Wearables or Infrastructure: Contrasting Approaches to Collecting Behavioural Data in the Home

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Abstract

This paper examines and contrasts two approaches to collecting behavioural data within the home. The first of these involves filming from static video cameras combined with network logging to capture media consumption activities across multiple screens. The second utilises wearable cameras that passively collect still images to provide insights into food related behaviours. The paper compares the approaches from the perspective of the researchers and participants, and outlines the key benefits and challenges of each, with the aim of further mapping the space of possibilities now available when studying behaviour in the home.

Author Keywords

Home, Wearables, Behaviour, Visual Research

Introduction

Domestic environments are of interest to researchers across a range of disciplines and concerns and new approaches to collecting data in the home are being enabled by technological developments. This may expand our ability to understand behaviours, verify or prompt further reporting, and collect data at greater scale or in greater depth than was previously feasible.

Figure 1 - IP Cameras setup in the household

Figure 2 – Multiscreens study: Still from IP Camera

Researcher time, privacy concerns, and a lack of capacity to reliably capture behaviours of interest mean that many existing studies of home behaviour rely upon self-reporting methods. However these have methodological concerns that could be ameliorated by the development of approaches that capture additional forms of data [1,4]. Both of the methods discussed in this paper primarily focus on visual data capture in the home, which due to its richness can be considered particularly sensitive [6]. Study participants are also likely to have pre-existing understandings and positions towards video surveillance, particularly given the rise of reality TV and 'fly-on the-wall' documentaries [3].

The contribution of this paper is to identify contrasts between visual approaches to studying behaviour in the home by reflecting upon two on-going projects that attempt this. We explore how the study methods and technologies impacted upon the life of the household, and how this results in differences and demands on the agency of researchers and participants. We also discuss how such methods make assumptions about the nature of homes, and as a result, how differences in homes and the actions of participants can impact upon the data collected. Through this we help to uncover some of the major issues facing researchers who wish to capture rich data over extended periods of time, without being present in the home environment.

The paper outlines the two methods and provides comparisons of the most salient features of these (ethics, recruitment, and data analysis) along with participant reflection on the methods.

Understanding the Multiscreen Household

The 'Multiscreens' project set out to use situated cameras and Internet logging to understand media use in the home, focusing on the relationship between media on the primary screen and simultaneous activity across devices such as tablets, laptops and phones. As the method described below requires significant installation of monitoring equipment, we consider this an 'infrastructure' based approach.

The multiscreens studies involved the deployment of up to three static IP cameras within the living space to capture device usage and the TV screen (see Figures 1 and 2). The exact setup was dependent on the layout of the room. This visual data was combined with logging of network traffic (time stamped, device specific URLs) to give an understanding of online activity, as the cameras would not be able to pick this up. To achieve this an additional study router was installed creating a dedicated Wi-Fi network from which network traffic could be logged and the cameras monitored remotely.

The study setup process required two researchers to visit the house and spend around 30 minutes deploying and testing the equipment to check that the system was working correctly. In addition to this, it was often necessary to visit once during the month long deployment to swap camera SD cards.

To date, four such studies have been carried out. The first two studies had pre-arranged recording and network logging hours – during the 'prime time' viewing period of 6-10pm. After feedback from participants and concerns that important non 'prime time' multiscreen data was being missed, the latter two studies moved to a motion detection approach, where filming was

Figure 3 - Autographer clipped on (top) and with a neck strap (bottom). Yellow shutter is closed in both.

Figure 4 – Food Behaviour: Autographer Image

triggered by people entering the room and network logging was always on.

Wearable Cameras and Food Behaviours

The *'Food Behaviour'* project used wearable cameras to capture data on food related behaviours in the home and public spaces. The aim was to capture the entire food purchasing and consumption experience to inform the design of technology to encourage consumers to adopt more sustainable behaviors [5].

The study was carried out in the UK and Malaysia and involved participants wearing an Autographer[1] camera for one week both in the home and public spaces. These can be clipped onto clothing, or hung around the neck and images are taken automatically every 10 – 30 seconds (Figures 3 and 4). At the start of each study, a researcher spent around 30 minutes going through 'information sheets' and consent forms with each participant, as well as introducing the camera. After the study period the cameras were collected and the images analysed to identify key food related moments to probe in hour-long retrospective interviews.

Ethics

One of the most fundamental ethical concerns related to visual methods is the need to ensure participant autonomy, and both studies had key challenges related to this due to the need to provide sufficient participant control over the data collection.he wearable camera studies caused the most concern due to their additional use outside the home. However it should be noted that these went through two different departmental ethics application procedures.

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[1] www.autographer.com

Multiscreens

In the *multiscreen* studies household members were told that they could switch off the cameras at any time, and could always access their original Wi-Fi to avoid logging if desired. If children were present in the household, participants were given the option to film only at times when the children were not in the room.

Whilst the recording scope of the *multiscreens* cameras was static and confined to a specific area of the house, there was a need to ensure that visitors provided consent to be filmed (administered by the participants), or alternatively that the cameras were switched off. Video data was recorded to SD cards on the cameras and so remained in the home until researchers visited. This choice was made because transmitting large amounts of data from the home network was not considered suitable in case of data limits that might apply in some households. However this also provided a clear mechanism for participant control, in that they could delete recordings from the cards if desired.

Food Behaviour

Ethical restrictions about where and when the wearable cameras could be switched on meant that instructions had to be given to participants to only capture images within the home and public spaces. As such, a large amount of responsibility fell on the participants to mediate the use of the camera.

As with the *Multiscreens* project, to ensure control, participants were told that they could switch off the cameras at any time or delete any images if desired. This control over recording times meant that the camera wearing hours varied significantly. Whilst some participants wore the camera whenever they were at

Figure 5 - Example of wider context of food practices. Here a participant is using food waste in their garden.

home, others only felt compelled to wear the camera when cooking and eating. However, the research team were also interested in the wider context of cooking and eating practices, such as exposure to information abut food, the use of shopping lists and recipes, or unexpected uses of food waste (Fig 5). Thus some data sets yielded more insights than others.

Recruitment

A key difference between the two projects was that in the *multiscreens* studies the entire household was being studied. In the *food behavior* studies, the focus was on individual participants but other house occupants might appear in images. Consequently we required 'third party' consent from these people.

Multiscreens
Recruitment for the study involved emails, an advert on the 'Call for Participants' website[2], flyers placed around the university, and word of mouth. Each household member received £50 in vouchers as compensation.

The recruitment page received 282 views, with five potential participants applying to take part through this. However, of these responses, only one was followed up with a study. Reasons for this included there being no TV in the general living space of the house, and the inability to get all household members to sign up to the study. Two emails were also received explaining that the method was too invasive. Informal discussions with others who had seen the advert indicated concerns with the introduction of logging equipment in the home, due to the potential to interfere with the existing home network setup. Other

individuals showing an interest felt that the study was too invasive, or too long, for the compensation given.

Of the households that did agree to take part, one had recently taken part in another study in their home conducted by the same research group. A further two households were known to the research team in a work capacity (though in other cases, colleagues were unwilling to take part). As such, an existing relationship of trust appears to be a factor in willingness to take part, but there are also individual differences.

Food Behaviour
Recruitment for the study in the UK used the 'Call for Participants' recruitment site and word of mouth, and £50 of vouchers was again given to each participant as compensation for taking part. The recruitment site page received 221 views, with eight follow up emails. Of these, six people became study participants, with two other participants recruited via word of mouth. Due to the homogenous nature of the respondents (mainly students living alone) further channels were later used to specifically recruit families and couples. In Malaysia nine participants were recruited via word of mouth.

Data Analysis
Multiscreens
At the conclusion of the deployment period, the equipment was collected and a high level overview of the data carried out to identify interesting behaviours to probe in the focus group. During these we also asked more general questions about media related behaviour in the household, and finally examined attitudes to the study protocol and monitoring technology.

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[2] www.callforparticipants.com

Data generated from the studies included transcripts of the focus groups, video recordings from the cameras, and network logging (both time stamped). The videos were viewed and categorised in order to characterise the behaviour and identify periods of activity for more in depth analysis. Despite work to make this process as simple as possible, it was still very time consuming. However this analysis has both the breadth and depth to provide key insights into behaviour patterns over time, as well as details of particular interactions.

Food Behaviour
The outputs of the study included all the images taken by the camera (minus those deleted by the participants) and transcripts of the interviews. A qualitative thematic analysis was carried out to identify key decision points and rationale behind food choices. This analysis was less intensive but the subsequent output was at a higher level, providing only initial insight about food behaviour.

Participant Feedback
When carrying out the focus groups and retrospective interviews participants were asked to feed back on their own experiences with the data capture devices.

Multiscreens
Households mentioned that they often forgot about the presence of the cameras, and that they were not generally bothered by them. For example stating that:

H3P1: "I think we all completely forgot about them within half an hour."
H2P2: "I was happy if they … just came on and off, like, it wouldn't bother me at all. I was quite happy to forget about them."

Interestingly, two of the households asked if they could have access to the clips for their own entertainment, indicating a lack of self-consciousness about the captured video footage, and also a connection between video as data and video as entertainment or memento.

Despite the perceived lack of awareness of the cameras, several participants appeared to take a degree of responsibility for maintaining data capture. For example they were keen to ensure that the camera angles remained correct. Stating that they would like:

H3P3: "…to be able to see what they were showing at certain points just to make sure they were pointing the right way. [I would] tidy up and knock it and then I think I don't know if it's got everyone in."

This attitude appeared to extend to the network logging, with participants reporting that they very rarely (if ever) used the original network. In fact, some participants were proactive at ensuring that they remained on the correct network:

H1P1: "…our phones sometimes switch between the study wireless and our house wireless. So we have to make an effort to actually look and check if it was actually on the right network."
H3P1: "I changed the settings to not reorder the networks,… [so it] defaulted to the study."

In other cases, data was missed as participants were not proactive, for example stating that:

H2P1: "I didn't change it *(the network)* on the Xbox; I completely forgot to change all the fusing on that."
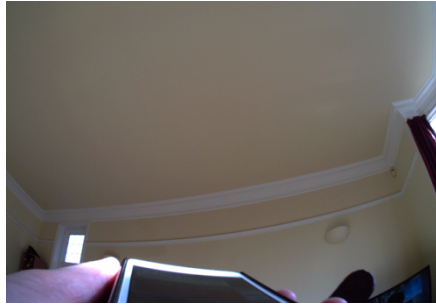
Figure 6 – Example of unclear Autographer image showing 'Multiscreening'

Part of the difficulty with this issue is the wide variety of devices that were being connected to the network, and the different connection approaches used by these.

Food Behaviours
In the *food* study participants also seemed comfortable with the presence of the wearable camera, although there were some minor frustrations with the camera being on a neck strap and therefore getting in the way. Additionally, due to the need for participants to control when the camera was on or off (either by switching the camera off or closing the shutter), there were occasions were it was left switched off for long periods of time:

P7UK: 'I did forget to turn it on a couple of times…On the second day… I was wearing it but then I was like, it's not been on...'

Almost all of the participants reported forgetting to wear the camera at least once, ranging from a few hours (e.g. missing a meal) to a few days.

P5M: 'If I forget to wear the camera one day, I end up not wearing it for a few days'.

Most of the participants who did not manage to wear the camera for a week, actually volunteered to extend the study to cover the days where they had not worn it. Some of them made suggestions that in future studies reminder text messages could be sent.

Although all participants said that they did not alter their behaviour while wearing the camera, when prompted further, some of them admitted that they tried to be more organised and do things properly when they were in the kitchen.

P2M: 'I think my feeling wearing this camera, you feel like you want everything to be done perfect'.

Several participants appeared to be involved in the orchestration of images to be taken. For example they were keen to ensure that certain healthy products that they consumed were captured, so positioned them directly in front of the camera.

The idea of using wearable cameras in the *multiscreens* project arose in two interviews where the participants were aware of the other study. However they felt that they would need to focus more clearly on capturing their TV set and devices as these would not naturally be in the camera shot when relaxing on a sofa (Fig. 6).

P7UK: 'I would forget I was wearing it… You'd have to be more aware you were wearing it for say [*multiscreens*], you'd have to position it…'

Discussion
Diversity and Adaptability
Awareness that media consumption has diversified in location and device use is central to the rationale of the *multiscreens* project. However, the method of study made assumptions about the features of the domestic spaces being studied. Specifically, we devised an approach that installed infrastructure to collect video data from a 'primary' viewing space (e.g. a living room). This could be considered analogous to approaches used in other studies using fixed cameras to study appliance use, such as the 'HobCam', where food practices were videoed from above a hob [2].

By taking on this assumption, we leveraged the expectation that video capture in the living space would
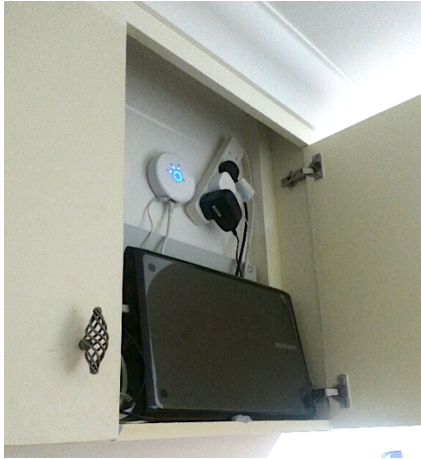
Figure 7 – Difficult Installation of Router In Situ

be more acceptable to participants than in other locations in the home, as research suggests that video is a highly invasive technology and also that the living room is the space where monitoring technology is most acceptable [6]. However, some potential participants had to be turned down, as they did not have a TV in their lounge and watched media in a highly distributed way. Additionally installing cameras to capture activity in living rooms of various shapes and layouts meant that each deployment was slightly different.

The network logging approach made additional assumptions about household infrastructure, but the positioning of routers was in fact highly variable. For example, we encountered difficulties such as having to install equipment in a small raised cupboard (Figure 7).

A wearable camera is portable and can therefore capture behaviours that are distributed across space. This was an ideal method for capturing a high-level overview of spatially distributed food related practices as, unlike [2], we wished to explore behaviours beyond the kitchen. Due to the success of this method in the *food* studies it was considered as a possible alternative data capture mechanism for the *multiscreens* study, removing the need for a 'primary' viewing space, potentially capturing device activity instead of relying on logging, and also possibly alleviating recruitment problems. However issues with viewing angle (see Figure 5) and participant control meant that this was not deemed appropriate for the needs of this study.

Participant Agency
With the wearable cameras, participants are relied upon to switch the camera on, and keep it on over an extended period of time. Experiences from the *food*

behaviour studies showed that this was not always the case, with some people forgetting to turn it on for a whole day. Therefore, whilst this added control ensured participant autonomy, it introduced considerable variability in the quantity and quality of data captured.

Whilst there was greater researcher control over the viewing angle, and timing of filming in the *multiscreens* studies, participants were able to retain control over data collection. This included being able to switch the cameras off and access the original WiFi network. However this was rare, and cameras were never left off for extended periods of time. It therefore appears that the lack of complexity over when the cameras are on or off reduced instances of cameras being forgotten.

Success of both the studies depended on participants being pro-active about setting up or using the equipment more effectively, such as adjusting WiFi priority settings and remembering to switch cameras back on. In the case of the *multiscreens* infrastructure, this could also require a level of technical knowledge to ensure that data was being collected, whilst the wearable camera was largely self-explanatory.

Recruitment
While recruitment for neither study was easy, there is some evidence that the wearable approach was more attractive. Clarity around the participant's ability to control data capture, the individual approach to consent, and the lack of alteration to the infrastructure of the home, are potentially factors in this.

Data Quality
The combination of video and Internet logging provided the ability to identify links between TV watching

behaviour and online activity at quite a low level of detail. However the scale and complexity of this data was sometimes challenging to analyse.

The wearable camera images were useful for prompting reflection about the rationale behind behaviour. However these devices have limitations in data capture due to the variability in the field of vision and while different types of lenses and ways of wearing cameras may improve this, it is our preliminary conclusion that a wearable approach would struggle to consistently capture useful data for the *multiscreens* project.

Conclusions

This paper has contrasted two different data collection methods in the home. As a wider range of technologies become potential research tools, the choices to make in designing studies to capture behavioural data in the home increase. Through making comparisons such as this, we hope to support researchers to make more informed choices for their future studies.

Whilst wearable cameras have the benefits of flexibility, data granularity was lower, and a lack of researcher control meant that data quality varied greatly between participants. Conversely the 'infrastructure' approach allowed for high quality video data collection, network logging, and greater researcher control. Yet this method is less appropriate when studying behaviours distributed across the home space, and relies upon making greater assumptions and conducting work to adapt to the house and household.

In designing home-based studies, sensitivity to privacy and participant autonomy is important. The method used in the *multiscreens* studies led to some difficulty in finding willing and suitable participants. In this regard, wearable cameras avoid this through clear provision of agency for participants, and lack of changes to household infrastructure.

Acknowledgements

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