The design and aesthetics of wearable activity trackers

Matthew George Pateman

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Note by the university

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ABSTRACT

Aesthetics in the context of human-computer interaction has been an area of much research. However this research has focused primarily on usability. In recent years wearable products have seen an increase in user adoption. Currently the form factors of fitness trackers on the market are limited and have distinct aesthetics and physical forms. This research investigates the relationship between activity tracker and wearer, and the resulting aesthetic experience. The author applies novel approaches as methods of research: (1) an investigatory diary study followed by a participatory design workshop which aims to understand the user's challenges with current devices; (2) designing and prototyping, through which the participants' ideas are evaluated and their designs subsequently realised as non-functional low-fidelity prototypes; and (3) in-situ evaluation of prototypes during which the prototypes are given to participants to use within their normal routine. During this final stage they are asked to document their reflections in form of an evaluatory diary. The study concludes with closing interviews. The author presents themes which designers of future wearable products should be conscious of during the design process: *sensory qualities of the device*, *perceived properties of the device, the context of use*, and *other influencing factors.*

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Chapter 1. Introduction

Wearable health devices have seen a rapid increase in development, with many companies offering devices with built-in sensors that provide insights for users performing physical activity. The collection of personal data about oneself is becoming increasingly popular. As technology has developed, the field of personal informatics has emerged, with many tools which allow users to collect and display information about their activity, and currently focuses on data such as step counts, heart rate and weight [59]. Self-tracking is becoming increasingly easier with the growing capabilities of mobile devices. Connected devices allow for data about users to be constantly captured and, through web-services, to be analysed and presented. Contextual information through other sensors such as GPS, or access to personal calendars, has started giving users better insights and awareness of their physical activity. This has lead to lifelogging functionality being added to a number of commercially available products [94]. Tracking is becoming embodied into everyday lives, making these what Rooksby et al. describe as lived informatics; a 'felt-life' experience [65,73]. However, while technology and tracking capabilities have seen rapid development (with components becoming smaller and a variety of new sensors being integrated into wearable activity monitors), the form and aesthetics of these products are predominantly confined to wrist-worn devices.

Aesthetics, and people's understanding or concept of taste is becoming increasingly relevant in HCI, with researchers exploring ways to design for an aesthetic experience [8,87]. Boehner et al. conclude that research should explore the subjective and personal experiences which users have. Experience in itself is also a "very dynamic, complex and subjective phenomenon." [10:424] It is determined by the sensory qualities of a design and its interpretation, taking contextual factors into account. McCarthy and Wright's 'Technology as Experience' framework looks at the sensual aspects of an experience including the visceral characteristics of an interaction [64]. Norman's model 'cognitive processing' describes the visceral level as one which makes "rapid judgement between what is good or bad, safe or dangerous" [69:22], and – taking aesthetics into account – what is aesthetically appealing or unappealing, tasteful or distasteful.

The author wishes to better understand the relationship between the wearer of an activity tracker and the device, the context of its use, and in particular the aesthetic experience. Little is known about the impact of physical design and aesthetics on the use of wearable trackers. Aesthetics can affect engagement with a product, its use and possibly also influence its abandonment.

Do the product aesthetics and physical design of these wearable trackers allow for the intended use by the user and encourage a healthier lifestyle or an increase in activity levels? Have they been designed to consider the practical constraints of users' lifestyles [21]? These are questions which the author wishes to explore in his research.

It is known that well-designed interfaces which follow a set of heuristics are more usable, with one heuristic highlighting the aesthetics and design of the interface [68]. Research into activity trackers additionally highlights aesthetics as one cause for abandonment [37]. Findings show that many users of commercial activity trackers have found workarounds to integrate their devices better into their lifestyle and routine. This research wishes to expand on previous research in order to further understand wearers, including those using workarounds, by allowing them to design their own custom device as part of a participatory design workshop.

Aesthetic experience is a subjective construct between artefact and viewer [87] and imposes a number of limitations on the methods that can be employed. The author discusses how he addresses this problem by utilising a novel approach to answer these research questions: the use of diary study, autoethnography and participatory design workshops, prototyping, in-situ evaluation and interviews. This approach to understanding the implications of device aesthetics and context is based upon the Context Mapping framework [85],[85] Experience Prototyping framework [10] and the simple design lifecycle [80]. It additionally seeks to challenge the archetype of activity trackers – wrist-worn devices – and to encourage participants of the study to design a device of their own. Participants' concepts are then realised by creating low-fidelity prototypes which are handed back for evaluation. Participants evaluated their prototypes in-situ and document their use and reflections in form of a diary study. The research concluded with a semi-structured interview. These methods allow the author to understand the

challenges participants face with their current devices and the needs they express through their workshop models.

The author's research aimed to understand the effects of aesthetics on products' use-cases and how the task of tracking one's physical activity is influenced by a device's physical properties, the device's form-factor and its resulting interactions. Devices for tracking both everyday activity and workout activities were considered in the study, however, depending on the tracking objectives, use and non-use cases are expected to vary.

This research demonstrates that the aesthetic experience of wearable products is highly subjective and varies depending on the wearer and the context in which it is worn. It provides a set of themes which designers of future wearable products should consider when designing with an aesthetic experience in mind: the sensory qualities of the device, the context of use, perceived properties and other influencing factors.

However, aside from the findings, the main contribution of this study is the evaluation of the unique approach taken to understand aesthetics in the context of wearable activity trackers. When dealing with highly subjective domains such as aesthetics, non-traditional approaches are required. This research explores participatory design, prototyping and in-situ evaluation. This research reports on the use of these methods and offers recommendations for HCI researchers and practitioners wishing to use these approaches in the future.

Chapter 2. Background and related research

2.1 Personal Informatics

Personal informatics (PI) is a term covering the collection of personally relevant information about users, and its subsequent analysis and presentation for the means of reflection. Health trackers are one of the most common personal informatics tools. There are many use-cases for wearable trackers, the main one being the ability to receive real-time information on one's physical activity. Previous work looks at self-tracking, in particular the concept of the 'quantified self', as a means of motivation [19,73]. As Choe et al. state, the group of 'Quantified Selfers' consists of many diverse people (including life hackers, computer scientists and health enthusiasts) who track many aspects of their lives in order to collect and explore data about themselves, either for preventative purposes or out of general interest. While this community is highly engaged in self-tracking, with many sites and meetups dedicated to sharing best practices, they also experience common pitfalls such as tracking too much data (which can cause tracking fatigue), or not tracking enough (which results in them not gaining appropriate insight and context to reflect upon).

While Quantified Selfers may represent an extreme case of living with personal data, many other people have different motivations for tracking such data. These motivations may relate to physical or mental health or to changes in living or working circumstances.

Wearable health devices have seen a rapid increase in development, with many companies offering devices with built-in sensors that provide insights for users performing physical activity. These devices are not only aimed at people tracking runs, gym workouts or intended physical activity, they also allow users to track their everyday non-exercise-related activity, or non-exercise activity thermogenesis (NEAT), as described by Levine [58]. With 26% of male adults, 24% of female adults and 19% of children (aged 2 - 15) in the UK being classified as obese it is important to discourage a sedentary lifestyle and encourage better nutrition and physical activity [61], and devices such as activity trackers aim to help users improve their health.

There are two forms of activity trackers: those intended for tracking workouts through specialised sensors (such as GPS for running or cycling) and those focused on NEAT activity with accelerometers and gyroscopes. Many products now blur the lines between both types of tracking with a wide range of health-related products which encourage physical activity. These range from apps and fitness programmes to health monitors and wearables which are available to a broad variety of consumers, including non-professional athletes and people curious about their activity levels.

When it comes to the tracking of physical activity, improving one's health and personal performance are two most common motivations. Currently available commercial devices give users data about their performance in certain sports including running [95], golf [96] and even tennis [97]. Other apps and devices are also positioned as 'digital personal trainers' giving users tips on how to exercise more efficiently and effectively [89,93]. Aside from physical health, smartphone apps are additionally focusing on mental well-being, nutritional advice, sleep tracking, and financial and reproductive health, and are incorporating lifelogging features.

Traditionally, the term lifelogging refers to the logging of aspects of one's daily life via a portable camera like SenseCam, a neck-worn passive image capture device that takes shots throughout the day which the wearer can review at a later date [25]. Lifelogging has expanded beyond photos to include the capture of more aspects of the user's daily life, and now incorporates smartphone use, messaging, health information and location. An early research project into capturing this extent of data was centred around MyLifeBits [33], a system designed to help organise one researcher's capturing of personal data which ranged from photos and emails to health and computer usage data. SenseCam made use of MyLifeBits to manage the vast amount of data it was creating. Commercial services such as Heyday [90] utilise a user's photos and geo-location data to create a log of the user's whereabouts throughout the day. Sony allows users to track their health data, entertainment app usage and communication information via an app called Lifelog [94]. Other services have focused on physical activity together with user location as another form of logging, this is seen in apps like Moves [98]. The data gathered from physical activity provides not only insights into fitness levels, but

also insights into other aspects such as levels of drunkenness, fever or smoking cessation [48].

Since the work by Hodges et al. on SenseCam [39,40], products such as Narrative's Clip [91] have been developed, and more research based on SenseCam has been done which has taken aesthetics and design further into account [35]. While logging for personal use has seen significant development, so has tracking for marketing and commercial purposes. Other forms of logging make use of 'checking-in' to locations either via a mobile phone application [99] or with RFID chips. Disney recently launched its MagicBand, a wrist-worn wearable product which allows visitors to their parks to check into rides, hotel rooms, and to pay in shops and restaurants. Whilst its focus is mainly commercial, the aesthetics of the device were considered in order to encourage visitors to wear them, these have been developed to the extent that they have become collectors items with limited edition designs [51,100]. Similarly, Barclay's recently launched its bPay products in the UK which includes a wearable NFC payments wristband [101]. This research into the aesthetics of wearable tracking devices can be applied in other fields of wearable products such as NFC wristbands. Due to the current popularity of activity tracking devices, they present an interesting case study on how their aesthetics and physical form affect their use. However, other, or even future, wearable products may face similar constraints.

2.2 Behavioural change

There are numerous research studies focusing on tracking physical activity. Researchers have looked at all of the ways users can track their activity the use of mobile phones [49] and have concluded that tracking with mobile phones and wearable activity trackers can be very accurate [15,83]. While sensors and tracking capabilities of devices are constantly improving, researchers are looking into the effects of personal informatics on behavioural change.

2.2.1 Collecting data as a means for reflection

Many people collect data to later reflect upon. SenseCam has been used by researchers who have found that the photos taken by the device acted both as reference points to ground conversations and as triggers to conversation topics when used in a collaborative work environment [40].

Reflection as a design goal can be seen in many products [26]. With the increase in collection of personal data (personal informatics), many products have been specifically designed to allow for users to review their data in order to reflect upon it. Baumer coined the term 'Reflective Informatics' to describe the main purpose of the data which users collect [5]. Whilst this is not a new category of informatics, it aims to provide a conceptual approach to the discussion of personal informatics technology which is designed for reflection.

Consolvo et al. highlight the importance of designing a system, such as Houston (a prototype mobile phone application which synced with a pedometer) [21], which allowed for social support and positive peer pressure to help users maintain a physical lifestyle. Houston enabled users to track and share their activity with friends, which in turn persuaded them to be more active. It was aimed at encouraging both opportunistic physical activities and structured exercise. Fish'n'Steps was another prototype which displayed people's activity as fish in a fishtank on a communal display. It was designed to encourage exercise amongst groups [62]. While nobody knew which fish represented their coworkers' activity, they were able to compare their activity with that of others. This generated competition amongst co-workers to be physically active and, more importantly, encouraged users to increase their activity if they noticed that they were underperforming.

More recently, Fleck and Harrison have argued that the sharing of personal information supports reflection and behaviour change [27]. By sharing personal information, users are able to compare themselves with others and reflect on their own performance as part of a sense-making process [64]. Once the personal information has been made available to others, users may reflect on it differently compared to when it is private. However, extending this argument, one may also consider that reflection happens prior to the act of sharing, as users may think of the sharing of their personal information as an actionable output when taking the stage-based model of PI into account [60].

Li's stage-based model of PI describes the process of behavioural change through personal informatics, concluding with the final goal of taking action [60]. Selecting devices, such as the previously mentioned commercial products, could be considered as part of the 'preparation' stage, which then leads on to the

'collection', 'integration', 'reflection' and 'action' stages. At each stage there are barriers which can cascade to later stages if not addressed. As Li. et al. conclude, people's lives are multi-faceted, however the tools used to track data are uni-faceted – apps for single purposes with limited ways to correlate data. This can limit how people reflect on their data and take action. Health tracking and financial well-being tools are both uni-faceted. However, with insurance companies financially rewarding customers who engage with trackers [81], there may be a need to integrate these tools in order to provide a more holistic picture.

Finding the right amount of interaction is another important aspect for researchers to consider. The reduction in size and energy consumption of components has meant that small sensors such as accelerometers, gyroscopes and heart-rate monitors, low-power processors, and wireless transmitters can be included in wearable devices. This has allowed for implicit HCI [78] – interactions becoming hidden from the user – making the device unnoticeable. With regard to wearable fitness trackers, implicit interactions mean that activity is constantly tracked through sensors which do not distract users from their primary task. In contrast, explicit interactions require active user input. Activity trackers should simplify the engagement with PI so that it becomes unnoticeable and its functions are straightforward for the user to understand. This use of implicit HCI results in the only noticeable part of the collection of PI being the physical form factor of the device and its aesthetics. However, while automation may make tracking more convenient for users, it may result in them being less engaged with their PI, which could lead to a reduction in physical activity [59]. In order for users to change their behaviours, they require feedback. Therefore, finding the right balance between automation and user engagement is important.

2.2.2 Displaying health information for behavioural change purposes

The display of PI data supports behavioural change. Ubifit Garden, a prototype consisting of a wearable fitness tracker together with a mobile phone app which displays the user's activity levels as a background image, was based on Houston and focused on providing personal awareness of activity levels [21,22]. Users need to be able to easily see their current activity levels. Activity levels were displayed in a glanceable format on the user's mobile phone screen background; a format which meant that users would notice it every time they glanced at the display. The results of testing this product found that the activity levels of users

without a glanceable display dropped in comparison to those who used the Ubifit Garden display. This research demonstrates the health benefits which easily viewable information on activity levels can provide. Wearable trackers with a glanceable display are more effective than those without and form factor has an effect on the user activity levels. The display may however be on the device itself, or even part of another frequently used product, which in the case of Ubifit Garden was the user's mobile phone.

The findings in all of this research demonstrates how users are able to improve their health through the use of PI. In the research studies mentioned above, users commented on device aesthetics and physical form-factor. Houston, was very bulky and not always suitable for every occasion [21]. Fish'n'Steps used a basic pedometer, however it had to be clipped onto the waist which became a nuisance for participants [62]. Ubifit Garden demonstrated that devices with a glanceable display are more effective than devices without a screen [22]. Researchers and companies are looking into how to embed technology into wearable products [7,92], however the placement of personal screens and tracking devices in context with users' lifestyle circumstances has been underexplored. Devices need to fit a user's lifestyle otherwise they can become discouraging to use and may be abandoned [21,53]. A device's form factor should meet the user's lifestyle requirements rather than the user having to change their habits around a product.

2.3 Aesthetics

For many companies, aesthetics is a key part of their brand strategy as it provides a competitive advantage. As Schmitt and Simonson state in the introduction to their book "Marketing Aesthetics", consumers are dazzled by their sensory experiences – visual, auditory, olfactory, tactile and gustatory. These sensory experiences impact every initial decision consumers make, providing a pre-reflective judgement of a product or situation. Whilst consumers basic needs are mostly satisfied, brands can easily provide additional product value to satisfy consumers experiential needs, their so-called aesthetic needs [79].

So, what exactly are aesthetics? The term aesthetics derives from the Greek term 'aisthesis', the perception from the senses, feeling, hearing, seeing and today it is commonly used as a term referring to the attractive appearance or sound of

something. [102]. Aesthetics, and people's understanding of 'what is beautiful' is becoming increasingly relevant in HCI with researchers exploring ways to design for an aesthetic experience [8]. Boehner et al. conclude that research should explore the subjective and personal experiences users have. This research takes McCarthy and Wright's 'Technology as Experience' framework looks at the sensual aspects, which include the visceral characteristics, of an experience [64].

Experience in itself is also "very dynamic, complex and subjective phenomenon." [10:424] It is determined by the design's sensory qualities and its interpretation, taking contextual factors into account. Norman's model 'cognitive processing' describes the visceral level as one which makes fast judgement between what is good or bad, safe or dangerous and – taking aesthetics into account – what is aesthetically appealing or unappealing [69].

2.3.1 Aesthetics and usability

Aesthetics in the context of usability has been the subject of much research. Much of this research is concerned with the relationship between aesthetics, usability and ergonomics, and its impact on users' online behaviour [13,68]. This raises an interesting question: How does aesthetics impact the use, usability and effectiveness of wearable products? In his book, Emotional Design, Norman suggests that aesthetics is directly correlated with usability, and in some cases may be more usable than those designed purely with functionality in mind [69]. He additionally states that product aesthetics affects the emotional state of users, which in return can affect users' interaction with the product and subsequent usability. It can therefore be considered as one of many components of user-centred design.

2.3.2 Aesthetic as part of user-centred design

Aesthetics and self-expression are topics designers engage with. As pointed out by Sonderegger in regards to fashion design, clothes perform one of two functions: a physical function (protecting from elements) or a social and cultural function, allowing its wearer to display his or her individual characteristics or social status [82]. With smart garments and sensors being embedded into fashion items [92] this is going to broaden use cases of garments significantly with possibilities ranging from health tracking or novel ways of data input through embedded sensors. However the latter, the social function, is closely connected to

aesthetics. Whilst a piece of clothing may be usable and provide the required protection against rain or the cold for example, it may not be considered user-centric if its aesthetics is not considered. This additionally applies to wearables. Research, in which participants designed their own UV monitoring device, concluded that participants were receptive towards the notion of crafting their own devices [2]. The results of this study were promising, however the number of participants was limited to five users (one female).

Wright, Wallace and McCarthy propose a framework for an aesthetic experience [87], which explores the interplay between the experience and the user, the context of use, culture and history. This approach does not simply analyse the aesthetics and perceived value of a product without any regard for user, but instead examines the relationship between the product and its wearer. It looks at the lived experience [65]. In their research on wearable products McCarthy and Wright propose moving away from terms such as 'wearable computing' and 'user' and replace them with 'jewellery' and 'wearer' to highlight their constant and intimate relationship. There are examples of research [29,56] and consumer products [103] in which visual aesthetics play a primary role. As Jordan describes in 'Designing Pleasurable Products', manufacturers may design products with common aesthetic values and users may have a preferred aesthetic style [42]. However, Petersen et al. take aesthetic interaction further in challenging the assumption that aesthetics are primarily concerned with the immediate visual impression of products [71]. This research wishes to further challenge that assumption and focus on the aesthetic experience and the enchantment it may create through the interaction with wearable products.

While vision may be the most important modality, it is not exempt from influences from other modalities, which can have an effect on its interpretation [14]. Therefore, these modalities should not be overlooked when designing for an aesthetic experiences.

2.3.3 Aesthetics, materials and associations

Many modalities can be influenced by the choice of material, which can have significant impact on a product's aesthetics and its related associations. While manufacturing processes and cost are primary reasons for selecting materials, research has shown that the intangible aspects of materials have become

increasingly important in the materials selection process [46]. While sensory properties such as smell, feel and general impressions have become of importance, so have the 'intangible characteristics of materials' [46:1084]. These characteristics include associations which the materials evoke, the symbolic meanings of the materials, and the meanings and associations the materials have in the final form or shape of the product. This research concludes that sensory properties and intangible characteristics are addressed before technical properties. Materials can give a product a personality which spans beyond aesthetics and covers the whole product experience [4].

2.3.4 Buying into brands and lifestyles

Brands additionally make use of these experience and product associations by presenting a lifestyle many may aspire to. The Nike digital sports products (Nike+ Running, Nike Training Club and NikeFuel) and Under Armour connected sports products (Endemodo, MapMyRun and MyFitnessPal) are prime examples of how brands are attempting to extend their presence from just sportswear to the user's phone or digital presence on social media [1]. Brands can enable a form of self-expression or lifestyle aspiration, which consumers can identify with. Apart from ideological and sociological pleasures which products from brands can provide [42], such as a sense of belonging to a community or the feeling of doing something towards a certain cause, these products can additionally provide physio or psycho pleasures; pleasures which are based on the sensory experience of the product – a so-called aesthetic experience. In 'Sharing Personal Data to Support Reflection and Behaviour Change' Fleck and Harrison discuss the implementation of the sharing features of health tracking apps and devices and suggest their implementation is to provide users with the ability to reflect on their data in order for them to feel more motivated [27]. One may argue that the sharing functionality, in particular on networks such as Facebook or Twitter, is primarily driven by their marketing efforts in order to connect their site to the 'social web' [34] and to drive customer acquisition and brand awareness. The act of sharing may be part of the emotional experience of the encounter with this technology. It offers participants a sense-making opportunity to recount their experience by telling others about it [64]. Brands inserting themselves into the emotional thread of this experience, the joy of completing a workout or hitting a milestone, may aim to establish stronger connections with the user and brand loyalty. In return the user may see this as part of the brand experience, which

they have bought into or, if they are not a current user of this product, wish to be part of.

2.4 From Smartphones to wearables

The forms of tracking has become broader with tracking capabilities being included in smartphones. Today, the cost of acquiring a tracker requires no financial investment for smartphone users, as there is an array of free tracking apps available to download instantly. Over recent years the number activity trackers sold has significantly grown with companies like Fitbit being valued at 8 Billion U.S. dollars [66]. However, whilst the activity tracking market is expected to grow, statistics show that the usage of activity trackers drops by a third within 6 months of purchase [20,54].

The categorisation of fitness trackers at times can cause confusion. Fitbit's CEO suggests Fitbit tracking devices should be classified as a health product / service and for comparative purposes of its active user rate should be compared to gym memberships [52]. But with smartwatches as a growing category, should fitness trackers be recategorised from a tracker to smartwatch? Do smartwatches therefore pose an additional cause for abandonment of trackers? With traditional watch manufacturers considering building their own smartwatches, health-related tracking may become a feature included with every watch. As per the definition from Cecchinato, Cox et al. a smartwatch is

> *"a wrist-worn device with computational power, that can connect to other devices via short range wireless connectivity; provides alert notifications; collects personal data through a range of sensors and stores them; and has an integrated clock". [16]*

According to the definition above, some activity trackers could be considered smartwatches, and likewise, smartwatches with their built in sensors may also be considered activity trackers. However, as the research points out: The aesthetic desirability of owning a smartwatch highly depends on personal preferences and currently users are unsure what smartwatches should look like. Another area which is under-explored concerns itself with the effects which the physical form-factor or aesthetics of a smartwatch have on its usage. Additionally the product aesthetics of a smartwatch and an activity tracker vary. The selected

materials, product designs and its associations differ significantly even when both devices offer increasingly similar functionality.

While the battle of wrist-worn devices is currently in full swing, other companies are exploring the next product to make 'smarter': smart jewellery. Many startup companies have developed ring-based products with a variety of capabilities ranging from notifications to sleep tracking [47]. Research in the HCI field has briefly touched on jewellery [28,29], wearable products with aesthetics as an experience [56], and awareness systems for emotional communication [24], but not in the extent required to evaluate personal informatics systems. This research would like to make an attempt towards filling that gap.

2.5 Barriers to use and abandonment

In Consolvo et al.'s study with *Houston*, one design recommendation from this work is to consider the practical constraints of user's lifestyles. [21]. This primarily focuses on form factors of trackers. The biggest cause of complaint was about the physical attractiveness and size of the product which caused unwanted attention at times. Additionally, the product caused complications with some outfits such as a dress. They conclude that tools encouraging physical activity should not require an additional device, or, if a device is required, its form factor and aesthetics are vital to its use.

Research into the abandonment of commercially available wearable activity trackers highlights that some users decided not to wear them as, after a while, they felt that these products were designed for other users, such as athletes, and did not resemble products with which they would always want to associate themselves [20,53]. Could better consideration to the aesthetics address this challenge? Lee and Nam argue that current activity trackers are worn in a manner making them visible, however little attention has been given to the fashion-related qualities of wearable tracking devices such as their aesthetics or ability to allow for self-expression [56]. While the abandonment rate of users is at around 35% after more than 12 months [55], the author wishes to focus on the user's who are engaged with trackers, in particularly those have found workarounds to integrate the commercially available devices better into their lifestyle.

Mass customisation has an ever-growing trend with companies like Nike and Converse allowing users to design their own shoes, Motorola and its 'Build yours' feature for Moto X [104] and Apple Watch with 3 watches cases, a selection of changeable watch faces, downloadable 3rd-party 'complications' and large variety of strap options [3]. Activity trackers additionally allow for customisation with devices being produced in various colours and accessories being sold specifically for these devices. From a business perspective it provides the benefits of a 'tailor-made' product at the cost of products of mass production [43] and can result in higher customer satisfaction and a significantly reduced manufacturing lead-time [84].

For users, customisation means they have various options to integrate the device better into their lifestyle. However for many, these customisation options are not sufficient, with 3rd party companies manufacturing additional accessories such as cases and crafts people selling jewellery-like encasings. In fact, many discussions on online communities such as 'Fitbit Fanatics UK' talk about how to either customise your device with other accessories or use them in alternative ways to continue tracking activity. Harrison et al. interviewed users with activity tracking devices and concluded that many users find workarounds to use their devices [37]. Many of these workarounds relate to the physical form and aesthetics of their devices. One may argue that such use-cases point towards a lack of user-centred design. This research wishes to understand the relationship between activity tracker and wearer. Understanding users, their workarounds, context of use and their unmet needs can identify themes and elements which need to be taken into consideration when designing future wearable products.

Chapter 3. Methodology

As mentioned in Chapter 2, experience and aesthetics are both highly subjective constructs. In order to better understand the relationship between the wearer of a tracking device and the device's aesthetics and physical properties a novel combination of methods was developed to gain insight into people's situated aesthetic attitudes towards activity trackers: (1) an investigatory diary study followed by a participatory design workshop which aimed to understand users' challenges with current devices; (2) prototyping, through which the participants' ideas were evaluated and their designs subsequently realised as non-functional low-fidelity prototypes that were made by the researcher using a variety of methods, including 3D printing, sewing, and appropriation of existing artefacts such as magnetic badges; and (3) in-situ evaluation of prototypes during which the prototypes were given to participants to use within the context of their daily routines. This chapter briefly discusses these methods and their rationales, including the preparation of the research study and the approach to data analysis used, as shown in Figure 1. Each stage of the research will be presented and discussed, together with its procedures and findings, in Chapters 4 - 6. The timelines listed in Table 1 outline the three stages of the research which stretched over a 7-week period; however participants were only required to commit to a diary study, a 2-hour participatory design workshop and a 5-day in-situ evaluation of their prototype which concluded with a 30-minute closing interview.

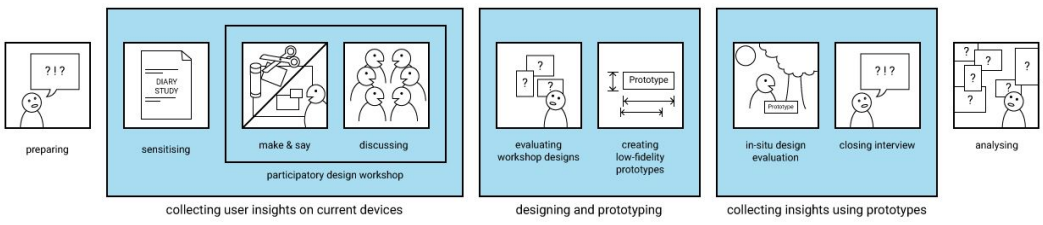

Figure 1 - Visualisation of the method of research

Weeks	Research phase	Description
Week 1	Collecting user insights with current devices	7-day diary study
Weeks 2 and 3	Collecting user insights with current devices	Participatory design workshop (attendance at only 1 workshop required)
Weeks 3 and 4	Designing and Prototyping	Researcher prepares and posts prototypes during this time period
Week 5	Collecting insights using prototypes	5-day prototype evaluation and diary study
Weeks 6 and 7	Collecting insights using prototypes	20 – 30-minute closing interview

Table 1 - Duration of the participatory design research

3.1 Selection of methods

Wright, Wallace and McCarthy define aesthetics as an experience that "emerges in the interplay between user, context, culture and history" [87:2]. It manifests itself in the relationship between user and artifact, and is therefore highly subjective. It cannot be measured objectively but, like experience with technology alone [65], must be lived in order to be fully understood [8,45]. Many conventional methods were not applicable, and an alternative, non-traditional approach was required.

The author explored other fields, such as design research and design practice, and identified participatory design as a method of research [74,85]. Participatory design engages multiple stakeholders, including users, in the design process. This makes it an appropriate method for evaluating areas of research which are as subjective as experience or aesthetics. However, unlike with many product or industrial design projects, the goal was not to design a new product. Instead, the aim of the research was to evaluate the aesthetics and physical form of activity trackers and their impact on HCI. Therefore, the methods were broken down into

three stages: Collecting user insights on current devices, designing and prototyping, and collecting insights using prototypes. These are discussed below.

3.2 Collecting user insights on current devices

The first stage of the research consisted of a diary study (during which participants were sensitised towards the research topic) and a participatory design workshop. Based on the Context Mapping Framework [85], participants required sensitisation towards the domain of research – in this case, the aesthetics of wearable tracking devices. This took the form of a diary study, which additionally encouraged users to reflect upon their experience with their current activity trackers.

The primary method of research for this stage of the study consisted of a series of participatory design workshops. Participatory design is a method in which multiple stakeholders including designers, developers, users and business analysts collaborate on the design of future products, systems and artifacts [75,105]. When designing for experiences, it is important to include real users of the product. As Sanders and Rim state, experiencing is constructive. Having access to those experiencing and those communicating or designing the experience can be a source of inspiration [76]. Participatory design workshops are a common research method used in product and industrial design, and they are increasingly being applied in the field of HCI research [2,41].

In the design workshops, users took part in various activities which enabled them to talk about their experiences with current activity trackers, their motivations for tracking and the frustrations they experience. Participants made a model of their own ideal tracker, based on their reflections during the workshop and diary study, and presented their design concepts to the group. These designs were translated into prototypes in the second stage of the research.

3.3 Designing and prototyping

The second stage of the research consisted of analysis of the outputs of the first stage and the creation of low-fidelity prototypes by the researcher. These low fidelity prototypes were based on the models created by the participants in the workshop and were made using digital fabrication techniques (3D-printing and laser cutting) in addition to sewing and reappropriating existing materials. The

researcher analysed the participants' diary studies and comments made in the workshops in order to develop their ideas further towards making a product which addressed their wants and desires for an ideal tracker. Details of this part of the research will be discussed in Chapter 5. These low-fidelity prototypes were handed to the participant for the final stage of the research: an in-situ evaluation of the prototypes which concluded with a final interview.

3.4 Collecting insights using prototypes

The final stage of the research consisted of an in-situ evaluation of the prototype and a closing interview. This method is similar to Experience Prototyping [10], a method aimed at quickly prototyping and evaluating experiences. However, unlike that method, which focuses on evaluating experiences within the setting of a workshop, this evaluation took place within the context of users' everyday lives. It is comparable to Jeff Hawkin's evaluation of the first Palm Pilot prototype, a block of wood that he evaluated through pretend use [6,44]. Participants were given their custom-designed device as a non-functional model and were asked to interact with it as if it were functional. This provided participants with another opportunity for reflection. Their final comments were gathered in a diary study and a closing interview.

3.5 Qualitative Data Analysis

The dataset from the three parts of the research were then thematically analysed [9]. Thematic analysis is a qualitative research method which can help identify and report on themes, patterns and key insights within the collected set of data. It allows for high flexibility which can result in rich descriptions of the collected data. It is widely used across various disciplines including psychology and HCI. This method can enhance the researcher's view of the data from which patterns of interest for the research can be identified.

An alternative method of qualitative data analysis is Grounded Theory. Researchers using Grounded Theory evaluate how their initial research interests fit with their data [18]. Charmaz emphasises that ideas and theories are not forced upon the collected data, rather they are analysed for emerging themes which relate to the research question. However, unlike Grounded Theory where the researcher attempts to validate a research hypothesis through a qualitative analysis of the data, a thematic analysis allows for researchers without an

hypothesis to search for themes. As highlighted by Mancini et al., surveys and standard interviews may gather large amounts of data but provide little insight into the actual thoughts and feelings of users in relation to the area of research, in this case aesthetics [63]. It is therefore important that a rich set of data is collected during the research phase. For this, workshops and semi-structured interviews present themselves as ideal methods.

3.6 Participants of the study

The participants were recruited using social media sites (including Twitter, Facebook and LinkedIn), posters placed around UCL and through word of mouth. Paid advertising on social media was not used as recommended by Cecchinato [17]. Instead, it was important to identify where participants, who were engaged in a certain topic, were located online; in the case of this research, on Facebook, Meetup groups about wearables and sites dedicated to the 'Quantified Self'. Facebook Groups offered a distinct advantage in recruiting engaged users as some groups were UK- and even London-based. The identified groups included 'Fitbit Fanatics UK', 'NikeTown Runners' and 'East London Runners'. Participants were incentivised with a £5 voucher and the opportunity to win a £60 voucher, or one of two £20 vouchers as part of a design competition when completing the study. For the design competition, the created models from the workshop were evaluated by a panel of researchers, looking at the process from the initial concept to the evaluation.

Participants were only recruited if they were current users of activity tracking devices or applications. This ensured that they were already accustomed to the field of personal informatics and would be able to complete the first stage of the research.

Fifteen participants took part in the study (6 male, 9 female). Seven of the participants were students. Most of the participants were professionals working in office environments with the majority based in London (as shown in Table 2). At the time of the study, many users owned or used a single device or app. Some had owned other devices in the past which they had replaced for a variety of reasons. These are mentioned later in the findings. However, a few users owned more than one device or app to track a variety of activities at the time of the study.

ID	Gender	Age	Occupation	Devices or Apps
1	Female	18 - 25	Student	Apple Watch, Nike+ Running
2	Male	36 - 45	Student	Fitbit Flex
3	Female	26 - 35	Consultant	Garmin Vivosmart, Moves App
4	Female	36 - 45	Accountant	Garmin 920xt
5	Female	18 - 25	Student	Apple Health, WeChat
6	Female	18 - 25	Research Worker	Strava
7	Female	36 - 45	NHS Administrator	Fitbit Charge
8	Male	26 - 35	Student	RunKeeper
9	Male	36 - 45	Local Government Officer	Garmin Fenix 3, Moves App, jawbone Up24
10	Female	18 - 25	Student	Google Fit
11	Female	56 - 65	Ass. Headteacher	Fitbit Flex
12	Male	26 - 35	Student	Fitbit Zip, Google Fit, Google Tracks
13	Male	46 - 55	Mobile Service Engineer	Fitbit Surge, Microsoft Band, Withings Pulse
14	Male	26 - 35	IT Architect	Fitbit One
15	Female	36 - 45	Business Improvement Officer	Fitbit Flex

Table 2 - Participant demographics and tracking devices

In preparation for this research, the methods were tested on a group of friends, all of whom became wearers of activity tracking devices during the initial diary study. While their results were not included in the final findings of the study, they helped the researcher plan the workshop agenda.

Additionally, the author wishes to highlight that as part of the preparation of the study an autoethnography was performed. An autoethnography, as described by Duncan, allows for the researcher to become an insider in a research setting, giving him or her a better understanding of an experience [23]. However, in this instance it was primarily used as a tool to gain empathy towards participants of the study, similar to previous work [70]. As suggested by Wright and McCarthy, empathy can also be used as a resource when evaluating user experience-centred

designs [86]. Unlike other forms of research, the experiences in an autoethnography have purposely been selected to be 'lived through'. For the sake of this study, the researcher spent two weeks exploring an array of activity tracking devices including the Microsoft Band, Misfit Shine and Garmin Vivofit 1, in addition to his previously owned Nike Fuelband SE. The insights gained during this phase allowed the researcher to better understand his knowledge of this field. Daily notes and artefacts, including photos, voice recordings and transcriptions of conversations, were collected. While the data was not used as part of the study, the process helped the researcher build empathy towards users who have been tracking their activity both long- and short-term. Research areas such as aesthetics and experience can benefit from this approach as they allow for the researcher or designer to better understand participants of a study.

The following chapters present each stage of the research in more detail.

Chapter 4. Diary Study and Participatory Design Workshops

4.1 Introduction

The objective of this stage of the study was to gain user insights on current devices in order to understand the needs and desires which they currently do not fulfil. Sanders et al. argue that the act of making allows for participants to express their latent or tacit knowledge; needs which researchers cannot discover either through observation or interviewing [76] (as shown in Figure 2). This suggests that while techniques such as interviews and observations can understand what people think and actually do, generative sessions can allow users to explore those needs and desires which exist, which they are not consciously aware of or unable to express with words. This stage of the research therefore made use of a diary study and participatory design workshops.

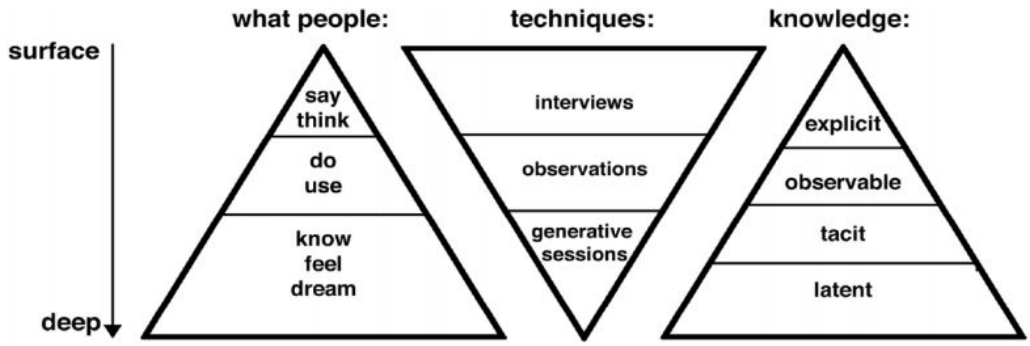

Figure 2 - Different levels of knowledge about experience are accessed by different techniques. Source: [85]

This stage of the research had similarities to the Context Mapping Framework (Figure 3), however with many changes which are discussed below.

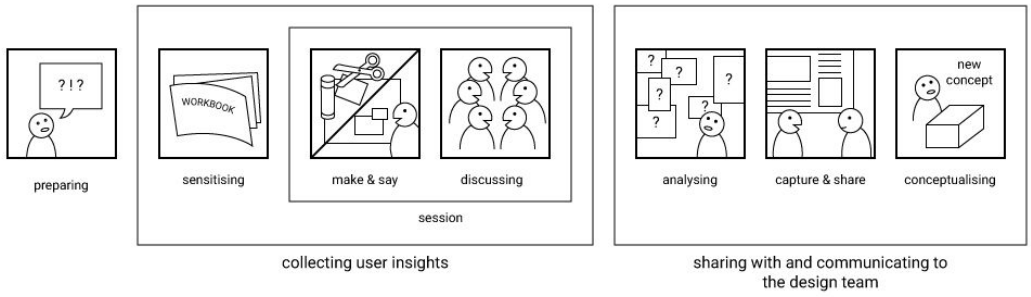

Figure 3 - Context mapping procedure

4.2 Methods

4.2.1 Diary Study

The initial diary study had two objectives: it allowed the researcher to gain insight into the participants' current use of activity trackers and, as its primary objective, sensitised participants to the study. As described by Visser et al. the sensitising process is intended to motivate and encourage participants to reflect on their environment and personal context [85], and is to be performed prior to the workshop session as shown in Figure 3. In order to encourage reflection of their experience with a currently used product, in particular their aesthetic experience [8], participants were asked a series of questions every day in the form of a diary study. Diary study and experience sampling methods (ESM) [38] were both considered for this research. Various tools were explored as shown in Table 3, however, in order to simplify this part of the process, a diary study (in which questions were sent to participants via email on a daily basis) was chosen as the preferred method.

Method	Tool	Requires setup	Comments
ESM	Wunderlist	Yes	Wunderlist allowed for notifications to be sent and lists to be managed by experimenter. Additionally attachments can be added straight from the participant's phone.
ESM	PACO	Yes	Whilst designed specifically for ESM the user interface was confusing and some of the functionality and triggers did not function with iOS8 devices
Diary Study	Evernote	Yes	Evernote is a great tool and was additionally used in the trial run. However the setup of shared notebooks caused challenges with their current version.
ESM	Google+	Sometimes	Many people may already be using Google services and have an account
Diary Study	OneNote	Yes	OneNote's setup during the trial was tedious as the sharing functionality is not straightforward. Additionally, the Notebooks shared on OneNote are not mobile optimized requiring those users to pinch and zoom
Diary Study	Email	No	Using email allows for no additional setup as participants registering are required to have an email address. Questions can be altered throughout the study as they are disclosed on the day

Table 3 - Participant demographics and tracking devices

The diary study questions were geared towards the participants' daily use of their activity tracking device(s). It was important to identify use and non-use cases [77], including challenges and barriers which participants faced. In addition to questions which were repeatedly asked every day, a selection of questions were added, these aimed to encourage the participants to reflect on various properties such as comfort, shape and materials.

4.2.2 Participatory Design workshops

The primary method of data collection for this stage of research was a series of participatory workshops. Unlike many participatory design workshops which usually include a broad variety of stakeholders, all participants in this study were

current users of activity tracking devices or apps, and were not involved in the development of activity tracking products in any way. Visser et al. mention in their paper on the Context Mapping Framework, that participants who currently use a product may not necessarily be users of a future version of the product and therefore a diverse group of participants is required [85]. However, in order to better understand the current use- and non-use cases of activity trackers, participants taking part in this study were required to have prior engagement with the area of research: activity tracking. Additionally, Wright and McCarthy highlight that good aesthetic interaction requires an understanding of users' sense-making of a design, particularly their interactions at an emotional, sensual and intellectual level [87]. Therefore to evaluate the aesthetic experience, it was important to have users who had 'lived through' these experiences as part of the participatory design research trial.

Using both the Context Mapping Framework [85] and a framework on tools for participatory design [74], a variety of techniques were selected in order to probe, and prime participants for the workshop and to generate design recommendations for future products (Table 4) [74,85]. Unlike Context Mapping where, after the participatory design workshops, the data is usually analysed in order to produce design requirements (as shown in Figure 1), this research included prototyping and evaluating as part of the process. This is discussed in Chapters 5 and 6.

Technique	Purpose			
	Probe	Prime	Understand	Generate
Diary Study	X	X	X	
Workshop				
Workshop Exercise 1 - Projective expression	X	X	X	X
Workshop Exercise 2 - Mapping of domain knowledge		X	X	X
Workshop Exercise 3 - Creative thinking through bisociation		X		X
Workshop Exercise 4 - Designing your own prototype			X	X

Table 4 - Study Outline

The exercises in the workshop were designed to encourage participants to reflect on their use of current devices, explore the needs they do not solve and to address them in a creative way within the workshop, and are outlined in the agenda below in Table 5. Break times were also scheduled. Visser et al. highlight the importance of recording and documenting break times and of scheduling time after the workshops for casual conversation. It is in these periods that discussions around the domain area can occur as participants might feel more open to share thoughts outside of the structured session [85].

Time	Description
10 minutes	Welcome Presentation
20 minutes	Workshop Exercise 1: Projective Expression
10 minutes	Workshop Exercise 2: Mapping of domain knowledge
10 minutes	Break
10 minutes	Workshop Exercise 3: Creative thinking through bisociation
30 minutes	Workshop Exercise 4 - Part 1: Designing your own prototype
20 minutes	Workshop Exercise 4 - Part 2: Presentation of designs
10 minutes	Closing remarks

Table 5 - Outline of workshop agenda

The welcome presentation of the workshop included some background information on tracking devices and wearables. In this presentation the researcher additionally highlighted jewellery and fashion as wearable non-tech products.

As part of the preparation for the workshop it is recommended that the researcher is aware of his domain knowledge in order to identify nuances or minute differences, which participants of the workshop might have [85]. Many findings may seem obvious in hindsight but might not have been previously identified or known by the researcher. These differences could be significant for the project but risk being overlooked. The autoethnography, used primarily to gain empathy towards participants, therefore presented itself as a starting point for this part of the method.

In order to comply with UCL ethics regulations, these sessions were held on site with one researcher and a member of UCL staff present. To ensure all participants were able to attend, two workshops were held during the week on

different days and one on the weekend. The participant information sheet and consent form can be viewed in Appendix 1.

Workshop Exercise 1: Projective Expression

The first exercise, 2-D collages, focused on 'projective expression' [75]. In the first exercise, participants were asked to express one of the following scenarios to visualise with pictures and words (Figure 5):

- How they feel when tracking their physical activity with their wearable device or app
- A memorable occasion with their activity tracking device
- A moment when they felt either excited or frustrated by the device

They were given 150 carefully selected words and images to express this scenario in the form of a collage (Figure 4). These 150 words and images, selected by the researcher, were intended to be interpretable in a variety of ways by the participant to allow for a rich expression of their thoughts about a scenario outlined in the exercise. Images of tracking devices, or objects directly related the physical product were purposely not selected. This exercise additionally probed the participant to take their experience during the initial diary study into account. "These stories often reveal their unmet needs and expose their aspirations for the future" [85:129]. Figures 5 and 6 show the collages composed by Participants 4 (frustration with her tracking device while weight training) and Participant 7 (tracking activity socially with friends in order to enjoy her holidays without having to diet).

Figure 4 - Selecting the photos during the workshop

Figure 5 - Collage from Participant 4

Figure 6 - Collage from Participant 7

Workshop Exercise 2: Mapping of domain knowledge

The second exercise, mind mapping, allowed participants to map out their current experience and domain knowledge [12], and create a mind map of everything related to activity tracking, focusing on a device's aesthetics, physical properties, how it is worn and the data it collects. Not only does this method allow for participants to gain a clearer understanding of their knowledge through visual representation, it allows them to explore and analyse some of the ideas and comments from the first exercise. This exercise was performed as a group with the researcher as a facilitator taking notes on Post-it notes, allowing the participants to brainstorm concepts. Figure 7 shows the words which participants highlighted in this exercise.

Figure 7 - Mapping of domain knowledge

Workshop Exercise 3: Creative thinking through bisociation

The third exercise made use of a technique based on Koestler's theory of bisociation [50]. Users were given two objects, both with their own concept and logic: one from a selection of body parts and one from a selection of data points which can be tracked with activity trackers. By combining two objects and exploring the forced intersection of them, abstract ideas could be generated which, through an iterative approach, could be turned into a feasible concept, as visualised in Figure 8.

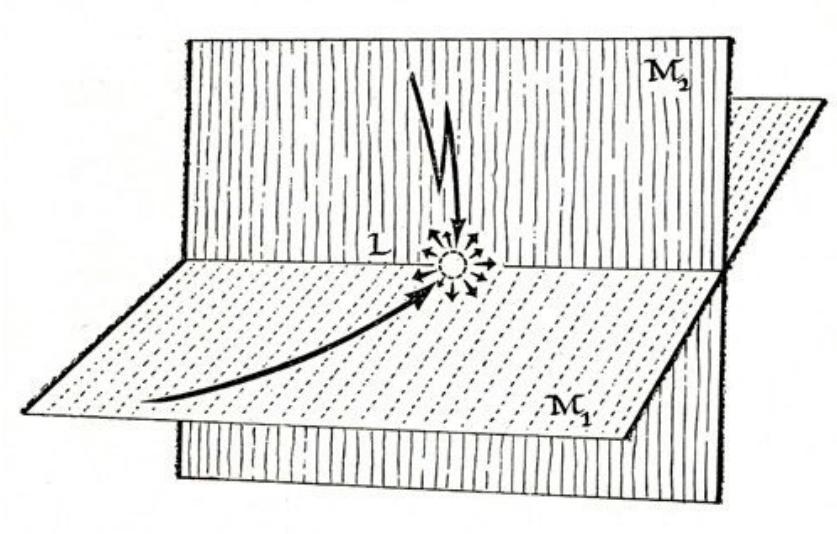

Figure 8 - Visualisation of the creative process of bisociation. Source: [50]

This is a creative thinking technique commonly used by product designers during initial research. While many combinations resulting from this technique may either seem very abstract or not at all unusual, the objective was to encourage creative thinking and the exploration of non-standard form factors. The cards were given to participants randomly which resulted in different discussions in each workshop, with some combinations generating discussion amongst participants about aesthetics and comfort. While this exercise was the most abstract one of all, it was important to challenge the archetype of an activity tracker and the participants' perceptions of what a tracker is and what it should do.

Workshop Exercise 4: Designing your own prototype

In the final exercise participants were asked to reflect on their product use during the initial sensitisation phase (diary study), along with the previous exercises of the workshop, and to design their own prototype. This exercise required the most amount of time of the 2-hour workshop. The aim of this exercise was to allow participants to again reflect on their needs – in particular their latent and tacit needs, expressed through the act of making [75].

In order for participants to feel more comfortable with the fidelity of their prototypes, the researcher took part in this exercise. Many participants

commented on their inability to draw or make ‘nice things’. It was therefore important for the researcher to reassure them about the objective of the exercise and that the designs would subsequently be prototyped.

Figure 9 - Making of the prototypes during the workshop

The materials available in the workshop were paper, card, fabric, string, wire, moulding clay and rubber. Figure 9 shows participants working on their designs during the workshop. Using craft materials in generative sessions had the benefit that the models created were very basic. This meant that participants were required to explain their designs when presenting them to the group. Presentation offered the chance for additional discussion around aspects of the concept. Additionally, the limited materials also reduced the pressure to create extraordinary designs, which made the workshop environment more relaxed.

Each participant was given the opportunity to present their designs to the group. While many people did not feel comfortable asking questions and engaging in discussion about each others designs, this exercise offered the

researcher an additional opportunity to ask questions about each prototype and how it addressed the particular challenges highlighted in Workshop Exercise 1.

4.3 Analysis

In order to analyse this stage of the research, workshops were recorded and transcribed. The transcriptions and the participants' diary study entries were thematically analysed in order to extract emerging themes. Workshop Exercises 1 and 4 in particular provided many insights into the participants' motivations for tracking activity, and their wants and desires for an ideal activity tracking device. These are presented and discussed below.

4.4 Findings

From the data gathered in this research phase the author was able to understand various motivations for tracking activity. People track their activity for a variety of reasons: financial incentives, to improve performance and health, to engage socially and in competition, and to to explore new technologies and collect data about themselves. Motivations can also change through use of the product. The motivations of the participants of this study are shown in Table 6.

4.4.1 Motivation

ID	Devices or Apps	Motivation
1	Apple Watch, Nike+ Running	1: Health
2	Fitbit Flex	1: Health
3	Garmin Vivosmart, Moves App	1: Financial discounts with health insurance provider, badges and competitions 2: Performance
4	Garmin 920xt	1: Collecting data
5	Apple Health, WeChat	1: Social competitions
6	Strava	1: Performance 2: Social engagement
7	Fitbit Charge	1: Health 2: Uses social motivation to maintain her motivation
8	RunKeeper	1: Health
9	Garmin Fenix 3, Moves App, jawbone Up24	1: Workouts: Social 2: NEAT Activity: Financial - discounts with health insurance provider
10	Google Fit	1: Health 2: Data and exploring new technology
11	Fitbit Flex	1: Collecting data 2: Social, but not as much anymore
12	Fitbit Zip, Google Fit, Google Tracks	1: Data 2: Social engagements and competitions
13	Fitbit Surge, Microsoft Band, Withings Pulse	1: Collecting and quantifying data, 2: Health
14	Fitbit One	1: Health
15	Fitbit Flex	1: Performance 2: Now also social competitions

Table 6 - Motivations by participant

Data as motivation

For two participants, data itself was the motivating factor for tracking activity. *"I have got 3 fitness trackers - I am a bit obsessed with them. [...] I just like quantifying things. I like being able to analyse all of the data and see sequences"* (P=13, Interview). While health may have been Participant 13's original starting point, his primary motivator has become collecting data. He was using three

devices at the time of the study: the Fitbit Charge HR, the Microsoft Band and Withings Pulse. Many participants highlighted that they liked collecting and seeing their data. Participant 10 noted that she *"love[d] to see her data"* (P10, Diary Study). While not his primary motivator, Participant 2 was "*happy that it just collects the data. I am more interested in using the data in an aggregate way with all my other data.*" (Workshop). This finding is comparable to Documentary Tracking, the motivation of tracking activities instead of changing them, as described by Rooksby et al. [73].

Financial incentives as motivation

Participants 3 and 9 highlighted that financial motivations encouraged them to track activity. For Participant 3, financial benefits available through her healthcare scheme were a starting point for tracking activity: *"At work we have [this healthcare scheme, and] depending on the steps you collect every day you will get rewards. So I thought: Oh, that is quite good. Now that summer is coming and I am getting bored, let's buy the shoes to start running. So I started running a lot and I bought my Garmin device to start counting the steps"* (P=7). Participant 9 tracked his workouts using a wearable tracker, but also tracked his NEAT activity with the Moves app in order to collect rewards with his healthcare scheme "*I like this app because it is linked to my [healthcare] scheme which rewards me with points for exceeding a target*". Both participants enjoyed collecting rewards [73], but unlike Participant 3, Participant 9's primary motivator was social engagement and competition amongst friends.

Social engagement and competition as motivation

For several participants, social competition was a key motivator, and was, for three participants, the key motivation for tracking activity. It allowed these participants to reflect on their own performance, to compare themselves to others, and acted as a way to maintain their interest in activity tracking. "*There is a app [on which] I found most of my friends. They will share their activity on the app and it will [...] automatically [allow for you and your friends to] compete with each other. It motives me.*" (P=5, Workshop). While for many this was not the primary motivator, they still enjoyed the interactions it generated. "*Whilst often I will be talking to a lot of friends about it. I sort of have persuaded*

a lot of friends to buy a fit themselves or a tracker. We laugh a lot." (P=11, Workshop)

Improving one's health and performance as motivation

Lastly, the majority of participants started tracking their activity either to understand and improve their performance or because of health reasons. Participant 7 used activity tracking as a method to manage a health condition and maintain a daily level of NEAT activity. "*The only way to fight this condition is to actually do what we are supposed to do and be healthy, eat properly, walk more and exercise more. So I decided to do a bit more and I [got] a Fitbit back then.*" (P=7, Workshop). In contrast, Participant 6's core motivation was to understand her workouts better. While she did not use a wearable device at the time of the study, she tracked her activity with Strava. "*If I am going to be using Strava I sort of push myself a little more.*" (P=6, Workshop). Participant 2 noted that his lifestyle had become more sedentary and his comments might indicate that the novelty of tracking health had worn off. In fact, he had stopped tracking activity at the time of the study: *"I've been looking at my data much less; I think because my routine has been more static and I know steps for my various journeys so there's no novelty in seeing how far I've walked. [...] The Fitbit strap has recently broken and haven't got around to getting a replacement."* While it is arguable that he had stopped tracking due to the damaged strap, he noted in the workshop that his phone also tracked activity, however his diary study indicated that he had not been using this option. This motivation is again comparable to one of Rooksby et al.'s identified styles of tracking: Directive Tracking [73].

4.4.2 Non-use cases

Understanding non-use cases additionally allowed the researcher to identify challenges with the system. Within the 7-day diary study, the most common times when devices were not used were while showering, taking a bath or charging the device (Table 7).

ID	Devices or Apps	When don't you use your tracker?
1	Apple Watch, Nike+ Running	Charging or taking a bath
2	Fitbit Flex	Device currently broken
3	Garmin Vivosmart, Moves App	Charging
4	Garmin 920xt	Charging, When weight training
5	Apple Health, WeChat	When at home
6	Strava	When at home
7	Fitbit Charge	In the shower
8	RunKeeper	Only tracks runs
9	Garmin Fenix 3, Moves App, jawbone Up24	When charging
10	Google Fit	When at home in front of the computer
11	Fitbit Flex	When leaving phone at home or busy working
12	Fitbit Zip, Google Fit, Google Tracks	When the battery iow and when charging
13	Fitbit Surge, Microsoft Band, Withings Pulse	Charging, in the shower
14	Fitbit One	No information
15	Fitbit Flex	In the shower

Table 7 - Device non-use cases

4.4.3 Participants technological desires

When reviewing comments made in the workshops and the times when participants did not track their activity (Table 7) correlations can be made between these non-use cases and the technical desires of the participants. In the workshops many participants commented on the battery life of the devices, and the most common non-use case was when charging. Participants 2 and 12 designed devices which charge wirelessly overnight. Tracking capabilities and access to data were also mentioned. *"I am happy that it just collects the data. I am more interested in using the data in an aggregate way with all my other data. [...] I want to integrate my data and have it."* (P=2, Workshop)

The materials from which these devices were made had an additional impact on their use. In fact, the material properties of the device emphasised its

perceived qualities. Many participants were keen to have a waterproof device; as Participant 15 stated: *"'drop to the bottom of the pool'-water proof"* (P=15, Workshop). Most participants owned water-resistant devices. While these devices and their designs included the affordance of being water-proof, participants were hesitant to use them in the shower or bath. *It says it's splash-proof but it is not. It would fail immediately."* (P=9, Workshop)

Participant 9 additionally thought his Jawbone Up felt too delicate. However, Participant 11 felt that the Jawbone Up seemed safer than the Fitbit. In fact, Participants 2, 11, 15 commented on their Fitbit falling off and Participant 6 lost a Fitbit in the past because it fell of while cycling.

4.4.4 Participants' aesthetic desires

Many participants were concerned with the appearance of the device with some commenting on size. Participant 3 focused purely on size in her design. *"I like two activity trackers: The Polar M400 and Garmin Vivocactive and they are extremely huge for my wrist so I look like my niece wearing her dad's watch. That's why I have got this [Garmin Vivosmart] as it is the smallest one I could find. So I [designed] this watch with the size I would like."* (P=3, Workshop). Participant 1 noted that her design should be available in a variety of sizes for both men and women, while Participants 5 and 12 designed rings to be small and comfortable. *"I made a ring small because I just want it to be small and comfortable to wear"* (P=5, Workshop). Participant 13 highlighted ergonomic challenges he was facing with his device when writing: *"The shape of it: It is not very good for writing because it is very bulky."* (P=13, Workshop).

Comfort was another factor highlighted by many. In fact, not only should the device be comfortable but, for Participant 8, not noticeable: "*Maybe it could also be something really thin that goes around around your arm [but] doesn't have [a substantial] form factor. You won't feel it when you wear it. Really paper thin*" (P=8, Workshop).

Lastly, customisation was an aesthetic requirement, mostly relating to the physical form. Participants 3 and 6 noted that they were unable to wear trackers during netball or anti-gravity yoga as their arm had to be free from devices. Participant 6's designed her device to be worn around the ankle. Participant 7 wanted the ability to *"keep the [tracking component and screen] together or you*

*[…] separate them." (*P=7, workshop) so that she too, could wear it around her ankle, but be able to see her step count easily. Participant 15's customisation aspects focused on allowing her to *"wear it [in different situations] because […] there these occasions where you can wear it like this – [like going] to a ball."* (P=15, Workshop).

4.4.5 Participants' models

Figure 10 shows the models made by the participants. Table 8 outlines the core concept of the participants' prototypes. While many concepts addressed some of the technological and aesthetic desires mentioned in discussion, many highlight needs which were not explicitly expressed, such as size and device visibility.

Figure 10 - Participants' models

ID	Core concept	Prototype description
1	Customisation	A device with the ability to either wear the tracking device as a watch or carry just the tracking component separately
2	Device visibility	A device which is invisible to the user and others by wearing it on the ear
3	Size	A smaller activity tracking watch
4	Data	A device which looks like a bracelet but can constantly capture basic data while the main device is not used i.e. when charging
5	Integration into lifestyle	A tracking ring
6	Tracking workouts better	A tracker which can be worn around the ankle and customised with different bands
7	Customisability	A device with the ability to wear the tracking component and screen separately at various places of the body
8	Tracking workout	A device which can be attached to the forearm which displays your progress
9	Device visibility	A device which can be attached to clothing rather than to the body
10	Health & performance notifications	A device which receives notifications about health and performance via haptic feedback
11	Integration into lifestyle	A tracking device which looked like a piece of jewellery
12	Integration into lifestyle	A tracking ring
13	Collect more data	A tracker which looked like a conventional watch which had the capabilities of all 3 currently owned trackers
14	Integration into lifestyle	A device which can be attached to a regular watch
15	Customisability	A device with the ability to wear the tracking component and screen separately at various places of the body

Table 8 - Core concepts of workshop prototypes

4.5 Discussion

The findings outline many of the challenges participants faced, and desires they had, which they self-identified during the course of the diary study and in the workshop through reflection on the use of their activity trackers. During the workshops many of the identified challenges related to aesthetic and technological desires. However, only little is known about the impact of context on their use. As the participants in this study were predominantly intrinsically motivated to track their activity, the context of use of their current activity trackers might not have been significant to them. However, this had the potential to vary in the third stage of research, in which they were asked to self-evaluate their own designs.

The motivations found in the workshop and diary study are inline with previous work in the field of personal informatics [73]. Rooksby et al.'s study looked at styles of tracking and characterised their use as 'lived informatics'. Thus, the motivations are grounded in both research and literature reviewed in this study.

Unlike the Context Mapping Framework, where the findings at this stage would be analysed and passed on to a multi-disciplinary design team to proceed with the project [85], two additional stages of research – prototyping and evaluation – were included. The generative sessions provided insights into unconscious needs of users [75], which the author wishes to validate within the second and third stages of this research.

Chapter 5. Designing and Prototyping

5.1 Introduction

The workshops and diary studies from the first stage of research generated many insights. These included the users' motivations for tracking their activity and also the challenges and issues that participants faced with their current activity trackers in certain situations or contexts. However, through creative thinking techniques, and having been given the chance to make their own activity trackers, they were provided with the opportunity to express their desires for an ideal device, from a functional, technological and aesthetic viewpoint. As highlighted by Sanders et al., the act of making allows participants to tap into their latent and tacit needs; needs which they are unable to express through words, but which can be embodied in their concepts [76]. The designs and concepts generated in the workshops are illustrated in the previous chapter, in Figure 10. Each participant (excluding Participant 1) generated a 3D-model of their ideas. They were then given the opportunity to present their ideas to the group. The presentations and comments from the workshops were transcribed and evaluated as part of the thematic analysis of the first stage of the research.

Some participants additionally provided sketches to illustrate their concepts in more detail (Figure 11). These provided additional insights into their desires, which influenced the design of their prototypes.

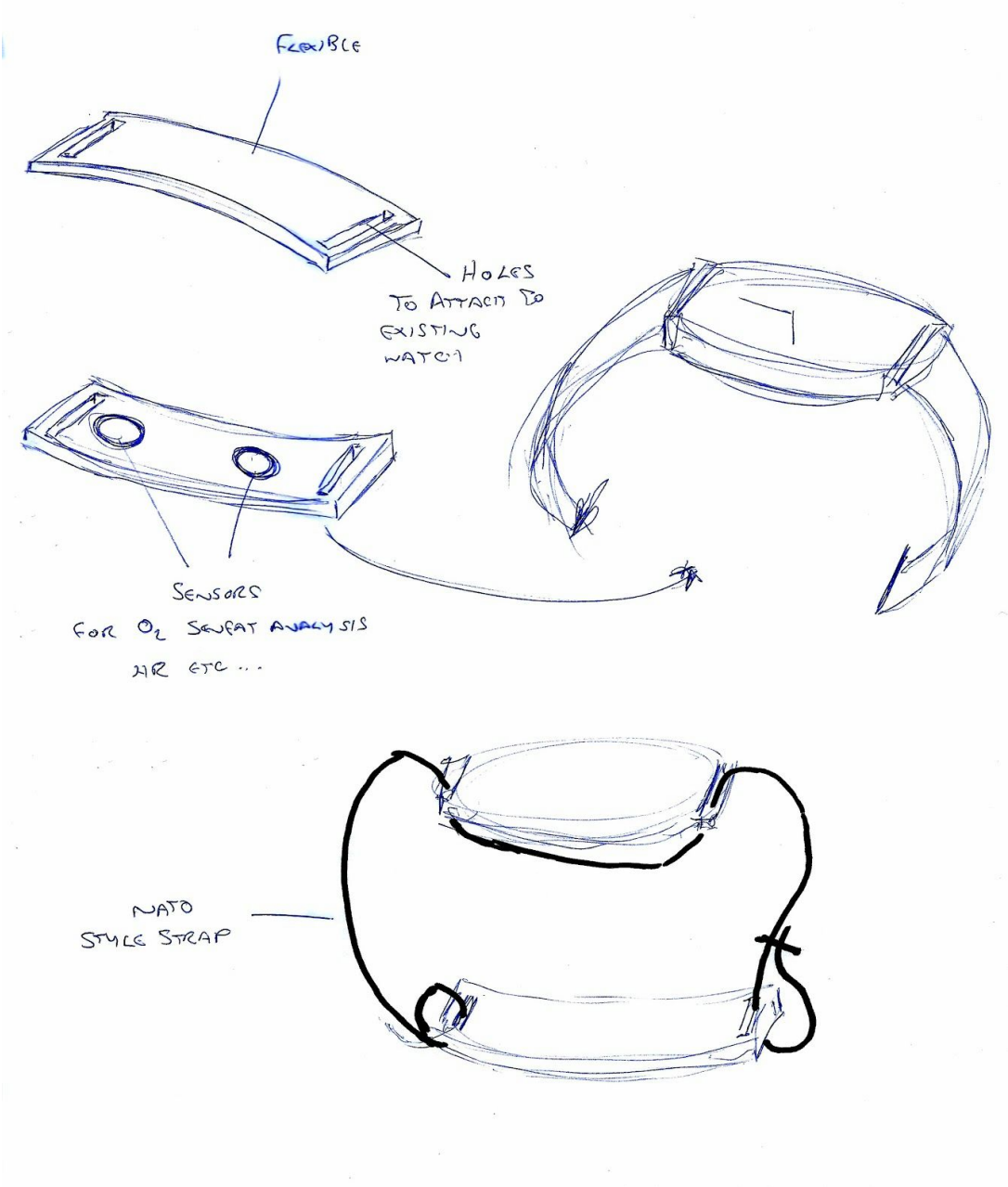

Figure 11 - Sketches from Participant 14

5.2 Methods

Design practice as a resource for research has been extensively discussed within the design research community. With the convergence of design and HCI, it has become increasingly relevant to the HCI research community with recommendations on how such methods of research can be integrated [88]. In his paper, 'What should we expect from research through design', Gaver states:

> "Over the last number of years, design practitioners have become increasingly integrated within the HCI community. Their work often takes the form of research through design in which design practice is brought to bear on situations chosen for their topical and theoretical potential, the resulting designs are seen as embodying designers' judgement about valid ways to address the possibilities and problems implicit in such situations, and reflection on these results allow a range of topical, procedural, pragmatic and conceptual insights to be articulated" [31].

Gaver's statement might suggest that the prototypes created in the first stage of this research embody a concept which their designers (the workshop participants) have chosen to address in a design brief which they have set for themselves. The artefacts created offer the researcher an opportunity to reflect on their designers' wants and needs. The researcher dissected these designs to extract the core concepts which they embody in order to turn them into low-fidelity prototypes.

Prototypes are representations of a design, made before the final product exists. They can be used to evaluate how a product looks, feels or works within the context of its use [10]. Taking Buxton's definitions of prototyping and sketching into account, the designs created in the workshop were treated as sketch models with the purpose of proposing and informing a design. In comparison, the low fidelity non-functional prototypes which were handed to participants were used to test and evaluate their design concepts [11]. They were reduced to the core concept of the participants' ideas, but made from more durable and wearable materials. In order for participants to focus on the evaluation of their design in the next step, specific materials were used for prototyping.

During the process of turning the sketch models of the participants into prototypes, the researcher additionally used sketches created by himself to ideate on the designs in order to enable an increase in fidelity (Figures 12 and 13).

Using tools and manufacturing techniques available to him, the researcher proceeded to manufacture the prototypes using laser-cut acrylic, laser-cut plywood, 3D-printed ABS and/or fabric (Figure 14) . Designs which were meant

to resemble jewellery were made using craft jewellery materials such as memory-shape silver-plated wire, beads, chains and fastenings. As the participants did not see each other's designs, elements from some designs could be reused for multiple prototypes. However, the researcher aimed to design each prototype to be as close to the participant's design as possible. Figure 15 shows a selection of participants' workshop models alongside their corresponding prototypes.

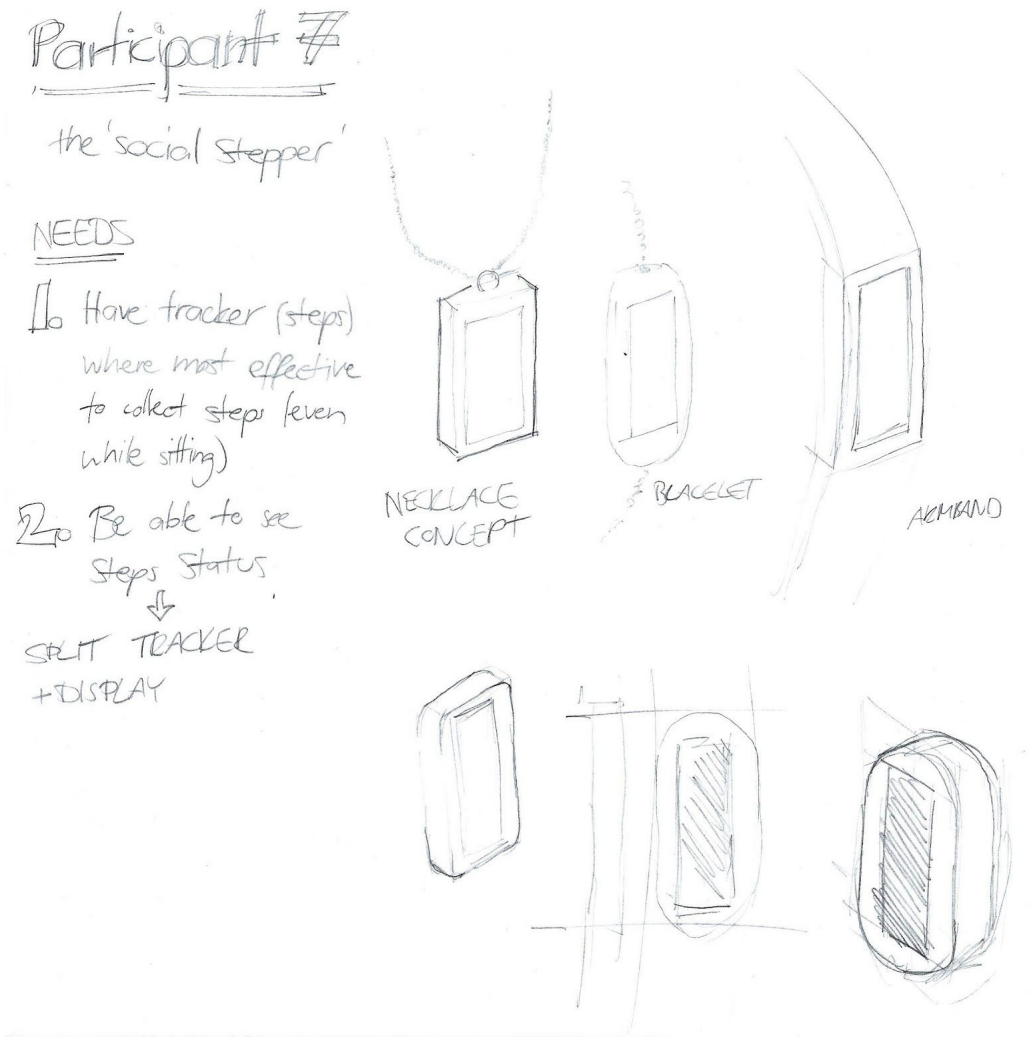

Figure 12 - Designs for Participant 7's prototype

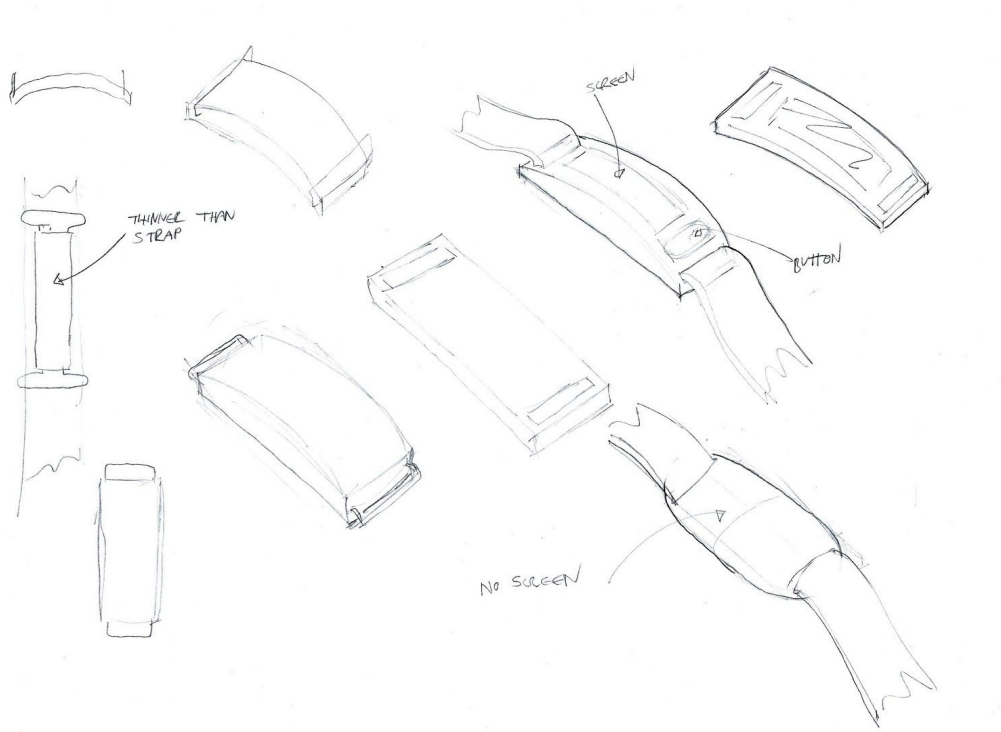

Figure 13 - Designs for Participant 14's prototype

Figure 14 - Finished prototypes

Figure 15 - Workshop Exercise 4 models with corresponding prototypes

5.3 Discussion

While the aim of this part of the research method was focused on fabricating low-fidelity prototypes, it also offered the author an additional opportunity to reflect on the participants' design choices and the outcomes from the first stage of the research. Furthermore, it developed the researcher's empathy towards participants and the specific challenges they wished to address with their design concepts. This was of value in understanding participants better for the third and final stage of the research.

CHAPTER 6. COLLECTING INSIGHTS USING PROTOTYPES

6.1 Introduction

In the previous chapter the author discussed the process of turning participants' ideas into prototypes and the insights and empathy towards participants gained in that stage of the research. Following that, the prototypes were handed back to the participants for the final stage of the research: the collecting of insights using prototypes, which consisted of an in-situ design evaluation and a semi-structured interview.

During this stage of the research participants were requested to wear their low-fidelity prototypes for a 5-day period. After posting the prototypes to the participants, and receiving a confirmation of their receipt, the 5-day trial started. Varying dates of arrival of the prototypes meant that the contextual design evaluation started at different times. It is important that the researcher acts as a support and help desk during this time period, as noted by Harrison et al. [36]. Fortunately, in this research study, all of the prototypes were non-functional and so technical queries did not arise.

6.2 Methods

6.2.1 In-situ design evaluation

In this stage of the study, participants were requested to wear their low-fidelity prototypes for a 5-day period. Wearing them in the context of their daily lives allowed participants to reflect on their design choices, the use-cases and the experience of the products. In order for participants to better understand this process, the example of Jeff Hawkins' evaluation of the Palm Pilot prototype [6] was given to them. This framed the task in a way that allowed participants to better understand objectives behind the exercise and reflect upon the situation in which they would use their design if it were functional. Additionally, the contrast between the real use of their existing activity tracking device and the simulated use of the prototype gave participants an opportunity for reflection, both on the contextual and aesthetic experience.

As previously mentioned, experience is very subjective. Using prototypes allows participants to "experience the design for themselves, rather than

witnessing a demonstration of someone else's experience" [10]. The evaluation of the product happens in situ rather than in a controlled lab study and allows for the designs to be tested in real unpredictable situations. As Rogers explains in her work on 'in-the-wild' studies, this form of evaluation can generate findings which the researcher had not anticipated [72], and offer additional detail to the design requirements for future products. They also provided further data items for the researcher's thematic analysis. In order to obtain these findings, participants were asked a series of questions every day via email as part of a final diary study. These included questions about the consistency of feelings towards the experience throughout the evaluation phase, whether the proposed design lived up to the participant's expectations and how they would change their product if given an opportunity to redesign it. The aims of these questions were to encourage the participant to reflect on the prototype, its use and non-use, significant moments with the design, and newly emerged challenges with both the design and the prototype.

6.2.2 Interviews

Once participants completed the 5-day in-situ design evaluation phase, closing interviews were scheduled and held either in person or via Skype. Even though the majority of people were based in London, due to the length of the study, many participants preferred a phone call over another scheduled meeting. The calls on average lasted 20 minutes.

The interviews were semi-structured, ensuring that certain topics were covered, but also allowed the researcher the flexibility to cover interesting areas which emerged in the conversation [80]. In preparation for the interview, diary entries kept during the in-situ design evaluation, together with individual findings from the first and second stage of the research were analysed and informed the questions for the semi-structured interview. As each participant focused on different aspects when creating their design, custom interview questions for each participant were generated by the researcher. The questions covered the experience with the prototype, areas of interest based on the workshop data and diary study, their view on aesthetics and the physical form and finally changes to their attitude or approach to tracking.

6.3 Findings

In this final stage the prototypes were worn and evaluated within the context of the participants everyday lives. This allowed for reflection on their prototype designs and validation of the core concepts embedded within them. Additionally, this final stage of the research allowed the participants to re-examine their experience with their current device when comparing it to the experience with their prototypes.

The findings from this stage of research allowed the researcher to better understand the previous findings and identify five primary themes: (1) motivations for using activity tracking devices, (2) the sensory qualities of the device, (3) the context of use (4) the perceived properties of the device and (5) other influencing factors.

All of these themes affected the aesthetic experience of using the device. Table 9 summarises the themes which emerged during the thematic analysis. While some of the elements have been previously identified, and may overlap, they have been assigned a primary theme. The remainder of this chapter presents the findings from the third stage of the research, focusing particularly on the contextual effects that the participants documented. For the sake of clarification, the author highlights if the participant is referring to a 'functional tracker' or a 'prototype tracker'.

Theme	Elements
Motivations for using activity tracking devices	• Data as motivation • Financial motivation • Social motivation and competition • Health and performance • Exploring new technology
Sensory qualities of the device	• Appearance • Size • Weight • Material Properties • Comfort
The context of use	• Device visibility • Personal awareness • Customisability and fashion • Ergonomic challenges

Perceived properties of the device	• Perceived device accuracy • Perceived device reliability
Other influencing factors	• Integration into users' routine • Technical factors • App aesthetics • Brand

Table 9 - Themes and elements

6.3.1 Motivations

While the main motivations were identified in the first stage, this part of the research brought nuances to light. In particular the difference between exploring new technology and data as a motivation. While Participant 13's core motivation was collecting data, Participants 2 and 12 were more interested in exploring new technology. *"Well, I guess originally [my motivation for tracking activity] was: I try a lot of gadgets so [...] I tend to buy a lot of stuff like that. So, that was the main reason I sort of first bought it."* (P=2, Interview). These findings are inline with past research, and are comparable to Fetishised Tracking, identified as one of the styles of tracking by Rooksby et al. [73].

6.3.2 Sensory qualities of the device

As previously mentioned, appearance of a device had a significant impact on the use-cases of many activity trackers. In fact, many people initially chose their activity tracker because of personal design preference or design philosophy. *"I like the design of the jawbone. [...] [as it] was quite unusual [and] I like things that are a bit unusual."* (P=11, Interview, functional tracker) Participant 10 said that she was exploring new products, ones using different materials, and she found that the appearance of the device and the price contradicted each other which stopped her from making a purchase. *"They said they use metal[s] but the design looks quite cheap [...], and the price is not cheap. I think they didn't properly design it and I didn't feel like I will buy it.* (P=10, Interview, functional tracker).

Participant 13, who was primarily motivated by data, received a prototype that looked like a watch, in fact it resembled a smartwatch. *"I quite like the fact that it looked like a watch but it wouldn't sort of be a deal breaker if it looked sort of very different"* (P=13, interview, prototype tracker).

Weight played an additionally important part. Participant 9 noted when evaluating his prototype that its weight caused challenges when attaching the device to certain parts of clothing as *"it flapped around too much. The device was heavier than expected."* (P=9, Interview, prototype tracker) Participant 10 found through comparison with the prototype tracker that her actual tracking device (a phone) was *"okay for walking or jogging, or hiking, but [...] a bit heavy for running."* (P=10, Interview, functional tracker).

Some of the materials and designs caused discomfort for the participants. During the workshop at the beginning of the study Participant 13 noted that a newly purchased tracker with the functionality he was interested in was causing skin irritations. During the closing interview he stated that it became unbearable and that he had stopped wearing the device. *"I am not wearing it at all for the minute because of what it has been doing to my wrist." (P=15, Interview, functional tracker).* He noted that an additional functional product, a chest-worn heart-rate monitor, was causing discomfort, but unlike the tracker he was willing to find a workaround in order to collect the data.

Participant 4 received three different bracelets as prototypes. When asking her which prototype she preferred she mentioned the larger one of the three: *"I envisaged it it was going to be a braided bracelet so this one works better. The other ones are too thin and I wouldn't be interested in that. Although the closures were probably better: more secure. I would need it obviously a bit bigger. [...] I also envisaged that the plastic bit wouldn't be plastic but metal and a bit interesting"* (Interview, prototype tracker).

Participant 7 preferred wearing her current (functional) tracker around her ankle in order to accumulate steps. Her prototype design was also intended to be ankle-worn. However, throughout the day (when wearing her prototype tracker) she noticed an increase in discomfort from her ankle becoming swollen. *"By the end of day [prototype's chain] around my ankle was becoming slightly irritating. Ankles swell so what was comfortable and slightly loose in the morning slowly tightens during the day. This means by bedtime you are keen to change it's position."* (P=7, In-Situ Evaluation, prototype tracker) Additionally, 3 participants (Participants, 5, 11 and 12) commented on the comfort of their

prototypes (activity tracking rings) during the trial and how the discomfort would have to be addressed first if it were to go into production.

6.3.3 Context of use

As noted in stage 1 of the research, many participants wanted smaller devices. *"I thought if I had a simple thing that just looks like a bracelet that did the bog-standard basics of capturing my steps, I might be more inclined to sometimes not wear my big chunky Garmin."* (P=4, Interview, prototype). However, apart from personal preference, the context of use and device visibility played an important role. Participants 3 and 5 did not want to wear a highly visible tracker (both prototype and functional) within a professional environment *"Sometimes we are with clients and if you have got a huge watch it really doesn't look nice."* (P=3, In-situ evaluation, functional tracker). *"I had a formal meeting, and I didn't wear [the prototype]. Since the ring is too big, it may draw some unexpected attention."* (P=5, In-situ evaluation, prototype tracker). Participant 6, who uses an app to track her cycling activity, wanted a device which would go on her ankle. In the evaluation of her prototype she discovered that this was too visible for her, making her feel self-conscious if other people noticed it:

> *I thought it would be really good to have something on me[...]. But then I actually [...] found that I didn't want to do that, because I didn't really want to draw attention to it and I thought that having something like that would draw attention to it too much. And actually a lot of time I was trying to cover it up with like trousers or shoes or something. [...] Because it is around your ankle [people] are [...] more interested in what it is whereas if it was something that is just around my wrist people don't really ask as much because they might mistake it for a watch or that might be more generic activity tracker.* (P=6, Interview, prototype tracker)

Participant 2 designed a tracker intended to be invisible to him and to others (Figure 16). In the evaluation phase he noted that his prototype was an interesting concept to evaluate, however he found the ear-worn device consistently uncomfortable. Notably, it was also not as invisible to others as he had hoped it would be.

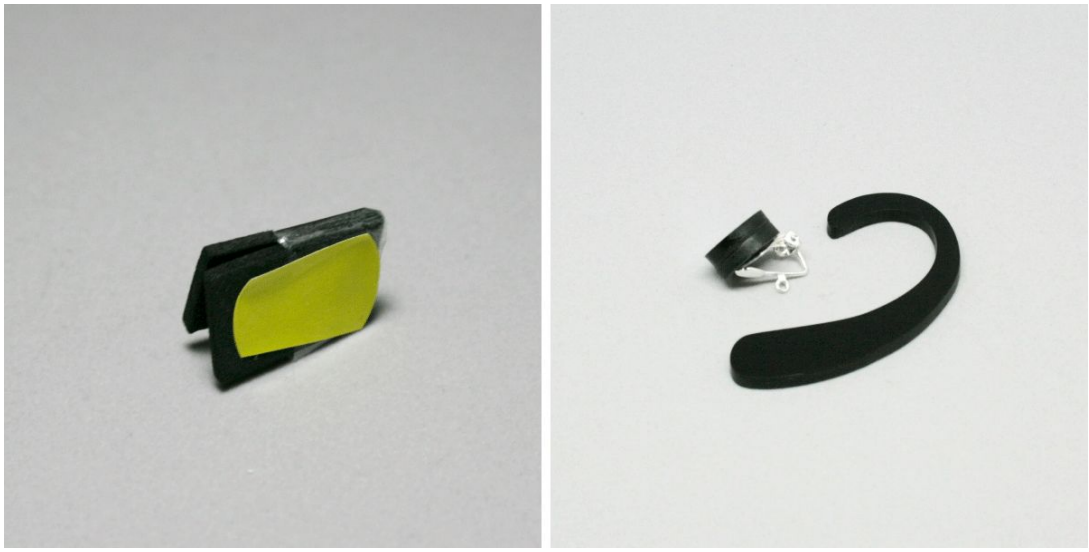

Figure 16 - Participants 2's workshop model and low fidelity prototypes

Participant 8 designed his prototype not to have a substantial form factor as he did not want to notice wearing a device. In fact, when evaluating it in the diary study, the prototype was irritating him: *"The occasional feeling of the adhesive on my skin was bothering me."* (In-situ evaluation, prototype tracker). In contrast Participant 10, who uses a mobile phone to track her activity, highlighted a heightened sense of awareness of her physical activity level when wearing the prototype *"I think part of the reason might be the prototype. [...] I think the prototype did work on some ways. I thought, if it could tell me in this unintrusive way, then I don't have to check anything. That could be more convenient"* (Interview, prototype tracker). Additionally, she wore her prototype at various locations on the body. While she did not indicate a preferred location, she found that wearing it on her sleeve made it more noticeable than other locations, primarily due to the weight of the device. Participant 11 noted that wearing her prototype at night was sometimes too noticeable because of the beads. At the time of the study she was wearing her current device to track sleep, and occasionally she was also wearing her watch and rings.

6.3.3 Customisability and fashion

At times standard designs did not meet users' requirements; even though many products offer customisation options, a variety of accessories or even colours to choose from. While Participants 7 and 15 focused on a variety of ways to attach their prototypes to their bodies, for Participant 1 customisability was

related to fashion. She highlighted that she particularly liked her current device, an Apple Watch, as it gave her the option to customise the appearance with a selection of additional straps. *"I think it is my [...] personal design philosophy. [...] I think the flexibility is quite important for me. [...]"* (P=1, Interview, prototype tracker).

Socialising was highlighted again as a situation during which participants would not wear their device. However, unlike previously, this time it was not related to device visibility by others but purely to fashion and style *"I don't mind if other people see it. It is just for example, if I was going to go out for an evening I would not necessarily want to wear my current tracker or something that didn't match my outfit."* (P=15, Interview, functional tracker) She additionally stated that she would not necessarily want a variety of accessories for her ideal tracker afterall, in contrast to her prototype design (which included a variety of accessories to allow her to wear it in various ways including an ankle bracelet so it could be worn more discretely). *"At times it was difficult [to wear with] wearing trousers and and socks, [...] because [her] trousers were quite tight at the bottom [and the prototype kept] catching"* (In-situ evaluation and Interview, prototype tracker).

6.3.4 Perceived properties of the device

The aesthetics and physical form of trackers and their resulting use-cases had an impact on the expectations of the device's performance and accuracy. While research indicates that the accuracy of tracking devices and tracking apps is quite high [15], many participants felt that their actual (functional) devices were occasionally inaccurate. This perceived inaccuracy was also related to the placement of the device. Many participants felt that having a device placed closer to the body, or attached to the part of the body which is predominantly moving (such as the legs), might improve accuracy. Participant 7 designed her prototype to be placed on her ankle based on her experience with her current device *"With the tracker on the ankle I feel the count would be the most accurate."* (P=7, Interview, prototype tracker). Participant 6's ankle-worn tracker was designed to track cycling more accurately. Participant 9 noted that while accuracy may not be crucial, it should work within reasonable expectations.

Participants additionally wanted reliable devices. While some referred to reliability in the sense that they could trust it not to run out of power, for others this meant that it should just function and capture workout data correctly.

> *"A couple of weeks ago I [took part in a cycle ride] and of course I made sure there that it was sufficiently charged the night before 100% because I knew it was going to be a long ride and I would be out all day and I even took a backup device. I have had so many instances where I never seem to get when I am on a milestone ride like that I have always seemed to have a problem with my GPS or battery fail or something. So I actually took 2 devices with me to make sure I could capture it properly."* (P=9, Interview, functional tracker)

6.3.5 Other influencing factors

The biggest pitfalls for participants were related to integrating trackers better into their current lifestyles and everyday routines. As previously mentioned, one of the main challenges faced was battery life and the resulting reliability. Participant 12 noted that he wanted 'fixed pattern charging' i.e. charge every day, once a week or every 6 months, instead of every 3 - 4 days as this made it hard to build a habit. Participant 9 wished devices would have standardised cables, and Participant 11 mentioned that the only drawback was having to plug a device into a phone to sync. The app aesthetics of wearable devices' accompanying apps had an impact for two people. Participant 4 and 11 liked the presentation of data within an app "*I love the scanning and zooming in [on the Withings App]. I think that is so well done.*" (P=4, Interview). "The *actual graphics [in the Jawbone App], when you saw how far you had walked etc. I liked the way that they had set that out."* (P=11, Interview).

One participant mentioned that she was 'semi-loyal' to the brand and would not consider any other tracking device (P=7, Interview). However, she mentioned that she was considering an Apple Watch as it would integrate well with her other devices. Whether this would actually replace her Fitbit was not clear. Participant 14 mentioned that while the brand of the activity tracking device was not important, the brand of his watch was. As he had made a significant investment in his watch, he would feel uncomfortable wearing it together with a cheap activity tracker. His design concept integrated with his current watch and focused

on how to attach it to his watch strap (his design concepts can be seen in his sketch in Figure 11).

6.4 Discussion

The findings from the third stage of research reinforced many of those identified in the previous stages and brought additional ones to light. Context of use was heavily considered in this stage. When wearing the prototypes that participants had envisaged in their designs, they highlighted contextual factors which were not considered during the workshop. These ranged from challenges with wearing the prototypes with certain outfits, on certain parts of the body or even to wearing the prototypes at all.

Participant 9 noted that the research process was quite enlightening: "*To actually seeing something that you designed and went through to prototyping - that was great. To actually wear that and realise actually the idea is not so great afterall - so enlightening is my summary of that.*" (Participant 9, Interview, prototype tracker). Participant 9 wore his prototype, shown in Figure 17 while running and at work. He noted when referring to the submitted picture below: "*The advantage though is that it can be attached or removed without removing clothing, [but] It could get caught here.*" (In-situ evaluation, prototype tracker).

The contrast between the situated use of their current functional and prototype trackers allowed participants to reflect on both designs. Participant 10 noticed changes in her behaviour towards activity tracking with her prototype in comparison to her actual tracker. Participant 7 highlighted the level of discomfort with her prototype towards the end of the day while wearing it on her ankle. However, when wearing her actual tracker (at the largest strap setting on her ankle) the discomfort was not highlighted.

In the next chapter both the findings and the methods used in this research will be discussed in more detail.

Figure 17 - Participants 9's workshop model, his prototype and a submitted photos of him wearing it at the office

CHAPTER 7. DISCUSSION

The aim of this study was to understand the relationship between aesthetics and physical form with the use of activity tracking devices. While there is a direct link between product aesthetics and product use, it has so far received little attention from the HCI community. As noted by Harrison et al., appearance and form factor are areas where individual preferences play an important role [37]. This research additionally took the perception of device properties, which result from aesthetics and physical form, into account.

In this chapter the author discusses the findings from all of the research stages. Additionally, as a different methodological approach was required to understand aesthetics, these methods will be separately discussed.

7.1 Discussion of results

7.1.1 Motivations

As a starting point it was important to understand user motivations for activity tracking. The primary objectives for tracking activity were: improving health and performance (n=5), social engagement and competition (n=4), collecting data (n=3), an interest in new technology (n=2), and finally financial incentives (n=1). The motivations had an affect on the core concepts of the devices designed in the study.

Those participants who were focussed on social aspects were generally more interested in having devices which would track data accurately, while those interested in improving their health and performance predominantly focused their designs on receiving feedback. Table 8 lists the the core themes of the products together with a product description.

7.1.2 Key themes

Research and literature on aesthetics has concluded that it is a subjective experience, which cannot be broken down into its individual components, and in order to understand it, it must be lived [87]. However, there are factors which can influence this experience. The author has broken these factors down into key themes which are discussed. The aesthetic experience varies depending on the product as it relates to the relationship between artefact and person. The themes

discussed refer to activity trackers, however the author argues that they apply equally to other wearable devices.

Sensory qualities of the device

Participants highlighted how certain sensory qualities affected their decision to buy a product, the way they used it and even caused them to abandon it. For Participant 11, the reason for buying a Jawbone Up was because she liked the design. Participants 5, 11 and 12 stopped using their prototype and Participant 13 abandoned his actual activity tracker due to discomfort.

Seven participants designed prototypes which resembled jewellery. While integration into one's routine and lifestyle may be a reason for selecting jewellery as a form-factor, the associations with jewellery and its materials differs from that of an activity tracker. Participants 1 and 5 described their tracking devices as sporty and bulky whereas their prototypes were designed to be elegant, 'wearable in the evening', attractive and small.

It is vital for designers to not only focus on functional properties but also on sensory qualities. These include not only the visual appearance, but also the intangible qualities of materials and associations which come with them. These can change based on the contexts in which these devices are used. With tracking devices worn for most of the day, apart from times when charging or bathing, these contexts can cover every aspect of users' daily lives.

The context of use

Directly related to understanding the context in which devices were used was device visibility. While most participants noted that they did not mind if their activity tracker or prototype was visible, there were situations when they preferred it was not. Many participants highlighted that they either felt awkward or self-conscious in the company of others if the tracking device, or the prototype, they were wearing did not look recognisable as either a tracker, a watch or a piece of jewellery. Customisation options can address this. While the majority of participants highlighted that they were not fashion conscious, customisation can be limited to alternative ways of wearing the device. Aftermarket accessories already address this challenge, however, they could also be considered from the start to include various fastenings. Mass-customisation capabilities could add the

required level of customisation. The way devices are worn may cause ergonomic challenges and users may choose to wear their devices in ways other than those intended by the manufacturer. Therefore designing with flexibility of use in mind is a recommendation.

Perceived properties of the device

Perceived and actual device properties are two different things. While research states that device accuracy is quite high, participants still questioned it; as well as device reliability.

Designers can address this response by ensuring that product aesthetics and design language match the actual properties of a device. If a device is designed to look durable and waterproof, it should meet these properties technically. While this may sometimes contradict the preferred device appearance (i.e. an activity tracking piece of jewellery) it is important for designers not to ignore this mismatch in actual and perceived properties of the device.

Other influencing factors

Finally, other aspects of the interaction can affect the aesthetic experience of the product. As Participant 4 noted with Withings: *"The app is beautiful, however, in comparison, the trackers are disappointing"* (Interview). Participant 7 stated that she liked the graphics on the Jawbone device but that syncing was frustrating. With wearables in particular, which have both a software and hardware component, the software may alter the expectations of the physical product. Additionally, the brand experience itself can both positively and negatively affect the perception of the device. These components can be forgotten by both engineers focusing on software and hardware integration, and by interaction designers focusing on a digital experience.

For Participant 2 the novelty of the device wore off and he lost engagement. Some participants had other incentives to keep them motivated however the loss of novelty is a factor adding to the reasons for abandoning devices.

7.2 The methodological approach

The selection of methods, and separation into three research stages, proved to be very insightful. They not only allowed for participants to be a source of

research, but also allowed them to actively take part in the design process of a tracking device and self-evaluate their design in context.

The stages of research in this study can be compared to the iterative design life-cycle model [80], however in this research only one iteration of the cycle was performed. The addition of prototyping and evaluation in itself offered a significant increase in insights in comparison to Context Mapping alone. However, researchers could consider multiple cycles, during which prototype fidelity is increased. This may provide even richer insights, but may not be suitable to perform with recruited individuals. It could be considered as part of an autobiographical design process [67]. These methods can be used by researchers wishing to build upon this three-stage approached with design as a resource for research.

7.2.1 Workshop exercises and participant engagement

The Context Mapping Framework originally suggested a workbook or cultural probes [30] for sensitisation of participants towards the domain of research. Due to time constraints, a diary study was selected. However, the author recommends to other researchers wishing to use these methods to also consider cultural probes or workbooks. These methods encourage participants to think more creatively rather than simply reflecting on the use of their current devices. While the questions during the diary study did vary, and asked participants about different aspects of their devices, there were times when some participants seemed less engaged in fully considering all aspects of tracking.

Participants highly engaged in the design process, such as Participants 7 and 9, offered the most feedback and were able to participate more effectively in Workshop Exercise 3 (Creative thinking through bisociation). The sensitisation method is therefore not only aimed at encouraging participants to reflect on their experience with the domain of research. It can stimulate them to think more creatively, engaging both sides of the brain, as highlighted by Buzan and Leopold [12,57]. The bisociation exercise proved to be challenging and this part of the workshop needed to be adjusted for each session. When reviewing the recordings, those who were most engaged in the initial diary study were also more engaged during this exercise of exploring alternatives to archetypal activity trackers.

Participant 6 noted that she felt, in the workshop, that she needed to create something interesting, but during the evaluation of the design she realised that her design did not meet her needs.

7.2.2 Prototype fidelity and ambiguity

The fidelity of the prototype which participants received caused an additional challenge. The prototypes which were more ambiguous were evaluated more thoroughly than those which were too similar to a final product. Depending on which aspects of aesthetics are being evaluated, fidelity plays an important role. For some participants, the materials of the product were important. Participant 9 particularly selected the Fenix 3 Sapphire edition activity tracker as it came with a metal strap which made it look like a normal watch, unlike the standard edition. These aspects of aesthetics are challenging to evaluate with a low fidelity prototype. However, if prototype fidelity is more ambiguous, participants are able to evaluate how it is worn and reflect on its physical characteristics. As Gaver states, ambiguity is not an excuse for poor design, however the inaccuracy, low-resolution and low fidelity of a product may encourage users to supplement them with their own interpretations and beliefs [32].

When asking participants how they perceived the accuracy of their prototypes, many considered them to be highly accurate because of their positioning on the body (Participant 7) or the secure fit of the device (Participant 4). This is an example of how participants added their own interpretations to their designs.

As mentioned by Gaver, designers craft product associations in order for its users to relate or aspire to the identities they imply. A product's aesthetics imposes a narrative of use. Participant 9 stated that he simply wanted an activity tracker which integrates well into his lifestyle and not a tracker for an athlete. The trackers he was referring to are not professional tracking devices but devices targeted at users like him. By removing the associations and the implied narrative of use dictated by the product's aesthetics, participants can more easily evaluate the product itself.

7.2.3 Participant's investment of time

Another area which can obscure the data is the level of financial investment which participants commit to when buying a tracker. When participants invest a certain amount of money they are more willing to test a device and put up with some of its challenges, including discomfort levels. However, during this study many abandoned wearing their (free) prototype after as little as six hours (Participant 12).

7.2.4 Prototype durability and comfort

Another challenge which prototypes used for evaluation face is durability and comfort. Participants 3, 13 and 15 highlighted that their prototype broke during the 5-day evaluation phase. An additional four participants (Participants 5, 9, 11 and 12) highlighted that it was uncomfortable to wear and one of them decided not to wear his after only six hours of use. It was important for the researcher to use materials, such as plywood and acrylic or pre-made components, which made it clear that the prototype was not a final product. However, depending on the use-cases of these prototypes, the materials should be carefully selected in order to ensure their durability and comfort throughout the evaluation phase. However participant may base their reflections too much on the fidelity of the prototype. Participant 4 based many of her reflections on the prototyping materials and not on those they represent.

As demonstrated above: aesthetic is very subjective. Experience in itself is also "very dynamic, complex and subjective phenomenon" [10:424]. Designing for this can be challenging. Autobiographical design as a method may address this. Autobiographical design is, by definition, the design of a system for self-use. This term was coined by Neustaedter and Sengers as "design research drawing on extensive, genuine usage by those creating or building the system" [67:514]. Many corporations test their products internally before distribution in order to identify bugs. However, unlike these products designed for their customers, autobiographical design is a method in which researchers and designers build products with themselves as real users in mind. While not officially documented, autobiographical design may be taking place in many research projects. The topic of aesthetics requires a 'lived experience' to fully understand its implications, therefore this method may present itself as a useful research method.

Due to time constraints, this method was not chosen as according to Neustaedter and Sengers, autobiographical design leverages long-term use of the product which is being developed [67].

7.3 Limitations of the study

As mentioned above the biggest limitations of the study were budget and time. Increasing the incentive to participate may have encouraged more people to take part in the study. Additionally, creating prototypes requires materials which have associated costs. Fortunately the author had access to manufacturing equipment which allowed him to produce prototypes. Other researchers may need to use external facilities which require extended lead times and come at an additional cost. Due to time constraints, 3D printing was only used for certain models, as the time to design a prototype with CAD software based on a workshop model was very time-consuming. For researchers wishing to make more use of 3D printing, having pre-designed components for participants to use in workshops could address this.

Chapter 8. Conclusion

In this study the author has explored the design and aesthetics of wearable activity tracking devices and the implications they have on product use. In order to understand aesthetics in the context of wearable devices, a novel approach was used. This research consisted of a three-stage approach: (1) An investigatory diary study followed by a participatory design workshop which aimed to understand the challenges user face with their current devices; (2) designing and prototyping, through which the participants' designs were evaluated and realised as a low-fidelity prototype; and (3) an in-situ design evaluation during which participants were asked to use their non-functional prototypes and pretend they were functional in order to evaluate them.

The research found that the product aesthetics of activity tracking devices span a variety of factors: the sensory qualities of the device, the experience with the product itself and the perceived properties of the device. Aesthetics, experience, and the aesthetic experience are all subjective and therefore one activity tracker does NOT fit all. It is important for designers to be conscious of the influencing factors which can affect the aesthetic experience of the product and its resulting use or abandonment.

The main contribution of this research was the approach taken to understand the aesthetic experience. Using a three-stage research methodology and combining participatory design, design as a resource for research, and an in-situ evaluation allowed for the gathering of rich, detailed data about aesthetics, motivations and user needs; in particular, those needs which current devices are not addressing. For research into fields which are as subjective as aesthetics, this three-stage approach presents itself as an ideal method of research.

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APPENDIX 1

This appendix consists of the participants consent form and information sheet.

Aesthetics and physical design of wearable activity trackers

This study has been approved by the UCL Research Ethics Committee as Project ID Number: UCLIC/1314/007

Contact Details

Investigator's Name: Matthew Pateman
Address: University College London - Interaction Centre
66-72 Gower Street
London WC1E 6EA
Contact Details: matthew.pateman.14@ucl.ac.uk

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, please read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

Details of Study

The purpose of this study is to investigate how the physical design and aesthetics of activity tracking devices affect the use of the product. You will be asked to take part in three parts of the study followed by a short Skype interview.

The most creative design will win a £60 Amazon Voucher. The 2nd and 3rd most creative designs will each win a £20 gift voucher. All participants will receive £5x. Terms & Conditions apply*.

Timelines

The study consists of 4 parts and will take place between 11 and 31 July 2015

11 - 17 July 2015	5-day diary study (5-10 mins / day max.)
18 / 21 July 2015	2-hour Workshop. You can **choose from one** of the 2 dates. Saturday, 18 July 2015 from 2pm - 4pm Tuesday, 21 July 2015 from 6.30pm - 8.30pm
20 - 31 July 2015	5-day diary Study (5 - 10 mins / day max.)
27 - 31 July 2015	15-minute Skype Interview

Part 1: Diary Study

During this 5-day study you will be asked to answer a few questions about the use of activity trackers. Additionally where possible you can add photos to your log. This should not take longer than 10 minutes per day.

Part 2: Workshop

This 2-hour workshop will take place on the 18 or 21 July 2015. You only need to attend one workshop. **This workshop will be video-recorded for later analysis by the research team**. No recording will be made public. Details of the activities will be disclosed on the day.

Part 3: Diary Study

The final 5-day diary study will take place between 20 and 31 July. In this part of the study participants will be asked to answer a series of questions. Additionally, where possible, you will be given the opportunity to add photos to your log. This should not take longer than 10 minutes per day. This study will close with a 15-minute Skype interview.

It is up to you to decide whether or not to take part. If you choose not to participate, you will not incur any penalties or lose any benefits to which you might have been entitled. However, if you do decide to take part, you will be given this information sheet to keep and asked to sign a consent form. Even after agreeing to take part, you can still withdraw at any time and without giving a reason.

Part 4: Skype Interview

This is an informal interview to allow you to comment on the experience of the research project and will give you an opportunity to ask questions or provide comments on activity tracking. The Skype Interview will be a maximum of 15 minutes and can be scheduled at your convenience.

Important Notice

In order to participate you must fulfil the following requirements:

- **Be located in the UK and be able to take part in the Workshop in London.**
- **Currently use an activity tracking device or application.**
- **Be aged 18 or over.**

All data including diary studies and video recordings will be collected and stored in accordance with the Data Protection Act 1998.

Competition Terms & Conditions

1. One Amazon Gift Voucher at the value of £60 will be given to the participant with the most creative design at the end of the study. One Amazon Gift Voucher at the value of £20 will each be given to 2nd and 3rd most creative design at the end of the study.
2. There is no cash alternative to the prize.
3. The researcher reserves the right to substitute the prize for an alternative of the same value.
4. In order to qualify for the prize, participants are expected to complete all four parts of the study.
5. Participants have the right to withdraw from the study at any time, however by withdrawing from the study participants forfeit their entry into the competition.
6. The winner will be contacted via email no later than 14 August 2015.
7. The winning entry will be selected by members of the research team and staff from University College London Interaction Centre (UCLIC).

Informed Consent Form for Participants in Research Studies

This form is to be completed independently by the participant after reading the Information Sheet and/or having listened to an explanation about the research.

Title of Project: Aesthetics and physical design of wearable activity trackers

This study has been approved by the UCL Research Ethics Committee as Project ID Number: UCLIC/1314/007

Participant's Statement

I .....

agree that I have

- read the information sheet and/or the project has been explained to me orally;
- had the opportunity to ask questions and discuss the study; and
- received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my rights as a participant and whom to contact in the event of a research-related injury.

I understand that I am free to withdraw from the study without penalty if I so wish. I understand the the workshop will be taped / video recorded and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Investigator's Statement

I .....

confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date: