Smartwatch *in vivo*

Stefania Pizza[1], Barry Brown[2], Donald McMillan[2], Airi Lampinen[2]

[1]CoRiS
Sapienza University of Rome, Italy
stefania.pizza@uniroma1.it

[2]Mobile Life Centre
University of Stockholm, Sweden
[barry, don, airi]@mobilelifecentre.org

ABSTRACT

In recent years, the smartwatch has returned as a form factor for mobile computing with some success. Yet it is not clear how smartwatches are used and integrated into everyday life differently from mobile phones. For this paper, we used wearable cameras to record twelve participants' daily use of smartwatches, collecting and analysing incidents where watches were used from over 34 days of user recording. This allows us to analyse in detail 1009 watch uses. Using the watch as a timepiece was the most common use, making up 50% of interactions, but only 14% of total watch usage time. The videos also let us examine why and how smartwatches are used for activity tracking, notifications, and in combination with smartphones. In discussion, we return to a key question in the study of mobile devices: how are smartwatches integrated into everyday life, in both the actions that we take and the social interactions we are part of?

Author Keywords

Smartwatches, wrist watches, wearable computing

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

The wristwatch is one of the oldest wearable technologies, allowing a user to quickly glance at the time and related information. This paper addresses the most recent evolution of the wristwatch in the form of connected 'smartwatches'. Google's range of licensed "Android Wear" watches and Apple's self named "Apple Watch" adopt functionality from the mobile phone, although in a new form factor and with a number of new design innovations. While technologically these devices are not radical advances on concepts that have been tested in the wearable technology community, they do collect together a range of functionality in well-designed and consumer-accessible technological form. The adoption of these devices, albeit at this point only at an early stage, presents some interesting user research questions.

For example, what does a wrist worn technology support in contrast to the screen of a mobile phone? The mobile is now the world's computational form factor of choice, supporting a range of different activities and types of media consumption. What then does the smartwatch add? Second, much of the functionality of commercial smartwatches is build around notifications, or gaining information quickly 'at a glance'. This has the potential to cause considerable distraction if it takes users' attention away from focal concerns such as interacting with others. How does the stream of notifications received on a smartwatch and mobile phone compare in this regard? Third, the health tracking functions of watches are central to their design and marketing, with watches tracking users' heart rates and exercise – echoing the function of popular devices such as the FitBit and the increasing mainstreaming of Quantified Self concepts as a path to wellness [14]. How are these functions actually used and in what way do they integrate themselves with daily practice? Lastly, what limitations and possibilities can we identify from closely studying smartwatches *in vivo* [44] for future design and innovation?

To answer these questions we provided twelve participants with a smartwatch for one month, with the final three days of use recorded with pairs of wearable cameras. These recordings were combined with interviews with each participant. This data gives us a uniquely detailed view on how smartwatches are used, what for, and in what contexts. From 34 days of recording we have over 168 hours of dual-aspect recording covering 1009 incidents of watch use – around 6 uses per hour, with each use being on average 6.7 second long. Moreover, our videos let us look in more detail at what and why watches are used in particular situations. We discuss the importance of *time* as a straightforward application for a watch, activity tracking, and the role of notifications. We go on to unpack why a wrist worn technology fits into situations and activities a phone might not, before examining how mobile computing could develop further with the watch. We offer these results not only to inform the future design of such devices, but also as a reflection on wider lessons for wearable technology. In discussion, we reflect upon what smart watches can teach us about the ways in which computational assistance – and interruption – come to be fused into everyday life and practice.

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BACKGROUND

The wristwatch became common for women in the late 1800s, followed post-war by men in the early 1900s [43]. The original design of the watch came from the adoption of pocket watches by the military. With military manoeuvres co-ordinated so as to happen simultaneously, watches were an important tool of war – yet, with hands full a pocket watch could not be consulted as easily as one tied to a solder's wrist [ibid].

More technological advances followed with the advent of the digital watch [54], and then HP's calculator watch in 1978, followed quickly by watches with a range of different features – from radio to television [4]. In moving towards the smartwatch platform we see today, there have been a number of computer-watches such as the Swatch/HP's Webwatch [63], the Microsoft SPOT [37], and the Fossil PalmOS powered Wrist-PDA. Recently the Android Wear platform as well as Apple's Watch devices have achieved some popularity [57]. Running in parallel, there has been an increase in the amount of wrist worn non-watch wearables – primarily aimed at health, fitness, and the quantification of personal action [66].

There has been a wealth of work on input modalities for this form factor. The mechanics of touch on small devices have been examined in detail [3, 27, 28, 34, 51, 59] as has text entry for small devices [11, 13, 16, 29, 35, 46, 50, 55, 70] as well as other input modalities such as tilting and twisting the screen [71], tracing letters on other surfaces with your finger [68], interacting around the device [36, 49], interacting with just gaze and attention [2], and even blowing on the watch [12]. However, there has been relatively little study of the use of smartwatches. Lyons [41] looked at traditional watch wearers' practices to learn lessons for the smartwatch. Giang *et al* compared notification distraction between smartwatches and smartphones [18], Cecchinato *et al* [9] and Schirra & Bentley [62] interviewed smartwatch wearers to better understand how and why they used the device. This last paper emphasised the importance of notifications as a watch function, as well as the importance of appearance in choosing a watch device. Giang *et al* moved the study of notifications, disruption, and distraction from the smartphone to the smartwatch, contrasting these with studies of notifications on the desktop e.g. [15, 31, 67]. On mobile phones, Pielot *et al* [53] found that over 60 notifications a day was usual, and Leiva *et al* [38] looked at the effect of task interruption by incoming phone calls.

WHAT IS A SMARTWATCH?

The two leading types of smartwatch, Android Wear and the Apple Watch, share much of their functionality. The most basic functionality is displaying the time, and users can choose from a library of watch faces that also display other data along with the time, such as the weather or a step counter. When not being used, the Apple Watch turns its display off to preserve battery power, illuminating the screen only when it detects motion of the user's hand, or when the user touches the screen. Each watch is coupled to a user's phone, relaying information from the phone to the watch. Notifications that arrive on the phone (resulting from text messages, phone calls, or applications) are 'forwarded' to the watch, where they create a sound or small haptic vibration on the user's wrist. If the user raises their hand within a few seconds, the details of the notification are then shown. After being read, notifications on the watch are kept on the watch for reference (in the 'notification centre'), until deleted by the user. Both Google and Apple's smartwatches allow users to send messages, launch apps, or perform other tasks using voice commands, and a range of other applications are offered for download on the app store. Lastly, users' steps and exertion are measured through a variety of sensors, monitoring physical activity.

METHODS

To understand smartwatches *in vivo*, we wanted to record what watches were used for and the situation and context of use. Research using tracking of mobile device use has grown in popularity as devices have become important parts of a broader range of activities [6-8, 24, 44]. In particular, naturalistic video recording of mobile device use has advantages for capture and analysis in that it allows for the study of the moment-by-moment details of how the environment and device are connected in use [6]. Accordingly, for this study, we had participants wear multiple portable wearable cameras that recorded their actions relatively unobtrusively, while allowing us to see and understand smartwatch use *in vivo* [44]. We made a small 'sensor bag' (Figure 1) which contained two cameras with long-life batteries that allowed them to record for eight hours each. One of the cameras was directed to record the scene around the participant (pointing forward). The second camera was connected to a small 'stalk' camera that was

Figure 1: Participant wearing watch and camera. The 'stalk camera' gives a rough analogue of the participant's view of their wrist (and the watch). The camera bag visible on the strap at the bottom left contains a front-facing camera that records the user's context. Camera views are on the right.

mounted at the shoulder of the participant (looking downwards), so as to capture the participant's body and wrist. This angle captured interactions with the watch.

We recruited twelve participants using social media and advertising on local activity websites (Couchsurfing and a student group on Facebook). Our sample was somewhat skewed in terms of age (between 23 and 36, median age 30), and five out of the twelve participants were students. The other participants' occupations included management consultant, entrepreneur, accounts clerk, medical researcher and fraud analyst. Seven of the twelve participants were female. All participants regularly used an iPhone, and had not previously owned a smartwatch or fitness tracker. Three of them regularly wore conventional watches. Participants were given an Apple Watch, with a choice of a small (38mm) or large (42mm) version, and were asked to use it for a month with the last three days of usage recorded using our camera setup. On the day the recording started, participants were given the cameras and asked to record the rest of their day, with a researcher meeting with them the next day to collect the recordings from the cameras and to address any problems or concerns. On the third day, the cameras and the smartwatch were collected by a researcher and if possible an interview was carried out there and then. In this way, we aimed to collect at least two full days of video of each participant, although participants were allowed to stop the cameras when they wanted, to preserve their privacy or that of others around them.

As with any wearable camera study, there were some issues concerning when cameras could be worn, and permission from those caught on camera but not part of the research.

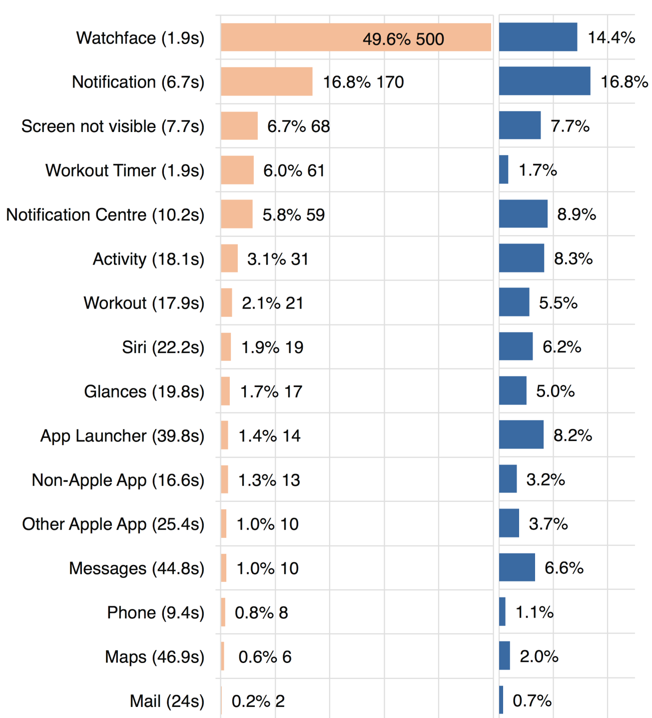

Figure 2: Watch usage by frequency of use (from 1009 incidents) and as % of time using watch (from 6777 seconds). Average use time per app is listed in brackets.

Therefore, we asked our participants to turn the cameras off when appropriate, as well as allowed them to choose on which days they were recorded. For practical reasons, two participants only recorded on 2 days making a total of 34 days of recording – 23 workdays, 11 weekend days. After the study all participants were interviewed for between 45 minutes and 1 hour, with questions covering their experiences of the watch and the recording procedure.

Our analysis started by watching the video and extracting clips where there was any interaction around or with the watch. For nearly all the video, the watch was visible, or if the watch itself was obscured (such as when it was under a coat sleeve) then the arm was at least captured such that the time of interactions with the watch would be visible (if not the actual interaction). For timing we counted from illumination to either the hand moving back to its original position or the screen going off. For each interaction with the watch, we extracted a video clip including ten seconds before and after to retain a sense of the surrounding activity. Each clip was logged with details including who was present, the type of watch interaction, and the length of interaction. This allowed us to gain an overview of watch use, in terms of the number of clips and the watch functions being used. For our analysis sessions, all authors collectively watched all 'watch use event' clips, around 8 hours of video in total. We selected for closer analysis clips that were particularly revealing of smartwatch use – either due to interaction with another person around the watch, or action involving the use of the watch. This smaller corpus of 110 clips was used for a more lengthy analysis of the interaction around the watch to examine patterns of talk, device, and bodily interaction. We drew on interactional analysis and the broader body of work in HCI that looks closely at the moment-by-moment interaction with technology [7, 17, 20-22]. Accordingly, our analysis took the form not of the repetition of a formal method, but a much more crafted set of analysis sessions and informed inspection of clips. Each extract was thus looked at as an individual, unique incident of use – but also inspected for exemplifying patterns that we can extrapolate to be present in other situations.

OVERVIEW OF RESULTS AND DATA

Our 12 participants recorded 168 hours and 21 minutes worth of video, from 34 days of recording. Each participant recorded on average just over 14 hours of video (with min 5hrs 29 min and max of 22hrs 15 minutes). These videos contained 1009 incidents of watch use. The range of watch use went from 1.5 per hour to 8.6 per hour, with a mean of 5.4 per hour. Watch use was on average 6.7 seconds long (max=205s, min=0.2s, median=2s). Clearly this is very different from the 38 seconds median usage for smartphones [7].

We can examine individual incidents of watch use by the app used, as outlined in Figure 2. The use of the watch is dominated by checking the time – making up 50% of watch

Figure 3: Diversity of smartwatch use, from left to right: Stepping down from a chair to read a notification while drilling, reading a message in bed, notification on getting off a bus, checking time during a child's art project, breastfeeding, cooking, playing an Xbox game, cooking, exercise bike, working, reading a message on bike, viewing Instagram while waiting outside supermarket.

uses. The time spent glancing at the watch was relatively short, though, averaging only 1.9 seconds, and this means that of the total time using the watch, checking the time drops to 14.4%. So while basic time functionality is important it is not as dominant as might first appear.

Notifications came second at 17% of usage, with a longer duration of 6.7 seconds. After clips where the watch is not visible (7%) the Workout Timer and Notification Centre come next ("Notification centre" refers to the Apple Watch's interface for managing notifications). Non-Apple third party applications make up a low amount of usage – only 1%. In terms of notifications, Messages was the most popular at 34%. Activity was the second most common notification at 20%. Other notifications came from non-Apple apps (20%), non-visible applications (16%), Mail (4%), phone calls (1%) and Timer (5%). However, these percentages come from a fairly small sample of only 170 notifications.

WHAT IS THE WATCH USED FOR?

Our detailed video data affords, however, not only an overview on smartwatch use but also the ability to understand in detail how the smartwatch is used in particular situations. Figure 3 illustrates this with frames taken from different situations of use: cooking, childcare, travelling, sleeping. Perhaps not surprisingly, a wearable supports multi-activity [19] both sequentially and simultaneously. Having access to the audio/visual recording of each of these moments of interaction allows us to begin to understand not just what the watch was used for, but why. In this section, we look at the most prominent uses for the watch in turn: Timekeeping, Notifications, Activity Tracking, and Applications.

Time

Just as phone calls are an essential role of the smartphone, so the smartwatch is used to tell the time. Glancing at a watch face can also be a potential site for information beyond the time. So, an initial question we asked was: why look at the time?

Prospection, retrospection, and 'scalloping'

From activity around watch looking, we can differentiate between *prospective* and *retrospective* checking of the time. Prospective is looking forward to an event or time that has some relevance to what you are doing now. So, for example, participants would look at their watch when they got onto a train or bus as part of their daily commute, calculating when they would arrive. In Figure 4 (left), one participant has put on a load of washing, and will need to go and move the washing to the dryer at a set time. Looking at their watch then lets them look prospectively into the future, calibrating their sense of time of current action with what is planned. In this example our participant must return to the task of washing at a set time in the future. Ceci [10] described this as strategic time-monitoring with three distinct phases: calibration where a cluster of clock-checking calibrates an individual's psychological clock, an

Figure 4: Prospective and retrospective time

intermediate phase of reduced clock-checking where other tasks can be performed, and what they called a "scalloping phase" wherein the frequency of clock-checking increases as the deadline approaches. We noticed that this would often happen in bursts during incidents of focal attention (such as working at a laptop, or reading). While looking at the watch is hardly a strenuous activity, it does involve a defocusing from the task at hand, and a slight physical movement. Clock watching can perhaps be seen as an indication that attention is waning from the primary task.

In contrast, looking at the watch *retrospectively* involves reflecting on how much time has elapsed. This can be done specifically, by looking at the watch face as in Figure 4 (right), or referentially, by reflecting on time as it makes itself known in the currently visible outcomes of its passing. In Figure 4 we see a participant who is going on a run and has started a workout timer on their watch. In this case, they checked the watch on four occasions during the run, each time looking at the time to see how long had passed.

Smartwatches can display more information than just the time: six of our participants chose the 'modular' watch face which displayed activity circles, weather, date, calendar entries, alarms, timers, and world clocks customisable by the user. So, in many cases there is a range of possible pieces of information that are being consulted. However, checking the time was a particularly short event, and while the user may have gathered other information – such as if there were waiting notifications (indicated by a red dot on the top of the screen) – time spent looking at the time was only 3.8 seconds on average.

Notifications

We now look at the second most dominant function of the smartwatch by the frequency of interactions in our data. *Notifications* are interesting in that unlike clock-checking the action is initiated by the watch (in the form of a haptic and/or audio notification). This can either be ignored or responded to by a user. With the Apple Watch we gave our participants, lifting their wrist within 5 seconds of the incoming message will show the notification instead of the watch face. It is not entirely clear from the data how many notifications are ignored (since this is not a visible action), although our participants in the interviews mentioned that notifications were usually read immediately on their receipt.

One important question concerning notifications is how much they interrupt activity. This has been an issue which has motivated much discussion. For example, prior work on smartphones in classrooms has found damaging effects on educational outcomes, and there has been considerable discussion of the costs of interruption on task resumption [61]. One immediate focus of our analysis, then, was to find examples of notifications interrupting or disrupting an on-going activity. As can be seen in Figure 3, clearly the watch is used in a range of different settings, while participants are engaged in a variety of different activities. Some activities took place in so called "dead time" [52] such as commuting on public transport, waiting for service, or in queues of different sorts. Other activities such as cooking, cleaning, and personal hygiene, while not 'dead time' were at least interruptible without much damage to the activity itself. Indeed, despite the HCI focus on the damage that disruptions cause, in our videos it appeared that little damage was done to the activities being carried out by the short watch interactions that we recorded. One possibility is that, in actuality, much of our daily activity is interruptible at little cost. If we look at some of the tasks being undertaken during watch notifications – doing the washing, reading a newspaper, drilling a hole in the ceiling – these were tasks that have natural breaks within the task (such as getting back down off the chair to fetch another part, or getting to the end of a story). Moreover, since they may not be particularly cognitively challenging undertakings, interruption may come at a relatively low cost, weighed against the possible (projected) benefits of reading the notification. Activities already feature micro-breaks and self-interruptions [1], and a watch notification might provide an opportunity to take a break from a task. Work done on micro-breaks in data entry [23] and crowdsourcing [60] has identified the potency of breaks of three seconds and longer in intensive tasks.

Text messages

Text messaging has been a longstanding use of mobile phones from SMS to IM, and it has gained recent renewed attention with the popularity of services such as WhatsApp and iMessage [47]. Receiving text messages on the watch is not an entirely different experience from a phone, although our participants talked about how when wearing the watch text messages would be read much quicker than when they were received on the phone, since any message coming in would trigger a notification and then, potentially, a quick glance at the watch to read the message. What impact does reading messages slightly earlier have on text messaging? Drawing on our data, we could see three potential advantages. The first was the ability to quickly triage incoming notifications, and possibly reply to those that were urgent, or could be quickly replied to using canned messages or emoticons. This allowed the wearer to attend *less* to the messages and notifications they deemed a lower priority than their current task – foregoing the action of taking out the phone to check the sender or content – while still giving sufficient attention to what they considered higher priority messages. This means less engagement with the phone, and therefore less physical disengagement from the current task and chance of the check of a notification to be sidetracked by the plethora of other apps. As one participant put it:

> *I think I reduced my phone time by I would estimate around 60%. I would see the messages and I wouldn't maybe reply directly to them.*

So something that would take a discrete amount of time on the phone could be done in small bursts throughout the day, potentially during activities where a small rest from the main task would be beneficial, or alternatively where the current engagement could easily be interrupted. Indeed, while we saw relatively little *replying* to messages on the watch (only 13 cases), messages were frequently read, and (as one participant put it in the interview), relevant answers composed before being later entered and sent on the phone:

> *I would wait a while so I could think about them. [...] I think in general I was better in answering my text messages [..] It was easier to answer them quicker than before. I could wait an hour or two to answer.*

This increase in the speed with which incoming messages are noticed by the recipient also has the result of raising expectations on the part of the sender. Our participants talked about how senders expected that messages would now get a quicker response, adding to the already prevalent social pressure to be reachable and connected at all times.

Activity tracking

Perhaps the most mentioned application from our interviews was the activity tracking software. The watch passively tracks activity as well as allowing users to explicitly log exercise. This was used to produce a running log of steps taken, calories burnt, and hours where the user stood, visualised as circles that showed completion towards a set goal. Our participants used the built in Workout application as well as more specialised ones for particular activities, such as running.

These applications provided information during and after exercise. They present the time elapsed during a particular session of exercise, and time until a particular goal. The watch also supplied exercise information during other daily activities (through step counts) and prompted users to stand up to break up sedentary periods. The Activity application provided an overview of the day in terms of time and activity, too, and this feature supplied a new retrospective outlook on a day – echoing that seen by people using other quantified self technologies. When asking about this in the interview, we obtained explanations that were not unlike those discussed above for the use of the time – prospective and retrospective purposes. The prospective purpose of looking at the 'rings' of completed activity was to see what activity might need to be put into the day to be able to meet the goals of completing the rings and hitting the exercise goal. On a daily basis, then, activity could be added to a day when necessary. Alternatively, there was a retrospective purpose of looking at the activity in that it offered a short overview of the participant's day. While this was only in terms of physical activity, it was still enough to support reflection on the day. While our data is suggestive then that the smartwatch did have a positive influence on physical activity it must be noted that we only have data from a short period of use.

Talking to the Watch

With recent improvements in the quality of speech recognition [26, 30], one feature of the watch that we were interested to see in practice was the use of speech recognition to interact with the devices' intelligent agent. This allows a user to speak commands to the watch, as well as have messages transcribed to be sent. Speech recognition is a challenging function for any device, although clearly it has considerable potential for a device such as a watch where free-text entry is not available.

We have only a very small number of incidents from our participants involving the use of Siri (17 or 2% of usage). Siri seemed to divide our participants, with most saying that they would never use it, but others claiming to be occasional users. While such a small set of examples is not heavily indicative, eight of our extracts involved setting a timer, and five sending a message. For the timer examples, Siri seemed to set the timer correctly in the cases we saw. It had less success with messages: in one case it incorrectly cropped the message that was being sent before its second sentence, and the participant had to use their voice to send a second message. In another case, the participant attempted twice to transcribe a message saying that she was going to a friend's house. The second attempt resulted in laughter at the proposed transcription and the user abandoning the watch to reply on the phone. Previous work on speech has discussed how participants format their voice and interaction to be "machine listenable" – attempting to talk in a format that they think will be more appropriate for the recognition algorithm [64]. This might extend to the tasks which the speech system was used for, in that setting a timer is a fairly straightforward recognition task. When we asked participants why they did not make greater use of Siri, explanations were given in terms of its low accuracy rate. This might be something of a hangover from earlier speech systems, or alternatively the lower accuracy obtained while the system trains itself to the speaker. Despite recommendations in the literature [65], there are no speech correction features supported in Siri, and this means that if a speech command has a fatal mistake, it must be repeated in total.

Other Applications

As we conducted the study, the Apple Watch was a relatively new device – and although it had managed to collect a surprisingly large library of applications, the actual software development kit restricted considerably the functions that an application could carry out on the watch. This said, most of our participants had tried to make use of a third party application. Notable third party apps used by our participant included Instagram, Twitter, Nike Plus, and various news applications. They still accounted for only a very small 2% of the interactions we recorded with the device. Notifications were an exception to this proportion. Notifications from non-watch apps are still displayed on the watch, and this means that any application that displays notifications on the phone can have a lightweight partial interface on the watch. 20% of notifications (34) received on the watch were from non-Apple applications.

THE WATCH IN EVERYDAY LIFE

Our analysis so far has given us an overview of some of the basic functions of the watch and how it was used. Our videos, however, let us examine in more depth the role of the watch in everyday activities. As with any new device, the smartwatch finds its home not simply by meeting particular user goals, but rather in how it is a "thread in the complex tapestry of everyday interaction" [6].

The Materiality of the Smartwatch

One of the most interesting aspects of the watch was the physical role that the watch played in action. Here, we will look at the role the watch plays on the body, and as another physical device to be managed and maintained by users.

On the Wrist, not in the Hand

The body-mounted nature of the device obviously makes it different from a phone. In a straightforward way the watch is more *convenient*, even if it has more limited functionality than other, larger devices. If we were to attempt an expanded description, we might describe the materiality of the watch, in how the way it is physically designed to sit on your wrist enables a set of interactions with the body and the world. Indeed, in Ferreira and Hook's [25] ethnography of phone use amongst Pacific Islanders, they describe how, in that setting, the prevalence of water mandates a different orientation to mobile devices and the physical environment. Islanders make use of their phones for messaging and the like, but since much of their life is spent in or above water, the use of their phones was different from those of us who live on dry land. This reminds us that our own orientations of our bodies and hands to mobile technology are not natural or universal but are a product of conventions of use, and the environment we find ourselves in. With the watch then we can see in our videos a similar emergent set of material engagements of body, the watch, and the environment. The watch is 'always there' and can be consulted by simply moving your wrist to bring the watch into your visual frame – the same gesture which triggers the screen. This attachment of the device to the wrist provides a context independent 'look' gesture that will obtain the watch screen in visual range. Interestingly, even though considerable amounts of our participants' time was spent using phones or laptops, both of which have always present clocks in the corner of the screen, the context insensitive familiarity of the gesture would mean that participants would often turn to their watch to get the time.

The always-available nature of the device means that a user did not have to go and find the watch, or take the watch out of a bag or pocket. Interestingly, this seemed to be a particular advantage when participants were at home. In these cases, the phone would likely not be carried around in a pocket, and this meant that using the phone involved going to get the phone. This was made visible in cases where participants received phone call notifications on their watches and would then quickly go to, or search for, the phone in order to answer the call. Few calls were made by participants through the watch. They reported not trusting the quality of the audio they would send to others. When a participant was out of their home or office, the phone would usually be available in a pocket or bag – and we saw cases where a participant gets a message on the watch and then quickly moves to their phone (which was available nearby) to continue the conversation.

If we unpack 'convenience' further, then, it is not only about location but also about the nature of the watch as a wearable device. Having a device mounted on the body means that it can be consulted without having to use one's hands to hold or control a device. In Figure 3, on the first image we can see a participant reading a notification with a power drill in one hand. While interaction with the device does demand a free hand, reading can be done while both hands are occupied. The lack of required hands, combined with the lack of needing to go anywhere to fetch the phone, means that one does not need to physically disengage from an ongoing activity that requires one's body. One example of this is physical exercise – when running or on an exercise bike, consulting the watch can be done while retaining physical involvement in the activity.

While phones can be used in these situations, taking out a phone can potentially create more physical disruption. A watch can interrupt a task with a short notification, and then the task can be continued quickly. This can also be seen in childcare or cooking (Figure 3). In these cases, the task quickly continues after the watch is consulted. Similarly in Figure 5 we can see a cooking activity involving a couple, where one grates cheese. The cheese grating only takes a few seconds during which the alarm goes off on the other person's watch. The watch user consults their watch, dismisses the alarm, then moves the pot of pasta (which the alarm indicated was cooked) off the heat. The watch alarm is elegantly incorporated into the cooking with little or no disruption.

This said, the watch does make some demands for physical interaction. Elements of the screen need to be touched, as well as the watch's controls. Indeed, the watch allowed for two modes of physical interaction. Scrolling or swiping was a function where the accuracy of the gesture was not particularly important and so the device could be held in the air and a finger placed on the screen to control the scrolling.

Figure 5: Cooking Pasta

Yet, certain functions of the watch required more fine grained pointing and manipulation – such as picking an application to launch or touching screen controls (choosing a reply to, or dismissing a text message). As Lyons and Profita [40] point out, usage of wearables moves between different physical configurations (which they call 'dispositions') over time. In our data, for closer interaction, the watch would be touched on the side with one or two fingers to stabilise and orient the rest of the hand, and another finger used to make the desired selection. While this was not universally the case, it seemed that placing a 'stabilising' finger on the watch allowed greater accuracy (as can be seen in three of the images in Figure 3). An ongoing panel survey of Apple Watch users has even suggested that the *nose* is a common way of interacting with the watch [69].

Lastly, the nature of our study gave us little data on reactions to the appearance of the watch (although obviously this is an important longstanding role for watches). The novelty of the watch did trigger conversations, as did our participants wearing cameras, but in our interviews participants were ambivalent towards the watch design. Clearly different methods and design work would fit better with examining questions around fashion and the physical design of the watch [33].

The Smartwatch as Screen

One interesting feature resulting from the physical location on the watch on the wrist is its arrangement in the visual field. O'Hara and colleagues present one of the most detailed discussions of the importance of materiality with technology in their discussion of writing from multiple sources [48], and the combination of paper documents with writing documents on screen. Their work clearly points out the importance of the visual field in arranging materials used in writing – such as being able to maintain a writing book alongside paper documents when writing. Back in Figure 3, again, we can see examples where arrays of documents are arranged. In one case a user arranged their credit card, a paper notebook, an iPhone, the keyboard of a desktop computer next to the watch. In that case a banking transaction was being made that required the card number and a text message code. The participant holds up the watch next to the keyboard and looks between the two to type in the code. In other cases we could see how the watch would be held in the visual field so it could be consulted in combination without requiring movement.

```
W:  It was supposed to be next week
A:  Yeah
W:  But because she has hosted the club
    before so
    many times|                <<left image>>
A:            |Okah
W:   Emm (1.0) She (0.7) made a big party
     for our school          <<right image>>
               <<opens bag while speaking>>
```

Figure 6: Checking notification during conversation Numbers in brackets indicate a `(timed pause)` **in talk**

Earlier research has described the watch as an 'extra screen' for the phone [62]. Indeed, much of the functionality of the Apple Watch relies upon the phone being close by. We did see some cases where use of the watch led directly to use of the phone – particularly in the form of text messages received on the watch that led to a reply being composed on the phone. Around 3% of watch uses were followed by iPhone use. Another combination of devices can be seen in 'second screening' where the smartwatch is another screen added to the already complicated tapestry of multi-device use many people manage on a day-to-day basis [32]. In traditional second screening behaviour, the primary focal device, such as the television, had the waxing and waning attention of the user who shifts to a complimentary – or in some cases unrelated – task on the second device. The cases we saw with the watch were different. When the phone was active for a particular task the participant would move attention to the watch to quickly consult some details without having to change their application on the mobile device. The limited multi-tasking capabilities of mobile devices go some way to explain this, yet we saw participants consulting the watch while using a laptop or a desktop computer simultaneously.

The watch in social interaction

Let us now turn to the place the smartwatch holds in social interaction. As we discussed above, there is potential for the watch to cause disruption, as a source of interruption for conversation and interaction with others. Indeed, some have argued that the smartphone is a disruptive and negative influence on social interaction [56, 58]. In contrast, our past video analytic work has argued for the ways in which smartphones can, rather than interrupting social interaction, actually benefit and initiate conversation by providing topic and being an ongoing agent in conversation [8].

We looked through our videos for situations where social interaction and use of the smartwatch influenced each other. In particular, we sought examples of where social interaction was disturbed by the watch and its notifications; in terms of a delayed response, a hesitation or halt in talk, or a turn that was later repaired where evidence could be found of the notification having a role. To our surprise, we could not find any incidents where talk was disturbed. This could have been a side effect of the data we collected – participants were on their own in 68% of our watch use cases. We found 117 clips, or 18% of watch use, involved conversation while the watch was being used. Figure 6 is one example of a notification coming in and being managed, in that the notification is read while the participant tells a story about the previous night, with the user pausing slightly after they read the notification. Yet, the conversation still continues afterwards. Indeed, while they speak the next turn they simultaneously open a bag of sugar, which may have led to the pauses in talk as much as the notification. This clip also emphasises the complexity of users' everyday activity – here, the participant is talking about last night, arranging some ingredients for cooking, and quickly reading a notification on the watch.

This is not to say that notifications did not influence or potentially disrupt interaction in other subtle ways. In our interviews some participants reflected upon this:

"It's like, something vibrated, I know something happened. I'm curious now, but I don't want to be rude so I'm not going to look. There are two processes, trying to listen to somebody and trying to not listen to your watch."

This temptation and potential distraction was balanced with the possible even greater distortion of using a phone:

"With the watch I also pick it up but it's much faster, so I think a process of check and go is actually better."

"I noticed that myself when my classmate who has an Apple Watch, I don't look at his watch very often but if he'll take up his phone, I would probably"

Visibly interacting with the watch

There is also potential for the device to *positively* contribute to conversation. For example, we saw a case where a news notification was read aloud by the participant – the notification in this case provided a topic of conversation of interest to the couple. Having a watch also means that a participant can use looking at the watch, in conversation, as part of gesturing to or emphasizing a planning or time related task. So, for example, in one clip (Figure 7) a participant is sitting outside having lunch. Before lunch they had mentioned the one pm meeting they had after lunch, and at 12:45 they turn to the watch to look at it, say "I need to get back" and then quickly pack their belongings to leave. To their lunch participants this gesture and exclamation is legible as 'lateness' – and indeed, the others

```
A: What is the time have you kept track of it?
W: [*] Oh quarter to [.] fuck, I need to get back
   (stands up)
B: Can we wait five minutes?
W: I have a meeting with ((my boss))
```

Figure 7: Lunch and meeting (translated from Swedish)

quickly pack up alongside their watch-wearing friend. Yet, in other settings, this gesture could be problematic. We frequently noticed participants checking their watch 'under the table' – in one extract a participant is in a day-long meeting and they frequently discreetly turn their hand under the desk. The watch does not detect this move, however, and the watch does not turn on until the participant touches the watch. The action here is seeable to others as 'looking at my watch', which might impart impatience or boredom.

Usability problems

While we did not conduct an extensive evaluation of the watch's interface it is perhaps worth mentioning that in our clips we do not see much in the way of confusion about the interface with some notable exceptions. Launching apps caused some problems in that users would get quickly lost in the overview of applications, sometimes abandoning the task. The touch screen itself also sometimes caused problems and would not register touches (it is not clear if this was a hardware problem, or a problem with the device becoming unresponsive). Interestingly, swipe gestures were quickly carried out unproblematically, and much of the interactional problems seemed to come from touching buttons. As the work on interaction with small displays has shown, it might be better to support swipe gestures more universally, than relying on having users touching small targets on a moving watch face [50].

For some participants they regularly attempted to turn the watch 'off' after they had finished interacting with it, a little like hitting the power button on a phone. They would do this by hitting the crown button. Yet while in some cases this returns the watch to the time screen (which seemed to fit with the notion of being 'off'), in other cases it would return the watch to the application launch screen and they would hesitate before touching the button again (which would return them to the time).

DISCUSSION

Clearly, the smartwatch in use is not a simple device. As a relatively new form factor it introduces new possibilities and problems. In discussion, we turn to three of these briefly. First, we will consider the broader issue of distraction and activity. Second, we mention the role of the watch, and the pressures of time and sociality. Finally we discuss the design of this generation of smartwatches.

Distractions

One topic we have engaged with in different ways is that of distraction. The link between notification, interruption, and distraction is not as strong as it may appear at first. In HCI, distraction has been a topic that, in its contribution to cognitive models of task activity [5, 67], has shown the challenge of managing interruptions alongside primary tasks. Our study has collected together an interesting corpus of watch notifications during activity. As we have discussed above, it is not clear that these are best understood in terms of interruptions. One alternative approach, growing out of conversation analysis is to use video to look at behaviour in terms of multi-activity. As Haddington *et al* put it "the organisation of multiple tasks and activities is a collective, collaborative and intersubjective process; it relies on participants' finely-tuned coordination practices and on the real-time and *in situ* organisation of joint activities." [19, p6].

Our data, ranging from cooking to multi-party conversation, demonstrates that a short refrain from a conversation or task can be unproblematic. Indeed, many tasks are arranged so that breaks and subtasks are a natural part of their execution. We might remark upon the watches ability to be consulted without changing bodily comportment, or engagement with an activity. So, for example, in cooking or preparing food the physical arrangement of the task need not be changed while a watch is quickly consulted. The watch may simply reduce the need, or temptation, to take the phone out. A notification, which may have caused the phone to sound an alert or vibrate, carries with it the mystery of what is being notified until the phone is retrieved. With the watch the compulsion to find out the source of the notification can be readily sated, and glancing at the watch may be less of a distraction than the cognitive load of wondering about the incoming message and negotiating access to the phone around the current task.

Time and sociality

"I have less patience with someone who doesn't wear a watch than with anyone else, for this type is not time-conscious. In all our deeds, the proper value and respect for time determines success or failure." ([42], p. 392)

A related issue concerns the potential for the watch as a part of the 'cultural norm of busyness' as Leshed and Sengers put it [39]. Certainly there is potential for use of a smartwatch to contribute to stress or unhappiness through the immediacy of notifications, or its use as a technology for intensification of work and life activity. Even the basic wristwatch sits in a long tradition of the clock and the intensification of industrial processes [45]. For the smartwatch we studied it appeared that it was not time as such, but the flood of messages that had the potential of intensification, and while messages were felt to be important they potentially drew participants away from where they were. For these reasons many of our participants were equivocal about the benefits of the device. Yet, this can be balanced by the potential to manage or hold back some temporal and social demand. Indeed, the value of the device may be in its role as an intermediary. The watch can serve as a way of reducing time spent on the phone, and to also balance availability to others with one's own concerns and demands. With a device that is only perhaps at the beginning of its development it is difficult to foresee how it will evolve, but clearly there is the possibility of the watch not as a device which simply renders busyness, but as something that can balance the forces and demands of sociality, leisure and work.

Design and the watch

As an empirical study, we have focused on documenting the uses of the smartwatch. Yet, some design possibilities are worth mentioning in passing. Three of our participants remarked upon the current need for the watch to be close to a phone for its functionality – remarking that the watch would potentially be more useful as a device that could be used when the phone had been left at home.

Considering our discussion of prospective and retrospective time, a watch face might prospectively display time – showing graphically, for example, how long it is until the end of the working day, or even bedtime, or helping concentration by dividing up activities into shorter parts that can be completed. In terms of retrospection, we were interested in how the activity tracker comes to be used not only as a way of looking back at calories and exercise, but also as a record of the day. Similarly, we might think about applications that allow for retrospection. A simple application might, for example, record times spent in different places, or time spent in different activities (such as conversation). Secondly, clearly notifications are a large part of the value of a smartwatch. Yet, notifications as they are currently implemented support only limited interaction. Notifications have the potential to at least support some broader forms of interaction – for example using voice to give a command after a notification has been read or using a hand gesture to answer a notification.

More broadly, we have discussed and demonstrated at length the ways in which the watch supports a form of 'task embeddedness' in that watches can be used without disturbing tasks that are in motion. Advice given to designers of smartwatch apps broadly has been focused on designing quick and simple interaction — and our results here do nothing to question this aim. Yet, a broader set of possibilities might exist in thinking about not only how as smartwatch might be used to enhance a task. For example, furniture assembly instructions could be given while construction was in progress.

CONCLUSION

In this paper, we have opened up the use of the smartwatch, drawing on naturalistic video recordings from 34 days of use across twelve participants. We have used these recordings to document the ways in which the smartwatch is integrated into participants' lives, and the possibilities for assistance but also disruption. From our data we have seen that the materiality of the watch lends itself well to its perceived role as a companion device for the mobile phone – providing quick, unobtrusive, and less disrupting access to incoming information. While it is early in its development, in a similar way that talk of the 'smartphone' has given way to simply talking about 'the phone' perhaps the term 'smartwatch' will disappear as wrist-mounted technology creates a place for itself on the wrist.

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