and the sound of my feet on the tarmac' Why do you associate these sounds?

A. I've been lucky in that for the most part of my life I have lived and exercised in the countryside, I just had to step out of my door to run through a wood so I would not be running in the city streets I would not like that at all, I need the sights and sounds to make it a pleasurable experience. The visual effect of the countryside with all its sounds, even insect wings!

Q. For card 15 you stated the most enjoyable moment of that run was 'Reaching the top of the highest hill and turning round knowing I was halfway through and had gotten past the worst of it.' Can you elaborate why this an enjoyable feeling?

A. because every time I do it, from the first time I went up that hill 10 years ago, one day I suddenly realize how steep a hill it was, at the age of 20 I probably wouldn't even have called it a hill! It's like 300m of just steady rising incline, but when I conquer it, I think 'yeah I wonder how many 72-year-olds can do that? and I want to be able to do that until I'm 80'.

Q. For card 18 you stated you would rather be 'Just at the lake district climbing the hills' instead of running today, why did you choose this place?

A. well for all the other things I said previously about the joys of exercise for me have always been in beautiful surroundings and you have everything you could ask for in the Lake District.

Q. For card 20 you stated that at the end of a run you like to feel 'That I did more than the last time! That my performance was superior.' do you often feel like this, why is it important for you to feel this way?

A. yes, but not so much as when I was keeping daily records. One of the reasons of keeping that record is because I had a mission of completing those 10 miles in the amount of time, I felt I should be doing it at.

Q. For card 21 you described your run as ‘Green’ why did you choose this colour?

A. partly because my surroundings: fields trees, partly because if I choose the right time of day, I will do my route and there won’t be any traffic, so when that happens, I feel every breath of fresh air I take is healthy, so its green in that sense too, oh and also my shoes are green

Q. For card 22 you described ‘One young lady who overtook me which was shameful, but she was way fitter than me, and younger! But I thought for a moment I could have beaten her! ‘As the features you remembered the most people you ran past, can you please elaborate why you think you focus on these features?

A. she didn’t seem to have the body you’d expect from someone who regularly runs, she was more like someone who played rugby, so it was deceiving how fast she was going and that made her quite memorable to me. It’s nice to see others exercising so it’s always a nice feeling when you see people running past.

Q. For card 24 you stated that when people see you running, they see ‘Many of them probably don’t want to admit that they think ‘I wish I could do that’ when they see me go past’ what is it that makes you feel this way when you come across strangers. Does it affect how you run in any way?

A. It depends on the age of the person seeing me, sometimes I go past kids on their way to school, 13–15-year-olds, and I do wonder how many are thinking look at that silly old fart, what’s he trying to do? He’s almost dead! I have no idea; I think older people or men who are obese I’m pretty certain they would like to be able to do what I can at my age.

Q. For card 25 you shared a picture of your running shoes, what do you feel when you look at them?

A.

Q. For card 26 the three words you would like to say to the weather today were ‘I wish it could be like this every morning: grey damp cool ‘why does this type of weather evoke this emotion?

A. it’s the best combination for intense exercise, I don’t like anything above 20 degrees it’s so uncomfortable so grey damp and cool is ideal, I prefer 2 degrees over 22 degrees cause ill run a hell of a lot harder at that temperature to get warm I assure you that!
I suppose also the fact that if it’s a sunny day somehow you would rather be on a deck chair on a sunny beach, so it’s not as conducive to exercise.

Q. For card 27 you stated that if you could run anywhere in the world, you would 'In the forests north of Rovaniemi in Finland' what significance does this place hold to you and why would you like to be there?

A. the combination of physically what is there, the trees the terrain, perfect for running and cross-country skiing and I suppose at certain times of the year the almost perfect silence. In winter the only sound would be your feet breaking the crust of snow.

Q. For card 28 you stated that if you could have any running partner dead or alive you would choose 'Emmylou Harris or Mary Bignal Rand' why did you choose this person?

A. I chose Emmylou Harris as a joke a bit because I love music! But I love Mary Bignal Rand was an amazing athlete I idolised when I was 14 years old and also had a big crush on her!

II. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.

b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

I found it very enjoyable and interesting to have a chance to sit and reflect so much about something that's almost second nature to me now.

c. Thank you for all your help with the Running to Your Own Beat project!

Participant 6

Running to your own beat! – Interview Schedule

In order to ensure a structured and consistent method of data collection for the *Running to Your Own Beat!* project interview stage, the following schedule is proposed to guide the dialogue with the participants.

I. **Opening**

a. (**Welcome**) – Hello, my name is Stuart Haffenden, and I am the researcher in charge of this project. I would like to thank you for coming in today for this interview and for completing the prior activities in this project.

b. (**Purpose**) – Today I would like to ask you a number of questions relating to your experiences with the previous activities you have completed and ask you to elaborate on some key topics and questions relating to your thoughts on music, technology and exercise.

c. (**Motivation)** – With the answers you give today I hope to provide a more in-depth analysis on the data you have provided so far. This will help us get a better

understanding of how people use music when exercising and the role technology has played in their quest to fulfil their fitness goals.

d. (**Timeline**) – This interview will take approximately 1 hour to complete, so please ensure you are prepared to dedicate this time for the interview and please confirm you are happy to proceed.
(Pause and allow participant to get ready if requested).

(Transition: Let me begin by asking you to elaborate on the answer you provided in the initial questionnaire)

II. **Interview Body**

a. **(Topic) Survey**:

1. Exercise Routine

1. You have stated that you exercised with a frequency of __2-4__ days per week. Can you please explain, what factors influenced you to choose this particular frequency?

   It would be due to what fits in with my work, and how busy I am, according to my job. And, and also my job is quite physical. So, it would be However, I'm feeling as well in terms of physically drained or I'm feeling fresher, in a sense. So, I'd adapt it around that. Obviously, the weeks where I'm doing less work, I would probably do more exercise-based activities. Okay, I am and feel more tired and not want to do the exercise. When I've worked more hours at my job,

2. In the questionnaire you have stated that your level of expertise was _____3____. Could you please elaborate why you have placed yourself in this category?
   I wouldn't say I'm at all an expert in any sort of sense. I'm not a sportsman. And I don't think I'm a beginner in that I you know, I've got a bit of a level See, I'd say I'm quite average in terms of my, my experience with exercise. Okay,

3. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show participant category list).

   I think mentally I am in a better place these days. I realized in the past, I didn't realize at the time, but I do now that I am more clear, more relaxed. And I have more emphasis on keeping fitter as I'm getting older as well. I guess five years ago, I maybe didn't feel as much need to be working on it because I've always felt like I was quite fit and active at that time. But these days, I'm trying more to be okay. not losing fitness. Scared to lose fitness.

4. Can you also detail, what the specific activities constituted this particular exercise routine you were following?

   mainly running and yoga

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   not really, I've just always had like this certain like level of activity that I try to keep up when I can.

2. **Motivation**
   1. You have stated your main motivation for exercising is 'General health and weight control. Can you elaborate why this is a motivating factor for you?

      I just try to do enough to feel good, I've always just spent time doing exercise, so I know what like you know feels good.

   2. Has this always been your motivation for exercising, or has this changed in any way?

      I guess, my parents were always very healthy fit people. My dad was a sportsman played football my mom was always into yoga. I do think that influenced me a little bit in that I was brought up to do a lot of exercise and, and we do go you know, on walks all the time, things like that. So, I think I became very used to having a normal lifestyle of exercise perfectly and I didn't necessarily then take up sport, but like them in a way I kind of just kept it more as a hobby where I just continue to have a level of fitness

   3. You have stated 'not much.' prevents you from feeling motivated to exercise. Why do you feel so motivated?

      I find it makes me feel better, so I'm quite motivated, though I do have to push myself to do it but once you're in it its easy just to keep going.

3. **Technology**

1. In the survey you stated you haven't used fitness tracking technology before.
    a. If NO:
        i. Before you started this project, what factors prevented you from using these products and technologies?

        and I'm a little bit old school and with technology, things like that. I find a maybe I'm just a bit lazy in that something new to Me, so I'm just, I'm happy with what I do. I'm not feeling the need to, to have something electronic to, to show me what I'm doing. In a sense, I'm already aware of that.

        ii. In question 8 of the survey, you have stated you feel I've just never really dug in; I imagine they could motivate you by seeing your progress about the impact these technologies could have on your progress. Please elaborate on why you feel this way.

        Yeah. Perhaps I feel that would be more of like, you're actually setting yourself a challenge more of a goal-based thing? And weirdly, maybe I am not doing that. Because then it it's like, I'm almost not setting myself a challenge. Right? If that makes sense. Yeah. So, I'm being a bit lazy in my habits. Okay, I'm

        iii. Has your opinion or perspective of this technology changed in any way since the start of the project?
        Not really, I mean it's interesting and I like trying things but yeah

4. **Exercise habits**
    1. You have stated that you exercise with a partner or a group of people 'most of the time' Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

        I find it encouraging and motivating having another human that you are sharing the experience with? And you can you know, push each other, and encourage each other

    2. In question 10 you said you listen to music whilst exercising about half of the time.
        a. If answer is some, half, most or all of the time:

i. Can you please elaborate why you like listening to music while you exercise?

I find it either motivates me the music itself, and encourages me to go faster, or it'll keep me more in a relaxed state.

ii. On what exercise related instances do you not listen to music and why?

And then I guess the other times where I don't have music, it would be because I quite like to just focus on the natural sounds. And I find it soothing, as well to not have something in your ears. dependent on the mood

3. In question 11 you stated that a song must feature 'I would want it to be mentally absorbing to take me to that higher plane where there is no physical pain. for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

Probably trance like high energy and the rhythm, fast and upbeat for running more aggressively, but more chilled out music for yoga.

4. In question 12 you gave us a list of your top 5 songs for working out or walking outside, you stated 'Spotify Curated Playlists' Can you elaborate why you chose this?

I guess just for ease, as I haven't spent the time compiling the music, in a sense, it's just a library that's already there. Also, kind of trust and in general, that it's based on the music I usually listen to the I don't know how it works, but they would play music that I would probably like,

5. In question 13 you stated you consider your musicality to be ___3_____. Could you please elaborate as to why you feel this way?

well I mean I don't really know much about music, but I love it so yeah.

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**

1. Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

   Q. For card 1 you if your run were a sound, it would be 'Loud yeaaaah!', why did this sound embody your run?

   A. it's a motivating burst of energy I don't know it's a fast release a rush of adrenalin.

   Q. For card 2 you stated your emotions before a run were '*Ugh I'd rather stay in!*' Can you please elaborate why you associate these feelings with the start of a run.

   A. because I feel that the difference of afterwards how you feel afterwards is completely the opposite and you are so happy you did it you know all the release of the good chemicals and it's very different when you feel that and so I guess before, it's the whole 'you're working yourself up a lot to get to that point' Yeah, and it's all mental I know it's

   Q. For card 3 you heard 'traffic' can you explain why you this sound was the most prominent?

   A. Well, I live on a busy road so it's kind of always there in the background.

   Q. For card 5 you provided a picture of a river why did you include this image?

   A. Fortunately it's on our doorstep we're very lucky. It's tranquil its very nature based it's away from the car pollution. It has a path as well it's you know, concrete, easy path to do. It's the circuit itself. It's not too far of a distance it's just kind of a nice amount of the scenery its lovely and what you see visually is motivating.

   Q. For card 7 you stated the most displeasing sound you heard was 'car horns, loud beeping, sirens' can you explain why you found this sound the most displeasing?

   A. Oh, they're just quite I guess not nice sounds they're not soothing they're the opposite they're a bit you know. Anxiety based Yeah. Aggressive loud

   Q. For card 8 if your shoes could speak you said they'd say, 'speed up!!!'

   A. I don't know I think I'm my own biggest enemy as well sometimes I'm always not thinking I'm doing enough and perhaps that's what I'm looking down towards where shoes always thinking I should be further ahead than I am and should be

faster going faster maybe I'm not as quick as I'd like to be I'm not at a level I want to be a bit more Yeah.

Q. For card 20 you stated that at the end of a run you like to feel '….' do you often feel like this, why is it important for you to feel this way?

A. yeah, it's a sense of you feel good that you've actually gone and done it

Q. For card 21 you described your run as 'Green'. Why did you choose this colour?

A. Green probably because of a lot of the scenery around, you know, the fields, the trees. In a sense, nature reminds me of green and when you return back to your home, I feel like it's less green is kind of like that period of time where you're there. Okay, perfect and Shana field would like the green.

Q. For card 24 you stated that when people see you running, they see 'I always think, I should be doing more of that, like envy!' What is it that makes you feel this way when you come across strangers, and does it affect how you run in any way?

A. I don't know, I guess I think it's generally the look on people's faces. You always see where they're a bit like, oh, well, I think it's because particularly we're in a village where people are doing their day-to-day shopping or things like that. So, it reminds them all of a sudden that and we're all humans that you know, some another human being is pushing yourself to do something. And I think we're all a little bit competitive in that sense, like, great.

Q. For Card you described the weather like 'beautiful, crisp and fresh' what do these associations make you feel in regard to the weather?

A. the cool, crisp weather is a little bit discouraging Because of the thought of putting warmer clothes on to do exercise? That's silly. But it's a nice day and it feels fresh.

Q. For Card 27 you stated you would like to be 'running in a forest somewhere exotic like Bali', why did you choose this place?

A. I think it's just nature. You know, I prefer to be around that scenery than harsh concrete, pollution, cars, fast, busy environments, slow environment is better. Perfect.

III. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.

b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

nope that's all it was fun!

c. Thank you for all your help with the Running to Your Own Beat project!

Participant 7

I. **Interview Body**

a. **(Topic) Survey**:

1. Exercise Routine

1. You have stated that you exercised with a frequency of __2-4__ days per week. Can you please explain, what factors influenced you to choose this particular frequency?

   umm getting it to fit round work, it just trying to balance work and social life and try to fit exercise around that.

2. In the questionnaire you have stated that your level of expertise was _____3____. Could you please elaborate why you have placed yourself in this category?

   because I recognise, I'm not a sporty person but I force myself to maintain a baseline

3. Do you feel your level of expertise has progressed since the beginning of this project? In which category would you class yourself now? (Show participant category list).

4. Can you also detail, what the specific activities constituted this particular exercise routine you were following?

   running and strength training at home

5. In what ways does your current weekly routine differ from the one you followed at the start of this project?

   I used to swim up until I was 25 which is a much more different experience

2. **Motivation**
    1. You have stated your main motivation for exercising is 'health. Can you elaborate why this is a motivating factor for you?

       well I stopped swimming because I started smoking a lot and partying and it sort of led to me stopping swimming and not being healthy at all. I then a few years later started noticing my breathing becoming very difficult so I realise I didn't want that for my future, so I started exercising again.

    2. Is this still your current motivation for exercising, or has this changed in any way since the start of the project?

       Well also I had a medical condition in my nose which I got surgery for, so this was also a motivation

    3. You have stated 'work.' prevents you from feeling motivated to exercise. Why do you feel so motivated?
       we're a bit overstretched at work so sometimes I just don't have time because I work 12-hour days sometimes

3. **Technology**
    1. In the survey you stated you haven't used fitness tracking technology before.
        a. If NO:
            i. Before you started this project, what factors prevented you from using these products and technologies?

               Price is a main one really, because I think I prefer having a personal trainer and invest that money like that, there's something about the human connection that motivates you. On those days when you're not quite up for it, not having that social support really affects it. I suppose apps work for some people, but I don't know.

            ii. In question 8 of the survey, you have stated you feel one that could help me improve technique. about the impact these technologies have on your progress. Please elaborate on why you feel this way.

I think those things are a bit too far in the future like a sensor that corrects all your postures during all sorts of exercises, if a gadget like that exists ill buy it in a sec.

iii. Has your opinion or perspective of this technology changed in any way since the start of the project?

4. **Exercise habits**
    1. You have stated that you exercise with a partner or a group of people 'some of the time' Please can you explain what factors influence you to exercise this way and for what reasons does it vary?

       Just having that feeling of encouragement from someone else is very nice. I'm the kind of person who doesn't motivate themselves so much but I'm great at motivating others but having someone to bounce off of like that motivate me.
    2. In question 10 you said you listen to music whilst exercising none of the time.
        a. If answer is some, half, most or all of the time:
            i. Can you please elaborate why you like listening to music while you exercise?

               I don't listen to music when I run really, just when I do strength training. It's a bit being lazy and cheap that I don't buy like strap for my phone, but I just don't think about it. I know if I had music, I might be able to last longer but I don't know.

            ii. On what exercise related instances do you not listen to music and why?

                when I run, I just don't know why it just happens

    3. In question 11 you stated that a song must feature 'like upbeat fast tempo. for it to be included in your playlist, can you please explain why you feel this is a prerequisite?

       I feel like different music has different effects on your body so like fast music for exercise you know some people listen to classical music to concentrate or whatever, so I think it is kind of like that for exercise too.

4. In question 12 you gave us a list of your top 5 songs for working out or walking outside, you stated 'YouTube playlists' Can you elaborate why you chose these songs?

   yeah, mostly electronic music I think like Avicii or David Guetta.

5. In question 13 you stated you consider your musicality to be ___3_____. Could you please elaborate as to why you feel this way?

   I can't live without music but I'm not like musical in any way

(Transition: Thank you for answering those questions. For the next section I will now be asking you to elaborate on your responses to the cultural probe activities you have recently completed.)

b. **(Topic) Cultural Probe:**
   1. Proceed to go through all the material and data the participant has returned and ask to elaborate on the nature of each response.

      Q. For card 2 you stated your emotions before a run were 'let's go get it' Can you please elaborate why you associate these feelings with the start of a run.

      A. yeah, it's a feeling I try to retain over the course of a run but it's hard

      Q. For card 6 you took a photo of 'the street' can you explain why you chose this object

      A. I live in such a busy street, so I just always see that before I go running

      Q. For card 7 you stated the most displeasing sounds you heard were' Traffic, car horns', what do you find most displeasing about this sound?

      A. They generate stress, especially on the busy road I live.

      Q. For card 9 you stated the most pleasing sound you heard was 'birdsong and dogs barking' can you explain why you found this sound the most pleasing?

      A. they're just very relaxing, it's not just nature but like sounds of the park, children playing dogs barking, I just channel everyone's joy of their spare time and that feels very relaxing that's what I associate with a pleasant sound.

Q. For card 12 you described your motivation for running as 'To lift my mood and personal satisfaction of having achieved this goal.' can you explain why this is a motivator for you?

A. No I think my mental state doesn't change too much but there gets to a point where my body starts demanding I do exercise almost

Q. For card 13 you stated the sounds you associate most with running are 'My footsteps and breathing' Why do you associate these sounds?

A. I just seem to concentrate a lot on my breathing now, especially with what I said about not being able to breathe when I was smoking.

Q. For card 15 you stated 'Finishing the run and feeling that sense of completion. Finding the perfect route for running the amount that I need and being able to complete.' Was the most enjoyable moment of the run.

A. it's just nice because running is like a long-term investment and finishing a run gives that sense of progress towards that better life almost

Q. For card 16 you stated 'bubble wrap and the keyboard being typed' was your favourite sound in the world, can you explain why you chose this sound?

A. I like percussive sounds like clicky sounds, I have no idea why it's just very attractive and relaxing.

Q. For card 24 you stated that when people see you running, they see 'I feel like a giant' what is it that makes you feel this way when you come across strangers, and does it affect how you run in any way?

A. Yeah, I always feel like a giant and I always think do I have a funny run? Do I look funny when I'm running?

II. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.

b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?

I found it very enjoyable and interesting to have a chance to sit and reflect so much

about something that's almost second nature to me now.

c. Thank you for all your help with the Running to Your Own Beat project!

Stop recording.

9.3 Appendix 3 – Cultural Probe Interview Code Report

Atlas.ti Report

Interview Data

Codes

○ Auditory feedback as a motivator

Used In Documents:
2 Participant 2 Interview.docx

Quotations:
2:14 44 – 45, First of all the time, I think time and distance are very important for me, because sometimes you're… in Participant 2 Interview.docx
2:24 79, because I want it to be a happy positive sound and that phrase makes me happy reminding me that I've… in Participant 2 Interview.docx
2:28 93, because it's nice to finish something, it's a good feeling to achieve something despite feeling tired… in Participant 2 Interview.docx

○ Auditory perception during exercise

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:29 61, We live in England, so I have to say it is a definite yes on the wind noise! I do my washing early in… in Participant 1 Interview .docx
1:34 64, Well I think it's a typical running sound as I described before with the footsteps and the

rustling… in Participant 1 Interview .docx
2:26 87, it's because I've become more aware of my breathing because of exercise techniques and meditation so I… in Participant 2 Interview.docx
2:34 104, I because it's a natural sound found at the beach or forest or park and its 100% natural, and the fe… in Participant 2 Interview.docx
3:40 71, I said previously the river really inspires me, maybe it's the sound of the flowing water and the fe… in Participant 3 Interview.docx
4:21 97, It's just horrible innit, its off putting, it makes you really aware of your surroundings and if you'… in Participant 4 Interview.docx
4:22 97, it's the opposite to the previous answer, it makes you feel more connected to nature and on your own… in Participant 4 Interview.docx
5:16 74, I exercise on narrow country lanes where you don't know what's round the next corner, if you're list… in Participant 5 Interview.docx
5:21 102, Because its life threating not just because its loud, but it's a life threating sound, especially if… in Participant 5 Interview.docx

○ Choice of running tech

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx

Quotations:
1:9 32, I first started using exercise apps about 5 years ago, but have gone through quite a few apps since… in Participant 1 Interview .docx
2:8 35, Nike like 4 years and Nike running the same, adidas was too complicated so I stopped using it, and u… in Participant 2 Interview.docx
2:9 36, I chose Nike just because I like how easy it was to use and the exercise routines included has been… in Participant 2 Interview.docx
2:11 36, Underarmour because I started tracking my food and from the different ones I tried, underarmour was… in Participant 2 Interview.docx
3:10 35, I've been using Nike for about 6 years on and off in Participant 3 Interview.docx
4:7 42, It's just that I don't use fitness to progress, I just use it to maintain a level of fitness I feel… in Participant 4 Interview.docx
4:8 44, I occasionally use a free pedometer on my phone but I don't check in on it with any regularity. in Participant 4 Interview.docx

○ Detractor for adherence

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:20 46, As I've said before running seems to take too much attention for me to stay motivated and that sort… in Participant 1 Interview .docx
1:28 61, Yes I often feel like this because I run early before work or when I get back, which means I would m… in Participant 1 Interview .docx
1:33 62, Yes, any activity that I feel is too distracting like I have said running is to me, always makes me… in Participant 1 Interview .docx
1:37 27, However, I feel like the process of exercising consumes so much time and attention I normally prefer… in Participant 1 Interview .docx
2:1 19, I would change it to a 3 or 4, I wouldn't say an expert, but at that time I was starting to exercise… in Participant 2 Interview.docx
2:25 83, his a day I was feeling lazy, so I had the option of staying in bed or going to exercise so that day… in Participant 2 Interview.docx
3:9 30, Yes definitely, as I said before, I used to have an expectation that you had to be a big gymbro to a… in Participant 3 Interview.docx
4:1 17, Well it's not a given its more to do with workload and the weather in Participant 4

Interview.docx
4:4 30, I was swimming up until recently but I find it not as accessible, because of mental barrier to doing… in Participant 4 Interview.docx
4:6 35, suppose knowing that I won't commit to something for a long period of time, I've caught myself out b… in Participant 4 Interview.docx
4:9 51, Because I have a deep bred thing from school of things being either good or bad, and if you were goo… in Participant 4 Interview.docx
4:12 57, hen maybe I would take part in it but I don't know anyone in my group of friends who does that so I… in Participant 4 Interview.docx
4:18 95, Well it's something that I have to really gear myself up to do and it's not something I do often and… in Participant 4 Interview.docx
4:19 95, and I worry what other people think of me. in Participant 4 Interview.docx
4:25 103, again, it stems back to school from being forced to do cross country and certain things that were sa… in Participant 4 Interview.docx
5:1 17, and be the weather, but usually it's from past history it's just what I know what I need to do to sta… in Participant 5 Interview.docx

○ Effectiveness of auditory feedback

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx

Quotations:
1:14 39, If there was some way that the sounds phones make were more pleasant or maybe have a way that only th… in Participant 1 Interview .docx
2:14 44 – 45, First of all the time, I think time and distance are very important for me, because sometimes you're… in Participant 2 Interview.docx
2:28 93, because it's nice to finish something, it's a good feeling to achieve something despite feeling tired… in Participant 2 Interview.docx
3:14 37, I like the voice feedback and videos for the warm ups and strength routines in Nike training club in Participant 3 Interview.docx

○ Embodied experience

Used In Documents:
1 Participant 1 Interview .docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:43 25, Especially as I've grown older I've felt it is important in order to spend more time with the people… in Participant 1 Interview .docx
1:44 49, I like listening to music because it helps me either be distracted from the unpleasantness of running… in Participant 1 Interview .docx
1:45 51, There is something about music that makes you want to dance that inherently fits with running, I don… in Participant 1 Interview .docx
1:46 61, it also has a nostalgic effect on me because it reminds me of a time when my mother bought me a nylon… in Participant 1 Interview .docx
3:27 71, I just had a great run and I just love that feeling of being exhausted from pushing yourself, so I a… in Participant 3 Interview.docx
3:30 71, As I said previously the river really inspires me, maybe it's the sound of the flowing water and the… in Participant 3 Interview.docx
3:32 72, I also said it's a lifesaver because I kind of think its umm such an indispensable tool for everyday… in Participant 3 Interview.docx
3:36 78, I find those two colours so energizing; I even have an electric blue bike! Since it was quite a fun… in Participant 3 Interview.docx
3:39 90, I love my mum to bits for all the sacrifices she's made for me so I want to do my best to be healthy… in Participant 3 Interview.docx
4:9 51, Because I have a deep bred thing from school of things being either good or bad, and if you were goo… in Participant 4 Interview.docx

4:13 63, because I don't want people to laugh at me! It's as simple as that. I will do group walks for like soc… in Participant 4 Interview.docx
4:19 95, and I worry what other people think of me. in Participant 4 Interview.docx
4:20 95, I included this image because this is the place where I usually run, there are some lovely cows, don… in Participant 4 Interview.docx
4:25 103, again, it stems back to school from being forced to do cross country and certain things that were sa… in Participant 4 Interview.docx
4:28 106, just because it makes me feel warm inside that I'm getting home and I can relax. in Participant 4 Interview.docx
4:31 119, I went there when I was 17 with my mum and it was our first holiday together, but it was so beautiful… in Participant 4 Interview.docx
5:20 100, it's partly the satisfaction of making a sound that tells yourself that you are satisfied with what… in Participant 5 Interview.docx
5:22 102, 'm lucky in that I have found a make of shoe that is perfect for the kind of exercise that I do, whi… in Participant 5 Interview.docx
5:24 107, I've been lucky in that for the most part of my life I have lived and exercised in the countryside,… in Participant 5 Interview.docx
5:28 125, partly because my surroundings: fields trees, partly because if I choose the right time of day, I wi… in Participant 5 Interview.docx
5:30 132, It depends on the age of the person seeing me, sometimes I go past kids on their way to school, 13–1… in Participant 5 Interview.docx
5:31 138 – 139, it's the best combination for intense exercise, I don't like anything above 20 degrees it's so uncom… in Participant 5 Interview.docx
5:32 142, the combination of physically what is there, the trees the terrain, perfect for running and cross-co… in Participant 5 Interview.docx

- Environmental/ecological factors of exercise

Used In Documents:
1 Participant 1 Interview .docx

Quotations:
1:1 18, I have a very sporty family and grew up with sport, my parents always signed me up for sports activi… in Participant 1 Interview .docx
1:19 46, I don't like running with other people as I sometimes feel awkward trying to match their pace, either… in Participant 1 Interview .docx
1:29 61, We live in England so I have to say it is a definite yes on the wind noise! I do my washing early in… in Participant 1 Interview .docx
1:30 61, I like running in green areas, where you get more natural sounds like trees and birds or maybe also… in Participant 1 Interview .docx
1:31 61, hahaha I definitely should use them more, they are quite nice running shoes so I even feel guilty I… in Participant 1 Interview .docx
1:32 61, I actually really enjoy the sounds of footsteps, but only when it's on interesting material like gras… in Participant 1 Interview .docx
1:34 64, Well I think it's a typical running sound as I described before with the footsteps and the rustling… in Participant 1 Interview .docx

○Exercise Preference

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:5 22, I normally start out with a 10 -15-minute warm up using some routines I found on the internet, then… in Participant 1 Interview .docx
1:6 23, I think I have focussed more solely on running than my other activities like cycling. in Participant 1 Interview .docx
2:3 26, Now I exercise 7 days a week even if I feel really bad 7 days a week I exercise. in Participant 2

Interview.docx
2:4 25, Running, gym routines, home routines in Participant 2 Interview.docx
3:4 23, my routine at the moment is to go out for a minimum of 30 minutes each day if possible, walking bris… in Participant 3 Interview.docx
3:5 22, I just enjoy going out for long walks at the moment, in Participant 3 Interview.docx
4:3 26, Walking is the main one, yoga from time to time, strength training at home as well. in Participant 4 Interview.docx
5:4 25, mainly jogging, sometimes, depends on the weather, I'll just do fast walking, which can turn into a… in Participant 5 Interview.docx

- Experience of Auditory feedback in run training technologies

Used In Documents:
1 Participant 1 Interview .docx

Quotations:
1:13 38, I heavily dislike notifications and alarms so I always switch them off and only have the vibrations.… in Participant 1 Interview .docx
1:14 39, If there was some way that the sounds phones make were more pleasant or maybe have a way that only th… in Participant 1 Interview .docx

- Experience of Run Training technology

Used In Documents:
1 Participant 1 Interview .docx

Quotations:
1:9 32, I first started using exercise apps about 5 years ago, but have gone through quite a few apps since… in Participant 1 Interview .docx
1:10 33, I started out with mapmyrun because a friend suggested it, but its free features were quite limited… in Participant 1 Interview .docx
1:11 34, I like how the data displayed is customisable and can be presented in different formats from graphs t… in Participant 1 Interview .docx
1:12 35, I don't like how the screen sometimes responds to touch and some for the button menus are weird. Ther… in Participant 1 Interview .docx
1:15 40, Not much has changed since this project, except maybe I've been looking at the more detailed data on… in Participant 1 Interview .docx
1:16 41, I have maybe challenged myself a little bit more as I've been looking at the numbers on the recorded… in Participant 1 Interview .docx
1:17 42, I might not as I enjoy tracking things accurately, I feel I wouldn't be satisfied with just knowing… in Participant 1 Interview .docx
1:18 43, Yes I think I will continue using this app for a little while longer as I don't want to invest on an… in Participant 1 Interview .docx

- Experience, Feelings and Adherence to Exercise

Used In Documents:
1 Participant 1 Interview .docx

Quotations:
1:2 18, So, Wile I have lots of experience with sport I am not really an expert or a fan. in Participant 1 Interview .docx
1:3 20, I feel that nothing has changed much as I still follow my same routine. in Participant 1 Interview .docx
1:4 21, I once read a sportsperson who I respected say that you should never go more than 2 or 3 days without… in Participant 1 Interview .docx
1:5 22, I normally start out with a 10 -15 minute warm up using some routines I found on the internet, then… in Participant 1 Interview .docx
1:6 23, I think I have focussed more solely on running than my other activities like cycling. in

Participant 1 Interview .docx
1:7 25, I have never been completely skinny and at one point felt quite out of shape when I was smoking, so… in Participant 1 Interview .docx
1:8 27, have enjoyed reflecting about my relationship with exercise so that kept me quite motivated in an us… in Participant 1 Interview .docx
1:20 46, As I've said before running seems to take too much attention for me to stay motivated and that sort… in Participant 1 Interview .docx
1:22 49, When I run without music I feel like I'm wasting time and I find myself constantly thinking about ho… in Participant 1 Interview .docx
1:25 51, But I also like music that makes me feel quite emotional when I run because it makes me think of all… in Participant 1 Interview .docx
1:28 61, Yes I often feel like this because I run early before work or when I get back, which means I would m… in Participant 1 Interview .docx
1:31 61, hahaha I definitely should use them more, they are quite nice running shoes so I even feel guilty I… in Participant 1 Interview .docx
1:33 62, Yes, any activity that I feel is too distracting like I have said running is to me, always makes me… in Participant 1 Interview .docx
1:35 66, Yes! Of course because if I came back from a run feeling perfect it would probably mean I didn't try… in Participant 1 Interview .docx
1:36 72, I really enjoyed reflecting on my experiences whilst running and I feel like if I could keep the pro… in Participant 1 Interview .docx
1:37 27, However, I feel like the process of exercising consumes so much time and attention I normally prefer… in Participant 1 Interview .docx
1:42 61, . It also reminds me a lot of my dad because he enjoys running a lot, so we always buy him nylon spor… in Participant 1 Interview .docx

○ Features of preferred exercise music

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:24 51, There is something about music that makes you want to dance that inherently fits with running, I don… in Participant 1 Interview .docx
1:26 52, don't have a top 5 because there is just so much good music and I don't always like listening to the… in Participant 1 Interview .docx
2:22 64, for me exercise is to keep me happy throughout the day. And I can't imagine waking up and listening to… in Participant 2 Interview.docx
2:23 66, They all sound happy to me, in Participant 2 Interview.docx
3:25 59, I like music I can get lost to, it doesn't matter if its rock, jazz, classical, dance, ambient music… in Participant 3 Interview.docx
3:26 61, as I said before any music I can connect to so I don't have a top 5. I really don't like cheesy tras… in Participant 3 Interview.docx
3:33 72, this song is just pure energy, it has like a powerful driving beat that just pulses and its quite a… in Participant 3 Interview.docx
4:14 67, because I love listening to music all the time and I use it to fit the mood I am in, or shift to a p… in Participant 4 Interview.docx
4:16 75, It just keeps me going at a high pace and energy and helps me deal with the strenuous feeling of exe… in Participant 4 Interview.docx
4:17 82, I hate curated playlist because they have quite awful chart music, but I feel like I'm quite good at… in Participant 4 Interview.docx
5:18 88, they all have high emotional content, they are deeply emotional songs all of them, but they are inte… in Participant 5 Interview.docx

○ Feelings/emotions regarding run training technology

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 5 Participant 5 Interview.docx

Quotations:

1:11 34, I like how the data displayed is customisable and can be presented in different formats from graphs t… in Participant 1 Interview .docx

1:38 33, switched to Nike+ because it felt simpler to use and a bit more friendly, in Participant 1 Interview .docx

1:41 33, I liked how Garmin can show you quite detailed information, but gives you so many options of display… in Participant 1 Interview .docx

2:9 36, I chose Nike just because I like how easy it was to use and the exercise routines included has been… in Participant 2 Interview.docx

2:11 36, Underarmour because I started tracking my food and from the different ones I tried, underarmour was… in Participant 2 Interview.docx

2:12 37, the different exercises included like yoga or stretching or cooling down, or routines for doing in y… in Participant 2 Interview.docx

5:8 46, Price is definitively one, everything I've seen that I would be interested in is far too expensive.… in Participant 5 Interview.docx

○ Instances where music is not preferred

Used In Documents:

1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:

1:23 50, I don't listen to music while I'm warming up because I need to pay attention to my balance and count… in Participant 1 Interview .docx

2:21 63, when I'm running with. Someone else or when I'm doing yoga. in Participant 2 Interview.docx

2:34 104, I because it's a natural sound found at the beach or forest or park and its 100% natural, and the fe… in Participant 2 Interview.docx

3:24 57, if I'm exercising with my partner I don't listen to music, and occasionally when I just want to clear… in Participant 3 Interview.docx

4:15 69, I wouldn't listen when I'm doing yoga or strength training, I often even just watch Netflix when Im… in Participant 4 Interview.docx

5:16 74, I exercise on narrow country lanes where you don't know what's round the next corner, if you're list… in Participant 5 Interview.docx

○ Issues with auditory feedback

Used In Documents:

1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx

Quotations:

1:13 38, I heavily dislike notifications and alarms so I always switch them off and only have the vibrations.… in Participant 1 Interview .docx

2:15 48, Maybe a bit more detailed to have more data, because it's quite limited, but I feel it could be very… in Participant 2 Interview.docx

3:13 38, I don't like the voice that updates you on your pace and distance, I always hate how long it takes t… in Participant 3 Interview.docx

3:15 41, As I said before I really hate the voice feedback, and I also hate the cheesy congratulatory remarks… in Participant 3 Interview.docx

3:16 42, a more concise way to tell me my distance and pace that isn't a robotic voice that takes 5 minutes t… in Participant 3 Interview.docx

○ Issues with technology

Used In Documents:

1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:

1:12 35, I don't like how the screen sometimes responds to touch and some for the button menus are weird. Ther… in Participant 1 Interview .docx
1:39 33, its free features were quite limited and the app felt a bit boring in Participant 1 Interview .docx
1:40 33, but after a while it felt like it was a bit too gimmicky and not as informative as I would have like… in Participant 1 Interview .docx
2:10 36, but I hate the feature of how it connects to Spotify in Participant 2 Interview.docx
2:13 38, the connection to my music is really annoying and I always just turn it off because it doesn't work… in Participant 2 Interview.docx
2:17 52, I think the one that I was talking about was the adidas one because it wasn't very nice to use, but… in Participant 2 Interview.docx
4:7 42, It's just that I don't use fitness to progress, I just use it to maintain a level of fitness I feel… in Participant 4 Interview.docx
4:23 98, I predominantly use it for work and it often has alerts but I try to ignore them but I have to keep… in Participant 4 Interview.docx
5:9 52, Strangely enough it's something that I don't think exists maybe. when I'm exercising, I'm perfectly a… in Participant 5 Interview.docx
5:10 56, Not so much, I can't really see so many benefits of having so much data being collected, when I am s… in Participant 5 Interview.docx
5:23 103, suppose because initially for me mobile phones were associated with work, obviously I had mobiles whe… in Participant 5 Interview.docx

○ Motivator for adherence

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:4 21, I once read a sportsperson who I respected say that you should never go more than 2 or 3 days without… in Participant 1 Interview .docx
1:7 25, I have never been completely skinny and at one point felt quite out of shape when I was smoking, so… in Participant 1 Interview .docx
1:8 27, have enjoyed reflecting about my relationship with exercise so that kept me quite motivated in an us… in Participant 1 Interview .docx
1:22 49, When I run without music I feel like I'm wasting time and I find myself constantly thinking about ho… in Participant 1 Interview .docx
1:25 51, But I also like music that makes me feel quite emotional when I run because it makes me think of all… in Participant 1 Interview .docx
1:31 61, hahaha I definitely should use them more, they are quite nice running shoes so I even feel guilty I… in Participant 1 Interview .docx
1:36 72, I really enjoyed reflecting on my experiences whilst running and I feel like if I could keep the pro… in Participant 1 Interview .docx
2:2 23, Because it was easier to do one day then have 2 free then another day to not feel overwhelmed and ti… in Participant 2 Interview.docx
2:5 28, Because I love food and snacks and all the delicious things that make you fat and not healthy so I n… in Participant 2 Interview.docx
2:7 31, no it has been actually really good, and in the past weeks when I struggled again, from physical th… in Participant 2 Interview.docx
2:29 94, because my shoes know that every time I wake up I don't want to go running, and rather be in bed watc… in Participant 2 Interview.docx
2:31 99, feeling better because it really boosts my energy for my day, instead of drinking a cofee I do exercise… in Participant 2 Interview.docx
2:36 107, because that kind of tiredness feels very good, that feeling of your body feeling the rewards of the… in Participant 2 Interview.docx
3:2 21, having to think about my exercise habits definitely helps to remind myself how bad I've been at keepi… in Participant 3 Interview.docx
3:3 22, before this I've been going through a period of little exercise really, not currently following a rou… in Participant 3 Interview.docx
3:6 26, as I said before having to think about your habits has definitely made me want to exercise more than… in Participant 3 Interview.docx

3:7 28, I'm the fattest I have ever been and as I'm approaching middle age I just don't feel as energetic as… in Participant 3 Interview.docx
3:8 29, I used to have a problem with my body image but I feel like I am now more motivated to do this for m… in Participant 3 Interview.docx
3:35 76, yeah recently I've been running to lower my stress levels as I know that mental health benefits from… in Participant 3 Interview.docx
4:5 33, Well because I know it works and if I don't do it I feel worse, and its proven to work, it also help… in Participant 4 Interview.docx
4:22 97, it's the opposite to the previous answer, it makes you feel more connected to nature and on your own… in Participant 4 Interview.docx
4:24 99, A lot of the day I'm chained to the desk and in meetings, when I'm feeling bored or don't know what… in Participant 4 Interview.docx
4:29 113, Because I don't run with a particular time goal or pace or anything like that, but it's a sense of r… in Participant 4 Interview.docx
5:5 31, because its expensive to buy new clothes because my waist line is increasing, and pride in my own app… in Participant 5 Interview.docx
5:7 38, I have the need to do it, I have the need to know that I am looking after my body. When I'm out runn… in Participant 5 Interview.docx
5:19 98, I love food so, so much that if I didn't run, I probably wouldn't have made it to my age! I have alw… in Participant 5 Interview.docx
5:25 111, because every time I do it, from the first time I went up that hill 10 years ago, one day I suddenly… in Participant 5 Interview.docx
5:31 138 – 139, it's the best combination for intense exercise, I don't like anything above 20 degrees it's so uncom… in Participant 5 Interview.docx

- Music as an ergogenic aid

Used In Documents:
1 Participant 1 Interview .docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:21 49, I like listening to music because it helps me either be distracted from the unpleasantness of running… in Participant 1 Interview .docx
1:23 50, I don't listen to music while I'm warming up because I need to pay attention to my balance and count… in Participant 1 Interview .docx
1:24 51, There is something about music that makes you want to dance that inherently fits with running, I don… in Participant 1 Interview .docx
1:26 52, don't have a top 5 because there is just so much good music and I don't always like listening to the… in Participant 1 Interview .docx
1:27 53, I consider myself to be somewhat musical as I can play keys and guitar but I've always felt I struggle… in Participant 1 Interview .docx
4:14 67, because I love listening to music all the time and I use it to fit the mood I am in, or shift to a p… in Participant 4 Interview.docx
4:16 75, It just keeps me going at a high pace and energy and helps me deal with the strenuous feeling of exe… in Participant 4 Interview.docx
5:15 73, tried using different tempos of music like rock, but that didn't work, and things I hear coming from… in Participant 5 Interview.docx
5:17 80, Once everything is functioning perfectly what you need for long distance running is to accept it and… in Participant 5 Interview.docx
5:18 88, they all have high emotional content, they are deeply emotional songs all of them, but they are inte… in Participant 5 Interview.docx

- Music for dissociation

Used In Documents:
2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 5 Participant 5 Interview.docx

Quotations:

2:37 58, I really just like my time with my music in Participant 2 Interview.docx
3:8 29, I used to have a problem with my body image but I feel like I am now more motivated to do this for m… in Participant 3 Interview.docx
3:22 52, Overall I prefer to do it on my own because I like losing myself in my music and thinking of things in Participant 3 Interview.docx
3:34 73, I felt calm and relaxed because I got lost in listening to the music as I had never heard it before… in Participant 3 Interview.docx
5:14 71, I don't specifically, I've done it periodically in part to test whether how it affected my exercising… in Participant 5 Interview.docx
5:17 80, Once everything is functioning perfectly what you need for long distance running is to accept it and… in Participant 5 Interview.docx

○ Music for Motivation / mood

Used In Documents:

1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx

Quotations:

1:21 49, I like listening to music because it helps me either be distracted from the unpleasantness of running… in Participant 1 Interview .docx
1:25 51, But I also like music that makes me feel quite emotional when I run because it makes me think of all… in Participant 1 Interview .docx
2:20 61, because the music motivates me if its happy or brings me happy memories, but also if it's something I… in Participant 2 Interview.docx
2:33 104, because the video is about a guy running so I always connect it to that video which I really like, s… in Participant 2 Interview.docx
3:23 56, I like listening to music all the time, I always feel excited about a new song I've discovered and I… in Participant 3 Interview.docx
4:14 67, because I love listening to music all the time and I use it to fit the mood I am in, or shift to a p… in Participant 4 Interview.docx

○Perspective of personal experience with exercise

Used In Documents:

1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:

1:2 18, So, Wile I have lots of experience with sport I am not really an expert or a fan. in Participant 1 Interview .docx
1:3 20, I feel that nothing has changed much as I still follow my same routine. in Participant 1 Interview .docx
1:20 46, As I've said before running seems to take too much attention for me to stay motivated and that sort… in Participant 1 Interview .docx
1:35 66, Yes! Of course, because if I came back from a run feeling perfect it would probably mean I didn't try… in Participant 1 Interview .docx
1:42 61,. It also reminds me a lot of my dad because he enjoys running a lot so we always buy him nylon spor… in Participant 1 Interview .docx
2:1 19, I would change it to a 3 or 4, I wouldn't say an expert, but at that time I was starting to exercise… in Participant 2 Interview.docx
2:16 50, I used it more because I started using it every day. I keep better track of my pace and distance and… in Participant 2 Interview.docx
2:36 107, because that kind of tiredness feels very good, that feeling of your body feeling the rewards of the… in Participant 2 Interview.docx
3:1 18 – 19, I have had an on/off relationship with exercise umm, there's been times where I have been good at kee… in Participant 3 Interview.docx
3:7 28, I'm the fattest I have ever been and as I'm approaching middle age I just don't feel as energetic as… in Participant 3 Interview.docx

4:2 21, Well no one is particularly sporting in my family so it's not something I grew up with and I also fo… in Participant 4 Interview.docx
4:13 63, because I don't want people to laugh at me! It's as simple as that. I will do group walks for like soc… in Participant 4 Interview.docx
5:2 20, I've spent most of my adolescence running several hundred miles a week, that gave me a good start, I… in Participant 5 Interview.docx
5:3 24, I've learnt more about myself but I'm not up to date with everything to do with running nowadays, wh… in Participant 5 Interview.docx
5:6 37, I think since I started work everything changed, when I was young running was always done purely for… in Participant 5 Interview.docx

○ Running as a social practice

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:1 18, I have a very sporty family and grew up with sport, my parents always signed me up for sports activi… in Participant 1 Interview .docx
1:19 46, I don't like running with other people as I sometimes feel awkward trying to match their pace, either… in Participant 1 Interview .docx
2:19 58, I change it when I started going to the gym but you get really distracted because you end up having… in Participant 2 Interview.docx
3:21 52, I used to hate running with other people however I like walking and jogging with my partner now. in Participant 3 Interview.docx
4:11 57, I think if a group of close friends were actively using something like in those apps where you can s… in Participant 4 Interview.docx
4:26 103, I've definitely gotten better at it and I do have friends who different types of exercise and I'm ho… in Participant 4 Interview.docx
4:30 116, I've been out with groups of friends and if someone has a weird run someone always comments about it… in Participant 4 Interview.docx
5:13 64 – 65, t's just habit, it's what I have always done, since I was in school I would just train on my own. Wh… in Participant 5 Interview.docx

○ Running outdoors vs. indoors

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:30 61, I like running in green areas, where you get more natural sounds like trees and birds or maybe also… in Participant 1 Interview .docx
2:32 102, Because I love the feeling of being outside running especially in summer. I associate the beach… in Participant 2 Interview.docx
2:35 105, Because I love the beach and whenever I go the beach I feel happy, so I like the idea of being at th… in Participant 2 Interview.docx
3:28 71, love running near the river by my house, there's something about the openness and the colours of the… in Participant 3 Interview.docx
3:37 82, love the feeling of going out just after it rains because the smell is just so delicious! The smells… in Participant 3 Interview.docx
4:20 95, I included this image because this is the place where I usually run, there are some lovely cows, don… in Participant 4 Interview.docx
4:22 97, it's the opposite to the previous answer, it makes you feel more connected to nature and on your own… in Participant 4 Interview.docx
4:31 119, I went there when I was 17 with my mum and it was our first holiday together, but it was so beautiful… in Participant 4 Interview.docx
5:24 107, I've been lucky in that for the most part of my life I have lived and exercised in the

countryside,… in Participant 5 Interview.docx
5:26 114, well for all the other things I said previously about the joys of exercise for me have always been I… in Participant 5 Interview.docx
5:28 125, partly because my surroundings: fields trees, partly because if I choose the right time of day, I wi… in Participant 5 Interview.docx
5:32 142, the combination of physically what is there, the trees the terrain, perfect for running and cross-co… in Participant 5 Interview.docx

○ Salient features of the environment

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:31 61, hahaha I definitely should use them more, they are quite nice running shoes so I even feel guilty I… in Participant 1 Interview .docx
1:32 61, I actually really enjoy the sounds of footsteps, but only when it's on interesting material like gras… in Participant 1 Interview .docx
1:34 64, Well I think it's a typical running sound as I described before with the footsteps and the rustling… in Participant 1 Interview .docx
2:32 102, Because I love the feeling of being outside running especially in summer. I associate the beach… in Participant 2 Interview.docx
2:34 104, I because it's a natural sound found at the beach or forest or park and its 100% natural, and the fe… in Participant 2 Interview.docx
3:29 71, e colours of the surrounding nature that always inspires me to make an effort to go out. in Participant 3 Interview.docx
3:37 82, love the feeling of going out just after it rains because the smell is just so delicious! The smells… in Participant 3 Interview.docx
3:38 86, haha as I said In the previous question I really really hate the heat, this was a mega summer… in Participant 3 Interview.docx
4:21 97, t's just horrible innit, its off putting, it makes you really aware of your surroundings and if you'… in Participant 4 Interview.docx
4:27 97, A. it's the opposite to the previous answer, it makes you feel more connected to nature and on your… in Participant 4 Interview.docx
5:21 102, Because its life threating not just because its loud, but it's a life threating sound, especially if… in Participant 5 Interview.docx
5:24 107, I've been lucky in that for the most part of my life I have lived and exercised in the countryside,… in Participant 5 Interview.docx
5:28 125, partly because my surroundings: fields trees, partly because if I choose the right time of day, I wi… in Participant 5 Interview.docx
5:29 128, she didn't seem to have the body you'd expect from someone who regularly runs, she was more like som… in Participant 5 Interview.docx
5:31 138 – 139, it's the best combination for intense exercise, I don't like anything above 20 degrees it's so uncom… in Participant 5 Interview.docx
5:32 142, the combination of physically what is there, the trees the terrain, perfect for running and cross-co… in Participant 5 Interview.docx

○ Technology / data as a motivator

Used In Documents:
1 Participant 1 Interview .docx 2 Participant 2 Interview.docx 3 Participant 3 Interview.docx 4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
1:15 40, Not much has changed since this project, except maybe I've been looking at the more detailed data on… in Participant 1 Interview .docx
1:16 41, I have maybe challenged myself a little bit more as I've been looking at the numbers on the recorded… in Participant 1 Interview .docx

1:17 42, I might not as I enjoy tracking things accurately, I feel I wouldn't be satisfied with just knowing… in Participant 1 Interview .docx
1:18 43, Yes I think I will continue using this app for a little while longer as I don't want to invest on an… in Participant 1 Interview .docx
2:6 29, Yeah and now I have the motivation from my smartwatch which reminds me to do my activities so now I c… in Participant 2 Interview.docx
2:18 53, probably not its weird but I really like tracking my data and keeping my record somewhere, I feel if… in Participant 2 Interview.docx
2:27 91, I use it all the time when I run to track my stats and its good for my motivation so I think I'm bett… in Participant 2 Interview.docx
2:30 97, I enjoy personalising my phone so much so I've personalised it with lots of shark stickers. I love cu… in Participant 2 Interview.docx
3:11 36, out of the ones I tried I enjoyed Nike because it has an app called Nike training club that has lots… in Participant 3 Interview.docx
3:17 43, I've definitely gotten back into using my tracker because I do enjoy following my data and progress, in Participant 3 Interview.docx
3:18 44, I feel it helps a little bit in being more disciplined however I've often tried to follow training pl… in Participant 3 Interview.docx
3:19 46, I think I am better now than before as I said I feel more motivated by having less ambitious targets… in Participant 3 Interview.docx
3:20 49, Yes I said I do enjoy using the app just to keep track of things but I hope it really sticks thi… in Participant 3 Interview.docx
4:11 57, I think if a group of close friends were actively using something like in those apps where you can s… in Participant 4 Interview.docx
5:27 118, es, but not so much as when I was keeping daily records. One of the reasons of keeping that record I… in Participant 5 Interview.docx

○ Technology as a hindrance

Used In Documents:
4 Participant 4 Interview.docx 5 Participant 5 Interview.docx

Quotations:
4:9 51, Because I have a deep bred thing from school of things being either good or bad, and if you were goo… in Participant 4 Interview.docx
4:23 98, I predominantly use it for work and it often has alerts but I try to ignore them but I have to keep… in Participant 4 Interview.docx
5:12 56, collected, when I am so in tune with my body and I feel having all these metrics would make me feel d… in Participant 5 Interview.docx

○ Technology as a tech fad

Used In Documents:
3 Participant 3 Interview.docx 5 Participant 5 Interview.docx

Quotations:
3:31 72, my phone is a bit old, so it's become really slow in recent times, I find this very annoying! Haha I… in Participant 3 Interview.docx
5:11 58, I feel that most people buy one to show off that they have one or to be part of the fad. in Participant 5 Interview.docx

9.4 Appendix 4 – Workshop Schedule

Introduction (5-10mins):

Good morning/afternoon, my name is Stuart Haffenden, and I am the principal researcher behind this project. I would like to start by thanking you for kindly agreeing to take part in this workshop and for sharing your thoughts with us today!

Before we begin, I would like to draw attention to the audio-recorder at the centre of the table. As mentioned to you in the participant information and consent package, this recorder will be used to capture all audio from this session. I would also like to take this moment to remind you that in order to ensure your confidentiality, all transcripts from this session will be duly anonymised to render your data unidentifiable and the original recordings will be destroyed. Therefore, any sensitive information, such as your name, will be removed from the final transcripts. So please remember to relax and enjoy yourself! This should be a fun activity!

By now, from reading the participant information sheet you will have gained a broad idea about the nature of this project but let us dig a little bit deeper so that we can begin to understand why we are all here.

Mobile technologies continue to play an increasingly important role in our day-to-day activities, and there have been few areas where they have been received with as much fanfare and attention as in the personal fitness market. From calorie counters to activity trackers and running apps to wearables (i.e., smartwatches), there are a multitude of products available aimed at helping you track and improve your health. However, most of these devices are designed to track your overall performance (i.e., pace, distance, speed, calories burned, etc.) and there are very few products available that are specialised in teaching you how to run better by helping to correct your running technique.

Furthermore, most exercise and activity tracking technologies have all been screen-based in some way or another. Screens present us with a few problems, particularly when we are trying to communicate complex information to someone engaged in a physical and attention demanding

activity such as running. One way to circumvent this problem is using auditory feedback. Most of us will be familiar with the typical speech-based feedback present in most running apps, not too dissimilar from the voice from a Sat Nav, that relays information such as your average pace, distance and time. While this information is useful to track your progress throughout a run, it is less useful in telling you just how well your running technique is and how to improve it.

The purpose of this project therefore is to, with your help, develop a system for improving running technique that communicates data from body-worn sensors through sound. However, before such a system can be designed it is important to understand what sounds are best suited for communicating running data and how runners respond to such sounds. Therefore, in this workshop we will try to uncover how different running contexts can influence a runner's listening behaviours, as well as the role sound, music and technology play in motivation, engagement and performance.

Workshop Activity 1 – Group Introduction (10-15 minutes):

We will begin by introducing ourselves as runners by going around the group and answering the following questions:

1. What is your participant number?
2. How long have you been running? i.e., what is your level of expertise?
3. How often do you exercise per week?
4. What is your main motivation for running?
5. What is your least favourite thing about running?
6. Do you use any personal fitness technologies? If so which ones?
7. What is your least favourite thing about personal fitness technologies?
8. Do you prefer to exercise alone or with someone else?
9. What is your favourite location for running?
10. Do you listen to music when you run? If so, what kind of music do you prefer when you run?

Workshop Activity 2 (Handout) – Listening test (30-40mins):

For the next activity, we will be listening to 7 different sonic interactions. On the paper handout provided you will find a chart with the sounds to be played across the first row. The first column of the chart contains a descriptive word, with its opposite found in the very last column. For each sound you hear, you will go through each of these polar categories and assign it a value between 0-2. 0 being

the left most word and 2 the opposite in the last common. For example, for sound 1 you will either rate it 0 for ‘clear’, 1 for ‘neither clear nor unclear’ or 2 for ‘unclear’. Each sound will be played a few times to allow you to rate it for each category

	Effect 1	Effect 2	Effect 3	Effect 4	Effect 5	Effect 6	Effect 7	
Clear								Unclear
Pleasant								Unpleasant
Positive								Negative
Airy								Solid
Smooth								Abrasive
Clean								Distorted
Motivating								Demotivating
Unobtrusive								Obtrusive
Calm								Energetic

Workshop Activity 4 – Bodystorming sensor mock-up (30-40 mins):

This next activity should be very fun and free! We have with us today a couple of cutting-edge sensors capable of measuring different attributes of your running technique and performance. We are looking to get an overall impression as to how runners react to new technology and listen to their concerns, ideas and tips on how these technologies can be improved.

At the start of the session, we have briefly discussed your favourite running apps and tech. However, it is now time to delve into your experience with them a little deeper by answering a few quick questions as a group:

1. Overall, would you describe your experience with running tech as positive or negative?
2. What do you think is the main benefit of using running technology?
3. What do you think is the main drawback?
4. How would you describe the in-run experience, are you constantly looking at the screen? Or do you solely rely on auditory feedback such as voice updates or alarms?
5. How would you describe the sounds produced by running apps? Obtrusive, unobtrusive? Informative, uninformative, useful, useless?
6. What is the main feature missing from your favourite tech? i.e., what needs improving?

We have with us today a few new sensors that we intend to use in building our system. I will now pass these sensors around the group so that we can familiarise ourselves with them and have a discussion on how we could use these to their maximum potential for improving our running.

7. What are your initial thoughts about the sensors?
8. Had you ever seen or used anything like these sensors before?

We have created a little demo to help you envisage how these sensors could be used to make sounds and to have you help us in thinking how a potential final product my look like and behave. We will now need one or two volunteers to come up and place these sensors onto their body!

9. How would you describe the overall feeling of the sensors on your body? Are they obtrusive or unobtrusive, discreet or attention grabbing, heavy or light, comfortable or uncomfortable?
10. How do you think they look? What does the group think of their appearance?
11. If you were wearing these sensors in public, what sort of things do you think people would think or say about them?
12. What potential problems do you think you would encounter when using these sensors?
13. How would you describe the sounds that the sensor is producing? Obtrusive, unobtrusive?
14. How do the bone-conduction headphones feel? Can you hear external sounds clearly or unclearly? Do you think these would be better to use when running than normal headphones?
15. What do you think would be needed to make this system into a useful product?

Any other thoughts or ideas you would like to express?

9.5 Appendix 5 - Coding and Quotations

○ Additional Feature Suggestion

Quotations:

2:31 Yes, it seems like you could also use it in other applications as well as in running, that could may…

3:11 will it be good to have something that prevents injuries I think that's always something I worry abo…

3:12 just something that makes it a bit less noticeable I don't 'wanna have to always be thinking about ha…

3:21 they have to be waterproof I suppose and maybe shockproof I'm sure like this wouldn't stand the fall

3:27 well, it should like integrate with everything else obviously people use like smartwatches so I'm su…

Linked Codes:

– is a → ● Interface Design Cues

○ Device Interactions

Quotations:

1:7 only to change the music on my playlist!

1:8 I look at my watch screen during exercise to see my pace and try to keep it up, I sometimes look at…

2:7 So, I've got haptic on every kilometre. So yeah, pretty much every kilometre, I'm doing a look at it…

2:8 Yeah, I spend checking it a lot too, my phone buzzes every kilometre and also every 5 minutes that g…

2:9 could quite happily live without it. I seem to use all that. But just because it's on all the time.…

2:10 yeah, I don't like the voices that tell you your distance, I had to change my app to just vibrate li…

3:3 keeping track of things as I said like my records of certain journeys, I take often so I keep trying…

3:7 yeah I do check it but I have the feedback on my headphones so tells me when I've completed like 5 k…

3:8 when I run, I use it to check what song I'm listening to if I'm listening to Spotify playlist so I y…

Linked Codes:

– is a → ● Experience of Running Technology

○ Feeling of Sensors on Body

Quotations:

1:18: I can't feel it but, I would wear it but I probably if it was like in a hat. I would never wear a…

1:19 you just get used to it don't you like everything you know as long as they're not heavy or whatever…

1:22 well, I mean it depends on what weather you like doing your exercises in and wearing something on yo…

2:15 I tried my mum's heart rate sensor once, which is a strap round your chest, and that feels kind of t…

2:18 But I mean you can't really tell they're there because it's just like the pressure of the headband.

2:19 I'm very aware of it

3:13 yeah they look pretty neat makes you look like Robocop

Linked Codes:

– is a → ● Embodied Experience

○ Integration into Runners' ecologies

Quotations:

1:29 So, you're actively deciding to use it as a device. So therefore, there's some kind of training that…
2:27 Yeah, it's pretty cool how it works I can see how you could use it and the effect is like quite clea…
3:27 well, it should like integrate with everything else obviously people use like smartwatches so I'm su…
3:28 yeah, I think it has to be like tailored to different people will use it differently so maybe like h…

Linked Codes:
– is a → ● Embodied Experience

○ Interaction Mapping issues

Quotations:
1:28 don't know I feel like you must arc your head a lot, like, it's more like confined to a motion th…
1:30 I think it needs like to have a thing that sets it to yourself because like everyone is different and…
2:24 Yeah, range is definitely too wide. I think maybe it's because it's your head it certainly seems lik…
2:30 Definitely you would have to calibrate because I feel it's fine if you're doing it slowly, if you do…

Linked Codes:
– is a → ● Experience of Sonic Interaction

○ Negative Emotional Experience

Quotations:
2:6 I feel really guilty when I don't complete training plans, and I get into this like rut or like habi…
3:14 Yeah that might be a bit too high tech for me

Linked Codes:
– is a → ● Embodied Experience

○ Negative Experience of Running Tech

Quotations:
1:1 I don't really use it on any sort of like regular basis so like maybe neutral?
1:5 just being obsessed with like weight and feeling bad for not doing exercise and having bought like fa…
1:6 Maybe that you need quite a lot of gadgets if you want to track all the little bits you can track no…
1:9 don't really know, I mean I'm sure it would like to annoy me having alarms and beeps or whatever goi…
1:10 Well I turned mine off and use vibrate mostly, they're mostly just beeps and stuff
1:15 nope never I'm a bit old school (laughs)
2:5 You push yourself too hard trying to get to a target.
2:6 I feel really guilty when I don't complete training plans, and I get into this like rut or like habi…
3:2 I used to track my weight using my fitness pal, but I just kept getting depressed from not eating we…
3:5 I think just that if you really want the nice gadgets, they cost a lot of money and like I don't have…
3:6 people just use gadgets and phones too much so it's not like we couldn't do exercise before it so I…
3:9 the voice is obtrusive because it makes the music go quieter it's not like a nice voice because it's…
3:10 I think it's like noise pollution maybe there's too many alarms and notifications and beeps going of…
3:22 also, it's just another thing to buy and to eventually turn into a landfill people have a lot of gad…

Linked Codes:
– is a → ● Experience of Running Technology

○ Positive Emotional Experience

Quotations:

2:13 Did you make this? (laughs) It looks like something I was playing around with when I was 14, I used…
2:14 I like things that look all techy like that, it's always fun to see how all those tiny things are co…
2:26 It's like the ultimate rave toy! I can control the music with my head bobbing up and down (laughs)
3:13 yeah, they look pretty neat makes you look like Robocop

Linked Codes:
– is a → ● Embodied Experience

○ Positive Experience of Running Tech

Quotations:
1:2 I have a smartwatch, which I do like using, I have it set to detect and begin tracking any sort of s…
1:3 Well, it helps to keep track of things and your progress and maybe like sharing it with friends to k…
1:4 Definitely keeps me active, I love looking at my progress each week and like trying to beat records…
1:16 yeah I tried some out but I don't own any yet
2:1 I've used like, Apple watch. Yeah, that's okay.
2:2 I have only really used apps, I've never really taken the plunge to buy a device, so just apps on my…
2:3 I can track my progress, so I've got something to compare against.
2:4 It helps me set out like a schedule and do training plans which I wouldn't really know how to plan w…
3:1 yeah, I use some apps before, and I keep track of like distance and times and it's fun to try to bea…

Linked Codes:
– is a → ● Experience of Running Technology

○ Running Tech Features

Quotations:
1:11 I mean maybe just something to help my posture like I'm always sitting down so maybe something to hel…
1:12 Just maybe for things to be cheaper so you can improve all your technique and get better without hav…
2:11 Well, I'd like to remove the need for the devices. like I think we'll get to the point where you can…
2:12 Well, I never know if I'm running ok, because a few years ago I hurt the sole of my foot with like p…
3:4 yeah if you use them right, I'm sure it will help you stay on top of your weight, but I don't know if…

Linked Codes:
– is a → ● Experience of Running Technology

○ Sensor System Components

Quotations:
1:13 Well, I wouldn't wear it Yeah, I'm too self-conscious about like doing exercise so I wouldn't want to…
1:14 yeah, they obviously look rough, but I don't mind sensors and bands so much, I might buy a heart rate…
1:17 well, it depends, if it was this size. I probably wouldn't wear it. P2: yeah they need to be waterproof…
1:26 yeah, a friend showed them me once, they're cool but I think you don't look very cool with them on,…
1:27 yeah I used to have a pair but I just prefer normal headphones to block out the traffic and awful so…
2:22 I mean yeah it would definitely have to be smaller and like hidden away
2:28 Yeah, they feel ok its weird being able to hear like voices and the room with music also playing

in…
2:29 I've seen those before and always thought they look really weird like they have a sort of minority r…
3:25 yeah the headphones feel okay they kinda slip a little bit they don't sit well on my head but I can…
3:26 I think yes I prefer normal headphones they seem to be more comfortable and they clearly sound a bit…

Linked Codes:
– is a → ● Interface Design Cues

○ Social Perception

Quotations:
1:20 I think if it was more like compacted like it was kind of within the design of the actual material r…
1:21 I mean if it's like just running around then yeah people are used to it now. Just don't wear it to w…
2:16 It looks sick. I'm sure there are some places where you could go where you'd fit right in but there…
2:17 (laughs) I think it looks like a bomb with so many exposed wires!
2:20 he does look like a cyborg (laughs) or like a science experiment gone wrong!
2:21 yes, I'm sure they would notice something like this, I would like to avoid that
2:23 but people use like armbands for their phone and stuff so I'm sure people are more used to it now.
3:15 I think that I'm aware of him just because everybody is looking at me but it's not like they're unco…
3:16 yeah I think that would make me feel self-conscious if I had wires sticking out all over me
3:17 obviously they look interesting, but they draw attention if you were just to wear this anywhere
3:18 yeah it looks like somebody is coming in for repairs at the robot shop
3:19 people would definitely be intrigued I'm not sure if it would scare people if they saw you with wire…
3:20 obviously you'd get asked a lot of questions at the pub or something but I'm sure this isn't the fin…

Linked Codes:
– is a → ● Embodied Experience

○ Sound - Action Perception

Quotations:
1:24 That's so weird! It reacts pretty quick. definitely reacts very quickly It takes a bit to get used t…
1:25 I mean yeah like you can definitely see and feel how it works and I think you can practice to get us…
1:28 don't know I feel like you have to arc your head a lot, like, it's more like confined to a motion th…
3:23 I think you can tell what it's doing so is I suppose obtrusive cause like the music disappears
3:24 yeah it makes the music go like a bit muffled and yeah so true sieve as well I'd say

Linked Codes:
– is a → ● Experience of Sonic Interaction

○ System Reliability

Quotations:
1:23 I think like with others its always the question if its accurate or not, like when you jiggle yol 1:30 I think it needs like to have a thing that sets it to yourself because like everyone is different an…
2:25 yeah, I think if you were running so much movement would make it sound all over the place, I think I…
2:30 Definitely you would have to calibrate because I feel it's fine if you're doing it slowly, if you do…

Linked Codes:
– is a → ● Interface Design Cues

9.6 Appendix 6 – Workshop Activity 3 Interviews

9.6.1 Workshop 1

1. Overall, would you describe your experience with running tech as positive or negative?

   P1: I don't really use it on any sort of like regular basis so like maybe neutral?

   P2: I have a smartwatch, which I do like using, I have it set to detect and begin tracking any sort of sustained activity like walking, so I capture all the bits of exercise I do throughout the day

2. What do you think is the main benefit of using running technology?

   P1: Well, it helps to keep track of things and your progress and maybe like sharing it with friends to keep you motivated

   P2: Definitely keeps me active, I love looking at my progress each week and like trying to beat records like my bike ride into work and things like that.

3. What do you think is the main drawback?

   P1: Just being obsessed with like weight and feeling bad for not doing exercise and having bought like fancy new gadget that you just don't end up using.

   P2: Maybe that you need quite a lot of gadgets if you want to track all the little bits you can track nowadays, it's a bit of investment with like new stuff coming out all the time.

4. How would you describe the in-run experience, are you constantly looking at the screen? Or do you solely rely on auditory feedback such as voice updates or alarms?

   P1: only to change the music on my playlist!

   P2: I look at my watch screen during exercise to see my pace and try to keep it up, I sometimes look at like the calories burned and heart rate graphs in my apple health app.

5. How would you describe the sounds produced by running apps? Obtrusive, unobtrusive? Informative, uninformative, useful, useless?

   P1: don't really know, I mean I'm sure it would like to annoy me having alarms and beeps or whatever going off.

   P2: Well, I turned mine off and use vibrate mostly, they're mostly just beeps and stuff

6. What is the main feature missing from your favourite tech? i.e., what needs improving?

   P1: I mean maybe just something to help my posture like I'm always sitting down so maybe something to help out with that?

   P2: Just maybe for things to be cheaper so you can improve all your technique and get better without having to pay like two grand or something silly.

7. What are your initial thoughts about the sensors?

   P1: Well, I wouldn't wear it Yeah, I'm too self-conscious about like doing exercise so I wouldn't want to have something that's obvious.

   P2: yeah, they obviously look rough, but I don't mind sensors and bands so much, I might buy a heart rate monitor some day or like a cadence tracker for when I go on my bike, so I do like these things.

8. Had you ever seen or used anything like these sensors before?

   P1: nope never I'm a bit old school (laughs)

   P2: yeah, I tried some out, but I don't own any yet

9. How would you describe the overall feeling of the sensors on your body? Are they obtrusive or unobtrusive, discreet or attention grabbing, heavy or light, comfortable or uncomfortable?

   P1: I can't feel it but, I would wear it but I probably if it was like in a hat. I would never wear a headband thing anyway but if it was like integrated into something a bit more covered like a hoodie or a or a hat? Yeah, I'd probably wear it.

   P2: you just get used to it don't you like everything you know as long as they're not heavy or whatever it's just something to help so yeah, they're ok.

10. How do you think they look? What does the group think of their appearance?

    P1: well, it depends, if it was this size. I probably wouldn't wear it.

    P2: yeah, they need to be waterproof for Manchester (laughs)

11. If you were wearing these sensors in public, what sort of things do you think people would think or say about them?

P1: I think if it was more like compacted like it was kind of within the design of the actual material rather than it being an additional you know bolt-on then I don't think it wouldn't be like noticeable and I don't think anyone would think about it if you if you're out in running gear and when you are running it's like a different mentality because you see a lot of people with a million and one straps and things. I suppose it's not like I'm going to be popping to the pub with it on

P2: I mean if it's like just running around then yeah people are used to it now. Just don't wear it to work or whatever (laughs)

12. What potential problems do you think you would encounter when using these sensors?

P1: well, I mean it depends on what weather you like doing your exercises in and wearing something on your head you can get warm quite quickly and I think you know, you could want to take it off. I mean it feels secure with the band but that's why I don't ever wear anything on the head when I go do exercise because I just want to take off because I just get too hot with it. but it's not like I feel like it wouldn't fit, or it would come loose or anything.

P2: I think like with others its always the question if its accurate or not, like when you jiggle your arms and your Fitbit counts it as steps, you want these things to work especially if you pay for a nice gadget.

13. How would you describe the sounds that the sensor is producing? Obtrusive, unobtrusive?

P1: That's so weird! It reacts pretty quick. definitely reacts very quickly It takes a bit to get used to, I think it definitely, like jolts you into in into noticing.

P2: I mean yeah like you can definitely see and feel how it works and I think you can practice getting used to it.

14. How do the bone-conduction headphones feel? Can you hear external sounds clearly or unclearly? Do you think these would be better to use when running than normal headphones?

P1: yeah, a friend showed them me once, they're cool but I think you don't look very cool with them on, they have this weird look that kind of like makes them stand out. I prefer like some nice headphones, I think.

P2: yeah, I used to have a pair, but I just prefer normal headphones to block out the traffic and awful sounds you hear running around here.

15. What do you think would be needed to make this system into a useful product?

P1: don't know I feel like you have to arc your head a lot, like, it's more like confined to a motion that isn't natural, like, within like a range of motion, other than what would actually be your kind of trajectory like it needs calibration. You'd have to train yourself to like, you know, you're obviously the thing is, if you're wearing something like this, you're actively wearing it. So, you're actively deciding to use it as a device. So therefore, there's some kind of training that goes into calibrating yourself to it as well, like, but no,

P2: I think it needs like to have a thing that sets it to yourself because like everyone is different and like it could respond less abruptly so like when you just move your head to check where you are going it just doesn't cut out.

9.6.2 Workshop 2

1. Overall, would you describe your experience with running tech as positive or negative?

P1: I've used like, Apple watch. Yeah, that's okay.

P2: I have only really used apps, I've never really taken the plunge to buy a device, so just apps on my phone yeah. They're ok.

2. What do you think is the main benefit of using running technology?

P1: I can track my progress, so I've got something to compare against.

P2: It helps me set out like a schedule and do training plans which I wouldn't really know how to plan without its suggestions.

3. What do you think is the main drawback?

P1: You push yourself too hard trying to get to a target.

P2: I feel really guilty when I don't complete training plans, and I get into this like rut or like habit of ignoring the notifications and reminders.

4. How would you describe the in-run experience, are you constantly looking at the screen? Or do you solely rely on auditory feedback such as voice updates or alarms?

   P1: So, I've got haptic on every kilometre. So yeah, pretty much every kilometre, I'm doing a look at it. Looking at the watch. Because it buzzes, not because I want to see it.

   P2: Yeah, I spend checking it a lot too, my phone buzzes every kilometre and also every 5 minutes that go past, so I check the screen and see my pace and my distance and all that.

5. How would you describe the sounds produced by running apps? Obtrusive, unobtrusive? Informative, uninformative, useful, useless?

   P1: I could quite happily live without it. I seem to use all that. But just because it's on all the time. But I think it's a bit obtrusive to have it buzz every five or six minutes.

   P2: yeah, I don't like the voices that tell you your distance, I had to change my app to just vibrate like P1's watch.

6. What is the main feature missing from your favourite tech? i.e., what needs improving?

   P1: Well, I'd like to remove the need for the devices. like I think we'll get to the point where you can probably put things inside yourself that give you information to your phone and stuff like that.

   P2: Well, I never know if I'm running ok, because a few years ago I hurt the sole of my foot with like plantar fasciitis I think it's called? My dad had it too. And it was at a time when I started running so it would be nice something that prevents you getting hurt or something.

7. What are your initial thoughts about the sensors?

   P1: Did you make this? (laughs) It looks like something I was playing around with when I was 14, I used to love taking things apart and putting them back together.

   P2: I like things that look all techy like that, it's always fun to see how all those tiny things are connected.

8. Had you ever seen or used anything like these sensors before?

   P1: no, just my watch

P2: I tried my mum's heart rate sensor once, which is a strap round your chest, and that feels kind of the same, it's a bit too much for me I think,

9. How would you describe the overall feeling of the sensors on your body? Are they obtrusive or unobtrusive, discreet or attention grabbing, heavy or light, comfortable or uncomfortable?
   P1: It looks sick. I'm sure there are some places where you could go where you'd fit right in but there aren't many of them
   P2: (laughs) I think it looks like a bomb with so many exposed wires! But I mean you can't really tell they're there because it's just like the pressure of the headband.

10. How do you think they look? What does the group think of their appearance?
    P1: I'm very aware of it
    P2: he does look like a cyborg (laughs) or like a science experiment gone wrong!

11. If you were wearing these sensors in public, what sort of things do you think people would think or say about them?
    P1: yes, I'm sure they would notice something like this, I would like to avoid that
    P2: I mean yeah it would definitely have to be smaller and like hidden away, but people use like armbands for their phone and stuff so I'm sure people are more used to it now.

12. What potential problems do you think you would encounter when using these sensors?
    P1: Yeah, range is definitely too wide. I think maybe it's because it's your head it certainly seems like it's quite long-distance travel between each side. So definitely calibrate it to a smaller range of motion, but yeah you have quite a bit of control.
    P2: yeah, I think if you were running so much movement would make it sound all over the place, I think like P1 said like less sensitive.

13. How would you describe the sounds that the sensor is producing? Obtrusive, unobtrusive?
    P1: It's like the ultimate rave toy! I can control the music with my head bobbing up and down (laughs)
    P2: Yeah, it's pretty cool how it works I can see how you could use it and the effect is like quite clear in the sound.

14. How do the bone-conduction headphones feel? Can you hear external sounds clearly or unclearly? Do you think these would be better to use when running than normal headphones?

    P1: Yeah, they feel ok its weird being able to hear like voices and the room with music also playing in my head.

    P2: I've seen those before and always thought they look really weird like they have a sort of minority report kind of sci-fi vibe, they remind me of the google glass. They sound ok, worse than normal headphones though.

15. What do you think would be needed to make this system into a useful product?

    P1: Definitely you would have to calibrate because I feel it's fine if you're doing it slowly, if you do it quickly, I'm not so sure it's so easy.

    P2: Yes, it seems like you could also use it in other applications as well as in running, that could maybe make it a very useful product

9.6.3 Workshop 3

1. Overall, would you describe your experience with running tech as positive or negative?

    P1: yeah, I use some apps before, and I keep track of like distance and times and it's fun to try to beat my record like on my journey to work or something.

    P2: I used to track my weight using my fitness pal, but I just kept getting depressed from not eating well and the app showing me all the crap I was eating

2. What do you think is the main benefit of using running technology?

    P1: keeping track of things as I said like my records of certain journeys, I take often so I keep trying a bit harder every now and again

    P2: yeah, if you use them right, I'm sure it will help you stay on top of your weight, but I don't know if that works for everybody.

3. What do you think is the main drawback?

P1: I think just that if you really want the nice gadgets, they cost a lot of money and like I don't have enough to afford all the nice ones really

P2: people just use gadgets and phones too much so it's not like we couldn't do exercise before it, so I don't know just it's another reason for people to use their phones

4. How would you describe the in-run experience, are you constantly looking at the screen? Or do you solely rely on auditory feedback such as voice updates or alarms?

P1: yeah, I do check it, but I have the feedback on my headphones so tells me when I've completed like 5 km in 15 km but yeah depends how fast I'm running I think

P2: when I run, I use it to check what song I'm listening to if I'm listening to Spotify playlist so I yeah, I do check it when I'm running but I wouldn't say a lot

5. How would you describe the sounds produced by running apps? Obtrusive, unobtrusive? Informative, uninformative, useful, useless?

P1: the voice is obtrusive because it makes the music go quieter it's not like a nice voice because it sounds like robotic so obviously could be better maybe more human or something else

P2: I think it's like noise pollution maybe there's too many alarms and notifications and beeps going off all the time

6. What is the main feature missing from your favourite tech? i.e., what needs improving?

P1: will it be good to have something that prevents injuries I think that's always something I worry about, but I don't know if like tech can do that just yet really

P2: just something that makes it a bit less noticeable I don't wanna have to always be thinking about having to track something

7. What are your initial thoughts about the sensors?

   P1: yeah, they look pretty neat makes you look like Robocop

   P2: yeah, that might be a bit too high tech for me

8. Had you ever seen or used anything like these sensors before?

   P1: no not really friends have like straps and things, but I've never used one before

   P2: yeah, no not at all for me either

9. How would you describe the overall feeling of the sensors on your body? Are they obtrusive or unobtrusive, discreet or attention grabbing, heavy or light, comfortable or uncomfortable?

   P1: I think that I'm aware of him just because everybody is looking at me but it's not like they're uncomfortable per se

   P2: yeah, I think that would make me feel self-conscious if I had wires sticking out all over me

10. How do you think they look? What does the group think of their appearance?

    P1: obviously they look interesting, but they draw attention if you were just to wear this anywhere

    P2: yeah, it looks like somebody is coming in for repairs at the robot shop

11. If you were wearing these sensors in public, what sort of things do you think people would think or say about them?

    P1: people would definitely be intrigued I'm not sure if it would scare people if they saw you with wires sticking out but people like that kind of sort of new tech kind of thing so maybe they're interested

    P2: obviously you'd get asked a lot of questions at the pub or something but I'm sure this isn't the final one or anything

12. What potential problems do you think you would encounter when using these sensors?

P1: they have to be waterproof I suppose and maybe shockproof I'm sure like this wouldn't stand the fall

P2: also, it's just another thing to buy and to eventually turn into a landfill people have a lot of gadgets already.

13. How would you describe the sounds that the sensor is producing? Obtrusive, unobtrusive?

P1: I think you can tell what it's doing so is I suppose obtrusive cause like the music disappears

P2: yeah, it makes the music go like a bit muffled and yeah so true sieve as well I'd say

14. How do the bone-conduction headphones feel? Can you hear external sounds clearly or unclearly? Do you think these would be better to use when running than normal headphones?

P1: yeah, the headphones feel okay they kinda slip a little bit they don't sit well on my head, but I can hear the sounds OK

P2: I think yes, I prefer normal headphones they seem to be more comfortable, and they clearly sound a bit better

15. What do you think would be needed to make this system into a useful product?

P1: well, it should like to integrate with everything else obviously people use like smartwatches so I'm sure people wanted to connect to their other devices and just for it to be easy to set up you don't want to spend a lot of time before your run just trying to get it to work

P2: yeah, I think it has to be like tailored to different people will use it differently so maybe like habit with different pre-sets for different people or stuff like that.

9.7 Appendix 7 – Prototype Study Interview Schedule

In order to ensure a structured and consistent method of data collection for the *Running to Your Own Beat!* project post technology probe interview stage, the following schedule is proposed to guide the dialogue with the participants.

I. **Opening**

a. (**Welcome**) – Hello. I would like to thank you for coming in today for this interview and for testing out the prototype for this project.

b. (**Purpose**) – Today I would like to ask you several questions relating to your experiences with the prototype and ask you to elaborate on some key topics and questions.

c. (**Motivation)** – With the answers you give today I hope to provide a more in-depth analysis on the data you have provided so far. This will help us get a better understanding of the impact, if any, our technology has had on your running technique.

d. (**Timeline**) – This interview will take approximately 1 hour to complete, so please ensure you are prepared to dedicate this time for the interview and please confirm you are happy to proceed.

II. **Interview Body**

a. **First reactions**

1. Overall, what were your first impressions when you first saw the sensors?
2. When you first placed the sensors on your body what thoughts or emotions did you experience?
3. Did the presence of the sensor make you uncomfortable in any way?
4. Did you discuss the study and sensors with any friends, family or acquaintances? What were their initial reactions to this?

b. **Exercise Routine**

1. Overall, were you able to complete your exercise routine comfortably and normally while wearing our sensor system?
2. Did you alter how you run in any way through the bouts of exercise because of the sensor system?

c. **Sensor Feedback System**

1. What was your favourite sound pre-set? Why?

2. Which was your least favourite pre-set? Why?
3. Overall, do you feel the feedback provided was useful and clear?
4. Did the bone-conduction headphones allow you to both hear external sound sources and the feedback clearly?
5. How would you describe the experience of adapting your running to the feedback provided? Was it difficult?
6. Did you at any point feel you did not understand how to adapt to the feedback?
7. Did you experience any technical glitches at any point? For example, did the sensors or feedback become unresponsive or stop working?
8. How would you describe the effect of the system on your running technique? Did you notice any differences?
9. Would you continue to use this system if it were a product on a day-to-day basis?
10. What features would you add or change to improve the system?
11. What was the most enjoyable experience/outcome of using this system?

III. **Interview Conclusion:**

a. Thank you very much for all the answers you have provided. Those are all the questions and indeed the end of the project. Thank you very much for your participation.
b. Before we finish, I would like to ask you for any thoughts or feelings you may wish to add regarding your overall experience with this project. Is there anything you particularly enjoyed, disliked or would change?
c. Thank you for all your help with the Running to Your Own Beat project!

9.8 Appendix 8 – Prototype Study Interviews

9.8.1 Interview 1

I. **Interview Body**

a. **First reactions**

1. Overall, what were your first impressions when you first saw the sensors?

   I felt quite excited they look pretty cool. I want to try them on.

2. When you first placed the sensors on your body what thoughts or emotions did you experience?

   I felt like was like some sort of cyborg, and that. Looking forward to seeing how they work.

3. Did the presence of the sensor make you uncomfortable in any way?

   No not really. I mean, like, I've worn like headbands before for my hair, so I'm used to stuff like that on my head.

4. Did you discuss the study and sensors with any friends, family or acquaintances? What were their initial reactions to this?

   Well yeah, I showed it to some friends, and we talked about it and yeah, it seems like there's like interest, everybody thinks it's quite an interesting project. But yeah, we're all just curious to see what work how it works.

b. **Exercise Routine**

1. Overall, were you able to complete your exercise routine comfortably and normally while wearing our sensor system?

Yeah, there was no problem I mean I can run with it comfortably sort of snug against my head so yeah, no problems just getting out there

2. Did you alter how you run in any way through the bouts of exercise because of the sensor system?

Answer No not really, I mean obviously I'm listening for the sort of change in sound, but that's the only way I have altered my running just trying to like, adjust to the sounds like we discussed.

c. **Sensor Feedback System**

1. What was your favourite sound pre-set? Why?

I think effect 1 was the most natural movement, because when I tilted my head down the sound dips. I think that was my favourite one

2. Which was your least favourite pre-set? Why?

I think the other two I didn't like equally maybe just because the effect to the sort of direction is weird, like when I move my head down. I expect sound to go down, I'm gonna move it up, sort of still there so yeah and then the other one didn't like this, just sort of hard to tell what's going on until like your heads really low. And it's all dissonant. So, sounds a bit out of tune I don't like it.

3. Overall, do you feel the feedback provided was useful and clear?

Yeah, I mean we had to make some adjustments, but I could understand what was going on with tilting my head. I think it needs a bit maybe more work but like, I can sort of realize the point where my head is too low.

4. Did the bone-conduction headphones allow you to both hear external sound sources and the feedback clearly?

   Yea they were okay I think, not as good as like headphones but I could hear what was going on, although when a car came past it was really hard to hear over it.

5. How would you describe the experience of adapting your running to the feedback provided? Was it difficult?

   Yeah, with some of them it was a bit harder. Some of them, some of the like exercises, it was too sensitive. But like we tweaked it a little bit and it was a bit better. But overall, I think it's like practice I need

6. Did you at any point feel you did not understand how to adapt to the feedback?

   Yeah, I think as I said like, with effect of the direction of it, it makes it sort of like weird, it's just not a natural movement

7. Did you experience any technical glitches at any point? For example, did the sensors or feedback become unresponsive or stop working?

   so, yeah, there was one time where I sort of maybe jolted it a bit, and sort of lost, lost connection so I think it just needs to be bit more like rough and ready for like being outside.

8. How would you describe the effect of the system on your running technique? Did you notice any differences?

   Well, I think I was like more conscious of trying to keep like my head up. So, I mean, I don't know if that's just because I'm trying hard to, because I'm listening to it, and

I know what I've got to do. But, yeah, I've been I've. I've definitely like, was able to do it and, and sort of like make a difference in how I was running

9. Would you continue to use this system if it were a product on a day-to-day basis?

I mean, yeah, if there's like obvious benefits to my posture, I would definitely do it. I work a lot like sat at my desk so definitely, definitely see like potential than I mean if it's, if it's clinically proven or whatever like I would definitely use it.

10. What features would you add or change to improve the system?

sort of like, maybe, a thing that just sets it like automatically to your, like, actual head, or like your like sort of your own body like personalize it and calibrate it. I think is the word. Just so that you're able to sort of make it more accurate for yourself. Maybe just to be able to use it everywhere, not just for running.

11. What was the most enjoyable experience/outcome of using this system?

Well just sort of to explore like future tech I think this stuff's pretty cool. I've seen stuff like it before in, sort of, like rugby teams and football teams I've, seen they use sensors during training and stuff, but it'd be cool if normal people could use it as well. So yeah, very interesting. Thank you very much.

9.8.2 Interview 2

II. **Interview Body**

a. **First reactions**

1. Overall, what were your first impressions when you first saw the sensors?

   I felt like a science experiment gone wrong

2. When you first placed the sensors on your body what thoughts or emotions did you experience?

   I mean I'm quite used to using stuff like this so not particularly different to when I go out wearing my smart watch or my heart rate monitor

3. Did the presence of the sensor make you uncomfortable in any way?

   I mean I only notice that coz I've got like long hair so I had to like to tie my hair back so it would be nice if my hair wouldn't get stuck in it

4. Did you discuss the study and sensors with any friends, family or acquaintances? What were their initial reactions to this?
   no not really it just sort of got on with it might have a chat with people later on.

b. **Exercise Routine**

1. Overall, were you able to complete your exercise routine comfortably and normally while wearing our sensor system?

   yeah, I mean I felt comfortable I was able to run as I would normally run so you had no changes I don't think

2. Did you alter how you run in any way through the bouts of exercise because of the sensor system?

   no other than the fact that I was aware I was supposed to be listening and concentrating but I just run the way I normally do I think

c. **Sensor Feedback System**

1. What was your favourite sound pre-set? Why?

   I think the first two presets were the nicest they sounded quite smooth, and it was quite easy to sort of control the like changes with your head

2. Which was your least favourite pre-set? Why?

   the third one is like quite interesting sound, but I mean it's not nice it's not like what you want your music to sound like really at least with the other ones the music stays sounding the same in a way just like a bit different but this one really sort of changes the sound quite a lot

3. Overall, do you feel the feedback provided was useful and clear?

   Yeah, I like the idea definitely I can sort of like react to it, but it just seems like it reacts too quickly still especially when I just sort of look down to see when I'm going.

4. Did the bone-conduction headphones allow you to both hear external sound sources and the feedback clearly?

   I didn't like them very much I understand why they work but they just don't sound as nice and I kinda wanna block out the traffic and all that I mean that's kind of why you listen to music sometimes

5. How would you describe the experience of adapting your running to the feedback provided? Was it difficult?

   overall, I found it OK as I said it seems to like not to be very smart and trigger when I'm just looking around briefly so sometimes you like overcorrect or something like that

6. Did you at any point feel you did not understand how to adapt to the feedback?

   yeah, again as I said when you sort of unconsciously move your head briefly and the sound changes it seems to react a bit too much

7. Did you experience any technical glitches at any point? For example, did the sensors or feedback become unresponsive or stop working?

   no everything seemed to work for the most part I'm not sure it would work in the rain though if it's not like properly encased

8. How would you describe the effect of the system on your running technique? Did you notice any differences?

   well, it makes you concentrate more on your posture and make cheque about it think I'm not sure how accurate it is, but it makes you make an effort and it's like a useful warning I suppose that you might need to change your posture

9. Would you continue to use this system if it were a product on a day-to-day basis?

   I think I would if it had like health benefits, I would definitely give it a go and I'm OK with wearing stuff like that but I'm sure a final product would be much like nicer if you want it to be sold at like an apple store or something

10. What features would you add or change to improve the system?

just to have it like be able to differentiate between when you just looking around and when you've actually moved your head to a bad position because I bet, you'll be running around looking at your feet not trying 2 trip or fall in the crack and the sensor would be telling you that you're running wrong

11. What was the most enjoyable experience/outcome of using this system?

it was fun to explore the sensor and I think it has like potential as I said if it could be smart until when it's best to correct then yeah, I think that would make it great overall it was like a fun experience to be a Guinea pig would do it again.

9.9 Appendix 9 - Code Analysis

- Embodied Experience

○ Feeling of Sensors on Body

Quotations:

- 1:1 I felt like a science experiment gone wrong
- 1:3 I mean I only notice that coz I've got like long hair so I had to like to tie my hair back so it would…
- 2:2 I felt like was like some sort of cyborg, and that. Looking forward to seeing how they work.
- 2:3 No not really. I mean, like, I've worn like headbands before for my hair, so I'm used to stuff like t…

Linked Codes:

– is a → ● Embodied Experience

○ Integration into Runners' ecologies

Quotations:

- 1:2 I mean I'm quite used to using stuff like this so not particularly different to when I go out wearin…
- 1:4 yeah I mean I felt comfortable I was able to run as I would normally run so you had no changes I don…
- 1:5 no other than the fact that I was aware I was supposed to be listening and concentrating but I just…
- 1:9 I didn't like them very much I understand why they work but they just don't sound as nice and I kind…
- 1:11 yeah again as I said when you sort of unconsciously move your head briefly and the sound changes it…
- 1:13 well it makes you concentrate more on your posture and make cheque about it think I'm not sure how a…
- 1:14 I think I would if it has like health benefits I would definitely give it a go and I'm OK with weari…
- 1:15 just to have it like be able to differentiate between when you just looking around and when you've a…
- 1:16 it was fun to like explore the sensor and I think it has like potential as I said if it could be sma…

2:5 Yeah, there was no problem I mean I can run with comfortably sort of snug against my head so yeah no…
2:6 Answer No not really, I mean obviously I'm listening for the sort of sound, but that's the only way…
2:13 so, yeah, there was one time where I sort of maybe jolted it a bit, and sort of lost, lost connection…
2:14 Well, I think I was like more conscious of trying to keep like my head up. So, I mean, I don't know…
2:15 I mean, yeah, if there's like obvious benefits to my posture, I would definitely do it. I work a lot…
2:16 sort of like, maybe, a thing that just sets it like automatically to your, like, actual head, or lik…

Linked Codes:
– is a → ● Embodied Experience

○ Positive Emotional Experience

Quotations:
2:1 I felt quite excited they look pretty cool. I want to try them on.
2:2 I felt like was like some sort of cyborg, and that. Looking forward to seeing how they work.
2:17 Well just sort of to explore like future tech I think this stuff's pretty cool. I've seen stuff like…

Linked Codes:
– is a → ● Embodied Experience

○ Social Perception

Quotations:
2:4 Well yeah, I showed it to some friends, and we talked about it and yeah, it seems like there's like i…

Linked Codes:
– is a → ● Embodied Experience

● Experience of Sonic Interaction

○ Sound - Action Perception

Quotations:
1:6 I think the first two presets were the nicest they sounded quite smooth and it was quite easy to sor…
1:7 the third one is like quite interesting sound but I mean it's not nice it's not like what you want y…
2:7 I think pre-set one was the most natural movement, because when I tilted my head down the sound dips…
2:8 I think the other two I didn't like equally maybe just because the effect to the sort of direction i…

Linked Codes:
– is a → ● Experience of Sonic Interaction

○ Interaction Mapping issues

Quotations:
1:8 Yeah, I like the idea definitely I can sort of like react to it but it just seems like it reacts too…
1:10 overall I found it OK as I said it seems to like not be very smart and trigger when I'm just looking…
1:11 yeah again as I said when you sort of unconsciously move your head briefly and the sound changes it…
2:9 Yeah, I mean we had to make some adjustments but I could understand what was going on with tilting m…
2:11 Yeah, with some of them it was a bit harder. Some of them, some of the like exercises, it was too se…
2:12 Yeah, I think as I said like, with effect of the direction of it, it makes it sort of like weird, it…

Linked Codes:
– is a → ● Experience of Sonic Interaction

● Interface Design Cues

○ Additional Feature Suggestion

Quotations:

1:14 I think I would if it had like health benefits, I would definitely give it a go and I'm OK with weari…
1:15 just to have it like be able to differentiate between when you just looking around and when you've a…
1:16 it was fun to like explore the sensor and I think it has like potential as I said if it could be sma…

Linked Codes:

– is a → ● Interface Design Cues

○ Sensor System Components

Quotations:

2:10 Yea they were okay I think, not as good as like headphones but I could hear what was going on, altho…

Linked Codes:

– is a → ● Interface Design Cues

○ System Reliability

Quotations:

1:10 overall I found it OK as I said it seems to like not be very smart and trigger when I'm just looking…
1:11 yeah again as I said when you sort of unconsciously move your head briefly and the sound changes it…
1:12 no everything seemed to work for the most part I'm not sure it would work in the rain though if it's
1:16 it was fun to like explore the sensor and I think it has like potential as I said if it could be sma…
2:9 Yeah, I mean we had to make some adjustments but I could understand what was going on with tilting m…
2:10 Yea they were okay I think, not as good as like headphones but I could hear what was going on, altho…
2:11 Yeah, with some of them it was a bit harder. Some of them, some of the like exercises, it was too se…
2:13 so, yeah, there was one time where I sort of maybe jolted it a bit, and sort of lost, lost connectio…
2:16 sort of like, maybe, a thing that just sets it like automatically to your, like, actual head, or lik…

Linked Codes:

– is a → ● Interface Design Cues