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Experiences of using a wearable camera to record activity, participation and health-related behaviours: Qualitative reflections of using the Sensecam

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Abstract

Objective: Upcoming technology is changing the way that we are able to collect data looking into activity, social participation and health behaviours. Wearable cameras are one form of technology that allows us to automatically record a collection of passive images, building a visual diary of the user's day. Whilst acknowledging the usefulness of wearable cameras in research, it is also important to understand individuals' experiences whilst using them. The aim of this study was to explore the acceptance, experience and usability of a wearable camera (Microsoft® Sensecam) to record the day-to-day activity and social participation of older people.

Methods: A total of 18 older adults, who had worn the wearable camera for seven days, took part in semi-structured interviews.

Results: Four themes emerged from the findings: 'Intrusiveness'; 'Importance of others'; 'Remembering the wearable camera'; and 'Ease of use'.

Conclusions: Individuals' expectations and experiences of using the wearable camera differed considerably. Participants believed that the wearable camera would be intrusive, difficult to use and would evoke public reaction; however, these worries were not borne out in experience. Individuals typically forgot about the presence of the wearable camera during use, remembering it only sporadically. One drawback to its use is that some participants were cautious of using the camera when around others, which impacted the amount of time the camera was worn, and, therefore, the nature of the data recorded. Design issues of the Sensecam were also a problem for the older adults in the study and affected their interaction with the technology.

Keywords

Wearable camera, Sensecam, older adult, life-logging, acceptance, usability, qualitative

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Introduction

Collecting data into activities, social participation and health-related behaviours can be challenging. The most common data-collection methods rely on self-report from study participants by way of questionnaires, diaries and interviews, or objective, performance-based measures such as pedometers and accelerometers. Self-report methods have the specific benefit of capturing information from the individual's own perspective[1,2] but are problematic due to their reliance upon

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memory and recall biases, a well-cited problem with the use of these data collection tools.[3] Pedometers and accelerometers also offer a method of gaining data regarding physical functioning; specifically, step count, intensity of movement and patterns of movement, which are all important aspects of health status and quality of life. However, performance-based methods can also be problematic as it can be difficult to detect slower walking speeds using these measures[4,5] These measures can also misidentify behaviours, such as standing being misclassified as sedentary behaviour, as they fail to record the context of the activities carried out.[6]

Continuous progression in mobile technology is beginning to allow information on daily living to be captured digitally with low participant burden.[7] Life-logging, also described as 'the quantified self', is the idea of automatically capturing several aspects of an individual's life using technology.[8,9] The wearable camera is one type of life-logging technology which is useful when recording and understanding daily functioning, and the context in which it takes place.[7] Wearable cameras automatically capture a continuous flow of images during use, essentially generating a visual diary of the user's day. The data produced by wearable cameras are advantageous over self-report measures due to digital memory being objective and more accurate than human memory which is 'patchy, emotion-tinged, ego-filtered, impressionistic and mutable'.[10] Wearable cameras offer a close equivalent of the 'gold standard' measure of observation within the assessment of health behaviours[11] and are more advantageous than manual cameras due to the automatic capture of images without user interaction, the long battery life and the ability to capture a large amount of images daily. Wearable cameras were initially used to help improve the memory of individuals living with cognitive deficits[12,13] and research in this area has shown images from wearable cameras to help improve people's memory for events.[14] However, since the early use of the Sensecam, its application has greatly widened, with wearable cameras being used to explore areas such as sedentary behaviour,[6] travel[15] and nutrition.[16]

While the functions of wearable cameras are primarily automated, their success as a data collection tool depends on the participant being fully cooperative in its use and accepting of its presence. One concern of collecting behavioural data using observation tools such as this, is the occurrence of the methodological Hawthorne effect; the potential of behaviour change as a direct result of being observed.[17]

Currently, the most comprehensive model of behavioural intention to use technology is the Unified Theory of Acceptance and Use of Technology; however, much of the work exploring the acceptance of technology use has been carried out within the field of information technology.[18] One other strand of technology experience focuses on immersion within the technology, and is termed '*flow*'.[19] The Flow State is a physical and psychological state that is experienced when a person is completely immersed within a performance. Despite well-established models of technology acceptance, experience and usability, recent discussion in the area has acknowledged the lack of research looking at the user experience and user acceptance of wearable technologies.[9,20]

Specifically, the user experience of older adults is a separate issue.[21] Contradictory messages about the technology use of the current generation of older adults prevail within popular culture. On one hand the term silver surfer[22] brings about images of older adults who are 'technologically savvy' and computer literate, whereas, older adults are also often portrayed as luddites who 'prefer to do things the old-fashioned way'.[23] Irrespective of the attitudes of older adults towards technology, it is important that the design of both hardware and software is suitable for the use, acknowledging the sensory, motor and cognitive functioning of older adults.[24–26]

The lack of published research into the user experience of wearable cameras is a gap in knowledge that this study aims to address. Specifically, the aim of this study was to explore user acceptance, experience and usability of using a wearable camera used to record day-to-day activity and social participation of older adults. Within this study, user acceptance is defined as the willingness to use the device, user experience is defined as the entirety of the individual's encounter with technology beyond its usefulness[18] and usability is defined as the device's ease of use.

Method

Design

This study is a qualitative study influenced by a Critical Realist ontology, a 'post-positivist' ontology which is situated in an anti-positivist movement in the social sciences.[27,28] This study utilised a Generic Qualitative Research methodology[29] as the nature of this research was unsuitable for traditional qualitative methodology.[30] This study draws on two models of technology use and acceptance to inform the interview schedule: the Unified Theory of Acceptance and Use of Technology,[18] and the Flow-State Scale.[31]

This study was conducted as part of a larger study to explore everyday functioning of older adults with chronic pain. The use of the wearable camera allowed additional insight into the effect of chronic pain on daily living that would otherwise not have been

gathered. As part of this larger study participants wore a wearable camera and completed a daily diary for a seven-day period. After this seven-day period, participants took part in two separate semi-structured interviews; one interview discussed the effect of chronic pain on daily living, and one interview focused on their use of the wearable camera during the study. It is this latter interview that is the focus of this study.

Sample

A purposive sample of 18 participants took part in this study (12 females, 6 males; aged 52–81 years). The participants were purposively sampled to fit the clinical profile of the larger study which looked at the impact of chronic pain on the daily functioning of older adults. Participants were excluded if they experienced cancer-related pain, were awaiting surgery or had undergone surgery in the last six months, or self-reported a diagnosis of dementia.

Purposive sampling was undertaken to include a wide range of participants, including those of different socioeconomic status, different living circumstances and different experiences of chronic pain. Although most participants were retired and living with chronic pain ($n = 14$), two older participants living without chronic pain, and two younger participants living with chronic pain were recruited for comparative analysis between groups, and included in the sample of this study. All participants were recruited from various social groups and organisations throughout the north east of England. None of the participants had previous knowledge, or experience, of wearable cameras prior to taking part in this research project.

The criteria for participation in this study was presence of chronic pain, with the use of the wearable camera being one way of measuring factors related to the presence of pain. It was explicitly stated within the participant information sheet that there would be no direct benefits for their participation, and participation would not affect treatment in any way.

Instrumentation

Sensecam

The wearable camera used in this study was the Microsoft® Sensecam (Figure 1).

The Sensecam is a small, light (93 g) camera and is worn on a lanyard around the neck, resting on the user's chest. The Sensecam comprises a camera (640 × 480 pixels) with a fish-eye lens to provide a horizontal 130-degree field of view.[32] The Sensecam automatically captures at least one image every 30 seconds (Figures 2 and 3).

Figure 1. The Sensecam.

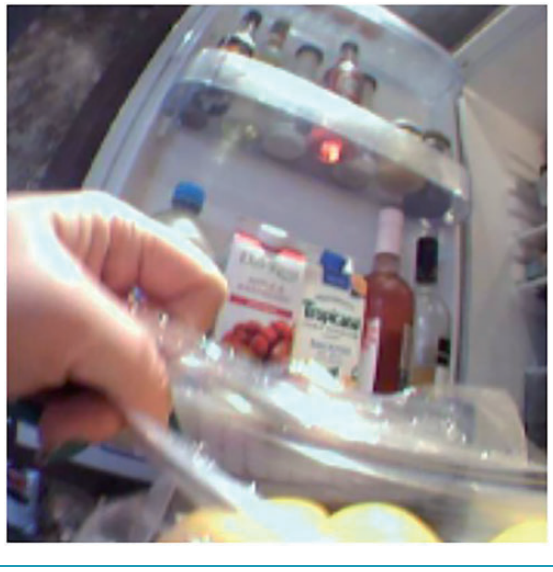

Figure 2. Image recorded by the Sensecam depicting food preparation.

Questionnaires

Participants completed two questionnaires about technology use and acceptance: the Unified Theory of Acceptance and Use of Technology[18] and the Flow-State Scale.[31] The Unified Theory of Acceptance and Use of Technology was completed twice; once before using the wearable camera, and once again after using the wearable camera for a seven-day period. Participants completed the Flow-State Scale once, after using the wearable camera for seven days. The answers from these questionnaires were used to guide the interview schedule without being restrictive, and acted as prompts throughout the interviews. This enhanced the depth of the discussion, and focused prompts on experiences before and after using the

device; however, it was important not to use these answers alone as these models of technology use and acceptance did not specifically consider wearable technology. Therefore, it was important to maintain an explorative analysis of the users' acceptance, experience and usability of using the wearable camera.

Interview schedule

The interview schedule comprised 20 questions which explored the participants' views on the wearable camera before use, during use and whether they had any intentions of using a wearable camera in the future (Figure 4).

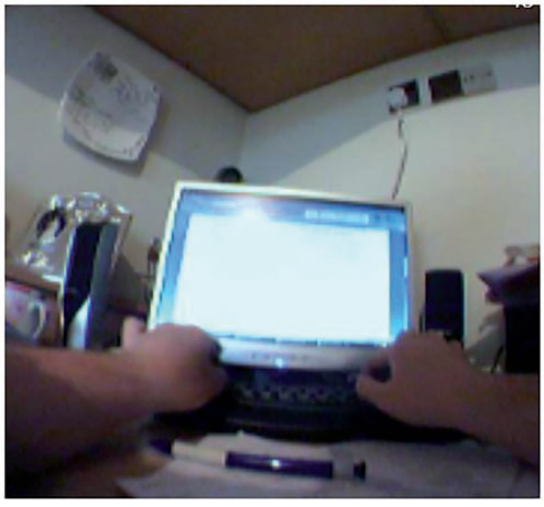

Figure 3. Image recorded by the Sensecam depicting use of a desktop computer.

The interview schedule was informed by the individuals' responses to the questionnaires. Prompts were provided throughout the interview to allow participants to expand on each answer, providing further detail to each response.

Procedure

Before gaining informed written consent from each participant, it was important that each individual understood how, and where, to use the wearable camera. GW carried out a preparatory visit to the homes of individuals interested in taking part in the study to explain the study and the use of the camera before they decided if they chose to consent to taking part. Participants received verbal and written instructions showing them how to use the camera, which they could refer to at any point during the study week.

A number of steps were taken to respect the privacy of participants and non-users. All individuals were shown how to use the 'privacy' button on the Sensecam which is pressed once to pause the recording of images, and is pressed again to resume recording. The individuals were made aware that they could either press the privacy button, or remove the Sensecam, at any time when using the wearable camera. Participants were also informed that they were to remove the wearable camera in any situation

- 1. Had you ever seen or heard of a wearable camera before beginning the study?
- 2. Were you happy with the thought of using the wearable camera before using it, or did you have some reservations?
- 3. Have your views changed about the wearable camera since using it?
- 4. Can you tell me how you felt about wearing the wearable camera?
- 5. Did you find the Sensecam easy to use?
- 6. Was the Sensecam clear and understandable?
- 7. Were you worried about making mistakes when using the Sensecam?
- 8. Was the wearable camera fun to use?
- 9. Were you apprehensive about using the wearable camera?
- 10. Did you feel comfortable/self-conscious whilst wearing the wearable camera? Why/why not?
- 11. Were there any problems with the Sensecam? Technical? Usability? Practical problems?
- 12. Do you feel as though you would have behaved differently if you were not wearing the wearable camera throughout the week?
- 13. Were there any activities that you did not want to take part in, or felt that you could not take part in because of the wearable camera?
- 14. Did you think that seven days was an appropriate lenght to be wearing the wearable camera?
- 15. Was it important that the research team were available when using the wearable camera?
- 16. Did others influence your decision to use the wearable camera?
- 17. Did your family and friends make any comments about the wearable camera?
- 18. Would you use a wearable camera again?
- 19. Would you use the Sensecam again?
- 20. Do you have additional thoughts or questions about the wearable camera?

Figure 4. Interview schedule.

that they felt uncomfortable wearing it, when partaking in water-based tasks or when at places such as schools, swimming pools or general practitioner surgeries. Participants confirmed their understanding of where they should not use the wearable camera as part of the consent form. Participants were asked to explain to others that the wearable camera was recording images when they entered their home, or when they entered the homes of others, and to remove the wearable camera if this was requested. On this preparatory visit, participants were given note cards which they could present to any individual that asked about the wearable camera. The note cards provided a brief overview of what the wearable camera was and also contained the contact details of one of the members of the research team.

Once participants were fully aware of how, and when, to use the Sensecam, they were asked to provide informed written consent. All participants in this study provided written informed consent according to ethical guidelines.

Participants completed the Unified Theory of Acceptance and Use of Technology questionnaire in order to gauge their initial views of the wearable camera before use, from which this data later informed the semi-structured interview schedule. At the end of this visit, GW asked participants to wear the Sensecam each day, for seven days. Participants were given the contact details for GW, and were encouraged to contact her if they had any questions, or needed any further guidance, at any point during the study week.

GW returned to the participant's home after the seven days of the study period. Participants were given assistance to upload their images onto the DCU Sensecam application software[33] and independently reviewed and deleted any of the images recorded on the wearable camera before any of the research team viewed them. Participants were given verbal instructions explaining how to do this, as well as written instructions (including illustrations). Each participant was asked to complete one copy of the Unified Theory of Acceptance and Use of Technology questionnaire and one copy of the Flow-State Scale questionnaire about their experiences of using the Sensecam. These responses guided the interview schedule.

GW left the participant's home and returned 1–2 days later to conduct semi-structured interviews with the participants, based on the interview schedule and their responses to the questionnaires. One-to-one interviews took place with the participants, and were audio recorded (mean length: 16 min; standard deviation: 18.76). The interviews were transcribed verbatim by GW before analysis.

Data analysis

In fitting with a Generic Qualitative Research methodology,[29] the transcribed interview data were analysed by GW using Thematic Analysis due to its '*theoretical* freedom'.[34] The aim of Thematic Analysis is to extract themes and sub-themes based on the written transcripts of the verbal accounts by participants essentially highlighting patterns within the dataset.[34] Specifically, the analysis followed the six steps of conducting Thematic Analysis: familiarising yourself with the data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; and producing the report.[34] GW developed each theme, and the themes were reviewed and defined with multiple team members. Using an iterative cycle, each theme was presented to DM and DJ alongside original quotes, and points were discussed, challenged and agreed. When conflicts emerged, raw data were re-examined and discussed until agreement was made between the research team.

Results and discussion

None of the 18 participants had any previous knowledge or experience of wearable cameras prior to taking part in this study. All but one of the participants continued to wear the Sensecam for the seven-day study period. There were four main themes that emerged when reflecting on the participants' experiences of using the wearable camera: 'Intrusiveness'; 'Importance of others'; 'Remembering the wearable camera'; and 'Ease of use'.

Intrusiveness

Prior to use, expectations of intrusiveness were based on the wearable camera acting as an observational tool and worry was expressed regarding the images that it would record: 'I thought ''oh gosh, this is too intrusive'', you know going everywhere with a camera around your neck' (P002, Female, 76). However, such worries were not borne out after having used it: 'Yeah [I thought it was going to be intrusive] but it wasn't . . . it wasn't intrusive at all' (P001, Female, 75). The intrusiveness of wearable cameras that capture automatic, passive images has been acknowledged.[35] Ethical guidelines highlight the intrusiveness of visual methods in terms of the large number of images captured and the potential for these to include 'unflattering' or 'unwanted' images.[35] An important part of the study's procedure was that individuals were able to review all of the images recorded over the study week, and delete any images that they did not wish to be seen, or analysed, by the research team. Participants were made aware that they were able to delete any of the images in the preparatory meeting, before agreeing to

take part in the study. The participants' heightened control of the images may have reduced participants' anxiety over the intrusiveness of the images themselves, within this study. It was not possible to distinguish how many images were deleted by participants. Missing images were easy to detect as all images were time-stamped; however, these images could have been 'missing' because the individual decided to delete the images, or, alternatively, because they chose to press the privacy button or turn off the camera during use. The research team did not discuss deleted images with participants so as not to compromise their privacy.

Contrary to initial expectations, it was the physical presence of the Sensecam that was felt to be intrusive by some participants. On occasion, the Sensecam got in the way of some daily tasks. For example, one participant felt it best to remove the camera whilst playing the ukulele due to its position on his chest:

> I think I did take it off to play [the ukulele], mainly because it was just where I wanted the ukulele, because you nestle it in your arm to play like that . . . it wasn't badly in the way but it was just easier to take it off. (P017, Male, 67)

Currently, research focusing on wearable technology highlights the importance of design and comfort in order to minimise the physical intrusiveness of the technology and to maximise physical movement during use.[36,37] The most recently developed wearable cameras, such as the Autographer® (OMG, Plc), can be clipped onto the user's clothes, as well as being able to be worn on a lanyard around their neck. This gives the user more flexibility in their use of the wearable camera, which may be helpful in minimising the camera getting in the way of certain activities.

The physical intrusiveness of the wearable camera also affected participants as they worried that they would break the camera during activities that caused the wearable camera to 'swing' (P016, Female, 52) or during activities such as baking, in which one participant was worried that the flour she was using could permeate the hardware (P009, Female, 65). The physicality of the Sensecam, in where it is worn, may be a design flaw in that individuals were worried about the wearable camera breaking and were cautious of using it. Currently, the Sensecam's design is as such that it is placed directly on the user's chest, on a lanyard, resulting in the camera occasionally getting in the way of daily tasks and swinging from side to side.

Importance of others

The importance of others dominated conversation within the interviews. Participants' expectations of how others would react to the wearable camera differed to their experiences. Wearable cameras, such as the Sensecam, are purposively designed not to be hidden from public view during use, including the visible flash of light signalling when each photograph is being taken.[38] Individuals were expecting others to comment on, or question, the use of the Sensecam whilst they were wearing it and most individuals felt that there would be more comments about the camera than they actually received: 'I was waiting for people to ask me what it was and they didn't, nobody did, and I mean I was really quite surprised' (P009, Female, 65). There were some instances in which participants felt that others had noticed the camera being worn around their neck, however, despite seeing the camera, individuals did not question participants about it: 'Not many asked about it but yes I'd say a lot of people noticed it, erm, and would look. But not many asked' (P016, Female, 52). These individuals wore the Sensecam in public, despite believing that others would notice the camera. It was upon wearing the Sensecam in public that the participants realised that the public reaction was different to that anticipated. However, the expectations of believing others would notice and comment on the Sensecam did affect use for some of the sample. Both P006 (Male, 74) and P015 (Male, 56) adapted the amount of time they wore the wearable camera solely due to their expectations of others' reactions to it. Although both P006 (Male, 74) and P015 (Male, 56) did not completely refrain from using the Sensecam, it did reduce the amount of time that the Sensecam was worn by these individuals over the study week. Purposively choosing to remove the wearable camera when around others presents an issue with the data captured, making it less representative of daily living. Not only does this affect information regarding social interactions, and time spent with others, but also biases and lessens the capture of other data, such as time spent walking in a public park or time spent at work.

Interestingly, participants were ethically conscious when using the wearable camera in the presence of non-users, and in some cases this affected the amount of time the camera was worn. One participant decided not to use the Sensecam outside of his house as he felt as though he was 'compromising' others (P006, Male, 74). Although the participants were happy to wear the Sensecam themselves, they sometimes worried about wearing it when around others and often removed the Sensecam whilst with others: 'I was more so wary that I was invading other peoples' privacy with it. That made me wary' (P016, Female, 52). One of the biggest issues surrounding life-logging technologies, specifically wearable cameras, is the ethics of their use, due to the unique risks that wearable cameras raise, and this is something that is still being

continuously discussed by leading academics in the field.[39] An ethical framework was developed for researchers to consider before employing visual methodologies, with four main guidelines: informed written consent of the participant; privacy and confidentiality; non-maleficence; and autonomy of third parties.[35] The guidelines highlight the potential intrusiveness of automatic visual technology and the importance of the privacy of non-users. One concern is for the privacy of 'non-users'; that is, the individuals who are recorded on the camera's images but who have not given any consent to be part of the study, or those who are unaware that they are being recorded on a wearable camera.[35,39] Within this study, it became apparent that the ethical use of the wearable camera was not solely an issue that the researchers were aware of, but that this was also important for the participants taking part in this study. Although the participants were happy to wear the Sensecam themselves, they sometimes removed the Sensecam whilst with others.

Remembering the wearable camera

Participants became accustomed to wearing the camera to the point that its presence tended to be noted only on certain occasions. Principally, participants forgot that they were wearing the camera, but there were often triggers that reminded them that they were wearing it. Participants sometimes 'forgot all about it by the end of the day' (P012, Female, 65) or were more aware of the wearable camera at the beginning of the week (P017, Male, 67). Alternatively, P002 (Female, 76) remembered the Sensecam when she saw the light flash on the top.

Forgetting the Sensecam in this way was both positive and negative. Forgetting the Sensecam was important as it meant that participants were more likely to behave in a way that was representative of their everyday life, without adapting their behaviour for the study. However, it was important that participants remembered the Sensecam in some situations in order to retain their privacy, and the privacy of others.

Two participants remembered the wearable camera and removed it when they felt that the images were 'boring' (P016, Female, 52) or they were doing repetitive activities: 'I think that I took it off on a night time simply because you don't want to see pictures of the ceiling, depending on what I was doing at the time' (P003, Male, 74). These two participants removed the wearable camera when they perceived the images were 'boring', which resulted in useful data being lost. Although removing the wearable camera during these 'boring' periods resulted in a loss of data, it was encouraging that participants simply removed the wearable camera, rather than changing their behaviour depending on what they believed the researcher wanted to see, as seen in the methodological Hawthorne effect.[17] The methodological Hawthorne effect has previously been seen with research using a manual camera, with participants using phrases such as that they wanted to produce 'good data',[40] whereas participants in this study removed the camera, as opposed to purposively changing their behaviour.

Finally, social influences also affected the awareness of the Sensecam. Participants sometimes became aware of the Sensecam when in the company of others, or when others asked about it. It was the behaviour of others that affected their own awareness of the Sensecam: 'I was conscious of wearing it erm . . . but only on the like the post office when I saw the look on the guy's face, I was conscious of him looking at me but apart from that no' (P003, Male, 74). Forgetting or remembering the equipment seemed to be sporadic for most participants throughout each day and participants tended to remember the Sensecam because of a physical trigger on the camera, the task they were doing or the social context that they were in. However, there were also tasks that participants took part in that did not trigger the awareness of the Sensecam. Although participants mainly removed the Sensecam when toileting there were some instances when participants forgot to do this and compromised their own privacy. In all of these cases participants deleted the images before the research team looked at them.

Ease of use

Prior to taking part in this study, none of the participants had either used, or were aware of, wearable cameras. This affected their expectations of using the wearable camera and most participants believed that the camera was easier to use than they had anticipated: 'I didn't know what it would be, what to expect, until you got it on and once I got it on, on that first day I was just, ok, it was completely different to what I imagined' (P001, Female, 75). After using the Sensecam, most participants gave positive feedback with regards to its ease of use, stating '[The Sensecam was the] easiest thing on the world' (P010, Female, 74) and 'No [I didn't have any problems with the camera] not at all' (P015, Male, 56). Rather than the Sensecam being difficult to use, participants had issues specifically with the design of the Sensecam as they experienced practical issues with its interface. The design of the Sensecam gives little indication of which button needs to be pressed for each function. P003 (Male, 74) described being anxious when using the Sensecam as he 'couldn't remember which button to press'. Additionally, although P011 (Female, 81) stated that the Sensecam 'didn't take any working really' she felt anxious when

pressing the buttons as she was worried of incorrectly pressing a button and ceased using it during day two of the study period.

As well as the anxiety of pressing buttons, the design of the Sensecam made it difficult for some of the older adults to physically press these buttons. Both P008 (Male, 66) and P009 (Female, 65) struggled to press the buttons as they were flat to the surface and were, therefore, difficult to press: 'I found the [buttons] on the camera it was a bit fiddly . . . that was the only thing that I found erm . . . difficult to use' (P007, Female, 65); 'The on/off [button] . . . having no finger nails I tended to use a key for the on/off [button]' (P008, Male, 66). Currently, the buttons of the Sensecam are flat to its surface, which created problems for the older adults using the Sensecam as part of this study. Research has expressed that the design of technology for use within the older population should be thorough, taking into account age-related changes including motor movement, sensory processing and cognitive functioning.[23,25] Specifically, decline in touch sensitivity can affect movements needed to interact with small targets and to press buttons,[24] making it difficult for these participants to interact with the Sensecam.

One participant stopped using the Sensecam during the study. P011 (Female, 81) stopped using the wearable camera on day two due to problems with usability. The participant felt anxious when using it, as she worried that she was using it incorrectly: 'I started getting a bit chewed up, a bit concerned about it you know . . . everything was going a bit wrong you know' (P011, Female, 81). The participant felt anxious when wearing the device, and because of this, ceased using it as part of the study. When specifically describing issues experienced with the Sensecam, it was apparent that she struggled to charge the device: '[I] put it on to charge up and when I put it on I wasn't sure whether I done I properly. Was it charged up when you got it back?' (P011, Female, 81). Participants were required to charge the Sensecam each night over the study period. Although others did not discuss issues with the charging process, P011 worried that she had not charged the Sensecam correctly, based on lack of information regarding its charge.

Participants' negative expressions of the user experience of the Sensecam focused on the use of its buttons; either with their anxieties of pressing the wrong button, or the physical difficulty in pressing the buttons. Additionally, one individual was anxious when charging the Sensecam, and worried about her ability to complete this process. However, there were some issues in the dataset, rather than from the semi-structured interviews, that identified potential difficulties in use that participants were unaware of. Of the 119 days that the sample took part in the study, 11 of these days were not recorded by the Sensecam due to user error of three participants. These participants were unaware that there were problems with their dataset and did not disclose any additional issues they felt they had experienced when using the Sensecam. It may be that individuals did not turn on the device, or that they did not charge the device correctly; however, as participants had assumed that these images had recorded and they had used the Sensecam correctly, further information as to why the images did not record is unknown.

Conclusion

This study explored the use of a wearable camera (Microsoft® Sensecam) with 18 older adults. Seventeen of the 18 older adults continued to wear the camera for the duration of the study period, with one user ceasing use of the wearable camera due to heightened anxiety and negative affect during use. Wearable cameras can be a valuable method of gathering objective, detailed data regarding activity, social participation and health-related behaviours. Wearable cameras provide an alternative to self-report methods, without relying upon memory for events, whilst allowing activity and participation to be recorded with the addition of contextual factors.

One recurring theme throughout the dataset was the difference between participants' expectations of using the wearable camera and their actual experiences of using it. Initial expectations were that the wearable camera would be intrusive, difficult to use and that being seen wearing the camera would evoke negative reactions from other people; however, these expectations were contrary to their experiences. In some cases, these expectations did affect the amount of time the camera was worn by some individuals who worried about compromising the privacy of others. The restricted use of wearable cameras in social situations has implications on what areas can be studied using wearable cameras. For example, studies focusing on social interactions, or activities outside of the home, may be biased due to the limited use of the wearable camera in these situations, restricting the use of these findings. Furthermore, these expectations may have an impact as to who would be willing to use wearable cameras as part of a research project, based on their assumptions of wearable cameras, once more having implications on findings from wearable cameras.

Participants generally became accustomed to wearing the camera and its presence only became an issue for them on specific occasions. Whilst this means that the data is more likely to be representative of daily living, forgetting the camera in some situations affected their privacy, and the privacy of others.

The apprehension surrounding the use of wearable cameras whilst being around others is another aspect that affects the nature of the data recorded. Participants were conscious of infringing others' privacy and this affected the amount of time some individuals wore the camera, therefore affecting the type of information shown on the camera.

There were design flaws to the Sensecam which hindered the usability of the wearable camera. The buttons of the Sensecam had little indication of their use which resulted in individuals being anxious of pressing the wrong buttons, and users also struggled to press these buttons as they were flat to the camera's surface. Despite wearable cameras no longer being manufactured, the problems older adults faced with the design of the Sensecam should be considered in the general design of wearable technology in order to ensure functionality and ease of use.

Limitations of research

Due to the predominantly qualitative nature of the study, there are limitations in the transferability of the findings. The population of interest in this study was specifically older people and care should be taken in extrapolating the findings. Furthermore, all participants were aware that the use of the technology was for only seven days and that it was for research purposes; therefore, results cannot be generalised to users choosing to use wearable cameras on a long-term basis outside of research. Finally, all of the participants that took part in this study were reasonably well-functioning older adults who were keen to use the technology.

Many individuals who were given information about the study did not wish to participate in the study. The number of individuals choosing not to take part in this study due to the use of technology is unknown as study information was presented to large community groups of older adults, with those interested in participating coming forward to the research team. Individuals may have chosen not to participate for a number of reasons, such as not presenting with chronic pain, and, therefore, this information cannot be determined. Of the individuals that spoke to the research team, or discussed participation with others but decided not to participate, some individuals were daunted by the technology itself and felt that they would not be able to use the technology, whereas others were more concerned about the content of the images that would be recorded by the camera and seen by others.

Issues surrounding the privacy of users have resulted in important information not being recorded as part of this study. Participants were able to delete any of the images recorded over the study period before this data was seen by the research team. In order not to impose on privacy, participants were not questioned about how many images were deleted or which images were deleted. It is, therefore, not known who deleted images, what images were deleted or why. Additionally, where missing data occurs, it is unknown as to whether the camera was turned off at this time or the images were deleted by the participant at the end of the study period. Despite being a limitation of this work, these ethical considerations conform with guidance from previous research which states that participant control is of priority, despite this compromising the data record.[39]

Future work

Before considering future research in this area, it is important to reflect upon the long-term application of wearable cameras. Due to the rapid progression of wearable technology it is important to look at the concept of the technology, rather than one specific piece of equipment. Only findings related to ease of use are specific to the Sensecam, with data concerning the intrusiveness of wearable cameras, the importance of others and the awareness of the device being transferrable to other wearable cameras. Since beginning this study, new models of wearable cameras have come onto the market; however, the premise of the product remains, and it is likely that individuals will experience many similarities when using other wearable cameras as they did with the Sensecam. This research has the potential to aid the development of future wearable technology.

From this research, it is recommended that further research involves a wider range of participants when looking at the usability, acceptance and experiences of the Sensecam, and other wearable cameras. Participants within this study were of a similar age and most were retired, with no experience of using a wearable camera. Furthermore, all individuals used the technology voluntarily, and for a set amount of time as a part of research. By gathering information from a wider range of participants, further research could add to the outcomes of this research regarding the important aspects of the Sensecam, or other wearable cameras. Data gathered from those not willing to use this technology as part of a research study would provide further information regarding the barriers to participation. Furthermore, data from 'secondary participants' would also be influential. Participants within this study expressed their perceptions of the views of 'secondary participants'; however, gaining the perspective these individuals first-hand would enhance knowledge in this area.

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