Using Photo Diaries to Elicit User Requirements from Older Adults: A Case Study on Mobility Barriers

David Swallow, Helen Petrie, Christopher Power, Alistair Edwards

HAL Id: hal-01599626
https://hal.inria.fr/hal-01599626

Submitted on 2 Oct 2017

Using Photo Diaries to Elicit User Requirements from Older Adults: a case study on mobility barriers

David Swallow, Helen Petrie, Christopher Power and Alistair D. N. Edwards

Human Computer Interaction Research Group, Department of Computer Science,
University of York, York, YO10 5GH, United Kingdom
`{david.swallow,helen.petrie,christopher.power,alistair.edwards}`
`@york.ac.uk`

Abstract. Older adults encounter numerous barriers to mobility, many of which are in the built environment. Technological solutions may enable them to mitigate these barriers and promote physical activity. To design appropriate technological solutions, it is crucial to understand the specific barriers to mobility older adults face from their perspectives. Photo diary studies allow older adults to autonomously document their experiences to support generation of user needs and requirements. We investigate the methodological appropriateness of photo diaries for exploring experiences of older adults and eliciting their requirements for new technologies. A photo diary study was conducted with 26 older adults, who were given disposable cameras to document things that affect their mobility. As well as presenting a selection of the mobility barriers identified in this study, the paper outlines a number of methodological issues relating to the use of photo diaries for eliciting the needs and requirements of older adults.

1   Introduction

Older adults encounter many barriers to mobility as a consequence of major changes in their lives. For instance, losing a partner or becoming a carer for someone, losing a driving licence due to illness or disability, and changing circumstances, such as retiring or moving house, can have a huge impact on the physical activity of older adults in the built environment.

Many mobility barriers that older adults encounter are in the built environment. This term refers to aspects of the physical environment that are constructed by human activity [9]. It includes the physical infrastructure of roads, pavements, cycle paths, railways, and bridges; transportation systems, such as bus and rail networks; the design of urban areas and the physical elements within them; and the distribution of activities (e.g. residential, commercial, industrial etc.) across these areas [5].

Technology can be used to support the mobility of older adults in the built environment. For example, walking aids, such as canes, crutches, and walkers assist peo-

ple with walking impairments. People with visual impairments commonly use canes as mobility aids. Wheelchairs and mobility scooters support people with more severe physical impairments. These mobility aids represent low-technology mechanical solutions for supporting mobility in older adults. Opportunities exist however, for high-technology solutions that enable older adults to mitigate the barriers they encounter and promote physical activity.

To design technology for supporting mobility in older adults, we must first understand how they experience and interact with the built environment. Many studies have investigated the impact of different characteristics of the built environment upon mobility in older adults (for reviews, see [8], [14]). Studies of this nature tend to assess the built environment either by objective measures of demographic and socio-economic characteristics (e.g. population density, land use diversity, street connectivity, or walkability indexes) or by subjective perceptions of local area characteristics (e.g. perceived neighbourhood security or the quality of neighbourhood facilities).

Whilst both objective and subjective measures show positive associations with mobility in older adults [1], [14], they each have potential drawbacks. Objective measures may be too general to identify specific mobility barriers, whereas subjective measures rely upon participants' perceptions of problems, as opposed to the actual presence of mobility barriers [8]. Further, neither approach is particularly suitable for eliciting the needs and requirements of older adults for high-technology solutions. A more appropriate method may be to have older adults identify specific mobility barriers in the built environment themselves.

Diary studies are a commonly adopted technique in the field of Human Computer Interaction for actively involving potential users in the requirements elicitation process [7]. These typically require participants to autonomously document their experiences through a series of diary entries that may later be used to prompt discussion with the users. Photographs, audio recordings and other media can be incorporated into diary entries both to enrich the data and ease the burden on participants to capture and later recall their contents. Indeed, a study investigating the use of different media in diary studies [2] demonstrated that photo diaries are the easiest for participants to capture and recognise at a later date.

Despite the apparent benefits of photo diaries, few studies could be found that utilise the method to examine the experiences of older adults. This paper explores the methodological appropriateness of photo diaries for examining the experiences of older adults and eliciting requirements for high-technology solutions. It investigates whether the application of photo diary studies can contribute to a greater understanding of the barriers that older adults encounter in the built environment and possible technological solutions to these barriers.

2 Related Literature

Many studies have considered the impact of characteristics of the built environment upon the mobility of older adults. Yen, Michael and Perdue [14] conducted a systematic review of 33 such studies conducted in the USA, Europe and Australia published

between 1997 and 2007, concluding that the neighbourhood environment has a large impact on older adults' health and functioning. Rosso, Auchincloss and Michael [8] conducted a similar systematic review of 17 studies conducted predominantly in the USA and published between 1990 and 2010, also identifying an association between characteristics of the built environment and mobility in older adults.

Yen et al. [14] included studies measuring both objective and subjective characteristics of neighbourhoods. Objective measures include demographic and socioeconomic composition, land use diversity, street connectivity, and 'walkability' indexes, derived from census and other administrative data. Subjective measures include perceptions of local area characteristics, such as perceived neighbourhood security or the quality of neighbourhood facilities, derived from survey data. Rosso et al. [8] only included studies measuring objective measures of the built environment.

Both objective and subjective measures of the built environment are positively associated with mobility in older adults [1], albeit potentially in different ways, as subjective measures show stronger associations with physical activity than objective measures [14]. Nevertheless, both approaches have potential methodological drawbacks. Objective measures may be the most common approach and the easiest for policymakers to tackle (e.g. installing cycle paths and walkways to promote a more active lifestyle [10]). However, they may be too broad to identify specific barriers to mobility in older adults and too impersonal to elicit the specific concerns of participants. Subjective measures, on the other hand, may be driven by psychological affect (the tendency to report consistently positively or negatively) [1], eliciting unfounded concerns that may be difficult to address. Indeed, Rosso et al. [8] excluded studies that used subjective measures because they rely upon participants' perceptions of problems as opposed to the actual presence of barriers.

A more appropriate method combining the subjective perceptions of older adults with the objective identification of mobility barriers is to have older adults identify specific mobility barriers in the built environment themselves. Diary studies are a commonly adopted technique in the field of Human Computer Interaction for actively involving potential users in the requirements elicitation process (for a summary, see [7]). These typically require participants to autonomously document their experiences through a series of diary entries that can later be used to prompt discussion. Photographs, audio recordings and other media can be incorporated into diary entries both to enrich the data and ease the burden on participants to capture and later recall their contents. A study by Carter and Mankoff [2] investigating the use of different media in diary studies demonstrated that photo diaries are the easiest for participants to capture and recognise at a later date. Though Carter and Mankoff do not specify the ages of participants, they do not appear to include older adults. Given the apparent benefits of photo diaries, it is surprising that we could find few studies that utilise the method for examining the experiences of older adults and eliciting their needs and requirements for technological solutions to mobility problems.

Ståhl, Carlsson, Hovbrandt and Iwarsson [12] identified environmental barriers and risk factors by accompanying older adult participants on walks along predetermined neighbourhood routes. This was triangulated with questionnaire data and focus group discussions, which identified and prioritised several measures aimed at increasing

accessibility and safety for pedestrians in the built environment. These measures included: the separation of pedestrians and cyclists; lower speed limits; and better maintenance of pavement surfaces. Whilst this study was successful in engaging older adults in the generation of needs and requirements, the methodology, by the authors' own admission, was demanding and complex to coordinate. Furthermore, the presence of a researcher during the observed neighbourhood walks as well as the use of predetermined routes may have compromised the spontaneity of participants' observations.

Schmehl, Deutsch, Schrammel, Paletta,Tscheligi [11] identified mobility barriers in the use of public transport using a modified cultural probe methodology. Unlike Gaver's original methodology [3], which is designed to elicit a holistic contextual experience, Schmehl et al. deployed directed cultural probes that were restricted to a specific issue. People with visual, cognitive or language-related disabilities, including older adults, were asked to document as many mobility barriers as possible during a two-week period using written diaries, cameras, voice recorders and checklists. Though the authors consider their approach to be an expedient modification of cultural probes, the number of diary entries generated by participants and the derived number of mobility barriers was disappointingly small.

A related technique, called *photovoice*, in which participants use cameras to record and reflect on their daily lives, has found several applications, including the identification of environmental barriers to and facilitators of walking in older adults [6]. While *photovoice* incorporates aspects of photo diary studies, its intended purpose is to engage communities, policymakers and stakeholders through focus groups and group discussions [13]. We found no studies that use photo diaries for the explicit purpose of eliciting the needs and requirements of older adults for technological solutions.

In this paper, we present a photo diary study of older adults on both barriers and aids to mobility they encounter in the built environment. We seek to answer the following questions:

1. What mobility barriers and aids do older adults encounter in the built environment?
2. Are photo diary studies an appropriate methodology for eliciting older adults' needs and requirements for new technologies?

3   Method

3.1   Design

Older adult participants were provided with disposable cameras. They were asked to take the cameras with them on any journeys they made outside of their homes during approximately two weeks and use them to take photos of things that affect their travels, both in positive and negative ways. This was followed by an interview in the participant's home during which they were asked to describe what they had taken in their photos and how it affected their mobility.

Participants were recruited from three locations in the UK: Hexham, a small town in Northumberland (population: 11,446); Leeds, a large city in West Yorkshire (757,700); and York, a small city in North Yorkshire (153,717). These locations were chosen as diverse examples of built environments, whose design, topography and infrastructure present a range of mobility barriers.

3.2 Participants

Twenty-six participants, all from the UK, took part in the study. Their demographics are summarised in **Table 1**. They were an invited subset of those taking part in the Co-Motion project[1], which is investigating the links between mobility and well-being in older adults. Participants were recruited on the basis that they were sufficiently mobile and willing to document their journeys. They received a £20 gift voucher in compensation for their time and effort.

Table 1. Demographic characteristics of participants.

Total	Gender		Age			Location		
	Male	Female	55-64	65-74	75-84	Hexham	Leeds	York
26	9	17	11	8	7	8	8	10

3.3 Equipment and materials

Participants were provided with a Kodak Fun Flash disposable camera with 39 exposures. Three participants opted to use their own camera or mobile phone camera. One participant opted to use the disposable camera but supplement it with photos taken with their own camera. Participants using a disposable camera were provided with a freepost envelope in which to return the camera to the research team for processing. Participants using their own camera were asked to email their photos to the research team.

Participants were provided with a detailed information sheet about the photo diary study, as well as a short reminder sheet describing the key objectives of the study. At the start of the follow-up interview, participants were asked to complete an informed consent form.

3.4 Procedure

Participants were invited to take part in the photo diary study based on their involvement in the Co-Motion project. Those who agreed were provided with the equipment and materials described above. Participants were asked to take the camera with them on any journeys they made during approximately two weeks and use it to take photos of things that affected their travels – both in positive and negative ways. Though the disposable cameras contained 39 exposures, participants were assured that they did

---

[1] http://www.york.ac.uk/chp/expertise/co-motion/

not have to use them all and could take as many or as few photos as they felt necessary. Participants who wanted to take more than 39 exposures were encouraged to use their own camera or mobile phone camera. Once participants had taken the photos, they were asked to send the cameras back to the research team.

Approximately one week into the exercise, a member of the research team contacted each participant by phone to check how they were doing with the study and to answer any questions. This contact point was also used as an opportunity to arrange follow-up interviews to discuss the participants' photos.

The follow-up interviews took place in participants' homes. Participants were asked how they found the photo diary study and whether they had encountered any problems, either in finding things to photograph or in using the disposable camera. The interviewer then went through the participants' photos and asked them to describe what they had taken and how it affected their mobility. Participants were assured of the confidentiality of the data they provided and that any identifiable aspects of the photos (e.g. faces, number plates etc.) would be obscured. The participants' consent for publication of the anonymised photos was obtained. Participants were also given the opportunity to exclude any of the photos from use in the investigation if they wished. With the participant's permission, audio of their voice was recorded for later analysis. The interviews lasted approximately 50 minutes.

3.5   Data Analysis

The audio recordings of each participant were fully transcribed prior to analysis. The photos were anonymised to ensure participants and anyone else appearing in the photos could not be identified. The transcriptions, with the accompanying photos, were then reviewed for all utterances that could be interpreted as representing either a barrier or aid to mobility.

This process built up a large collection of mobility barriers and aids. These were classified, using an emergent grounded theory approach [4]. The initial classification grouped the mobility barriers and aids according to different aspects of the built environment (e.g. pavements, roads, public transport etc.). Further analysis identified several distinct themes incorporating mobility barriers and aids from across all aspects of the built environment.

During the initial coding stage, the primary coder coded all 653 photos (and accompanying interview snippets) generated by all participants in the study. Two secondary coders coded approximately 10% of the photos (and accompanying interview snippets) to establish inter-coder reliability.

4   Results

4.1   Productivity of the photo diary study method

Participants generated a total of 653 photos (mean number of photos per participant = 25; min = 9; max = 44). The photos were accompanied by a total of 21 hours of interview data (approximately 50 minutes per participant). A total of 1,384 instances of

mobility barriers and aids were identified across all study locations (Hexham, Leeds, and York). This includes 816 instances of mobility barriers and 568 instances of mobility aids. Many of the photos incorporated multiple barriers and/or aids to mobility.

Many participants identified similar barriers and aids to mobility. Taking this into account, a total of 354 unique barriers and aids to mobility were identified across all study locations. This includes 187 unique mobility barriers and 167 unique mobility aids.

4.2 Thematic analysis of barriers and aids to mobility

The grounded theory analysis identified six distinct themes incorporating mobility barriers and aids from across all aspects of the built environment.

Stability and consistency of the built environment. A number of participants were unsteady on their feet or concerned for others with such mobility problems. Consequently, many barriers and aids to mobility were related to physical aspects of the built environment and the objects within it. **Fig. 1A** is an example of a participant's photo from this category.

Participants identified many mobility barriers relating to the poor condition of pavement and road surfaces. These included tripping hazards caused by protruding gratings and drains, broken or uneven paving slabs, and exposed tree roots. Several participants attributed these mobility barriers to poor workmanship and a lack of local authority funding. One participant said, about the local council: "They just never seem to get round to doing anything. And in these days of health and safety, they seem to get so uptight about health and safety and then these things can lie around like that. Potential hazards."

Environments that are stable, consistent and free of physical hazards promote mobility in older adults. Participants identified many mobility aids relating to pavements and road surfaces that are in good condition. Smooth, wide pavements that are open and free of clutter were identified as being particularly important. Several participants described how they were used to identifying aspects of the built environment that help and hinder mobility. One participant said: "When I'm pushing the wheelchair, I'm spending the time looking on the ground. People say hello and then I look up and see them. I'm always looking for hazards."

Although technology is unable to directly address many physical mobility barriers, it may allow older adults to circumvent them. Navigation apps, such as Google Maps[2], already supplement driving directions with traffic information, weather reports and business data. An extension of this could supplement walking directions with data on mobility barriers, allowing older adults to plan routes that will avoid them.

Clarity and visibility of the built environment. Participants identified many barriers and aids to mobility related to the clarity and visibility of aspects of the built envi-

---

ronment. This not only included the physical infrastructure, such as roads, pavements and street furniture, but also information sources, such as bus or train timetables and street signs. **Fig. 1B** is an example of a participant's photo from this category.

Poor clarity of pavements and roads were the cause of numerous mobility barriers, particular in areas shared by different users (motorists, pedestrians, cyclists etc.), where there may be little distinction between the two. This was a particular concern where pavements are divided into separate lanes for cyclists and pedestrians and unclear signage can lead to confusion. One participant said, about shared pathways: "Cyclists don't always realise that pedestrians may be coming off the pathway to cross the road. So they're cycling along at a mad speed, they don't ring the bell, and the pedestrian, who is probably slightly hard of hearing anyway, turns to cross and is at risk of being knocked down."

Environments that are easy to perceive and understand promote mobility in older adults. Clear and accurate information sources, such as bus and train timetables that are easy to read and include route maps, precise times, and other useful information, were identified as important aids to mobility. Electronic display boards for buses and trains were considered particularly useful. They not only provide reassurance that a bus or train is coming but also avoid lengthy waits at bus stops or train platforms. One participant said, about electronic display boards: "You have the backup of when the next bus is due, which means if you get there too early and it says 15 minutes to go, you can always nip into the shop or something rather than stand there in the cold."

Technology such as electronic display boards evidently goes some way to improving information delivery within the built environment. Although travel information is increasingly available via mobile apps, it is often limited to a particular location, company, or mode of transport. Greater unity and integration of travel information will make it easier for older adults both to plan journeys before leaving the home and access up-to-date travel information on the move.

Fig. 1. Examples of participants' photos of barriers and aids to mobility:
A: Broken pavement. B: Electronic display board. C: Busy road.

Safety and security of the built environment. Participants identified many barriers and aids to mobility related to the safety and security of the built environment. These impact upon both the physical safety of older adults as well as their emotional security and well-being. **Fig. 1C** is an example of a participant's photo from this category.

Participants identified many mobility barriers relating to busy roads that are difficult and dangerous for motorists and pedestrians to navigate. One participant said: "It is a problem for pedestrians to know precisely 'can I cross here or not safely?' So, some will think 'ah yeah, I can put a foot out into the road and get across' but there's no legal obligation on cars to stop."

Several mobility barriers were related to perceived threats to safety in the built environment, such as vandalism, the absence of street lighting, and a perceived lack of concern about such matters from the police and local authorities. One participant said, about an arson attempt in their local area: "If you report that to the police, they won't even bother coming out. But if it was cleaned more regularly, would vandals still do it? Would they think that someone was keeping an eye on it and think, 'Well, we won't bother'?" Whilst such problems may not represent direct barriers to mobility, they can result in older adults being reluctant to leave their homes.

Environmental features that promote safety, such as pedestrianised streets and shared spaces, traffic light-controlled pedestrian crossings or footbridges, and traffic-calming measures, such as speed bumps and speed restrictions, were identified as important mobility aids. One participant said: "The pedestrianised area is flat and easily accessible and less of a danger for people who are either elderly or frail. And for children to be able to run around a little bit as well. A pedestrianised precinct in certain areas is really positive for everybody of all ages."

Technology has an important role in promoting safety and security for older adults in the built environment. The mere presence of a mobile phone often provides passive reassurance to older adults and builds confidence in leaving the home. Mobile phones also provide a convenient means of reporting crime or alerting emergency services.

Beauty and upkeep of the built environment. Participants identified many barriers and aids to mobility related to the aesthetics of the built environment. These referred to both the inherent physical appearance of the built environment as well as the upkeep and maintenance of objects within it. **Fig. 2D** is an example of a participant's photo from this category.

The poor appearance of pavements, roads and street furniture, properties that are standing empty, litter and animal mess, the absence of trees, flowerbeds or hanging baskets, as well as the dull appearance of urban areas were the cause of several mobility barriers. One participant remarked: "What a dull and dismal place to live! Why don't we have a tree? … We get coachloads of tourists! Okay, it's not helped by the fact it's raining but why not some imagination?"

Similarly, the upkeep and maintenance of objects in the built environment, such as overgrown trees and bushes and the debris they produce, blocked drains, and water-logged pavements, was the cause of many mobility barriers. Participants attributed many mobility barriers to a lack of local authority funding, support and attention. One participant said: "I don't think it's cuts, I think it's full stop. Cuts mean you cut down a bit but maintenance just seems to have stopped and it's going to cost a fortune isn't it?"

Environments that are well maintained and attractive promote mobility in older adults. The presence of trees, gardens and flowerbeds were identified as important

aids to mobility. Whilst the appearance of the built environment may not directly impact upon mobility, it evidently influences the well-being of older adults and their desire to be mobile.

Though technology may be unable to increase local authority budgets, it may assist in prioritising and allocating resources. For example, older adults could use cameras in mobile phones and tablets to capture mobility barriers in situ and report them to local authorities, alerting them to aspects of the built environment that need attention.

Fig. 2. Examples of participants' photos of barriers and aids to mobility:
D: Mobility scooter in crowded area. E: Handy bench. F: Local bus service.

Propriety and thoughtfulness in the built environment. Participants identified many barriers and aids to mobility relating to the behaviour of individuals and consideration for certain groups of people, such as older adults or mobility scooter and wheelchair users. Courtesy and respect for each other promotes mobility in older adults. **Fig. 2E** is an example of a participant's photo from this category.

Aspects of the built environment shared by different groups of people, such as pavements, roads, and public transport, inspired several barriers and aids to mobility. Many related to the use, and misuse, of pavements, such as cars parking on or overhanging pavements or pavement obstructions (including bin bags and refuse bins, roadworks, A-boards[3], and restaurant chairs and tables). One participant said: "The A-boards were there and I was in the wheelchair, and I couldn't get round. It was just dreadful. And when people put chairs and tables outside. It's alright if there's plenty of pavement, but when there isn't…"

Participants identified many mobility aids relating to the provision of facilities for people with mobility problems. These include benches and places to sit, disabled parking spaces and wide parking bays for easy access, dedicated assistance on trains and planes, and considerate use of pavements and public areas. One participant said: "Putting a seat on stone paving in the middle of a grassy area for the elderly to rest. I thought that was good, the way it wasn't just put down but on a nice firm footing because it can be very muddy. So that's a positive. I thought that seat was good. Nice, well-planned, well thought out."

---

[3] A-boards are a type of advertising placed on pavements outside shops, cafes or other businesses. They comprise two boards displaying text or images hinged to form an 'A' shape.

In spite of many displays of carelessness in the built environment, there are many examples of thoughtfulness and consideration for older adults, be it wheelchair-accessible routes or convenient benches. Technology could be used to pool awareness of mobility aids among older adults and promote positive aspects of the built environment.

Freedom and flexibility within the built environment. Participants identified many barriers and aids to mobility relating to individual freedom and flexibility within the built environment. This freedom and flexibility may be a consequence of personal finance or health, or it may be due to public transport systems and provisions for older adults. **Fig. 2F** is an example of a participant's photo from this category.

Irregular public transport and the absence of connecting routes between certain locations were identified as mobility barriers. One participant said: "Where I used to live before it was one bus but now I have to get two buses there and it's quite a journey. It takes about an hour and coming back in the dark." This was considered to be a particular problem at night, when irregular or absent bus services may discourage older adults from venturing out. One participant said: "The #7 bus, which is very frequent in the day stops completely. So if I go out at night, unless I want to walk, I have to get a taxi, which costs a lot. My difficulty is if something has finished, a concert maybe, there's nowhere to wait in the warm."

Having a driving licence and access to a car was identified as an important aid to mobility, offering freedom and independence in older age. One participant said: "I took a picture of my car because I love it so much. I didn't start driving until quite late on in my 50s. I don't know what I'd do if I couldn't drive. It represents enormous freedom." However, the cost of running a car as well as the cost of parking was identified as a major mobility barrier. One participant said: "Parking charges … are as expensive as London. And the council are deliberately trying to get people to use the Park and Ride[4]. They want to kick people out of the city centre. I just think they've got a really anti-car attitude within the town."

Similarly, the cost of taxis and train tickets were identified as barriers to mobility but transport schemes such as the Senior Railcard and the free older person's bus pass[5] were highly praised by many participants. One participant said: "The best thing is the free bus. There's no doubt about it. I mean, in theory, I can go to London… if I wanted to travel on 30-40 buses and take 4 days! That's the beauty of it. That's the best thing."

Technology has a vital role in enabling freedom and flexibility within the built environment. Whether this involves clarifying and tailoring travel information, identifying accessible routes between locations, highlighting potential hazards or promoting positive experiences, there is huge potential for high-technology solutions to support the mobility of older adults.

---

[4] Park and Ride is a scheme to reduce car traffic in city centres. Free car parks are provided on the city outskirts, from where occupants can take a dedicated bus into the centre.

[5] People of pensionable age and disabled people in England are entitled to free off-peak travel on all local bus services anywhere in England.

Design solutions. A potential high-technology solution that draws together each of these themes is a mobile navigation app that allows older adults to plan walking routes in their local area. The app could identify routes that not only direct users away from known mobility barriers (e.g. roadworks, uneven surfaces, or steep steps) but also direct users towards known mobility aids (e.g. pedestrianised areas, good transport links, or simply nice places that encourage mobility). The data for such an app could be generated by users themselves and used to not only refine potential walking routes but also inform local authorities of neighbourhood mobility barriers.

Such an app could also be used to identify pedestrian desire lines. These are paths that pedestrians take informally, rather than using pavements or set routes. The app could (literally) crowd-source movement patterns in busy urban areas to identify routes taken by different user groups. The app could then use this data to create 'digital desire lines' informing users of the safest and most efficient route to take.

4.3   Methodological reflections on the photo diary method

In addition to identifying the barriers and aids to mobility that older adults encounter in the built environment and suggesting potential high-technology solutions, we also reflected on different methodological aspects of the photo diary method.

Familiarity with camera technology. The use of disposable cameras in this study was reasonably successful. Although participants were permitted to use their own camera or mobile phone camera, the majority of them used the disposable camera provided.

In addition to the reduced cost and lower risk of using disposable cameras, we anticipated that older adults would be more comfortable using this type of camera. Surprisingly, several participants said that they were more familiar with digital cameras and that it took them a while to reacquaint themselves with what they considered "primitive" or "prehistoric" technology. Not being able to immediately view photos resulted in many participants being uncertain about whether the camera had worked properly. Only one participant said they enjoyed using a disposable camera, remarking: "It was quite nice having what I would call an 'old-fashioned' type of camera. It wasn't digital. I didn't have to understand, I just had to point and press and wind on. I enjoyed that."

Four participants used their own camera or mobile phone camera to take photos. This proved to be a more efficient process, reducing the cost of processing, producing better quality photos, and allowing participants to use a camera that they are familiar with. Though only a small number of participants in this study were willing to use their own camera or mobile phone camera, we anticipate that older adults' increasing familiarity with digital technology will reduce the need for future studies of this nature to provide disposable cameras.

Feelings of self-consciousness. Taking photos of mobility barriers in public places made many participants feel slightly uncomfortable. Eight participants commented

that they had felt awkward or self-conscious. For some participants, this was due to the unusual nature of the exercise. One said: "Yes [there are difficulties], if you start taking photographs of inanimate objects. There was a sign where there was a road closed, and I was stood taking a photograph of that. That felt a bit odd." Another participant said: "There's a little snickleway[6]. As I approached it, there were two men and a woman who were taking pictures of the snickleway, so I had to wait for them to finish. And I felt a bit weird. They're taking a picture, they're probably tourists, and I'm taking a picture and I live here! It just felt a bit peculiar."

Other participants were more concerned about what other people might think. One said: "I find it quite difficult going around taking pictures because some people look very suspiciously at you if you stop and take pictures outside their shop. They want to know what it's all about and what you're doing, which is understandable." Another said: "[I was] fine, once I stopped feeling a little bit conscious that people would think I was spying on them. When you're doing it in your local area, you know other people in the houses, you're thinking they're going to wonder what on earth I am doing here!"

In spite of these concerns, three participants commented that once they informed observers about what they were doing, the observers became very interested. One participant said: "When I was taking the [photos] of the cars parked on the road, I had to wait several times for pedestrians to walk past. And they said: 'What are you doing taking pictures of the cars parked on the pavement?' And they all agreed that it was a nightmare." Another said: "I had one of the security men coming over and stood at the side of me and looking to see what I was doing. But he was really interested when I started telling him what it was about."

Remembering to take photos and recall them later. Diary studies place a considerable burden on participants to conscientiously document their experiences. Photo diaries may ease this burden by simplifying the process of creating diary entries. However, participants must still remember to take the camera with them and use it once they are out and about. Several participants in this study commented that they had struggled with this. One said: "With the photos, I sort of had to think. I had to remember to take the camera and then think to actually take anything. Sometimes I'd seen something I wanted to take and I'd forgotten the camera." Another said: "I've got out of the habit of looking at things with a view to photographing them. Time was, I wouldn't move without my camera. So, it was quite hard to think about what I was looking at and to see if there was a study for photographing."

Diary studies also require participants to recognise and discuss their diary entries during follow-up interviews. Photo diary studies have been shown to have advantages over other diary methods in this regard [2]. Despite an interval of approximately one to two weeks between the study period and follow-up interviews in the current study, several participants had forgotten what they had taken or why they had taken it. This resulted in some photos being unnecessarily discarded.

---

[6] 'Snickleway' is a Yorkshire dialect word for a small alleyway.

Flexibility of study duration. We recruited participants over a period of approximately 12 months. This meant that they completed the photo diary exercise at different times of the year. Though this did not cause any major problems, several participants who we recruited in the winter months commented that bad weather during the study period prevented them from going out and taking as many photos as they would have liked. Conversely, a number of participants who we recruited in the summer months expressed disappointment at being unable to take photos of weather-related mobility barriers, such as snow and icy surfaces.

The photo diary exercise required a reasonable degree of commitment and dedication from participants. Some participants felt the study period (approximately two weeks) was too short and they had run out of time. Others felt the study period was unnecessarily long. Their attitude appeared to depend on how they had approached the exercise. Some participants completed all diary entries in a single journey and found the study period too long. Others completed diary entries on different journeys throughout the study period and found the study period too short. Though the latter approach is what we originally encouraged participants to take, it did not seem to make any difference to the quality or variety of photos they produced.

Spontaneity of photo diary entries. Participants differed according to the spontaneity of their photo diary entries. The majority of participants completed diary entries whenever they noticed barriers or aids to mobility. However, some participants planned their diary entries beforehand. For example, one participant commented that they had completed the exercise "straight away, the first day I got it, I went out and managed to take quite a lot of photos. I knew the kind of things that I wanted to take." Another described how they "made a list of 18 [mobility barriers / aids]. I lay there and thought, 'right, this is what you're aiming for' and that's what I did, basically." Another participant said: "Once I started doing it, then ideas kept coming to us. As I drove round, there's some stuff I saw at random, and other stuff that I thought I would go and have a look at anyway."

Several participants found it difficult to capture certain barriers and aids to mobility in situ. For example, one participant mentioned they were unable to take a photo of them struggling to get onto a train with a heavy suitcase because they would have needed an extra hand. Some participants addressed this problem by taking photos to represent problems (e.g. a suitcase) rather than the actual situation in which they occurred. One participant said: "When you're travelling along you've already gone past something and you think 'I wish I'd taken that'. And it's too late then. So it's quite hard actually to find things to actually take photos of."

Attitudes towards the diary study method. Many participants commented that they had enjoyed taking part in the photo diary study. One said: "It was a really nice project to do. It was like being back at school. I got really enthusiastic about it." Several participants commented how the photo diary study had made them more aware of barriers and aids to mobility in the built environment. One participant said: "I found it quite interesting thinking of the things that are good and then also the sort of hiccups

that might cause chaos." Though we gave participants a £20 gift voucher for completing the photo diary study, several commented that they enjoyed merely being involved in the project and were not expecting a monetary incentive.

Some participants struggled with the photo diary exercise. Despite giving them an information sheet, a reminder sheet, and verbal instructions, several participants were still uncertain about what to take photos of. One participant said: "I had no problems taking the photographs, except I was a bit uncertain of what things would be best to take. Certain things that I thought in retrospect would have been better to take didn't get taken. Some things I took might have been better not taken."

Though we instructed participants to take as many or as few photos as they felt appropriate, the number of available exposures in the disposable camera (39) was too many for several participants, who felt pressured to use them all. One said: "With there being 30-odd photos, I found it difficult. I felt that I wasn't doing enough and I didn't want to repeat things." Another participant said: "[I found it] quite hard really. Because I don't get out, well, I do I get out a lot but it's all in this area and I tend to repeat the same journeys. So I had to actually look for things." Another participant said: "It's not easy. The biggest hazard is uneven pavements. But there's only so many uneven pavements you can take."

5   Discussion

The results indicate that photo diaries are an appropriate methodology both for identifying barriers and aids to mobility in the built environment and eliciting needs and requirements from older adults for high-technology solutions. Participants generated a substantial number of photos identifying numerous barriers and aids to mobility.

A grounded theory analysis of the data identified six distinct themes incorporating mobility barriers and aids from across all aspects of the built environment. These themes provide a basis for generating requirements for high-technology solutions that will enable older adults to mitigate mobility barriers and promote physical activity.

Many of the barriers and aids to mobility identified in the current study are similar to those identified in previous studies. Ståhl et al. [12], identified barriers relating to uneven pavement surfaces, busy roads, difficult road crossings, and the inappropriate behaviour of cyclists – all of which participants identified in the current study. Though Schmehl et al. [11] focused specifically on public transport, several of the mobility barriers they identified, such as inaccessible steps and exposed bus shelters, were also identified by participants in the current study. The focus groups and public discussions conducted by Lockett et al. [6] also elicited similar mobility barriers and aids to the current study, such as the difficulty of having insufficient time to cross busy roads or the benefit of pavements that have been cleared of snow and ice.

The similarity of the barriers and aids to mobility identified in these studies is perhaps unsurprising, given the similarity of the participants and study locations. However, in comparison to focus groups, cultural probes and accompanied walks, the photo diary method used in the current study offers a much simpler and less time-consuming approach, both for participants and researchers. Photo diaries elicit a com-

bination of the subjective perceptions of older adults and the objective identification of mobility barriers, avoiding many of the pitfalls of studies that rely exclusively on objective or subjective measures of the built environment (e.g. [8], [14]). The autonomous nature of photo diaries also omits the need for researchers to be present, as in Ståhl et al. [12], allowing for greater spontaneity and ecological validity of the data. Furthermore, depending on the purpose of the investigation, the data from photo diaries could easily be shared with policymakers and stakeholders, as in Lockett et al. [6], to stimulate broader discussions.

There were some limitations to the photo diary methodology used in this study. For example, the use of a camera possibly biased participants towards taking journeys on foot and identifying barriers and aids to mobility from that perspective. This was not always the case, as participants took a number of photos on public transport, on bikes, and in cars, but the vast majority of photos were taken from the pedestrian perspective. Similarly, the instructions we gave to participants possibly biased them towards taking photos of very 'concrete' physical barriers and aids to mobility in the built environment. Again, this was not always the case, as participants took photos of people, places, and artifacts such as bus passes or mobile phones, but the vast majority of photos taken were of physical barriers or aids to mobility. While there is great potential to address such barriers via appropriate policy interventions [8], the scope for addressing physical barriers through high-technology solutions is more limited. In light of this, it may be necessary to refine the photo diary methodology to encourage older adult participants to consider a broader range of barriers and aids to mobility.

Participants in this study were an invited subset of those taking part in the Co-Motion project and were recruited on the basis that they were sufficiently mobile and willing to document their journeys. This meant that Co-Motion participants who were less mobile, and perhaps faced the biggest mobility barriers, were typically not invited to take part in the photo diary study. Future studies should aim to recruit a broad selection of participants who vary in mobility. Some of the more able-bodied participants in the photo diary study felt it was intended more for people with severe mobility problems. As a result, they tended to take photos of things that might help or hinder people with mobility problems (but did not actually affect them personally). There is a danger with this approach that the study only captures perceived, rather than actual, barriers and aids to mobility. Future studies should perhaps place greater emphasis on issues that directly affect participants.

Carter and Mankoff [2] demonstrated that photo diaries are the easiest method for participants, both for generating diary entries and later recognising their contents. However, some of the older adult participants in this study experienced difficulties both in remembering to use the camera and recalling what they had taken during the follow-up interview. In some photo diary studies, researchers prompt participants to complete diary entries at particular times of day [7]. Such an approach would not have been appropriate in the current study, given the emphasis on capturing mobility barriers and aids whenever and wherever they occur. The follow-up phone call made to participants in the middle of the study period did however prove useful for providing additional guidance and encouragement. Ensuring a minimal amount of time between the study period and follow-up interview also ensures that participants recall as much

information as possible. Some participants in this study kept notes of what they had taken, which they used as prompts during the follow-up interview. Though this would add to participants' workload, it may be a sensible recommendation for any future studies.

Participants in this study differed according to how they completed their diary entries. Some planned their entries before embarking on a journey; others captured diary entries more spontaneously. Similarly, some participants completed all diary entries in a single journey; others completed them on different journeys throughout the study period. Though we encouraged participants to make spontaneous entries diary entries throughout the duration of the study period, it did not seem to make any difference to the quality or variety of photos they produced. However, for participants who planned their photos beforehand, it is, again, possible that they were capturing perceived, rather than actual, barriers and aids to mobility. For instance, one participant said: "The only thing I couldn't find when I wanted one was an overhanging tree. That was something I couldn't get. All the ones along here that had been annoying me for weeks have all been cut back." Future studies should perhaps place greater emphasis on issues that actually, rather than potentially, affect participants.

Many of these methodological drawbacks could easily be addressed in future studies. The feelings of awkwardness or self-consciousness that many participants experienced when taking photos of mobility barriers in public places may be more difficult to address. Future studies should perhaps encourage participants to discuss what they are doing with interested observers, as this appeared to satisfy their curiosity in this study. Ultimately, many participants in this study enjoyed the photo diary exercise and felt it had raised their awareness of barriers and aids to mobility. With some methodological adjustments, photo diary studies can be considered an appropriate methodology for eliciting older adults' needs and requirements for new technologies.

6   Conclusions

In this paper, we have presented a photo diary study conducted with 26 older adults in the UK who were given disposable cameras to document things that affect their mobility. We have presented a selection of the mobility barriers and aids identified in this study, grouped according to six distinct themes reflecting older adults' experiences from across all aspects of the built environment. We have also outlined several methodological issues relating to the use of photo diaries for eliciting needs and requirements from older adults.

The photo diary method is not without its limitations. We have outlined several issues relating to the use of disposable cameras with older adults; older adults' self-consciousness when photographing their neighbourhoods; older adults' difficulties in remembering to create photo diary entries; and older adults' differing interpretations of the study protocol.

However, this study has shown that photo diaries are an efficient, flexible, and productive method both for identifying barriers and aids to mobility in the built environment and eliciting needs and requirements from older adults for new technologies.

Research Data Availability. Researchers wishing access to the data used in this study should visit the following URL for more information: http://www.cs.york.ac.uk/hci/comotion

References

1. Bowling, A., Stafford, M.: How do objective and subjective assessments of neighbourhood influence social and physical functioning in older age? Findings from a British survey of ageing. Soc. Sci. Med. 64(12), 2533-2549 (2007)

2. Carter, S., Mankoff, J.: When participants do the capturing: the role of media in diary studies. In: 23rd SIGCHI conference on Human factors in computing systems, pp. 899-908. ACM, New York (2005)

3. Gaver, B., Dunne, T., Pacenti, E.: Design: Cultural Probes. Interactions 6(1), 21-29 (1999)

4. Glaser, B., Strauss, A.: The discovery of grounded theory. Weidenfield & Nicholson, London (1967)

5. Handy, S.L., Boarnet, M.G., Ewing, R., Killingsworth, R.E.: How the built environment affects physical activity: views from urban planning. Am. J. Prev. Med. 23(2), 64-73 (2002)

6. Lockett, D., Willis, A., Edwards, N.: Through seniors' eyes: an exploratory qualitative study to identify environmental barriers to and facilitators of walking. Can. J. Nurs. Res. 37(3), 48-65 (2005)

7. Palen, L., Salzman, M.: Voice-mail diary studies for naturalistic data capture under mobile conditions. In: Conference on Computer Supported Cooperative Work, CSCW 2002, pp. 87-95. ACM, New York (2002)

8. Rosso, A.L., Auchincloss, A.H., Michael, Y.L.: The urban built environment and mobility in older adults: a comprehensive review. J. Aging Res. 2011 (2011)

9. Saelens, B.E., Handy, S.L.: Built Environment Correlates of Walking: A Review. Med. Sci. Sports Exerc., 40(7 Suppl), S550–S566 (2008)

10. Sallis, J., Bauman, A., Pratt, M. Environmental and policy interventions to promote physical activity. Am. J. Prev. Med. 15(4), 379-397 (1998)

11. Schmehl, S., Deutsch, S., Schrammel, J., Paletta, L., Tscheligi, M. Directed cultural probes: detecting barriers in the usage of public transportation. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (eds.) INTERACT 2011, Part I. LNCS, vol 6946, pp. 404-411. Springer, Heidelberg (2011)

12. Ståhl, A., Carlsson, G., Hovbrandt, P., Iwarsson, S.: "Let's go for a walk!": identification and prioritisation of accessibility and safety measures involving elderly people in a residential area. Eur. J. Ageing, 5(3), 265-273 (2008)

13. Wang, C., Burris, M.A. Photovoice: Concept, methodology, and use for participatory needs assessment. Health Educ. Behav. 24(3), 369-387 (1997)

14. Yen, I. H., Michael, Y. L., Perdue, L.: Neighborhood Environment in Studies of Health of Older Adults: A Systematic Review. Am. J. Prev. Med. 37(5), 455–463 (2009)