Interaction Space: Older Adults and in-Home Systems

Exploring technology with and for older people

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Abstract— **This paper discusses important considerations when developing assistive technology with and for older adults. Two case studies demonstrate the use of Experience Labs to engage older adults in a participatory design process in the early stages of development of novel sensor systems. Firstly, we present the 'Interaction Space' as a holistic way to model and understand interaction between people, products, technology and environments when developing complex systems. It is argued that looking at the interaction between older adults and technology benefits from a holistic view of the Interaction Space in which primary and secondary users are continuously acting together with the technology. We then highlight considerations when developing technology systems with participants who are not confident technology users, in order to design meaningful spaces for critical reflection and creative collaboration. We conclude that the Experience Lab approach enables the complex Interaction Space of sensor systems to be dissected into comprehensible elements leading to a better understanding of the impact of the proposed technologies.**

Keywords- older people; participatory design; interaction design; technology; sensor system.

I. INTRODUCTION

The health and care environment is fertile ground for innovation to support patients, families, and health professionals to achieve the Scottish Government '2020 Vision' that "everyone is able to live longer healthier lives at home, or in a homely setting" [1]. Digital technology has the potential to make an important contribution to realising this vision. In this respect, it is becoming increasingly important to involve those who will be using the technology, whether in receipt of or in the delivery of care, at a much earlier stage of the design process [2] to ensure that the proposed technology solution meets their needs and is adopted in use. The field of participatory design offers a wealth of approaches to meaningfully involve end users in the design process [3]. When designing digital technologies with and for patients, families and health professionals, it can be challenging to separate out the different responses and reactions to the proposed technology within a complex interplay of people, objects and spaces with or within which users interact. The concept of an Interaction Space to describe human-computer interaction has been explored in a variety of ways. The Mixed Interaction Space is used to distinguish camera-based interaction from other types of sensor-based interaction in terms of the ability to track a fixed point in relation to the mobile device [4]. The Multimodal Interaction Space presents a framework to explore the different levels, modes and modalities of interaction [5]. Finally, the Continuous Interaction Space describes the physical space above a traditional touch surface to form part of the interaction experience [6]. These interpretations all focus on the physical environment around a device at the moment of active interaction. We propose the Interaction Space as a means of exploring the impact of individual and cumulative interactions with the different parts of the system, as distinct from the physical interaction individuals engage in. The role and position of new technologies within the Interaction Space between humans and systems is of particular interest when considering technological developments in the area of health and care.

In the following part of the introduction we will explore existing knowledge on older adult's perception of technology and the principles of experience design. In Section 2 we will outline the methodology of an Experience Lab and highlight previous work exploring the Interaction Space in Experience Lab projects. In Section 3 we present two case studies describing the context, Interaction Space and findings for each project. Finally, in Section 4 we will discuss how the methodology of an Experience Lab leads to a holistic understanding of the Interaction Space for older adults and in-home systems.

A. Older adults and technology

A key factor contributing to the increased demand on health care services is the global issue of an aging population and shifting demographic [7]. Older adults are therefore a key group to involve in discussions about technology, in order to determine the ways in which technology can benefit everyday lives. General experience with technology is lower for older adults than younger generations, but in health and social care they often form the target users that proposed technologies aim to support. Research on the interaction between older adults and technology is primarily focussed on using computers and accessing the Internet [8]-[11]. Barriers to using technology as expressed by older adults are often related to a lack of confidence leading to a dismissive attitude [8], low

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awareness of the benefits of technology [9], and the fear of 'breaking something', strengthened by overestimating the price of technological devices [10]. Incentives to start using technology and particularly the Internet relate to a change in health condition, mobility or social contact (e.g., to communicate with family who live at a distance) [11].

Previous research has identified that older adults do show a willingness to adopt new technologies. Particularly in the health and care domain it is recognised that there are several benefits, e.g., to support disease management, medication observation, remote patient monitoring, cognitive fitness and assessment, and social networking [12]. The social aspect of taking part in a training session and subsequently sharing the knowledge gained with peers was also appreciated [10].

Everyday technology is widely perceived to be designed for a younger target group, but this does not mean that supportive technology for older adults needs to be designed specifically for them as this can feel stigmatizing. Rather there is a need to understand the wider context of how older adults live and the potential role for technology. Therefore, when designing a new technology or application of technology, it is important to involve older adults at the beginning of the design process and to employ a participatory approach. This ensures that the ideas taken forward meet the needs and expectations of older adults.

B. Understanding and designing for experience

The introduction of technological products or services for older adults is the means to an end and not the end in itself [9]. This is particularly true in the health and care environment where the goal is to enhance the wellbeing of the individual. Wellbeing is rarely achieved by the simple act of using a technology, but rather it depends on the support being provided by other professionals and individuals. This kind of interaction is a continuous interplay between the older adult, other individuals and the technology. Edmund Husserl and Martin Heidegger first described the experience of this interaction in the early 20th century in their philosophy of phenomenology [13]. Phenomenology opposed the Cartesian view that there is a truth in looking at things abstracted from reality, and that the ability to think and analyse determined our place in this world [14]. Phenomenology described the fact that we *have* a body and our presence in this world at this very moment determined how we perceive and experience things. French philosopher and phenomenologist Maurice Merleau-Ponty later argued that perception is inherently interactive: it is an interplay between perceiver and perceived [15]. Interaction does not happen because the person has an exact cognitive model of steps, be it person-to-person, person-to-technology, or person-through-technology-to-person. Rather it is an event that continuously unfolds depending on how things are perceived and responded to. The study of design is therefore focused on designing products and systems aimed at intuitive and engaging interaction that do not require a cognitive model of use [16]. Experiential approaches to design put "experience before functionality… leaving behind oversimplified calls for ease, efficiency, and automation or shallow beautification" [17]. This requires an understanding of what really matters to the desired end users and how their experiences of using technology can be more meaningful.

II. THE INTERACTION SPACE WITHIN AN EXPERIENCE LAB

The Experience Lab methodology provides a way to understand the needs and experiences of users within the design process. Led by the Glasgow School of Art, Experience Labs form a core part of the Digital Health and Care Institute, an innovation centre based in Scotland. There is a clear need to involve users at an early stage in the design process [2] and methods of addressing that need are well documented [18]. The Experience Labs build on human-centred design knowledge and existing research methods, e.g. Living Labs, and aim to provide a safe space for collaboration and creativity, affording the opportunity for experiential learning [19].

In terms of enhancing or achieving wellbeing for older adults through the use of technology, we define the Interaction Space as a conceptual space encompassing all individuals and the technology being proposed. The different streams of interaction between persons or person and technology all contribute to the perceived benefits of the system. We propose that Experience Labs offer a method for exploring the perceived benefits of new technology systems with end users. The Experience Lab aims to create a holistic understanding of the Interaction Space, and enable participants to perceive how different streams of interaction all lead to a continuous and holistic experience. This experiential understanding enables participants to provide insight and feedback to inform the development of the technology.

Exploring the Interaction Space with participants in the early stages of concept development is a challenge, as the proposed technology may be intentionally undefined. To address this, Experience Labs create pop-up spaces for multiple stakeholders (e.g., patients and primary users, academic, business and civic partners) to engage in iterative exploration and early trialling of ideas, concepts and prototypes in a safe and collaborative environment. The pop-up spaces chosen for the Labs are based on real intended use environments. Each Experience Lab, or set of Labs, is bespoke to a project. Typically, projects selected for a Lab propose a conceptual solution, often with limited consideration of the needs of the potential user. The Labs provide the opportunity to step back and (re)discover the needs of the different users and reflect on how the proposed solution can be strengthened in response to the needs and experiences expressed [20].

The goal of an Experience Lab is to enable participants to be at the centre of a participatory design process in which their lived experiences form a rich contribution to ideas and concepts. The sessions in a Lab break down the complex

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reality of a new supportive technology and provide participants with the tools to experience elements that make up the Interaction Space. Using generative tools and bespoke artefacts, the Labs allow participants to experience a concept that is unknown to them, and reflect and provide feedback as well as share and build on each other's ideas.

Previous work reviewed the Interaction Space of six Experience Lab projects, highlighting three potential roles for technology within the Interaction Space, with different levels of complexity as shown in Figure 1. The Venn diagram shows the potential cross-overs, particularly when technologies are intentionally undefined.

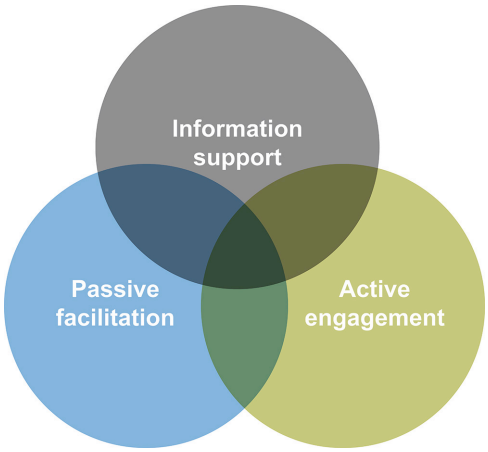

Figure 1. Different roles of technology in the Interaction Space.

The first area involved understanding the way technology provided an information source to the user. Experience Labs for projects such as these focussed on what information needed to be available, when, and how that information was presented (e.g., a directory of services for ambulance clinicians [20]). For these projects, the technology needed to be available when required but did not have a role in facilitating communication with other people.

The second area involved understanding the role of technology in facilitating interaction between people through an online platform. The Interaction Space in this area included a minimum of two people communicating through a digital medium (e.g., a community platform to broker receiving and delivering small services).

The third and most complex Interaction Space involved understanding technology taking an active role by responding to behaviour of people and the animate world. In this space, it was possible for the technology to trigger actions (e.g., sending alerts to carers in response to abnormal behaviour) that influenced how users perceived the environment.

III. CASE STUDIES

The two projects that reflect the complex Interaction Space are further elaborated on in this paper, in particular how the Experience Labs support older adults to understand the potential of the new technology and how it might influence existing relations with other people.

A. *Case study 1: Assisted living for older adults*

1) Context: The project described in this case study explored and developed a new concept for assisted living which aimed to support and empower older adults to live independently at home for longer [21]. The project involved three sequential Experience Labs, which were designed to explore the full potential of the proposed system and user-test the initial hypotheses behind the concept by developing and validating a refined solution with users.

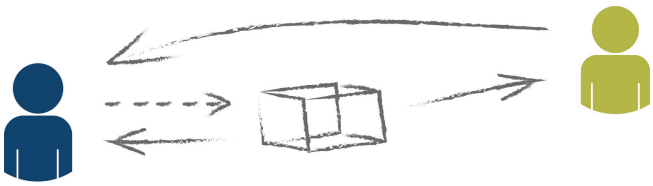

Figure 2. Diagram of the Interaction Space for case study 1, showing potential streams of interaction.

2) Interaction Space: The Interaction Space in this project (see Figure 2) involved the proposed observing system shown as the box, participants who were older adults living at home (blue person) and a family member or friend from the older adult's support network (green person). The streams of interaction, as visualized by the arrows, happen between different people and the system. The system can observe the environment of the older adult (dashed arrow) and potentially trigger a response to the older adult. Another stream of interaction could also be between the system and a carer who may look after the wellbeing of the primary user remotely. The first Experience Lab involved visiting older adults in their homes to understand their home life, routines, networks of support and current use of technology. The second Lab involved a field trip to a department store to allow participants to interact with technology and supportive home products, with the aim of understanding their perceptions of and preferences for technology and the types of scenarios-of-use. These initial Experience Labs provided a rich understanding of the participants' current awareness, use and perceptions of technology and informed the design of the final Lab.

The challenge was to create a realistic environment in which older adults could experience and interact with the proposed assisted living system. The final Experience Lab involved creating a non-functioning prototype, which was operated by a member of the team to give the impression that the system was fully functional. Participants were guided through a role-play scenario using the prototype, allowing them to experience the Interaction Space, physically and interactively, and to discuss the potential use of the system in their own home. The Lab team helped users explore the

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concept and share their feedback and ideas for improvement. The Lab also provided the opportunity for the family member or friend to observe the system in use. As an extension of the experience, participants were then invited to a workshop environment where they were given the opportunity to explore and visualise ideas using playful materials (e.g., clay, puppets, craft materials and an electronic sensor/actuator kit) to allow them to construct scenarios where they felt the proposed system might provide support.

3) Findings: The sequential nature of the Experience Labs allowed participants to gradually build an understanding of the system. The first Lab took place in the home environment and provided the opportunity to gain perspective on the current role of technology in the everyday lives of older adults: their perceptions and usage. Building on this experience, the field trip to a department store enabled insight to be gathered on the types of technology and products that are preferred by older adults, and provided insight into their buying decisions. Finally, by creating an opportunity to explore the system in a realistic environment, participants were able to experience the concept in a non threatening way and the use of an unfinished aesthetic, together with playful materials, encouraged participants to become 'makers and designers' themselves by making their ideas tangible.

The findings of the Labs indicated that personalisation was of key importance given the differing circumstances of older adults in terms of home environment, networks of support and confidence with technology. The findings revealed that participants were already making adaptations using both low and hi-tech solutions to make everyday life easier and address personal challenges. Through visiting the participants in their homes, it was possible to see these types of solutions already in use. Progressing the Labs sequentially also made it possible to ideate solutions together with reference to existing technology (e.g., products available in the department store) and to generate ideas for the system through scenarios and experiential learning in the final Lab.

B. Case study 2: A novel indoor tracking system for people living with dementia

1) Context: The project, initiated by Glasgow Caledonian University, focussed on developing a novel unobtrusive indoor tracking system for people living with dementia. The aim of the system was to recognise abnormal behaviour (e.g., wandering in the middle of the night) and alert the carer for a timely response, thereby positively affecting the safety and wellbeing of individuals. The project aimed to understand the experience of living with dementia, and the perceptions of the indoor behaviour tracking system from the perspectives of people living with dementia and their professional and personal carers.

2) Interaction Space: The Interaction Space in this project (see Figure 3) includes the proposed sensor system shown as the box, the person living with dementia (blue person), a professional carer (red person) and a personal carer or relative (green person). The system is tracking the

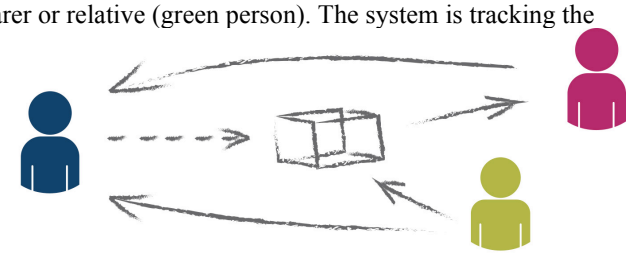

Figure 3. Diagram of the Interaction Space for case study 2, showing potential streams of interaction.

behaviour of the person with dementia (dashed line). It could potentially send continuous data or alerts to a professional carer. A personal carer has the opportunity to log into a platform, allowing them to observe registered behaviour. Both carers can then take action as required, responding to the person living with dementia. The proposed system was at proof of concept stage and therefore it was not possible for participants to engage with the system in the Experience Lab. The challenge was to create an environment that allowed participants, in particular people living with dementia, to understand the proposed system and express lived experiences relevant to the system's potential use, reflecting on the impact the system might have on their lives and the behaviour of others.

The first Experience Lab explored the different elements of the Interaction Space for the tracking system in a series of bespoke activities and design tools. Scenario cards as shown in Figure 4 were used to focus the conversation on experiences of living with dementia, of large indoor environments and the support gained from other people. A second session introduced a small wearable device to present the potential sensor, which participants were asked to wear during lunch. Researchers 'tracked' participants with pen and paper as they moved between rooms, as well as their behaviour within the room. This tracking information was used to discuss potential insights a system might get on behaviour during everyday events. Finally, the appearance of a wearable sensor itself was discussed by relating it to accessories worn by participants on the day and the associated experience.

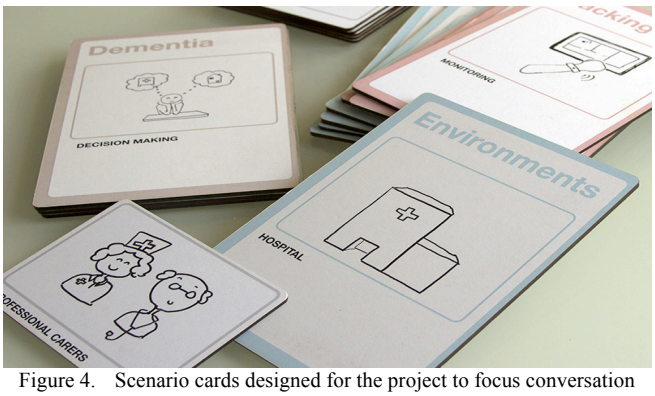

Figure 4. Scenario cards designed for the project to focus conversation topics.

Insights gained from the first Lab led to the development of three scenarios-of-use to discuss potential Interaction Spaces representing shared experiences, concerns and ideas. The scenarios particularly focussed on expressing how the system was introduced, what behavioural aspects were captured by the system, and how and to whom this information was shared. The scenarios were acted out by researchers and filmed, each resulting in a two-minute video. During the second Experience Lab the videos were shown one at a time and participants were invited to reflect on what was shown and how it would affect their individual situation.

3) Findings: The first Lab provided conversation topics including the experience of indoor environments and wearable devices. The sessions relied on the participants to imagine the implementation, opportunities and implications of the indoor tracking system. This led to the identification of a number of concerns in relation to the anticipated support that would be provided and the sharing of positioning data. Participants phrased this as a desire to "know who is at the other end". This phrase embodied concerns about the human support they expected, the reliability of support and the potential privacy issues of tracking in their homes. It is suggested that these concerns emerged because there was no concrete solution participants could either agree or disagree with. The presented Interaction Space was open and relied on input from participants to express their preferences for the tracking system. An aspect of the Interaction Space that participants could conceive very well was the appearance of the sensor. The sensor was required to be in direct or indirect line of sight with the light source, meaning that it would have to be visible and not hidden. Relating it to visible accessories participants felt strongly about not wanting to wear a necklace, preferring an arm-worn device or something you could pin onto clothes. They also wanted the aesthetic design of the sensor to empower individuals rather than show vulnerability.

The second Lab presented videos that showed a 'closed' potential Interaction Space in which it was made clear: the people involved, information shared and support offered by the system and/or carer. Although real life was of course seen to be more complex than the scenarios presented, participants no longer felt as strongly about the privacy concerns. When issues from the first Lab were revisited, participants unanimously responded by acknowledging that the support they were provided with, e.g., by a relative, professional or informal carer, was more important than the privacy concerns they had previously expressed. The involvement of carers was seen as the key value in the system, and the technology was merely seen as a means of initiating timely contact.

Both Experience Labs focussed on creating an environment for participants to understand the proposed technology and the support it could deliver. The technology was well received in the first Lab, yet with some concerns about data sharing. The second Lab addressed these concerns by proposing realistic scenarios showing what information would be shared when and with whom. In the overall project the Interaction Space was described by participants' own experience in combination with the proposed technology in the first Lab and then concretised for further feedback in the second Lab.

IV. DISCUSSION

A. Breaking down complex interactions

The systems presented in both case studies represent two highly complex systems which have the potential to positively impact the lives of older adults. At the initial stages of participatory design in the Experience Labs it can be difficult for participants to imagine the potential use of any complex technological solution. The use depends on a variety of factors such as what the system or sensors are capable of measuring and registering (e.g., movement, light, sound), in what environment they are deployed, the types of events that would trigger a response and how this could possibly lead to false triggers, and what the result of a trigger will be.

The progressive and sequential nature of the Experience Labs described within the case studies provided a way to break down the complexity of the system and introduce participants to the new technology. By exploring the everyday experiences of participants and their current relationship with technology, the Labs helped participants to recognise the ways in which these technologies could impact on their everyday lives. Focussing on separate elements of the system enabled participants to realise what criteria were important to them. For example, case study two overcame challenges in communicating a complex indoor tracking system by breaking the system down into individual elements, with activities in the first Lab separately exploring: experiences of indoor environments, tracking daily activities, support provided by other people and a wearable sensor device. These sessions covered different streams making up the Interaction Space between individuals and the system. Subsequently the final Experience Lab could create an experience prototype embodying these criteria, enabling the participants to reflect on each element as part of a holistic experience and give meaningful feedback.

The older adults involved in the Labs were reasonably familiar with technology through computer and occasional mobile phone use. However, many of the barriers highlighted in the introduction were also supported in the case studies such as lack of confidence with technology and fear of breaking something [9]. Considering this somewhat limited experience with technology, it is essential to incrementally build understanding by relating it to participants' existing technology references, environments and daily life. In this way it becomes easier for participants to imagine how the proposed technology fits with their everyday life and home environment. There is a need to create a balance between an open and suggestive approach when ideating with older adults in order to ensure that the proposed technology is comprehensible to participants. Failure to do so may lead to limited ideas and feedback.

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While some might argue that this limits the possibility for radical innovation [22], in practice it uncovers insight into the real needs and aspirations of older people and highlights places where technology is not acceptable, opening up new opportunities to innovate services to support older people. It also offers insight into how new technology can be marketed to support adoption [21]. The use of bespoke design tools as described in the case studies demonstrates a promising method of introducing complex technology to older adults in a meaningful way.

B. Older adults and technology over time

Older adults see technology as a means to an end. It is important to consider the individual streams making up the Interaction Space to enable a valuable discussion with participants regarding the effect on achieving this 'end', particularly when multiple people are involved. For example, in relation to case study two, information picked up by the sensors can be shared with carers to alert them to a safety issue or reassure them that the older person stable. In the case of safety issues, the exchange of potentially private information is less of a concern for the older adults as long as they know it will achieve the end result of getting them human support at a time of need.

The next generation of older adults are often described as digital natives, or at least familiar with using smart devices. However, the development of technological devices and support systems will not slow down, rather it is likely to diversify, for example looking at developments such as the Quantified Self, Internet of Things, virtual immersive environments and autonomous systems. This diversification indicates that the barriers to using technology today as experienced by older adults are not likely to dissolve with the next generation. Alongside the increasing complexity of technology, the ageing process of older adults can amplify barriers to usage, particularly where older adults are living with dementia. Discussing the potential benefit of a supportive sensor system in case study two highlighted an important aspect for participants, namely to introduce a system at an early enough stage when people, particularly when living with dementia, still have the capability to comprehend the changes and benefits. This highlights an additional requirement for the technology, namely ensuring it is not stigmatising and offers progressive functionality that can adapt to the changing needs of the owner. Participants were aware of the progressive nature of their condition and appreciated being involved in the participatory design process at an early stage when they could share what aspects were experienced as empowering or as stigmatising. The progressive nature of long term conditions suggests that this increase in support over time can be seen to be beneficial. The Interaction Space then becomes not only a model to describe how different streams of interaction between person and technology influence other streams, it can also be seen to include an element of time; describing how interactions could be adapted to lead to different results at a later phase of life. Implementations of the support systems in the case studies are recommended to adapt or present opportunities for personalisation to reflect changing needs. The changing needs are expressed as an incentive to start using technological support [11]. The Experience Lab can provide the opportunity to consider the anticipated changing needs and how these can enhance the experienced benefits of a system.

V. CONCLUSION

The Experience Labs provided a platform to involve older adults at an early stage in the design process. The Labs encouraged sharing of experiences and reflecting on proposed concepts of technology to address potential barriers for older adults to accept and use a new system. Through an iterative approach the complexity of support systems was broken down into elements of the Interaction Space that participants could relate to and understand. The Interaction Space model was used to reflect on the case studies in this paper. This presents an opportunity to reflect on and understand the different modes of interaction within a complex system to identify challenges, opportunities and ideas within participatory design research. Further research is required to explore if and how the Interaction Space model could be communicated to facilitate an active dialogue with participants to further support the understanding of a complex system.

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