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# A Quantified Past: Towards Design for Remembering with Personal Informatics

**Chris Elsden[1], David S. Kirk[1], Abigail C. Durrant[1]**

*[1]Open Lab, Newcastle University, UK*

## Authors' Mini-bios:

**Chris Elsden** (c.r.elsden@ncl.ac.uk, http://di.ncl.ac.uk) is an interaction design researcher with an interest in memory-related technologies and the experience-centred design of personal informatics; he is a Ph.D student at Open Lab in the School of Computer Science at Newcastle University.

**David S. Kirk** (david.kirk@ncl.ac.uk) is a psychologist with an interest in the human-centred design of memory-related technologies; he is a Reader in Cultural Computing at Open Lab in the School of Computing Science at Newcastle University.

**Abigail C. Durrant** (abigail.durrant@ncl.ac.uk, http://di.ncl.ac.uk) is an interaction design researcher with a longstanding interest in how digital technologies enable and constrain expressions of identity; she is a Leverhulme Fellow at Open Lab in the School of Computing Science at Newcastle University.

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## Notes

***Background.*** This article is based on the ongoing Ph.D work of the first author.

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***HCI Editorial Record.***

## ABSTRACT

This paper questions how people will interact with a *'Quantified Past'* – the growing historical record generated by the increasing use of sensor-based technologies and in particular, personal informatics tools. In a qualitative study, we interviewed 15 long-term users of different self-tracking tools about how they *encountered,* and *made meaning* from historical data they had collected. Our findings highlight that even if few people are self-tracking as a form of deliberate lifelogging, many of them generate data and records that become meaningful digital possessions. These records are revealing of many aspects of people's lives. Through considerable rhetorical *data-work,* people can appropriate such records to form highly personal accounts of their pasts. We use our findings to identify *six characteristics* of a *quantified past* and map an emerging design space for the long-term and retrospective use of personal informatics. Principally, we propose that design should seek to support people in *making account* of their data, and guard against the assumption that more, or 'better', data will be able to do this for them. To this end, we speculate on design opportunities and challenges for *experiencing, curating* and *sharing* historical personal data in new ways.

## KEYWORDS

Memory, Personal tools; Search; Social Theory; Social Computing

## CONTENTS

# 1. INTRODUCTION

As our digital footprint grows, research has considered 'The Future of Looking Back' (Banks, 2011). Social media, email, and sensor-rich smartphones have all been characterised as emerging 'technologies of memory' (Van House & Churchill, 2008), especially since their everyday use can capture digital traces of our lives. Recent studies (e.g., (Gulotta, Odom, Forlizzi, & Faste, 2013; Lindley, 2013; Schwanda Sosik, Zhao, & Cosley, 2012; Zhao & Lindley, 2014)) have questioned how we encounter, experience and manage these diverse and rich sources of personal history. Growing public awareness of the value of historical data is evidenced by applications (apps) like Timehop (timehop.com) and Memoir (www.memoirapp.com). These seek to reinvigorate historical social media offering daily vignettes, resurfacing past status updates and photos. In 2014, Facebook (facebook.com) itself produced popular 'Look Back' and 'Year in Review' videos of users' 'personal highlights' using the site. However, such features are clearly sensitive, and many have met controversy through the way they unexpectedly bring to light difficult pasts - for example, reminding the bereaved of the death of a loved one (Meyer, 2014).

Social media and photo collections are not the only vast and emotive digital records. In light of the arrival of low-cost sensors, wearable digital technologies and the clamor for an 'Internet of Things' (IoT), we are finding that everyday life is becoming quantified and recorded in increasingly novel ways. Despite this, little research has been conducted to date to explore how we will retrospectively interact with the diverse digital traces that these emerging technologies produce and store – which, we suggest, fashion a '*Quantified Past'*.

In this paper, we wish to closely consider the fate of digital traces created by personal informatics, a rapidly developing class of tools, which '*collect relevant personal information for the purpose of self-tracking and self-monitoring'* (Li, Dey, & Forlizzi, 2010). These sensor-based, and frequently wearable, technologies are representative of a cultural trend described by Lupton (2013) as leveraging data and technology towards optimizing and - in the title of her article - *"understanding the human machine."* This philosophy is epitomized by the 'Quantified Self' (QS) movement (quantifiedself.com), promoting *"self-knowledge through numbers"*. The central premise of this movement is an ancient one – the Delphic maxim to '*know thyself*': changing behavior to lead optimal, healthier, more productive and happier lives. This premise is an increasingly mainstream concern. Pew reports (2013) that one in five Americans use digital technology to track their health - MyFitnessPal (myfitnesspal.com), a food-intake app, has over 50 million downloads; and besides producing a smart watch, Apple's new iOS8 includes a 'Health Kit' as a center for personal informatics apps.

As an increasingly 'quantified' life becomes possible, we feel it is timely to consider more complex relationships between people and their data. This goes beyond designing for motivation, persuasion, and rational self-analysis (e.g., Li et al., 2010; Li, Dey, & Forlizzi, 2011) to understand how these tools actually come to be 'lived' and experienced (e.g., (Dong, Ackerman, & Newman, 2014; Rooksby, Rost, Morrison, & Chalmers, 2014)). Mortier et al. (2014) even argue that a new field of 'Human-Data Interaction' is

emerging, to face the ethical challenges of a data-driven life. In particular, we argue that whatever else they do, personal informatics tools also create novel records of everyday life and inevitably come to represent the past in a certain way. These records are primarily quantitative, flexible in representation and often passively recorded and 'always on'. We argue that these tools sense and record the everyday quite unlike other media, and quite unlike human memory.

Put simply, whilst someone may track and analyze their run today in an attempt to run faster tomorrow, interacting with that data 10 years on presents a different experience entirely – one that we have yet to design for. In this study, our approach regards these technologies as more than tools for behavior change or wellbeing. It explores the prospect of their evolving lifelong use rather than temporary use, and recognizes their novel role alongside other media, creating what we term a '*Quantified Past'*.

This work contributes to discourses on both personal informatics and memory, as they interrelate. We question 'if' and 'how' quantitative personal data records evolve from present-focused, motivational tools to more meaningful biographies (akin to the 'biographical objects' discussed by Hoskins 1998). First, building on the concept of 'lived' informatics (Rooksby, Rost, Morrison, & Chalmers, 2014), we report on an interview study with 15 individuals revealing current experiences of looking back on their own historical personal informatics data. We study if, and how, these records can become meaningful to people over long periods of time, as *virtual possessions* (Odom, Zimmerman, & Forlizzi, 2014). This extends extant memory literature by describing how novel and emerging digital records mediate the *experience of remembering* one's past.

We then identify six *characteristics* of a quantified past, which demarcate personal informatics and the records they create from more traditional forms of mementos and records. We also work to frame a design agenda by proposing a reimagining of the roles and possibilities of personal informatics. We develop an experience-centred perspective on the subject; to propose interaction design should support people in making accounts of and with their data. We further identify *design opportunities* and challenges, which map out the fertile design space around the *long-term,* retrospective use and value of personal informatics. In particular, these opportunities consider making *narrative* of one's data through: creating new means of *experiencing*, *curating*, and *sharing* data.

## 2. RELATED WORK

We now turn to ground our research in extant studies, first capturing the research understanding about technologies of memory. Secondly, we review personal informatics literature, along with work in sociology and the interdisciplinary field of human computer interaction (HCI), supporting a recent critical turn to experience (McCarthy & Wright, 2004).

### 2.1. 'Technologies of Memory'

The design of technology that captures and records lived life has been a long-term concern within HCI. Efforts from a more cognitive perspective sought technological solutions to achieve the 'total capture' of one's life (Gemmell, Bell, & Lueder, 2006), by

augmenting and externalising human memory in a 'lifelog'. Such thinking led to the development of devices such as SenseCam, a wearable automatic camera. Refining this vision were more user-centred approaches, which drew on theories of Autobiographical Memory (van den Hoven & Eggen, 2008). However, Sellen and Whittaker (2010) call for the design of lifelogging systems to move '*beyond total capture'*, to support specific goals, such as recollecting or reflecting. These have been fertile avenues for research, producing many requirements and perspectives on the relationship between technology and memory. There has been a great emphasis in particular on technology to support reminiscing and reflection for wellbeing (e.g., Fleck & Fitzpatrick (2010), Isaacs et al. (2013), Peesapati et al. (2010)). However, deliberate and comprehensive lifelogging remains a minority pursuit, which arguably overvalues veridical recall. As such, rather than a focus on lifelogging, recent memory related work in HCI has turned to digital traces, and the means and occasions through which aspects of the past are preserved and managed, regardless of whether these activities are framed as 'lifelogging' or not.

Harper et al. (2008) identifies the limitations of a focus on veridical recall, reframing *'memory-as-a-resource-for-action'* rather than *'memory-as-something-in-the-head'* as a way to reimagine the future of devices like SenseCam. Viewing memory this way enlivens what we see as the role and *experience of remembering*. Such an approach invites research and design supporting Bartlett's *'imaginative reconstruction'* (Bartlett, 1932) and personal meaning making, as it relates to present, specific contexts, practices and values.

This more situated and socio-cultural perspective demands attention to the role of artifacts, including records, in remembering. Literature on material culture is replete with studies, which show how possessions, both physical and digital, help to construct a sense of one's past and oneself (Belk (1990) the foremost among these). Marcoux (2001) elegantly describes how this process occurs over a lifetime, describing the 'Casser Maison' ritual and divestment that occurs when older people move from their homes into care. Artifacts – such as Proust's much cited account of consuming a madeleine – are often attributed to triggering a set of memories in the mind, awaiting elicitation. However, others have identified a more nuanced, less indexical, role for objects, recognizing the reconstructive nature of remembering. Radley (1990) describes objects which persist and become marked out in particular ways as giving a *'sense of the past'* and offering *'opportunities and directions for appreciating the past',* rather than simply cueing pre-formed memories. Middleton and Brown (2005) also talk in these terms: artifacts can act as '*structures or envelopes into which we can insert and develop recollections'*. Specifically, they remark that objects and records help us '*package up'* and '*punctualise'* the past. In this way, everyday objects and records often compound, become representative of certain perspectives on the past and offer a valued way to reminisce and reconstruct that past.

The functioning of cherished physical and digital possessions in human remembering has been well-studied in HCI (Golsteijn, Van Den Hoven, Frohlich, & Sellen, 2012; Kirk & Sellen, 2010; Odom et al., 2014; Durrant, Frohlich, Sellen, & Lyons, 2009). Particular attention has focused on: the curation of digital and physical artifacts for representational purposes (ibid); digital legacies (Gulotta et al., 2013) and 'technology heirlooms'(Banks,

Kirk and Sellen 2010; Odom et al., 2012). Others have studied the archiving, curation and presentation of personal data as valued possessions (Lindley, 2013; Marshall, Bly, & Brun-Cottan, 2006). Extant research has also considered how we confront and manage an everyday digital past, which Schwarz (2014) compares to living with a somewhat ghostly '*past next door'*. The potential challenges of this past are brought into focus by work that highlights a role for 'design for forgetting' (Sas & Whittaker, 2013), and forgetting in digital systems as a potentially important feature rather than an error (Bannon, 2006). Most of the digital traces created throughout our lives are not curated nor designed for reflection, yet they often persist as a lens on the past. When Petrelli, van den Hoven, & Whittaker (2009) asked families to create 'Time Capsules' for 25 years hence, a striking inclusion was that of credit card bills, paper clippings and other '*ephemera'*. These were valued precisely for their mundanity and for *'representing today'*.

More recent studies have turned to social media, which might be seen as generating one sort of digital ephemera. Zhao & Lindley (2014) describe how various social media accounts are '*curated through use'* as they become archives. Hogan (2010) notes a distinction of digital traces is that they are curated both by users and algorithms. Others show how Facebook features such as the 'News Feed' and 'See Friendship' afford particular temporalities, narrative and reflections on identity and friendship (Harper, Whitworth, & Page, 2012; Schwanda Sosik et al., 2012). This work magnifies complex everyday experiences of archived personal data – the consequence of a life lived online.

However, this body of work has only rarely considered remembering with quantitative or self-tracking data. Earlier work has visualized media use; the PieTime project (Zhao, Ng & Cosley, 2011) emphasises the value of supporting storytelling rather than patterns in reflection on their archives; TheMail focused on visualizing relationships (Viegas, Golder & Donath, 2006). Likewise Donath et al. (2010) is prescient in describing the artistic renderings of data such as email or social media usage as 'Data Portraits'. Designer Nicholas Felton takes this furthest in his 'Annual Reports' – beautifully rendered compilations all manner of personal data, often painstakingly recorded. Though limited to an ethnographic study of old homes, Dong et al.'s (2014) work brings these discussion into the home, and questions the long-term and future uses of home monitoring devices such as the Nest thermostat (nest.com). Using a location-tracking tool, Kalnikaite et al. (2010) suggest that maps mediate quite different experiences of remembering from passively captured SenseCam images. In this paper, we aim to extend these rare approaches to consider personal informatics, particularly as they become embedded in our lives through the Quantified Self movement, wearable technologies, and an 'Internet of Things'. We argue that, as with social media (e.g., Harper et al., 2012; Schwanda Sosik et al., 2012; Zhao & Lindley, 2014), the data such technologies produce will represent the past in particular ways and could become significant personal archives beyond their everyday use.

## 2.2. Personal to 'Lived' Informatics

Quantified and 'scientific' self-tracking is not as new as it might seem. Neuringer (1981) reports self-experimentation and weight tracking in the 16th century; Weight Watchers was founded in 1963; and today Withings (withings.com) offers a digital scale connect-

ing to countless other devices. Measuring and recording facets of one's life has become possible on an unprecedented scale.

Li et al. (2010, 2011) have led work on personal informatics in HCI and describe five different stages of user interaction with these tools – preparation, collection, integration, reflection, and action identifying the technological barriers and challenges at each stage towards *behavior change*. Many of these issues appear in six annual workshops[1] at the ACM Conference for Human Factors in Computing Systems (CHI), which provide a broad review of personal informatics research to date.

However, Rooksby et al. (2014) have critiqued this work as 'technology centric' and portraying an overly rational human, at the expense of understanding more everyday experiences with these tools. In their own interview-study, rather than stages, they present five different '*styles of use'* – directive, documentary, diagnostic, collecting rewards and fetishized tracking. Following McCarthy and Wright (2004), they suggest design implications based on a better understanding of the *'felt-life'* and experience of '*lived informatics'* as they become *'enmeshed in everyday life'*. As the field matures, these issues are coming to the fore, questioning how personal informatics data is shared (Epstein et al., 2015) and becomes a part of one's identity (Choe et al., 2014)

Despite forays into the critical design of personal informatics (e.g., Khovanskaya *et al.* (2013), sociologists have been quicker to critically examine the Quantified Self movement and entanglements of people and data. Broad criticisms highlight the '*solutionism'* (Morozov, 2013) and '*function creep'* (Lupton, 2014b) of self-tracking. Describing the '*ideology of dataism… a widespread belief in objective quantification and potential tracking of all kinds of human behavior',* van Dijck (2014) captures a core concern, that the assumptions underlying the production of data are often overlooked. Concerns about the production of data can be traced even further back, considering the process of commensuration.

> *"Commensuration can be understood as a system for discarding information and organizing what remains into new forms. In abstracting and reducing information, the link between what is represented and the empirical world is obscured and uncertainty is absorbed. Everyday experience, practical reasoning and empathetic identification become increasingly irrelevant bases for judgment as context is stripped away and relationships become more abstractly represented by numbers."* (Espeland & Stevens, 1998)

Many contemporary issues are present in a careful reading of this above description; particularly that '*uncertainty is absorbed'* and that empathy and everyday experience become '*irrelevant bases for judgment'*. Drucker (2011) argues that to emphasise the inherent constructivism in the use of data, we should talk about *capta* – that which is *captured* – rather than *data* – that which is *given*. The concern for Rettberg, (2014) is that data often appears 'beyond argument' as it presents an authoritative representation of the world.

[1] The proceedings of these six workshops are available at www.personalinformatics.org.

In the context of a 'Quantified Self', Lupton (2014a) and Ruckenstein (2014) call such data representations *'data doubles'*. A term first introduced by Haggerty and Ericson (2000) in surveillance studies, it describes the numerous possible personal representations created by tracking devices, which users grapple with to understand. Lupton emphasises the malleable nature of data doubles, subject to change and reinterpretation, especially as new data from different sources is combined. Rettberg (2014) argues that along with automated diary apps like 'Momento' (www.momentoapp.com) and 'Heyday' (www.hey.co) – which combine social media, photos and self-tracking data – we see and represent ourselves through data. In so doing, as Rooksby et al. (2014) also report, we become attached to our data, through which we tell stories and even express ourselves. Personal accounts of self-tracking and encounters with data doubles – such as Tom Armitage's 'ghostcar' (2012) a service he created to echo where he 'checked in' on Foursquare (www.foursquare.com) a year ago – affirm that there is something compelling, almost ghostly, about confronting our data doubles from the past.

What this body of work points to is the need for designers to move beyond a sole focus on technological challenges – such as the accuracy of activity recognition or exporting data – and to recognize the numerous roles personal informatics may play in our lives, especially in the construction of the self. Specifically, we argue that personal informatics document and represent people's lives in new ways, which allow a re-imagining of self-awareness not only in the present, but also in the long-term.

## 3. PAPER AIMS

Taken together, the above review suggests a novel design space that extends the scope of extant work in HCI on both memory and personal informatics. Often as a by-product of their primary *style* of use, personal informatics tools are creating digital records which are primarily *quantitative*, and usually designed and visualized to motivate behavior change. Where this data is passively collected, these records might be more mundane than traditionally cherished media and perhaps less likely to be deliberately curated or reflected upon. However, this sort of data is increasingly revealing of our behavior. Indeed, very often it *is* our behavior.

Personal informatics tools are specifically designed to 'objectively' reveal and represent different facets of one's life – be that fitness, mood, location, diet or productivity. But might this data also digitally '*represent today'* or capture some of the '*context of life'* (Petrelli et al., 2009)? How does the everyday use of these tracking tools – for behavior change or otherwise – and the more *objective* view of human life they often promote mediate remembering? What different temporalities, narratives and modes of reflection are promoted by the design of these tools?

In this article, we aim to explore how different personal informatics tools are currently experienced retrospectively, and question their possible roles in the long term. We aim to understand how a 'Quantified Past' is created, encountered and valued by individuals. And in so doing, we aim to re-envision the possibilities for personal informatics tools.

## 4. STUDY DESIGN

To understand what the 'Quantified Past' might look like, we can readily find different examples of the everyday use of self-tracking tools and records users have created. In this section, we outline our methodology, study method, participants and data analysis.

## 4.1. Methodology

In line with other recent work in HCI and in related fields (Harper et al., 2008, 2012; Kirk & Sellen, 2010; Zhao & Lindley, 2014), we seek to study the experience of remembering qualitatively, from the socio-cultural perspective developed by social psychologists Middleton and Brown (2005). Rather than a cognitive focus on mental processes, their work offers an enriched view of how and why remembering is meaningful to people, fitting the demands of experience-centred design. Likewise, drawing strongly from the work of Bartlett (1932), we focus on *remembering* as an "*imaginative reconstruction"* – it is a dynamic, situated, present-oriented act, rather than simply recall of the past.

In this study, we aimed to understand how people experience and make sense of different historical personal informatics data they have accumulated. To closely understand these phenomena, we adopted an interpretive phenomenological analysis (IPA) approach (Smith, Flowers, & Larkin, 2009). This method has an idiographic focus, and is well suited to understanding individual sense making, especially as it relates to important life events. IPA is an in-depth, and detailed interpretative method, which dictates a small sample from which codes are inductively generated. Rather than testing hypotheses, IPA seeks to describe and carefully interpret the experience of the participant.

## 4.2. Study Method

In our study, we sought to recruit 15 participants who had been independently self-tracking at least one aspect of their life for no less than six months, and had a significant amount of personal data to look back upon. To explore a broad range of personal informatics tools and data, a diverse sample was sought, with data histories varying greatly in age, type and the activity being tracked. We recruited using a snowball sampling method, via adverts on campus, social media and word of mouth. Our participants were necessarily early adopters, interested in new technologies, by virtue of having a history of self-tracking. However, unlike in some previous personal informatics studies, we did not recruit from 'Quantified Self' groups and few, if any, of our participants could be described as 'extreme users'(Choe et al. 2014). Most participants were highly educated; however few had technical backgrounds, and all used 'off-the-shelf' tools, rather than hacking or visualizing their data in other ways. This is reflected in our sample, which included many smartphone and desktop tracking apps, rather than more expensive wearable devices. Participants were given a £10 shopping voucher as an incentive to take part.

Participants took part in a two-part, semi-structured interview with the lead author, lasting between 30 and 45 minutes. These were audio recorded for full transcription. First, participants were asked to present and look back on some of the historical data on their own devices. In a very open ended way, we asked them to describe 'what their data is about'. As prompts, they were asked what came to mind looking at their data, what they remembered about it, and to describe anything that sticks out to them as particularly interesting. This open-ended approach induced a long narrative as participants related to,

and made sense of, their historical data during the interview. This is similar to approaches by Harper et al. (2008), where people presented and narrated SenseCam images they had captured. The second part of the interview focused on participants' experiences of looking back, and how they imagined the value and meaning of their records would change in the future. This tended to contextualise the aforementioned narrative.

## 4.3. Participants

Our study included 15 (8M, 7F) participants who are shown in Table 1. They all lived in the North of England in the UK with an average age of 28.3 years. A number of participants tracked their exercise and fitness or diet with different tools, but others were interviewed about, for example, financial tracking, music listening and programming history.

Participants had a variety of motivations and *styles* (Rooksby et al., 2014) of tracking, and some tracked more than one thing. Most were *directive* and related to behavior change: losing weight; being more active; monitoring training progress. For others, tracking served as a way of '*checking up'*, and was seen as a good, responsible thing to do. Their tracking tended to be more *documentary* than towards attaining goals. On average, participants' data dated back three years prior to interview. Many had, at times, temporarily stopped tracking or changed tools, as found in other studies (Rooksby et al, 2014). All but one participant were still tracking at the time of interview. The sample included a mix of more active and passive tracking and required different degrees of user interaction.

==== FIGURE 1 (Table of Participants) here ====

## 4.4. Data Analysis

All interviews were transcribed in full by the first author. IPA (Smith et al., 2009) enabled an open-ended, 'bottom-up' and idiographic engagement with the data, seeking to understand how each participant made sense of their past life as it appeared through their personal informatics data. While inquiring into and interpreting the particular experiences of each participant, the analysis was inductively oriented, and determined a grouping of emergent thematic codes, from which common patterns in experience were derived alongside rich pictures of individual sense making.

# 5. FINDINGS

Our findings describe how people *encounter* their quantified pasts*;* then how these are *made meaningful* as digital possessions; and finally, consider how the *experience of remembering* is mediated by personal informatics.

## 5.1. Encountering the Past

Around half of the participants described having deliberately turned to their historical data to think about the past prior to being involved in the research. However, even in pursuing everyday goals, there are numerous different ways in which they encountered historical data on their own, that we describe here.

Looking back, participants displayed different *rhythms of reflection* in line with reports by Li et al. (2010) and Choe et al*.* (2014). Those tracking physical activity would often

immediately reflect on their run or cycle as a means to instantaneously judge and assess their '*effort'*. A few rarely looked back much further than this, however many sought to *compare* present and past achievements. Strava's interface for a cycle tracking app explicitly supports this through leaderboards. Applications like Moves and MyFitnessPal (MFP) tended instead to invoke and support daily or weekly reflection, often seen as a check-up '*to keep myself honest'* (Jason, Fitocracy).

Looking back was occasionally more specifically directed and user driven. At times, this was diagnostic; Brianna looked back with Moves data at events leading up to an illness. Moves also offers her a quick overview of her recent past, when she might ask herself *'what happened this week?*' or *'why am I tired this week?'* Some, like Lily, regularly refer to particular pieces of data; a specific day of record-breaking activity recorded on her Misfit Shine (e.g., Figure 2), is a frequent source of motivation, inspiration and pride.

> *"So I have kept this week, glancing back at that one.... I do keep going back, going: 'Hmm, that was a good day.'"* (Lily, Misfit Shine)

==FIGURE 2 here== (Misfit Shine)

Participants such as Lily and Brianna were clearly personally motivated to reflect frequently on historical data. However, the design of the system could make this data more or less apparent through daily interactions. As Imran explains, reflecting on his Moves data (e.g., Figure 3), "*the way it breaks it down for you, it just encourages you to look at it per day."* The Nike+ running app, however, also displays the most recent runs on the main dashboard. Graphs also often provided a longer-term perspective. Lily frequently manipulates the graph of her weight (e.g., Figure 4) to emphasise periods of rapid weight loss. Highlighting *records* (e.g., most steps, top speed, 10-day streaks) is a further common way the past is resurfaced by personal informatics systems.

== FIGURE 3 here ==
== FIGURE 4 here ==

Furthermore, some participants intimated surprise that they had not 'properly' looked back before and were enthusiastic about how they might reflect on their data in the short and long-term future.

> *"But that kind of tells you more about your life than you perhaps would have thought that it would." (Leanne, MFP)*

== FIGURE 5 here==

What became evident is that even if participants were not lifelogging in a traditional documentary sense, many still accumulated and encountered historical informatics data, which, in at least a small way, documented and represented their lives. Furthermore, although not always with users' awareness, these records persisted at the time of the study, with the potential to become meaningful resources for remembering. Based on these find-

ings, it is germane to question what these personal data records mean to people; how they are experienced; how they are different from conventional artifacts and technologies of memory; and how they could be designed to support desired experiences of remembering.

## 5.2. Making Meaning from Historical Data

A quantitative record of one's past, whether intentional or not, developed a variety of meanings for the study participants. For many, their data helped construct or confirm current or desired identities. Stefan described his Github as a '*showcase'*. Several also saw self-tracking as a sort of personal '*work'*, and felt obliged to keep it up. As such, many saw their records as valued possessions, which they would be upset to lose, even if they struggled to articulate a clear future purpose for them. We now consider a few more specific ways in which historic data was found or became meaningful for participants.

### *5.2.1. Remarking on Change*

Overwhelmingly, participants remarked upon transitions and things that had changed in their lives. Old houses and neighborhoods; forgotten places; weight loss; improved fitness; changed diet; teen music tastes; recently moving in with a partner; recovery from injury; leaving university. The data, in various ways – through maps, graphs, peaks and troughs, absences – offered a legible reflection of these life changes, no matter what the metric recorded. And it was the description of these changes, as they related to the data, which made participants' accounts compelling to them. Remarking on change is one key means to designate what is 'in the past' (rather than on-going) and reflecting upon it. Henri Bergson's philosophy questions how one moment becomes connected to another; he describes the '*indivisible flow of experience'*. It is in recognizing change – trends, turning points, the new and the forgotten – that participants could '*punctualise'* (Middleton and Brown, 2005) and gain a purchase upon the *'whole mass of the past'* (Bergson, 1896/1988). Many historical markers reflect such change, though personal informatics can be particularly explicit in comparing past and present, highlighting out-of-ordinary events and displaying trends. Whilst these may relate to narrow spheres of one's life, they are inextricably linked and often easily related by participants to broader personal histories.

### *5.2.2. Reminiscence for Moments and Periods of Life*

Often, these changes were a source of nostalgia or reminiscence. Thierry reminisced about a music festival with an older group of university friends. Lily missed '*proper lunches'* since starting a diet. Joanne recalled a triathlon victory. This was not universal, however. Tony's comment reflects a curiosity with data, frequently described as '*interesting'* without being as *'emotive'* an experience as perhaps, looking back through a photo album or handling an artifact.

> *"I don't feel nostalgic about this data... It's kind of an interesting sort of marker of time, but I don't." (Tony, SportsTracker)*

Participants remembered and reminisced about both specific days or moments and periods of their life. Lulls in activity-related data often reflected periods of injury, illness or

busyness. The scale, visualization and granularity of the data (e.g., a running chart over a month in Nike+ vs. a detailed breakdown of one cycle ride in Strava) clearly had the potential to mediate this temporal bounding of a narrative.

More specifically, the data was sometimes oriented to through memorable events. Particularly with apps like Moves or the Misfit Shine watch, which highlight daily activity, well-remembered days were regularly turned to for reflection. While often mundane, the data around these special occasions could be '*another layer' (Leanne)* or offered valued detail.

> *"A photograph of [that meal] would have been like 'oh yeah, you were with your friends again', but then this gives you more details. Exactly about what you did and erm.... kind of what you shared together which is nice. But then at the same time, some days are so anonymous."* (Leanne, MFP)

Participants' opinions were found to be clearly mixed, and even the same participants (e.g., Leanne above) found their data was both detailed and anonymous on different occasions. Bartlett (1932) describes how remembering is situated – in this case it is a research interview. Remembering in other contexts – with friends or family, for example – may lead different aspects of the data to be highlighted.

#### *5.2.3. Attachment, work and loss in collecting personal data*

While data was often recorded for a present, directive purpose, as it collected over time, some participants felt more strongly about their data as an important personal collection:

> *"This data is very personal to me, it's my data and my numbers and my figures. And it feels a lot more mine."*(Lily, MFP/Misfit Shine)

Many felt they had *worked* to create their data, even when passively tracked, felt obligations to record faithfully and were keen *"not to mess up the history of it"* (Thierry, last.fm). For others, the data represented a desired identity or facet of their life, seeing themselves and their lives reflected in it.

> *"It sounds ludicrous, but you get a personal attachment to… you. Because that's what you did."* (Aaron, MoneyLover)

This resonated with some participants' reluctance to lose their data. Peter felt that as he accumulated more data, it was '*important to retain it'*. Imran suggested he was '*invested'* in tracking his activity – a lot of hard work has gone into it and it was nice to '*have a little bit of a record of all that work*'. However, for at least one participant, their attachment to their data depended upon it offering a positive reflection of her life:

*"I think in reality if I had lost all my data I wouldn't be that bothered […] because I haven't lost that much weight. Because if I'd lost like... say I had lost two stone in the last six months, I would be bothered because it would be a measure of that success. Whereas at the moment, this is just a reflection of my failure."* (Collette, MFP)

While Peter mused that there were "*certain stats"* that he felt would endure and remain meaningful to him in the future, it is interesting that a desire to hold on to data arose despite few participants having specific plans or future intentions for their data. Rather, the invested work and sense of attachment to their data as it collected over long periods of time largely ensured its preservation – whether it was frequently reflected upon or not.

#### *5.2.4. A lack of editing or curating data*

Interestingly, despite these claims about the importance of some of their data, few people took any steps to retrospectively edit, manage or curate their data by, for example, deleting unwanted or excess data, gathering important data together, or adding comments or annotation. At most, curation involved sharing data between apps. People like Leanne did combine calorie data from her Fitbit with MyFitnessPal, but this happened automatically, without her input. However, Brianna imported her Moves data into a journaling app, Momento (momentoapp.com) along with other media, giving her a place to annotate and reflect on different streams of personal data together.

Curation did occur on occasion, through the sharing of personal informatics to social media. Lily explained "*on the days when I had massively beaten my goal I have taken a screenshot of it and put it on Twitter"*. In this way, her 'best' days of activity recorded with her Misfit Shine have become marked out and put aside, elevated to being worth posting publicly and gaining a representation that may persist beyond the original app.

Notably, no one in our study admitted to deleting or editing any of their data. Even though some data was deliberately avoided and not talked about during the interview, it appeared that people who tracked saw value in and wanted to keep the records they had created. To selectively edit them would potentially undermine them as an objective record. Nevertheless, with the exception of journaling tools, or exporting data (often a non-trivial technical process), there appear to be few opportunities to personally curate one's data. Like much curation, these seem effortful processes. Therefore, curating data was overwhelmingly system-driven. Features such as dashboards, records, achievements, 'recent activity' and graphs over time offered people different 'cuts' of their data (Epstein et al., 2014). These features are primarily designed to motivate or deliver useful 'insights' to people. However, they implicitly curate what historical data is most accessible/present to people on a daily basis.

#### *5.2.5. Sharing (or not) of historical data*

Finally, the analysis revealed a range of attitudes around sharing past personal informatics data. Many of these are very much in line with earlier studies, which identify many barriers to sharing personal informatics data (see Epstein, 2015 for an overview of prior work) – few people shared data on social media, though more described co-presently sharing data with close friends or a partner. However, such sharing was always at the time of, or shortly after any activity or event – no one described sharing *historical* data online. Perhaps this is because Facebook and online media tend to be so 'in the now' (Harper et al., 2012). It should also be noted that most participants in this study were tracking themselves and their own activity exclusively – were they to track between families and friends, or in shared environments, different social roles of data may well emerge.

A prevailing feeling was that one's own data was most likely uninteresting to anyone else. For many, even if their data was public, it was so personal – *"because it's just me"* – that to share it with someone would be *"very selfish in that way"*. Looking back at personal data was at times more private, like a diary or a more '*intimate'* experience. However, generally these concerns were not privacy-driven. Rather, participants felt that their data was overly detailed, or just provided too much information to be of interest to someone not connected to the event or activity itself.

However, where data was a joint achievement or event, some participants did see this historical data as a potentially valuable shared resource for future reminiscence.

> *"I kind of thought it would be nice to say to him in five years' time, do you want to go out and do the Coast to Coast [cycle ride] again, and see if we can beat the record? And I can send him a graph or something."* (Imran, Endomodo)

There are, however, limited opportunities for people to easily and *selectively* share the data of interest, besides taking a screenshot.

## 5.3. Experience of Remembering with Personal Informatics

The interview began with asking participants to open up their app and talk through their data, from their earliest record through to the present day. As well as describing generally 'what their data was about', participants were asked to talk about anything that stood out to them, that surprised them, or that they felt was interesting. Typically, this produced a rich and open narrative, as they recounted and related and contextualised their data to relate its relevance to their life. By analysing this rich discourse and then questioning the participant's experience of remembering with their data – both during the interview and in their own time – we present findings about how remembering with data is achieved and experienced.

### *5.3.1. Data-work: Contextualizing and making sense of data*

Throughout the interviews, all participants very directly and visibly interacted with their data. They made sense of it quite naturally, in-situ, and aloud as they narrated what they remembered. The tension produced between what was remembered, and what the data implied led to points of *negotiation*. Here, participants were attempting to *communicate* the meaning of their data, and crucially, to subjectively interpret it, to construct a coherent story and achieve their own sense of *verisimilitude*.

These instances were seen as particularly rich points of discourse. Examining this discourse closely – asides and embellishment; pauses and explanations; self-reflective commentary; surprise and questioning of data – are all examples we observed of what we call *data-wor*k. By this, we mean the language and 'work' that is required to qualify and make sense of one's data. In this case, the data was made *accountable* to the past as participants knew and remembered it, and in a way that was reasonable and presentable in the context of the interview. In this attention to the accountability of personal informatics data, and how it is made sense of in-situ, we are sympathetic to a long history of studies

that seek to understand the local accountabilities of interaction (see Button, 1991). We equally point to Crabtree et al.'s ethnomethodological study of the local interaction surrounding photo narratives (Crabtree et al., 2004) and similar ethnographic work on the situated organizational practices surrounding 'home-mode' photos and videos (Kirk et al., 2006, Kirk et al., 2007). While the term 'data work' has arisen rather briefly before (specifically on work about data infrastructure in collaborative research environments (e.g., Jackson & Baker, 2004; Karasti & Baker, 2008)), we adopt it contemporaneously here to describe how individuals interact with personal data in-situ. We see data-work as complex and situated, and worthy of further research, but introduce it here to offer another lens to think through human-data interaction (Mortier et al., 2014), and in particular Taylor's conceptualization of 'data-in-place' – a description of how data becomes *'entangled with wider forms of life'* (Taylor et al., 2015).

The following extracts are typical, and give a flavour of the rich narratives of participants. We underline remarks that exemplify the interpretive and contextualising 'data-work' that is undertaken.

> *"Oh this is funny, so this is... the day before Tim was born. His birthday is the 16th. So that's the flat that Jill and I moved to so… how funny... that's a really short route. Oh it's not that short. I kind of went down into the Dene – this bit in the middle is Jesmond Dene, and so I always try and kind of work a run through there." (Tony, SportsTracker*)

> *"Yeah here is just exactly when I moved to Newcastle. This is the week that I moved here. So this is the first time that I... I live really close by Leazes Park so that's why everything starts changing now, because it's in the park, I can't run at night anymore, because it gets weird and the birds are getting [sic] weird noises and it's really scary. But this is the first time that I ever ran in Leazes Park."* (Tanya, Nike+)

Notably, participants flexibly interpreted their data, skillfully making sense of it, and providing a commentary that weaves it into a coherent narrative to tell particular stories about their lives. In the telling, certain data and meanings are rhetorically privileged in the way they are emphasised, described, embellished, commented on, or even contradicted. The quotations above are both about a run in the park, and yet both have special significance to the participant, which is instantly recognized and explained.

== FIGURE 7 here ==

To different degrees, the data or the participant led these narratives. Data divergent from one's own version of events might be further probed, attributed to a common plausible error and undermined to render the account more flexible, and fit more easily within the current exposition.

> *"The 14th of September, I apparently had no tea that day as well – which I don't believe – porridge for breakfast, and more pasta for lunch and some prawn cock-*

*tail crisps, a horrible mugshot thing and some grapes and I did loads of walking, which doesn't feel like very much on that day either." (Leanne, MFP)*

*"See, I would say, it's probably not that I've only listened to seven songs, I've maybe, I dunno… Or maybe I did only listen to seven songs. Or maybe I just didn't scrobble them somehow. I'm not exactly sure, but it is kind of odd because there's sort of, a consistent number of over 100 plays each week and then it is this gap."* (Darren, last.fm)

However, our participants clearly also sought a sense of *verisimilitude* – that their account was close to real life as they experienced it. This was found somewhere *in between* what was remembered and what was recorded. Participants like Leanne above were quick to disregard or undermine data if it was unaccountable to their own remembering. However, even when the data was perceived as inaccurate – especially where there were gaps and errors – it remained highly interpretable. While participants often found and sought affirmation in their data, it also refined their narrative – adding a specific detail, or curbing inflated claims.

*"I can see there... how I went from 30 minutes swimming in the morning, just a casual swim, to 60 minutes, at least forty-fi...at least 40 minutes." (Joanne, Excel)*

However, the tension between past-as-remembered and past-as-recorded is evident, and not easily resolved.

*"Because obviously, I don't take [the data] as a, you know, 'this is what happened.' But at the same time, your memory doesn't always remember things in the correct way either."* (Brianna, Moves)

Whether to argue its accuracy, or question its completeness, *data-work* was a means of negotiation with the data. The work is to resolve the tension between record and memory, and results in reconstructing a coherent account of a past event or experience in the present. In certain contexts, people placed more trust in the data, or their own memory. Joanne above, a fitness addict who fastidiously and actively records her activity in an Excel spreadsheet, claimed total confidence in her data and stood corrected by it. Darren suggested that "*in my mind, I probably listened to as much music that week'*. However, he could attempt to explain and reverse engineer perceived errors within last.fm to support his doubts. His data was still informative, but not always authoritative. Further work might ascertain if the uncertainty people feel is greater using passive or active tools.

Such narrative work and tensions undoubtedly also surrounded retrospective interpretations of other media like photographs or social media posts. However, particularly in the context of the aforementioned '*dataism'* (van Dijck, 2014) – the belief in the objectivity of data – this data work is a critical concern for understanding how people constructively and flexibly interact and remember with data. Personal informatics tools are deliberately employed to provide 'objective' *measurement*, differing from other recording tools or historical markers, and create a record often as a by-product of their everyday use.

### *5.3.2. Inferring the past and vivid recollection with different media*

Data-work also reveals how our participants engaged both in vivid remembering of important moments and events and inference and sort of personal detective work, relating recognizable features of the data to remembered experience, routines and known facts about one's life.

> *"And I remember running down there, and thinking: 'bloody hell, this is miles, I really wish I could cut across', but coming across the fence, and then it being rough terrain. Isn't that funny, I actually remember that really distinctly."* (Tony, Sportstracker)

More vivid memories such as these were evidently surprising and pleasurable to participants. However, there was also an inclination and satisfaction to working out one's past, being able to put it in order and tell a coherent story.

> *"I must have went to boot camp... yeah. So… and then I've even put my water consumption in, which I never track so I must have been messing around with what I could track …Yeah... must have been... I guess it was January, so it would be people having silly selection boxes of sweets. Bring them in don't they, to get rid of them…"* (Colette, MFP)

This example also highlights the very live sense-making process interacting with one's data, and the desire to resolve and explain it. In a study with Microsoft's SenseCam, Kalnikaite et al. (2010) differentiated between vividly remembering as 'true recall', and more inferential guessing and reconstructing what must have happened in the past. This also resembles the distinction between episodic and semantic memory in Autobiographical Memory theory (Cohen & Conway, 2007). Kalnikaite et al. (2010) suggest that visual cues offer more detailed recollection, whereas location data led more to inference about the past. Our qualitative work supports this only to the extent that it shows that people do both vividly and inferentially remember through data.

However, during the interview, participants were prompted to compare remembering life events with photographs to remembering with their data. The majority of participants described photos as being more emotive, evocative or having a '*warmth of feeling'* in terms of remembering. However, some participants also described their data as being more personal, private and intimate – something they were much less likely to share. Some participants suggested their data lacked detail to evoke specific memories of an experience in the way that photographs taken at a time and place *'pick out particular moments and episodes'* (Lily). For Tony, his running data was missing the weather – a *'big part of the experience*' – and subjective measures like *'just how knackered you were'* – the detail making it far more evocative.

> *"When it comes to photographs, it can be funny sometimes to see how you used to look when you were a lot younger. It doesn't really trigger, the same emotion, because this is just kind of a chart."* (Darren, LastFm)

==FIGURE 6 HERE== (LastFm)

A unique comparison of photos and data came from Thierry. Although agreeing photos were more evocative, he suggested that *'having to work for the memory'* – as was the case when looking back on his last.fm data – was potentially a more interesting and rewarding experience. Rather than the type of media or data, Peter, who cycled several times a week at the time of the study, attributed a lack of vivid recollection to simply the passage of time. A ride for him, a very regular cyclist, was eventually reduced to *'just numbers'*, though he said that he would occasionally add a short description to a tracked ride if, good or bad, it was somehow out of the ordinary.

In many ways, this makes plain the dominance of photography as a medium and technology of memory. Nonetheless, however accurately, and for whatever purpose, it is clear from our study that for these participants, personal informatics also cut distinctly across core and meaningful aspects of people's lives. Even mundane data and digital ephemera can provoke the associative and inferential power of memory and become of meaning to people or lead them to rationalize their past in new ways. We might therefore consider the consequence of different historical media being encountered together, such as through smart journaling apps like Momento and DayOne or the sorts of qualities and reach of personal informatics, which can record the parts of one's life a camera can't reach.

In summary, our findings suggest we will increasingly encounter a quantified past through living a data-driven life – even if such a retrospective or long-term use is initially unintended or unanticipated. These new records can be meaningful to people in the way they show the changes in one's life over time; support reminiscence for special moments or periods of one's life; and represent 'work' and time invested in tracking. Such meaning may arise despite a lack of curation or shared tracking, through which further value could be accrued. Interacting with personal informatics data entails 'data-work' – to situate and contextualise one's data in a present narrative, accounting for this data in relation to everyday life, as recognized and remembered.

## 6. CHARACTERISTICS OF A QUANTIFIED PAST

Before moving to a discussion around opportunities for design, it is worth distilling these findings to distinguish the key characteristics of a Quantified Past. We present these characteristics as representative, rather than categorical, mindful that we worked with a heterogeneous sample. Participants reflected and remembered with lots of different types of data in different contexts. Nonetheless, there are a number of common threads that merit distinction, especially where they contrast with other more studied memory artifacts, such as photos, social media, souvenirs and diaries.

### *6.1. Passive, Third-Party Recording*

Many of the devices and apps that contribute to a Quantified Past work passively, are always on in the background and require minimal user input. The record of one's life is achieved largely by a third party – usually a wearable device, smartphone or adaptable sensor. Even apps that rely on user input (e.g., MyFitnessPal) include processes and transformations, which limit and mediate what is recorded and how it is stored and categorized. This can be contrasted with point-and-shoot cameras, written journals, or treas-

ured souvenirs, where what is recorded is usually deliberately chosen, framed and directed by a group or individual. Likewise, social media content, though produced in the course of everyday life – usually without thought for its retrospective use – is deliberately authored from a first-person perspective.

Records generated by personal informatics tools are often a by-product of their everyday use. Rooksby et al.'s (2014) study found few people who were self-tracking in a deliberately documentary way. Personal informatics are therefore rarely designed or intended for nostalgia, and as we have seen, data is rarely personally curated for posterity. By contrast, the everyday use of a diary is explicitly to generate records for the future and it is designed and used in this way. Personal informatics are more similar in this respect to a once well-used everyday object, which, displaced from its original context (Radley, 1991; Hoskins, 1998), can be an important marker of the past.

### *6.2. Quantitative and objective*

A quantified past is overwhelmingly quantitative, both as a raw measurement, and usually in its presentational forms. Arguably, some are more quantitative than others. GPS coordinates are usually represented on a map. Data can be attributed to certain categories or thresholds, and graphs show can show an overall trend without scale. However, numbers are omnipresent in personal informatics. Recorded by a third-party, and often subject to *'data-ism'*, personal informatics data thus gains the appearance of objectivity. Self-tracking tools employ quite a definite tone – they rarely err on the side of caution, or present any degree of uncertainty. They propose to measure exactly and accurately. It is '8,773 steps' rather than 'around 9000'. Seen in contrast to our own reconstructive and 'fallible' memories, it is unsurprising that participants experienced a tension remembering with data that depicts the past so quantitatively, definitively and objectively.

### *6.3. Removed from the past-as-remembered*

Given all this, a Quantified Past seems quite different and removed from the past-as-remembered. Cameras (whether they are automatic and wearable or otherwise) simulate what we see, and written or spoken words capture how we think. In contrast, the data captured and represented by personal informatics is often far removed from how we experience and remember. The manner that these tools sense is quite different from what people sense or feel. Running is not experienced nor remembered as a graph of speed over time, but as scenery flashing by, jumping a fence, pain in one's chest. Good or bad sleep is not experienced in percentage terms. Furthermore, self-tracking tools depict the past in far greater detail than is usually remembered. They gather precise (not necessarily accurate) details and facts about everyday life: exactly when you left the house; how long you slept for; precisely how far you walked to work; or everything you ate for lunch on Sunday. This sort of largely factual and mundane detail is not usually experienced at the time – it is often overlooked or even unobservable. It is the sort of detail that is rarely remembered in the course of day-to-day life. We argue that personal informatics present a more formal and definitive version of the past than the past that people flexibly and reconstructively remember.

We observed above that some participants found their data actually *lacked* details. Perhaps this is indicative of the mismatch between machine and human memory we have

hinted at above – though precise and detailed, they are not details that necessarily matter to people. In fact, Bartlett (1932) claimed that "*literal recall is extraordinarily unimportant"* in people's everyday affairs. A significant challenge for design is to understand when, and how, such unnaturally precise and mundane details become meaningful to people.

### *6.4. Ego-centric*

Personal informatics also appear to be particularly ego-centric as recording devices. Data recorded is largely about one's own body, the bodies of those closest to you, or your immediate environments. These devices record you and your actions directly. In contrast, cameras, diaries, social media and mementos tend to record your perspective and thoughts on a shared world. Furthermore, the intentionality with which cameras, social media and diaries are used to record often include an awareness of a potential audience, even if that is only one's future self. Personal informatics tools enact no such discretion.

### *6.5. Subject to Abstraction, Reduction and Commensuration*

A further consequence of 'always on' third party recording is the production of masses of data about parts of people's lives which would rarely ordinarily be recorded and would take a lifetime to review. Wearable cameras attempt to overcome this with algorithms that automatically search for and filter images they calculate will be most interesting to the user. For quantitative data – after the activity recognition that transforms the 'raw' data into a meaningful unit such as a 'step' – people's days and activities are presented in necessarily reduced and abstract forms to support comparison and subsequently actionable insights. Daily summaries, graphs, averages and records all work to package and present data in a manageable form, towards context-specific aims such as – "am I getting enough exercise?" or "is our baby sleeping better this month?"

Usually, by reducing subjective difference, this sort of commensuration is designed to motivate, direct or diagnose, rather than reminisce, which seems to happen on a more detailed scale. Peter's numerous bike rides are reduced to '*just numbers'* that can be compared on a chart. From a memory perspective, we can appreciate how commensuration can result in a tension, with people's own perceived fading memories becoming '*irrelevant bases for judgment'* (Espeland & Stevens, 1998). The way in which personal informatics reduces and abstracts from lived experience clearly has the potential to mediate how those experiences are remembered. Similarly, large periods of time are represented in single figures or graphs, as was the case with Lily's weight loss. As we described in our findings, photographs often literally capture moments of one's life. Curated together in albums, they can also represent the period of a holiday or one's childhood. However, personal informatics relies on summaries and abstractions to render the masses of data meaningful and actionable. They are a key part of such products, which advertise the self-knowledge, insight and power to be achieved through the overview and commensuration of one's life.

### *6.6. Amorphous*

It might seem contradictory to highlight that a Quantified Past is unnaturally detailed, and yet also subject to processes of abstraction, reduction and commensuration. Rather, what this highlights is how easily personal informatics data can take different forms and repre-

sentations. Odom goes so far as to describe virtual possessions in general as characteristically formless – easily reproduced, reformed and remixed in different contexts (Odom et al., 2014). Clearly photos, for example, can be printed out in different contexts; can appear on Facebook; can be viewed as a thumbnail photo; can be digitally manipulated; and indeed, all of these things at once. However, we would argue that some virtual possessions are more formless than others – that is, some can be rendered into more different forms, and more readily, than others. In all of the previous examples, a photo remains recognizably a photo, usually very literally representing a moment in the world. Self-tracking data seems more amorphous. We can recognize our data doubles as many different graphs, charts and infographics. These are subject to many possible transformations. Lupton also emphasizes that as new data is added, or data from different sources is increasingly combined, entirely new perspectives can be gained (Lupton, 2014a). Increasingly, these can be connected and represented in non-numerical ways through platforms like IFTTT (www.ifttt.com), or more critically in projects such as Armitage's aforementioned 'ghostcar' (2012).

Within memory studies literature, Hoskins (2011) has highlighted a 'connective turn' – distinguishing digital memories, specifically email and social media content, by their accessibility, visibility and mobility. We argue this characterization is especially true for an amorphous quantified past as people live increasingly data-driven lives. A critical issue when designing for experiences with data is defining the ways in which it is materialized and made present in people's lives. Through these characteristics, we have begun to distinguish some of the qualities of a 'quantified past' which might be drawn upon as a design material, towards a goal of designing for remembering with, and through, personal informatics.

## 7. DISCUSSION AND DESIGN OPPORTUNITIES

The principal aims of our study are to explore the notion and characteristics of a '*Quantified Past'* and reveal some of the ways in which people currently interact with their historical personal informatics data. In the first instance, our study uncovered very human experiences, and showed that personal informatics tools and their data, much like SenseCam, unquestionably offer 'memory-related experiences' (Harper et al., 2008). These findings offer a new perspective on personal informatics tools to the HCI community – specifically, on how their use and value could extend well beyond motivating behavior change and monitoring health, especially in the long-term. In the discussion that follows, we urge a focus on supporting people in *making accounts* and story-telling with their data, before discussing specific design opportunities for remembering with personal informatics.

### 7.1. Design Perspective: Making Accounts with Data

Current design of personal informatics tools is strongly influenced by the logic of the 'Quantified Self' – to 'know thyself through numbers'. Often prevalent within the design of such tools is the presumption that, with enough technology, sensors and data points, we can achieve some otherwise ineffable truths about our world, which can empower and motivate us. The goals for design in this case risk becoming technology-centric. They are oriented towards finding new sites for sensors, improving machine-learning algorithms

and providing more powerful tools to visualize and deliver the objective insights about our messy everyday lives. Though these developments are essential in the uptake and practical use of personal informatics, they must be considered hand-in-hand with an understanding of how people actually interact with the records they create.

Quantified Self tools certainly offer exciting new ways of seeing and understanding ourselves, and the everyday. But when looking back, our findings suggest that rather than any single, objective past truth, they offer only one particular perspective, which is then made sense of in the context of one's own 'imaginatively reconstructed' past. Wright and McCarthy (2004) describe *appropriation* – relating a particular experience to one's larger sense of self – as a key sense-making activity. In our own study, we saw this as people rapidly and skillfully incorporated and elaborated upon their data. They translated it from numbers and graphs on a screen into deeply personal stories about becoming a father, moving to a new country or teenage fandom. We have termed the way in which people managed his as '*data-work'*. This rendering of quantitative to qualitative is akin to what Davis (2013) has identified as the 'Qualified Self' when she remarks that: "*narratives and subjective interpretations are the mechanisms by which data morphs into selves"*. Our interviews revealed just such narratives and subjective interpretations throughout.

In making historical data accountable to the past-as-remembered, we found strong support for Harper's notion of the *"past as a place one ventures into"* (2008). The past was not merely recalled and repeated from a veridical record; it was appropriated and reconstructed from the many different traces of the past people's data offered. Maps, timestamps, key dates, records and graphs were all resources, which became available to aid, structure and cue situated remembering, focused on the *present* story participants were trying to tell. They '*punctualised'* (Middleton & Brown, 2005) and afforded '*opportunities and directions for appreciating the past'* (Radley, 1991). Remembering for many was an exploratory experience, resonating strongly with a reconstructive view of memory.

Within this, people also sought to achieve verisimilitude, but what 'truth' the data represented appeared decidedly up for debate for each individual. What we suggest is that *personal informatics tools alone cannot produce verisimilar accounts of real life*. For them to be meaningful, the data must be contextualised, and made accountable to one's lived experience. Therefore, in the long-term, seeking to design for the experience of remembering with personal informatics data – a more technology-centric view and drive for simply more or 'better' data – can only take us so far. Instead, as a key contribution, we propose a shift in design perspective, with attention *to how personal informatics are experienced and made accountable to people's lives*. By this, we mean to support people subjectively making sense of their data, rather than designing data as objectively truthful, powerful, meaningful and insightful by itself. Rather than simply trying to persuade, or to support 'checking up', we should design to empower people in questioning, trusting, twisting, talking about and sharing data as it becomes entangled in their everyday lives. QS data should be designed not only as objective facts, but something for people to talk about and use in creative ways.

While this might seem a radical turn, we see it as a further articulation of lived informatics (Rooksby et al., 2014). It also resonates with a great deal of previous work on technologies of memory, which has consistently called for supporting story-telling and meaning making (e.g., Harper et al., 2008; Petrelli et al., 2009; van den Hoven, 2014; Zhao, Ng & Cosley, 2012) . Local Meetups of Quantified Self groups are arranged as '*Show and Tell'* sessions, emphasizing each individual's story (Choe et al., 2014). Like Rooksby et al. (2014), we do not seek to undermine the wealth of personal informatics work that has gone before. However, our findings reveal that tools recording, measuring and representing everyday life can, and do, offer far more than scientific assessments of habits and health. Forming a Quantified Past is just one example that we have focused on in this paper. Therefore, we close our discussion herein by considering opportunities and challenges for interaction design to support remembering with personal informatics. These do not seek to be prescriptive, but we intend for them to help to map an emerging design space that supports people living with an increasingly quantified past. Our opportunities and challenges are gathered around three provocations; that data can be experienced, navigated and shared quite differently when looking back.

## 7.2. Experiencing Historical Data

A driving concern in this paper has been that the experience and personal meaning of data may change over time. We propose an opportunity to offer new modes of experiencing amorphous and malleable data, beyond traditional maps, charts and graphs, which tend to invite more rational analyzes and commensuration rather than subjective retrospection.

### *7.2.1. Creating evocative experiences of cherishable data*

Although much of the vast data people collected was retrospectively found to be '*anonymous*' and repetitive, most, like Peter, felt *"certain stats"* would remain meaningful. Many also felt a sense of attachment to their data – it was a personal possession that participants would be sorry to lose. However, there are few opportunities (besides taking a screenshot) for people to mark out and cherish or make any sort of memento from this data. We propose that, rather than designing to produce 'insight' or 'self-knowledge', we might design to produce evocative or emotional engagements with this data. Making cherishable digital objects is not a new proposition (e.g., Golsteijn et al., 2012). However, it is curious that as suggested in Giaccardi et al.'s (2014) work, beyond simply cueing remembering, these 'data souvenirs' might also be 'read' and directly depict, or leave traces of, the past. These cherishable 'data-things' (Nissen & Bowers, 2015) would seek to be frequently re-engaged and re-interpreted – offering a different rhythm of reflection.

Whitelaw's 'Weather Bracelet' (2009), a 3D-printed tangible representation of 365 days of Canberra weather data, is a further example. The bracelet represents a large, scientific dataset on a much more intimate, tactile, human scale. It affords novel interactions over long periods of time, with highly local data, upon which personal meaning and stories can be overlaid. Perhaps new modalities and materialities for experiencing data such as this can convey multiple alternative accounts to accompany one's own first-person experience, and support a different kind of sense making?

### *7.2.2. Remembering moments with personal informatics*

We consider a further provocation for experiencing data to design for *remembering a moment*. The Quantified Self movement tends to advocate extensive tracking over a period of time to reveal patterns and trends in behavior, which can then be acted upon. However, specific moments and events can also be deeply meaningful for people to remember. Photographs, which are highly visually stimulating, clearly capture moments for later reflection. But could personal informatics convey a unique perspective on important moments in our lives? Our findings suggest that on occasion, they can invoke vivid recollection and mediate the remembering of moments in a visceral and felt way. Selby's 'Earthquake Shelf' (Selby and Kirk, 2015) creates an experience of real earthquake data from Christchurch, New Zealand, through a delicate vase balanced on a shaking shelf. Rather than a specific objective insight, this experience of data creates a condition for remembering and reflecting on momentous occasions in one's life. While many photo-based apps aim to help users 'capture the moment', designers could consider what data might be relevant or meaningful to capture, and how it could be evocatively represented.

## 7.3. Curating historical data

Our findings also connect with ongoing design explorations of how to best represent and navigate one's personal informatics data. Recent work considering different *'visual cuts'* of lifelog data (Epstein et al., 2014) found that people's preferences varied dramatically. As the diversity of systems that people use increases, and companies seek to become major centers for this data (e.g., Apple HealthKit, Google Fit, Microsoft HealthVault), we can expect rapid developments in this area. However, focuses for this research have tended towards helping people to achieve specific goals, enabling the sharing of data between multiple devices, and thus leveraging bigger data sets for greater 'insights' and self-knowledge. Gurrin, Smeaton & Docherty (2014) follow the 'total capture' approach to lifelogging, with a focus on visual lifelogging, and as such, anticipate solutions akin to '*personal big data'*. Hence, limited research to date has considered how to curate personal informatics on a human scale as meaningful digital possessions – viewing these as rich personal archives rather than databases to be queried. Designing for human curation therefore presents a useful departure for the design of long-term personal informatics.

As a starting point, Rooskby et al. (2014) described people *"wayfaring in information,"* reminiscent of Harper's description of people *'venturing'* into the past with their SenseCam images. However, a significant challenge to wayfaring was that our participants rarely curated or edited their data, for example annotating, favoriting, deleting, gathering or visualizing and refining their data in other ways. A lack of motivation or opportunity for curation is a well-known issue within work in Personal Information Management literature (Lindley, 2013; Marshall et al., 2006). Without curation, data could often only be navigated chronologically or day-by-day, and for all the meaningful and evocative data captured, much was '*so anonymous'*. Though during interviews, we suggested that people 'start at the beginning' of their data, many moved around in their narrative, and frequently sought particular remembered events or histories. Zhao et al. (2013) similarly found 'big events' as a key basis for remembering one's past. In this respect, the lack of curation hindered them in the reflection and sharing of their data, as there were few signposts or shortcuts through which they could quickly bring together important pieces of data as part of their current story. Curation of personal archives is

seen as fundamental to meaning-making and story-telling (e.g., (Gulotta *et al.,* 2013; Harper et al., 2008; Lindley, 2013)) and is highly valued once motivated (Petrelli et al., 2009). While it remains unclear exactly how, when and who people might curate their data for, we can point to a dearth of opportunities for people to do this, a void which design could seek to fill.

#### *7.3.1. Curation through use*

Considering social media, Zhao and Lindley (2014) have highlighted that many curatorial acts come with the everyday use of Facebook, emphasizing that *curation is inherent to use*, rather than a purely retrospective process. In this respect, personal informatics presents two challenges. The passive and automatic nature of much self-tracking limits curation through use – or rather, the role of what to record and how is largely passed onto the device and software. Secondly, curation should not get in the way of everyday use of personal informatics, especially since documentary uses are usually not the primary concern.

How people perceive the manipulability of their data is strongly related to this. Deleting or editing data would for many be antithetical to the aims of objective self-tracking, and yet curation demands some level of filtering, selection and manipulation to render the data more sensible and meaningful. Epstein et al. (2013) also highlight how deleting, transforming and refining data can be in tension with other values such as honesty and accountability. Nevertheless it is not yet clear how much people should toy or play with their quantified self, or where and when they could do this with current tools. Many personal informatics tools advocate the collection of as much data as possible, often without the user's active and subjective selection. This challenges what 'curation through use' might mean for personal informatics. Given the opposition to deletion, curation could occur through active selection, tagging, bookmarking or favoriting of data highlights or events. It could also be undertaken using tools that allow the artful integration of different data sets around key events or threads. In such a case, a fine balance would exist between easing such curatorial actions, without excessive or uncanny automation that hinders people in making their own accounts of their data.

#### *7.3.2. Orienting to key events and threads of history*

We found participants frequently sought and oriented to specific remembered events and anecdotes. Some interfaces such as Moves or MyFitnessPal are oriented to daily monitoring rather than looking further back, and locating meaningful events can then be laborious without recollection of a particular date. Frequently, as in Tanya's narrative of running, it was 'firsts', and times of change that evoked a rich narrative – an interface could offer means to emphasize these. Novel and one-off events were evocative, but there was also an inclination to pursue particular *threads of history*. For example, Darren desired a view of all of the occasions of listening to a favorite band, rather than a somewhat random weekly snapshot of past listening. We suggest that these threads could provide the basis for a more narrative-led, historically focused cut through one's data. Data should be malleable to the sorts of common stories people tell about their lives – whether favored anecdotes, or life lessons.

Orienting to events and threads may also be an opportunity when combining diverse records created across multiple platforms. The convergence of personal data offered by tie-

ins between fitness firms and major operating systems seems sensible and convenient, especially for enthusiastic trackers. However, we should be wary of the belief that mashing enough data together will ultimately offer meaningful insights to people. When asked, few of our participants sought or attempted to combine data from other apps or media, which was seen as effortful. Other opinions recalled Lindley's work (2013), which suggests that '*place matters'* and that different content often belongs on different sites. We should consider carefully how the aggregation of data would help people make accounts of their lives. Relatedly, through a visualisation of email histories,Viegas, Golder & Donath (2006) describe 'big picture' (haystack) and 'detail-oriented' (needle) modes of exploration. Tools should hence support curating data both important events, such as a marathon, and 'big-picture' periods of one's life, like a year studying abroad.

#### *7.3.3. Personal informatics as personal metadata*

A final means of curation may lie in attaching personal informatics to other media. As Leanne suggested, data can offer '*another layer'* to a particular account of the past. Particularly data that is perceived to be more *'in the background'* (e.g., heart rate, music listening) could be conceived of, or repurposed as, personal metadata providing rich contextual detail to more traditional memory artifacts. Petrelli et al.'s (2009) time capsule study highlighted a desire to preserve '*ephemera'* as a route to interesting context about important events or periods of one's life. 'Kennedy' (kennedyapp.com/) is a mobile diary-taking app that promises to 'capture the now' by collecting context around diary entries, such as location, weather conditions and latest news headlines. However, as we made clear before, a significant challenge is understanding when and how this sort of precise detail and context – which personal informatics can distinctively provide – becomes relevant and meaningful to people. Such particulars are routinely forgotten about, and as others have argued (Bannon, 2006; Mayer-Schönberger, 2011), it is their unusual preservation by digital tools which may be of particular concern. Would one's heart rate be a valuable annotation to a wedding album? Or like Tony, would his exercise or music listening around the time of his son's birth be interesting to reflect upon?

Future work should ascertain what is achieved through such blending of media and when it is appropriate and valued, without transgressing this sense that *'place matters'* (Lindley, 2013). With wearables and connected devices, such amalgamation is technologically quite feasible, as many journaling apps evidence. However, perhaps more interestingly, as with GPS data attached to photographs, this data is not only a contextual annotation. More powerfully, personal informatics could be a further means to organize, navigate and curate personal archives.

## 7.4. Sharing of historical data

We anticipate personal informatics tools will become enmeshed in our social lives. Although designed as intensely personal and egocentric devices, capturing digital traces of our lives, they inevitably incorporate the social. More explicitly, tracking often encompasses shared experiences, such as a cycle ride (Imran), birthday meal (Leanne) or honeymoon (Suzanne). It is clear that people do desire to share and discuss such events. Indeed, these were often the most valued of people's data, presenting a significant opportunity for design. Furthermore, the body of work on making data public in a street or

community, highlights the potential value of co-presently sharing data and the roles it can play (Bird & Rogers, 2010; Koeman, 2014, Taylor, 2015).

Nevertheless, the 'when' and 'how' to design for the sociality of self-tracking remains decidedly unclear – Epstein et al. (2015) have highlighted many of the challenges. Related work on remembering has urged the design of '*technologies for telling'* (Harper et al., 2008; Lindley et al., 2009) and our design perspective would lead us to suggest that tools should support crafting of multiple shared narratives and interpretations of data. In our analysis of data-work, we showed how people render and appropriate data into a narrative and highlighted a search for verisimilitude. Our approach may lead to quite a different way of working than merely focusing on providing answers and objective 'insights'. As a brief example, digital jewelers Meshu (meshu.io), offer to 'make beautiful mementos' from location data or 'check-ins'. These are somewhat abstract, but can become laden with meaning. Their ambiguity can invite further discussion and personal elaboration. Future work should consider how personal informatics could be designed and materialized to open up rather than limit discussion. As such, personal informatics could become a greater resource for social rather than individual action – e.g., collectively remembering, presenting one's identity, and affirming a sense of community, each extending the value and lifespan of personal informatics data.

## 8. CONCLUSIONS

We have addressed a call to consider the lived experience of personal informatics more closely, and examined the growing body of work describing complex relationships emerging from burgeoning digital possessions. Our qualitative study questioned how people might encounter and make meaning of their *'Quantified Past'*. Whilst people turn to self-tracking devices primarily to improve their present quality of life, we show that in the long-term, they also document people's lives in a unique way. Through the notion of *data-work*, we describe how people subjectively appropriate their 'objective' data to reconstruct particular narratives, such that their data gains enduring personal meaning.

We therefore invite interaction designers to look beyond goals to persuade or monitor, and look towards supporting people in *making accounts* of their data. Grounded in our findings, we have set out six characteristics of a Quantified Past, which is: a largely passive, third-party recording; quantitative and appears objective; removed from the past-as-remembered; ego-centric; subject to abstraction, reduction and commensuration; and amorphous, capable of taking on many forms. Beyond these we map an emerging design space that raises new opportunities for experiencing, curating and sharing historical personal informatics data. Rather than being prescriptive, we offer these as a starting point for discussion, to work towards the design of personal informatics tools for remembering. as they increasingly accompany people throughout their lives.

## NOTES

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## LIST OF FIGURES

**Figure 1: List of participants, and their personal informatics data**

| Name | Metric | Principal App(s) | Device(s) | Age of data (years/months) |
|---|---|---|---|---|
| Colette | Food Intake | MyFitnessPal (MFP) | Smartphone | 6m |
| Brianna | Location/ Activity | Moves | Smartphone | 8m |
| Lily | Food/ Activity | MFP/ Misfit Shine | Smartphone, Misfit Shine | 11m |
| Joanne | Fitness | Excel/Fitnotes/ RecordMySwim | Pen and paper, Desktop, Smartphone | 1y 8m |
| Imran | Activity | Endomodo/Moves | Smartphone | 2y |
| Tanya | Running | Nike+ (iPod) | iPod, Desktop | 2y 1m |
| Tony | Running | SportsTracker | Smartphone, Desktop | 2y 4m |
| Suzanne | Running/ Cycling | Runkeeper/ Pebble Watch | Smartphone, Desktop, Pebble | 2y 6m |
| Jason | Fitness | Fitocracy | Desktop | 2y 7m |
| Leanne | Food | MFP/Fitbit | Smartphone, Fitbit | 3y 2m |
| Aaron | Money | Accounts/ MoneyLover | Smartphone | 3y 6m |
| Peter | Cycling | Strava/Garmin | Desktop, Garmin | 4y |
| Stefan | Coding | Github | Desktop | 4y 6m |
| Thierry | Music | last.fm | Desktop | 5y |
| Darren | Music | last.fm | Desktop | 7y |

**Figure 2: Screenshot of Misfit Shine app**

**Figure 3: Screenshot of 'Moves' app showing one day's activity**

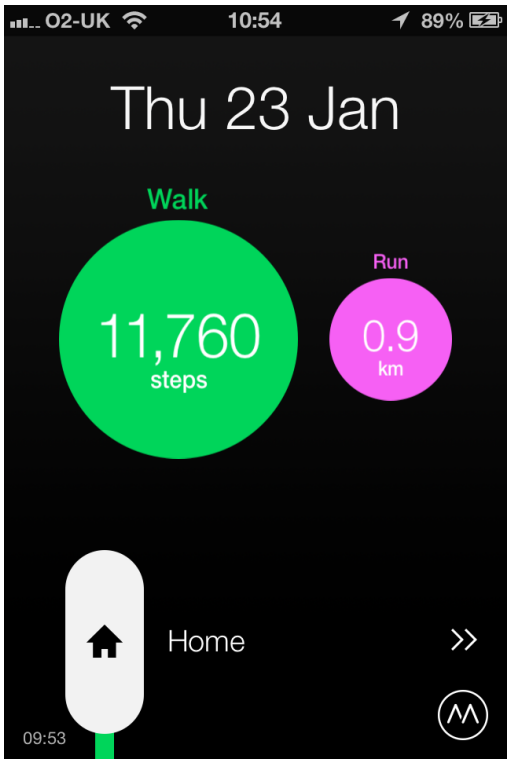


**Figure 4: Graph of weight in the MyFitnessPal app, shown here over 3 months**

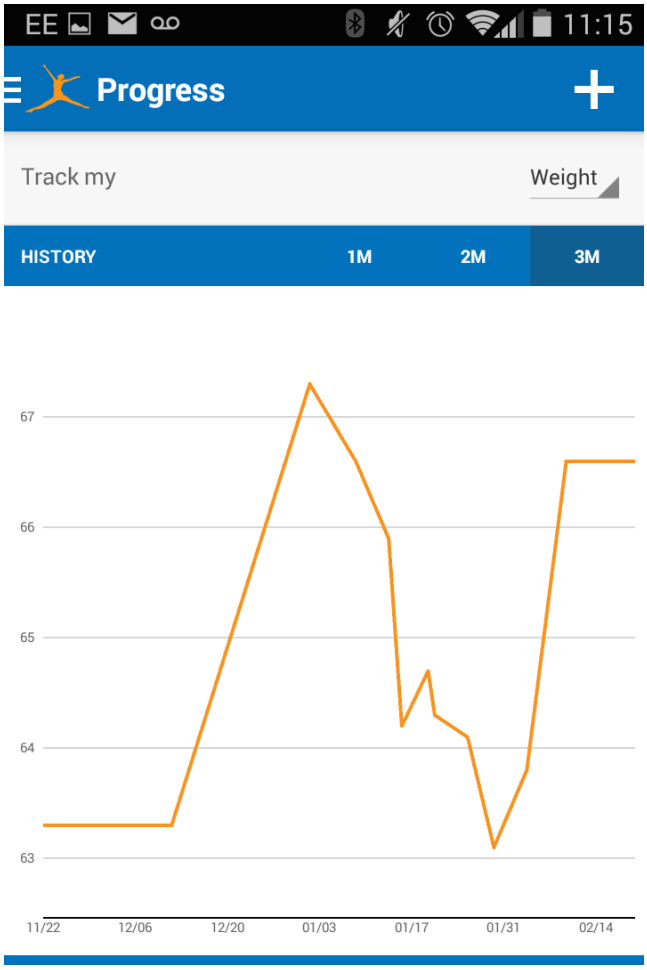


**Figure 5: Historical food entries in the My Fitness Pal app**

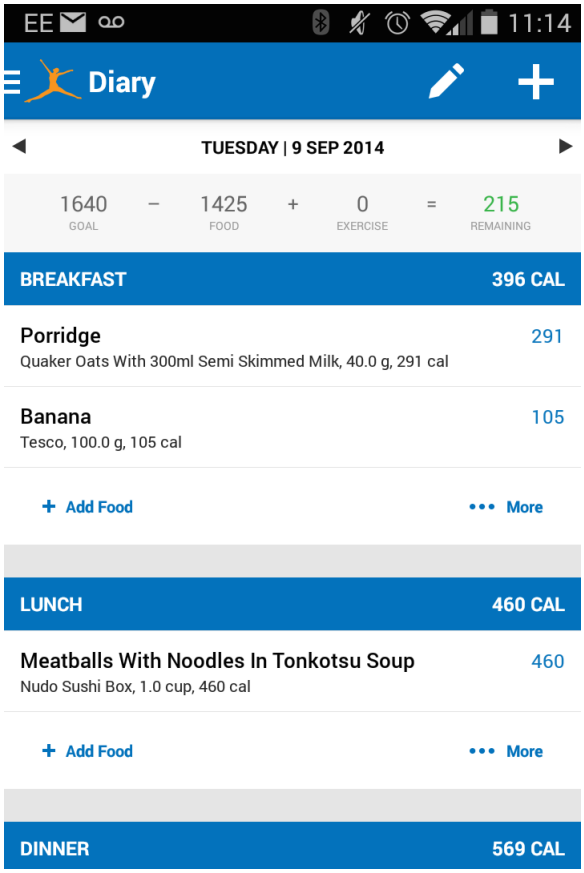


**Figure 6: Charts of music listening recorded in last.fm over 7 years of use**

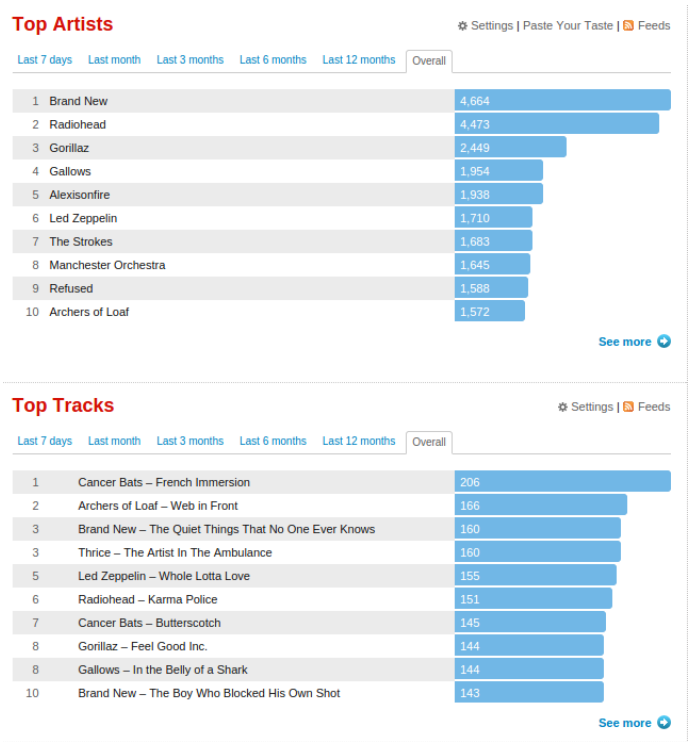
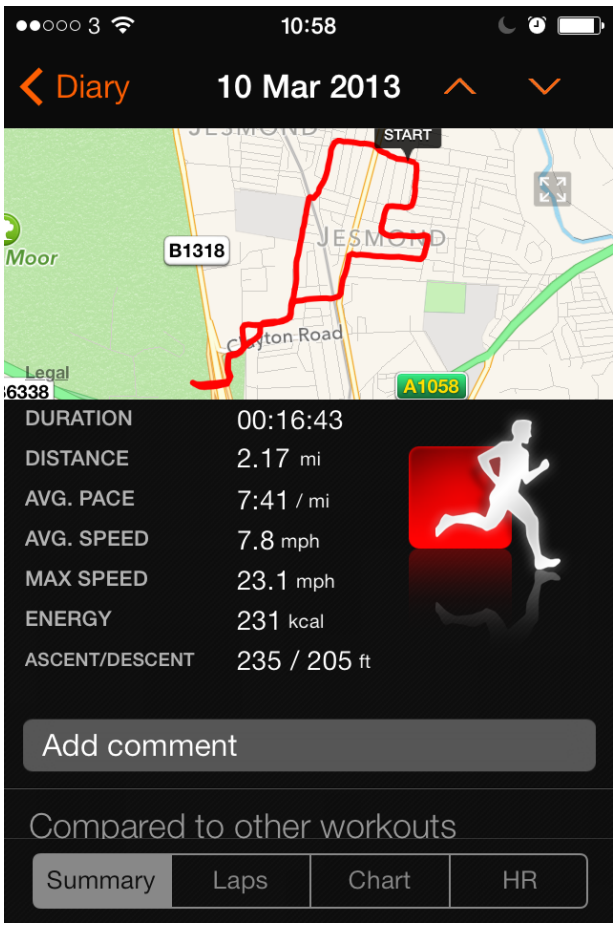


**Figure 7: A map and statistics of a run recorded by the Sportstracker app**


●●○○○ 3
10:58
Diary
10 Mar 2013
START
B1318
JESMOND
Moor
Clayton Road
Legal
6338
A1058
DURATION 00:16:43
DISTANCE 2.17 mi
AVG. PACE 7:41 / mi
AVG. SPEED 7.8 mph
MAX SPEED 23.1 mph
ENERGY 231 kcal
ASCENT/DESCENT 235 / 205 ft
Add comment
Compared to other workouts
Summary
Laps
Chart
HR