Experiences of In-Home Evaluation of Independent Living Technologies for Older Adults

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ABSTRACT

Evaluating home-based independent living technologies for older adults is essential. Whilst older adults are a diverse group with a range of computing experiences, it is likely that many of this user group may have little experience with technology and may be challenged with age-related impairments that can further impact upon their interaction with technology. However, the evaluation life cycle of independent living technologies does not only involve usability testing of such technologies in the home. It must also consider the evaluation of the older adult's living space to ensure technologies can be easily integrated into their homes and daily routines. Assessing the impact of these technologies on older adults is equally critical as they can only be successful if older adults are willing to accept and adopt them. In this paper we present three case studies that illustrate the evaluation life cycle of independent living technologies within TRIL, which include ethnographic assessment of participant attitudes and expectations, evaluation of the living space prior to the deployment of any technology, to the final evaluation of usability and participant perspectives.

1. INTRODUCTION

Independent living means something different to each older adult. For some it may mean not depending on others for assistance with daily activities. It might also mean having the mobility to retain an active life, or simply the ability to live at home, as opposed to living in a care facility. Independent living technologies facilitate remote monitoring of older adults in their homes. Such technologies can only be successful, however, if older adults are willing to accept and adopt them. As such, technology should assimilate effortlessly into people's existing homes and their daily routines, in addition to being intuitive to use. Evaluation is necessary to ensure these criteria are met.

In this paper we discuss experiences of evaluating pilot trials of independent living technologies for older adults in-situ, i.e. in their homes. We focus on the participant, evaluating the usability of technologies placed in the older adult's home as well as assessing the impact of such technologies in their day to day lives. This work represents a collaboration of design, ethnographic and usability research conducted within the TRIL Centre (Technology Research for Independent Living). The goal of the TRIL Centre is to accelerate research and development of independent living technologies that help older people to live in the homes of their choice, even in the midst of age-related illnesses and injuries. As such, TRIL deploys a number of interactive technologies and sensor systems in older adults' homes to collect physiological, environmental and computational context data for clinical study into falls prevention, social connectedness and cognitive function of older adults. To be successful in the short term, in-home deployments must collect high quality context data, suitable for clinical research and useful for feedback to the older adult. To be successful in the long term, technologies must ultimately help older adults 'age-in-place', ideally in their own homes [12].

Evaluating the impact of in-home technologies on older adults is crucial. Many studies focus on the clinical and cost benefits of in-home technologies for independent living, without considering the older person's perspective [6]. However, user-centred evaluation of in-home technologies is necessary for a number of reasons:

- To inform design.
- To open up understanding of user behaviour and experience.
- To ensure the home-based technology is usable and receptive to user needs.
- To ensure optimal interaction.
- To ensure seamless integration with the participant's day to day living, minimising any negative impact on the participant.

To gain insightful data, it is necessary to conduct longitudinal studies within the home context. While this presents some challenges for the collection of clinical data (in terms of battery life of sensors, for example) it is particularly difficult to assess user impact and usability in situations where sensors are placed in the home or must be worn by participants, or when interaction is required between the older adult and a piece of technology on a day to day basis.

Ethnographic assessment of user impact is a key aspect of the evaluation cycle. For example, the participant might be required to wear sensors for the collection of health-related data. It is critical to examine how this might affect their day to day living. Fundamentally this is not only from a practical point of view: 'are the sensors uncomfortable to wear?'; 'do they stop the older adult performing certain activities'?, but also from within a framework of individual, social and cultural attitudes to monitoring: 'what might the wearing of a health related monitor signal to others'?; 'how does the older adult justify the need to be monitored'?

As we have developed elsewhere [3], attitudes may be formed through past experiences, as well as present understanding. Thus within TRIL, whilst we work with older adults in their own homes to elicit how 'new' technologies may help sustain independent living, we also evaluate older adults' life long relationship with technology as part of everyday life. Within the first year of TRIL, three ethnographers had contact with 26 households and visits ranged from one to 10 over a 10-month period. The visits fitted around the lives of the participants and included taking part in their routines, such as going shopping, meeting with family, friends and neighbours, joining a prayer meeting or going for a walk. Participants' everyday activities, routines and interests, including challenges and coping strategies were recorded. We gathered information on social networks and on health status as well as on future hopes and concerns. Our evaluation cycle thus includes ethnographic assessment that positions older adults as individuals with diverse life course experiences that in turn, may impact on present use and understanding of technology.

Moreover and as we discuss in case study 1 below, before setting out to deploy new independent living technologies, we conducted a small pilot and evaluation of existing in-home, 24 hour ambulatory monitoring of fallers. The TRIL cohort includes older adults who have a history of falls and/or black outs. To further understanding of why people are falling or having black outs, some fallers are invited to undergo ambulatory monitoring. This entails wearing an appliance that records specific physiological readings (such as heart rate or blood pressure) over a period of time, usually 24 hours. This means that the wearer takes the monitor into his or her home. Case study 1 outlines four usability issues that emerged from this pilot and that have significance for longer term wearing of sensors for the collection of health-related data.

Within TRIL, we have found that prior to the deployment of independent living technologies, it is necessary to evaluate the living space. This is primarily a design-led approach, whereby the participant's living space is mapped out to ascertain what spaces are used for certain activities, and assisting identifying optimal locations for technology placement. This is a crucial step for in-home studies as it can help to determine whether or not the technology deployed will be accepted by participants, successfully adopted and whether the data captured by the technology will be effective. Ideally, any technology placed in the home should not only be aesthetically pleasing, but also unobtrusive.

Finally, assessing usability is a critical aspect of in-home independent living technologies. Such technologies have older adults as their target user group, who are typically not familiar with technology and who may have age-related physical or cognitive impairments which can inhibit their ability to learn to use technologies. Furthermore, independent living technologies aim to *assist* older adults to age in place - they should not create new challenges to their daily lives [11]. If a technology is not usable it may impede the collection of clinical data which relies on interaction with that technology, as it will simply not be used. For a technology to be usable by older adults, it should be easy to use, ideally be error free (or support recovery from errors) and be easily learnable. However, there are a number of challenges associated with assessing the usability of technologies placed in the home for long periods of time. Methods are needed to collect both quantitative and qualitative usability data, without observers or evaluators being present in the home each time the technology is used, that can inform re-design and that allow us to understand and optimise the user experience.

In this paper we present experiences of field evaluations of pilot TRIL technologies in a number of older adults' homes. We outline three case studies - an ethnographic assessment of the impact of clinical monitoring technology on older adults, as this raised usability issues that could inform longer term wearing of sensors for the collection of health-related data; evaluating the living space and usability assessment of in-home interactive technologies. These studies provide an overall picture of our experiences in conducting in-home evaluations of independent living technologies that focus on the participant.

2. CASE STUDY 1 - ETHNOGRAPHIC ASSESSMENT OF USER IMPACT

As outlined in the introductory section, ethnography is integral to our in-home evaluation of independent living technologies for older adults. Emergent findings from our first year of participatory contact with older adults underpinned the development of more focused multidisciplinary TRIL in-home pilot projects, including in-home usability of movement sensor technology, internet phone systems and testing cognitive alertness. Deployment ranged from 24 hours to several weeks. Our research activity also raised questions about how multidisciplinary teams of clinicians, engineers, research scientists, designers and ethnographers can work with older adults to introduce new technology into their homes and respond to ongoing user experiences.

We have written elsewhere about what we learned about recruiting and retaining older adults onto home based technologies research [1]. As others have asserted [5] we also found that older adults are not averse to new technology providing it is practical and useful and critically, appropriately introduced. For example we found that when introducing a new form of internet phone system, participants need time to 'play' with the technology, to get used to 'keys', 'controls' 'functions', to be able to ask what they may feel are 'stupid questions', such as 'where does the email 'go' when you send it'? and to have these answered. They need space to be curious, to build confidence and eventually, to replace understandable 'worry' about 'not doing it right' with new found confidence and rewardingly, curiosity and excitement about the potential of the technology.

Before deploying 'new technologies'in the home, we conducted a small pilot and evaluation of existing in-home 24 hour ambulatory monitoring of fallers. Four TRIL participants, with histories of falling, took part in the pilot. During the monitoring, two of them agreed to the ethnographer spending time with them in their own homes and two were interviewed retrospectively. Three of the participants were being monitored to collect blood pressure recordings and one, heart rate tracings. From within the clinical setting, the wearer was given clear verbal and written instructions and also asked to record a simple activity diary (e.g. time of going to bed etc.), so that what is monitored may be correlated with what is self recorded. The monitoring day was followed up the next morning with either a telephone interview or a home visit to reflect on the night time monitoring experiences From content analysis of field notes and transcripts from ethnographic observations and retrospective and evaluative interview data, four usability issues were identified:

1. In relation to the monitoring process, how written and verbal instructions/guidance offered in a clinical setting are 'acted upon' in the home/wider environment;

2. Wearer's understanding of and interaction with, the monitoring device;

3. Wearer's sense of ownership of the device;

4. Impact of wearing the device on everyday behaviour.

2.1 'Acting upon' clinical instructions at home

All four participants were articulate and during the clinical setting, responded well to instructions. The activity diary asked participants to record their 'daily activities.' Whilst for one participant, walking the dog was viewed as a daily activity and recorded, for another, hanging out the washing was part of the taken for granted back drop of everyday life and not recorded.

Marking wakefulness and sleep periods seemed straightforward except one participant was disturbed by the monitoring process, awake for periods of more than an hour, up, active and making tea. This was not her usual night time behaviour and she was unsure whether she should record this.

2.2 Wearer's understanding of and interaction with, the monitoring device

The monitoring devices were bulky, consisting of a palm size monitor that could be worn with a shoulder or waist strap and this attached either to a blood pressure cuff [this recording taking half hourly to hourly readings] wound around the upper arm, or to leads, attached with sticky dots to the chest. All the participants had a rational explanation for undergoing monitoring, for example:

"*it's good to know if the [blood] pressure drops when I stand or bend down, that's why I need to put in that log what I'm doing and the time, they set it against what the monitor says, clever that*"

Underlying tangible worries were also expressed: what if the monitor 'isn't *working*', '*gets damaged*', '*does something it shouldn't*', *is really uncomfortable and does me 'damage'* (e.g. cuff too tight; 'stickies on chest causing bad rash').

2.3 Wearer's sense of ownership of the device

There was some surprise at an emotional reaction to '*the need to be monitored*' even though rational explanation had been given and some exploration of the relinquishing of personal autonomy. For example, Thomas recently widowed and suffering from 'frightening' blackouts, whilst initially cheerful and very positive about '*this helping to get me sorted*', shared a meal with the ethnographer and confided:

". . .see it's not the contraption itself, this is hard to explain, you know it is a bit of a bother, blowing up your arm [a BP cuff taking half hourly readings]*, but you think, Jasus [sic] imagine if you HAD to have things done to you all the time, if you had to be thinking all the time that there was this thing wrong with you and you needed to be checked and you might end up, well not being your own man, am I making sense?"*

2.4 Impact of wearing the device on everyday behaviour

These monitors were bulky and ambulatory sensors can be much more unobtrusive, streamlined, incorporated into an everyday object such as a watch or attached to everyday clothing such as a belt. However wearing of the device had social implications beyond the bodily sensation of wearing it. Liam is married, a slight man in his late 70s who likes a daily routine of a solitary afternoon walk and meeting with his pals for a drink in the local pub: *"gets me out of the house"*. However whilst wearing the heart monitor which was discreetly tucked away under his clothing, a vest, shirt and jumper, Liam decided to abandon this routine. The monitor is not visible, yet he says *"imagine all the questions and the jokes about going to the dogs."*

During the BP monitoring, one participant said to the ethnographer that he will carry on with his normal routines (walking the dogs, heading to the local shop for a newspaper, meeting up with a 'pal' for dinner in the local bar). As the day progressed these activities were abandoned: "*well it's*[the monitor] *not a fuss but it's probably best just to stay quiet, it's only a day and the daughter will take it back*[to the hospital] *tomorrow and then I suppose I have to wait for the results."*

This pilot demonstrated that even when older adults express willingness for ambulatory monitoring, evaluating its usability 'in-situ' and within the context of everyday life is critical, not only to improve on design but also for the participant themselves. Social aspects such as embarrassment or heightened awareness of health status may not be thought through when first presented with a wearable device. Yet these can have profound implications for ongoing use. As the following case studies illustrate, if technologies and sensor systems in homes are to collect high quality physiological, environmental and computational context data, suitable for clinical research and useful for feedback to the older adult, in-home evaluation of the usability and impact of such technologies is crucial.

3. CASE STUDY 2 - EVALUATING THE LIVING SPACE

Much research into assistive and independent living examines the idea of smart homes to monitor activities of daily living. Smart homes may involve developing new homes, or living laboratories, embedded with sensors that support continuous mobility assistance, health monitoring, disease prevention etc. [13], [10], [7]. While such smart homes have been described as "an authentic yet experimental setting" [10] they do not relate to 'real' homes, which are different shapes and sizes and that may contain (potential) obstacles to home deployments. In TRIL our goal is to place such technologies into older people's *existing* homes, ensuring they are unobtrusively integrated within the normal living environment of the older adult.

In some instances, depending on the technology to be deployed, it is necessary to visit the home to evaluate the living space. This evaluation is important to determine whether or not the technology to be deployed will be accepted by participants and successfully adopted within the home, as well as ensuring the technology will enable us to successfully acquire clinical data. In the planning stages of a project, a list of minimum criteria is drawn up. This list is used to evaluate the living space and the participants' potential use of the technology. 'Living space' refers to those areas of the home within which participants move around and carry out every day activities. Once each of the criteria are met, the assessment of which is conducted by both engineering and ethnographic researchers, the technology can then be deployed. Practical concerns such as access to power sources and internet connectivity need to be in place for the technology to function at all. Also of great importance is ensuring that the technology integrates seamlessly with the participants' day to day living. The greater the number of engineering and user-centred concerns that arise during the planning stages, the longer the set of criteria for evaluating the home. These evaluations are separate from evaluations of the technology itself. Considerations such as how the participant interacts with the technology are not taken into account in this instance. What is taken into account is *where the participant interacts*, *where the technology is placed* and *how the technology could potentially impact on the person's day to day living*.

As previously noted above, the level of evaluation depends on the type of technology to be deployed. In some cases very little evaluation is required beyond determining that there is a space to set up the technology. In other instances a more in depth evaluation is required. This is illustrated by the following example.

Within TRIL, one home deployment involved placing motion sensors in specific locations in eight peoples homes. The home owners were fallers, and the TRIL pilot wished to correlate specific movements within the home, with possible causes for falls. The motion sensors included five 'dwell' sensors and one 'rail' sensor. The 'dwell' sensors were placed above doorways and ceilings in the living space - typical positions where a person may have cause to dwell. For example, dwell sensors would ideally be placed at the crossover between spaces of significant light to dark transition, steps, regularly used rooms such as the kitchen, bathroom, main bedroom and the main living area (Figure 1). The 'rail' sensor consisted of three motion sensors positioned at equidistant intervals on a plastic rail, that would be attached to a wall along a main pathway in the home, such as a hallway for example (Figure 2). The rail sensor was used to determine velocity of the person at various times of the day. Data collected by the sensors were relayed wirelessly to a laptop computer placed in an unobtrusive location within the home. The entire system was intended to be completely unobtrusive. The sensors collected data from the participant without requiring the participant to interact with the technology in any way.

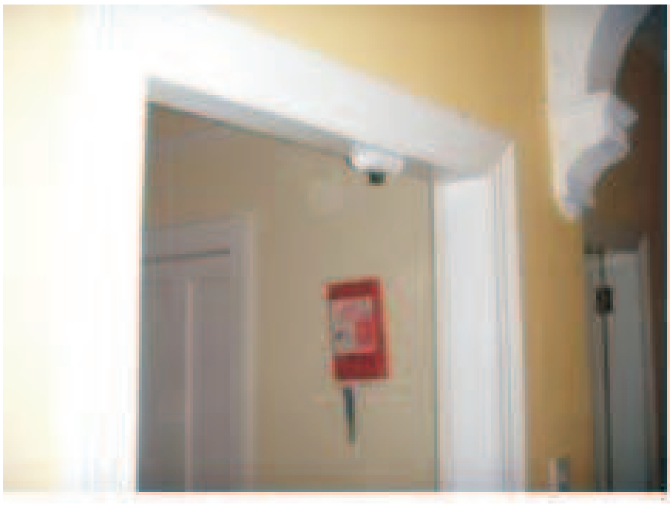

Figure 1: Dwell Sensor Location

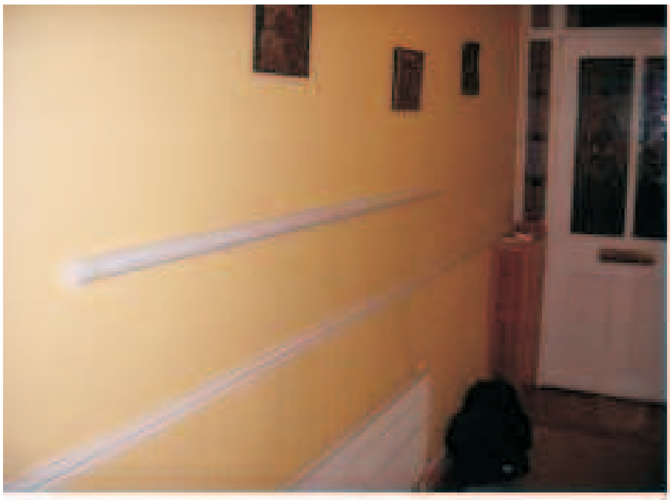

Figure 2: Rail Sensor Location

In order to determine the optimal location for the sensors, a home visit was made. A set of minimum criteria was used to assess the suitability of the home layout for the sensors. Some of the criteria included:

- A pathway with a wall, regularly passed in parallel by the participant, with consideration for rail length (min 1.2m, max 2m) plus space on either side of the rail to capture the participant's full walk past all three sensors.
- Suitable locations for dwell sensors: A light to dark transition area, a step area, regularly crossed thresholds in the primary living space (kitchen, living area).
- An unobtrusive location to place the laptop, which must be within range of data coming from each of the sensors.
- Due to the heat sensing nature of the technology, sensors could not be placed in line of direct sunlight or close to a direct heat source, such as a radiator.
- The home owner had to live alone and have no pets.
- The home owner could not be absent from the home for more than two weeks over the duration of the six to eight week study.

During the home visit to evaluate the living space, possible locations for the sensors were established. Once determined that the home met each of the criteria, a quick sketch was made showing the layout of the spaces, the frequently used pathways in the home and markings of the possible sensor locations. This sketch was then translated into a simple house plan and the possible sensor locations were discussed relative to the use of the space by the participant so that the best possible data would be captured (Figure 3).

However, very few homes met all of the identified criteria and as such, compromises had to be made. On the next visit to the home the sensors were installed, but notes were made regarding possible data that may be captured during the study that could be misleading. For example, in the hallway (the most common location for placement of the rail sensor, given that it represented a long walkway) the person may have had their telephone positioned in line of one of the rail sensors, or there might be a radiator. In some doorways, a participant might have a relatively slow dwell time as a result of an obstacle such as an armchair. The complexity of how a person uses their living space, with routines, movements and activities that are often taken for granted, became very apparent early on. As a result, in almost every instance, sensor placement was not 'ideal'. Instead, sensors were optimally placed and data collected had to be considered later on in relation to the actual use of the space around each sensor.

The house visits prior to deployment then, were necessary so that an understanding of the participant's use of the space and the actual space itself could be ascertained and recorded so that later on the data could be understood. In the following section we describe issues concerning usability evaluation of technologies placed in the home.

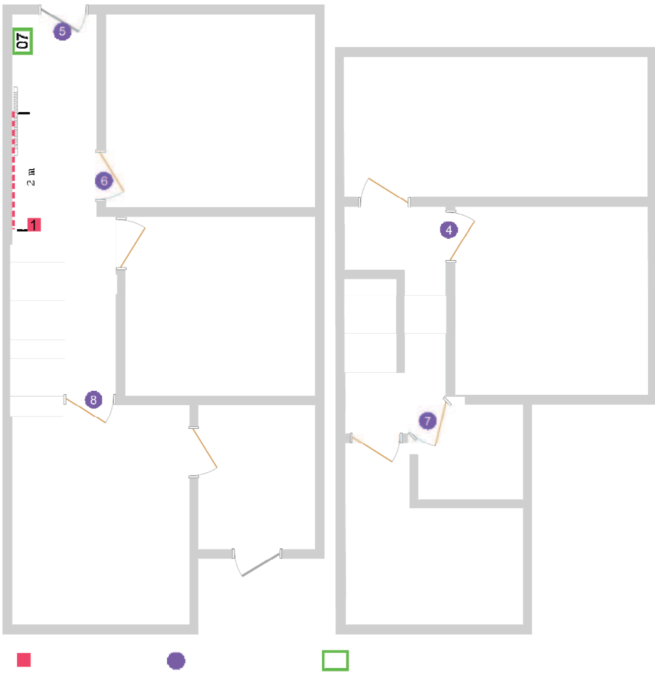

Figure 3: A simple house plan showing the layout of the sensors. The numbered purple dots are the dwell sensors and the red dashed line is the rail sensor. The green square is the data aggregator (the laptop) location

4. CASE STUDY 3 - ASSESSING THE USABILITY OF IN-HOME TECHNOLOGIES

A number of the technologies TRIL deploys in-home depend on a high level of interaction between the user and the technology. For example, our Building Bridges project is exploring the use of technology to connect older people with their family, friends and people in their community, with the ultimate aim of reducing social isolation and loneliness [14]. The Building Bridges technology consists of a 12 inch touch screen device, a phone handset and speakers. It utilises Skype technology. The central idea behind Building Bridges is to connect older adults through daily broadcasts, covering topics such as current affairs, health issues, stories and music, which are played over the speakers. Following each broadcast, the user can lift the handset and join a conversation, or 'group chat' with other listeners. In addition, users can initiate group calls, individual calls or send messages. Given that older adults have little or no computing experience, it is necessary to evaluate the usability of the touch screen device to ensure usability issues are not impeding social connectedness. As such, a series of formative usability trials have been conducted in homes to evaluate all aspects of usage and usability. Through evaluation techniques such as remote logging, observation, think-aloud testing and various semi-structured interview methods, we have gathered vital data allowing us to iteratively improve usability of the device for older adults. Based on these experiences, this section highlights some of the challenges of evaluating usability in-home, how measures of usability can be collected and when such testing should be carried out across a longitudinal study.

4.1 Challenges of Evaluating Usability In-Home

Recognised evaluation strategies are necessary to scientifically assess the usability of technological systems. However, such strategies typically relate to traditional in-lab usability testing, as opposed to assessing the usability of in-home technologies. Laboratory studies typically take place in a controlled environment, with researchers present and allowing researchers to collect data through both quantitative and qualitative methods. In a lab environment, participants typically follow a scripted set of task scenarios and answer a scripted set of questions based on these tasks. While it is important to conduct usability tests in-lab prior to home deployments, to validate the technology, gather user opinions and generally to identify any issues with respect to the technology's robustness and reliability before it is deployed to the home, such studies cannot capture the true user experience in-context and it is difficult to generalise the results in a non-laboratory setting. Hence, it is arduous to identify all possible issues or problems that might be confined to the home environment.

However, assessing the usability of a technology during a longitudinal in-home study introduces numerous challenges. These relate to how to best set up an evaluation context - the methodologies that should be used, means of data collection and addressing issues of privacy and ethics. Automatic data capture through software logs is particularly important for in-situ usability testing. Such logs can provide detailed quantitative data, including usage statistics, error rates and time on task. In setting up such logs, it is necessary to ensure before hand that we know exactly what we want to measure, and how, so that the auto-logging tool can be setup appropriately. However, auto-logging cannot collect qualitative data. Qualitative data in a home context includes satisfaction, user opinions and experience and assessing how well the technology integrates into the participant's life. Traditional in-lab usability techniques to collect such qualitative data, including observation, think-aloud testing, post-task questionnaires and interviews are not possible throughout the whole in-home study. However, such techniques can be conducted at intervals throughout the study. We have found it particularly useful to measure usability when the technology is first deployed to the home, at the midway point and again at the end of the study. This allows for detailed observation and discussion with participants.

Privacy and ethical issues further inhibit how data may be collected throughout a longitudinal in-home study. For example, the usage of certain monitoring devices, including video cameras which are typically used during in-lab usability studies to capture facial expressions or audible expressions of satisfaction/frustration can typically not be used in the home. While we have found that participants agree to us recording them during our in-home observation session, obviously we cannot leave such monitoring technology in their homes for the duration of the study. Furthermore, it is difficult to get ethical approval for this means of data collection.

A further issue complicating the collection of usability data during a longitudinal in-home study, is the uncontrolled nature of the home context. Possible interruptions during usage cannot be explained through automatic logging scripts. Interacting with a technology in the home is more 'free-flowing' than interaction during a controlled lab test. The technology is (or should become) part of the user's everyday life. It can generally be used as much or as little as the participant chooses. Evaluating how well the technology integrates with the participant's every day life requires qualitative evaluation, which, as we noted, is particularly difficult to collect in a longitudinal in-home study. Providing feedback and motivation to participants throughout the study should ideally contribute towards a seamless integration and discourage drop-outs. As such, methods are necessary to monitor usage, as well as to evaluate the effectiveness of feedback and motivation techniques in keeping users involved. It is important to keep users motivated and involved throughout a longitudinal usability study to ensure the data required for effective analysis is collected. As with many technologies, motivation to use decreases in time when the novelty of the technology has 'worn off'. Given the importance of motivation in conducting longitudinal in-home tests and more importantly, given that the technologies that TRIL deploys aim to promote independent living for older adults, it is imperative that we integrate methods of motivation in our home trials.

To date within TRIL we have identified two means of motivating participants. Firstly, we monitor usage logs regularly and if we notice that a participant isn't compliant we will phone the participant to ask them why. Sometimes the participant has been away, or has had a busy period. However, it might also be the participant finds the technology difficult to use. In this situation we have been able to visit the participant's home to offer guidance and further training. Stressing the potential benefits the technology can offer is another major motivator. While we cannot always offer feedback at the end of the study in terms of clinical benefits for our participants, given that our studies are currently formative tests, or pilots, participants are happy to know that they are contributing to an overall research project, which in the long term will have many benefits for older adults. Even when participants feel the technology is currently of no benefit to them (for example, because they do not see themselves as 'socially isolated' in the context of the Building Bridges study) they are very willing to take part in research to help others. Reminding participants of this throughout the study can also encourage motivation. However, it should be noted that to date, our studies have lasted, on average, eight weeks. As we aim to move to larger scale evaluations conducted over periods of months as opposed to weeks, additional methods of motivation will need to be integrated. In reviewing existing literature on motivating older adults to use technology, introducing games [8] or a social element with family and friends [9] appear to be good solutions.

4.2 Qualitative Data Collection

In examining methods to solicit qualitative feedback from older adults over the course of a longitudinal study, a diary seems an appropriate tool. In another TRIL project focusing on ethnographic research to capture a life-space diary of daily activity and mobility, within the context of a larger project looking at falls prevention in older adults, we found that a daily log was not enjoyed by participants, whereas a diary was [2]. The log consisted of 15 items designed to capture daily activities (such as getting up, eating etc.) within a certain space (room, neighbourhood) and time (logging real time). Participants were asked to complete this daily for the 28 days of the study. However, participants reported the log as being 'tiresome', 'limiting', 'repetitive' and 'confusing'. On the other hand, all participants enjoyed keeping the weekly diary. Not only was the diary of benefit for TRIL researchers, but it also made the participants aware of their routine, particularly the repetitiveness of their routine.

While assessing usability in-home, we have also identified a number of techniques that work well in soliciting qualitative data from older adults. Following an in-home observation session, rather than using a questionnaire or formal interview process to gain additional feedback, we have used a modified version of Microsoft's Desirability Toolkit [4]. Normally, this involves presenting a participant with approximately 100 adjectives, both positive and negative, having them highlight all words they feel apply to their experience with the system being tested and then having them choose the top 5 words that best describe their experience. An interview then follows with the participant to identify their reasons for choosing these adjectives. In modifying this technique for older adults, we present them with a list of approximately 25 words. Through trial and error we determined that the best way to conduct this technique was to ask the participant to read aloud any word they felt 'jumped out at them' regarding their experience with the technology. We initially asked them to 'tick all words that apply' and then to choose their top five. However, the in-home setting was not conducive to this, as the participant was generally sitting in an armchair for this part of the evaluation and found it difficult to mark the pages containing the words. The 'read-aloud' technique appeared to work very well and gave us good feedback, as the participant was not limited to 5 words. Each time the participant read aloud a word from the sheet, there followed a short informal discussion surrounding the reasons behind the choice. This technique is known to encourage negative, as well as positive, feedback and as such proved very useful for formative usability evaluations within TRIL.

5. CONCLUSIONS AND FUTURE WORK

Within TRIL we work closely with older adults to determine how technology can sustain independent living. Independent living technologies provide huge potential for older adults to continue living in their homes as they age, to assist in remaining mobile and active and to make them less dependent on others for assistance with their day to day living. Such technologies can only become successful on a large scale if older adults are willing to accept them into their homes. As such, evaluating the impact, as well as the effectiveness, of home-based independent living technologies is of paramount importance.

In this paper we have presented three case studies describing our experiences of conducting field research, each of which is integral to the evaluation life cycle of home-based independent living technologies for older adults. Ethnographic assessment is a critical component in understanding older adults' attitudes to technology, which may be borne from past experience or current understanding. It is essential to understand how these views might impact on their use of technology. Of equal importance is understanding their attitudes to being monitored. This not only encompasses practical issues but also the social implications of being monitored and how this impacts on older adults.The next phase of the evaluation cycle involves evaluating the older adult's living space. If we are to integrate technology that is unobtrusive into *existing* homes, we need to decide where best to locate this technology and how the technology could potentially impact on the older adult's day to day living. The final phase examines the challenges involved in evaluating the usability of home-based independent living technologies with older adults and identifies some solutions based on our experiences within TRIL. These three stages of evaluation provide an overall picture of what is necessary to conduct in-home evaluations that focus on the participant.

With regard to ongoing and future work we are currently in the process of implementing a pattern language framework to capture experiences from researchers in the field of conducting evaluations of healthcare technologies. As healthcare technologies are becoming increasingly pervasive, moving from controlled clinical environments to patient's homes and hospital bedsides, new challenges arise in evaluating the impact of these technologies and interactions in their context of use. Patterns appear an ideal method to capture knowledge and encourage collaboration between interdisciplinary members of the healthcare community. In addition, whilst each of the case studies presented in this paper represents an important stage of evaluating *user* experience and impact, there are other key aspects of home-based evaluations which lie outside the scope of this paper. These include the need to validate sensor systems prior to their deployment to participants' homes and the evaluation challenges posed by the potential issues concerning battery life of sensors and unreliable wireless network connections, which may compromise the efficacy of collected clinical data. Indeed, evaluating and analysing the health benefits that occur as a result of independent living technologies is integral. These issues are also taken into consideration when designing TRIL evaluations.

6. ACKNOWLEDGEMENT

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