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Co-designing technology and aging in a service setting: Developing an interpretive framework of how to interact with older age users

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Abstract

Background: Engaging older users in co-design processes has become increasingly desirable in the approach to develop and test technologies suitable for them and according to their needs. This analysis draws on the involvement of older adults aged 65 and over in Israel in co-design activities while developing a smartphone and smart-television application (App) called 'Age TechCare' designed to record and prevent falls.
Objective: This article builds upon conceptual and theoretical work regarding codesign and the co-constitution of aging and technology (CAT-model) and value co-creation (Service-Dominant Logic) to offer an interpretive framework that contributes to our understanding of the dynamic relations between aging and technology that come about during co-design interactions. Based on the interdisciplinary approach, we propose an interpretive framework for understanding the context in which older users discuss, use, and imagine technology as well as their needs and routines: understanding the context of the problem and then re-contextualizing and de-contextualizing it as an interpretive framework that enables co-designing a valuable App for users within their service network.
Method: The research was conducted using discussions in four focus groups: three focus groups with older users aged 62 years and over (n=36), and one focus group with health care professionals who are Key Opinion Leaders (KOLs) from the users' service network (n=8). Through group interactions and discussions, we were able to underline the interactive and shared experience of falls as a contextualized experience.
Results: These interactions have empirical and theoretical importance, specifically in the ways by which older users make sense of their lived experiences and the aging process while using and designing technology. When designing innovations for older adult users, it is not sufficient to assess only their expressed problems and needs in co-design procedures and workshops. These assume that aging problems and needs exist in advance, with no relation to the technology being discussed in the workshop. It is also important to enable the users to rediscover their new (real or imagined) roles as older people. This means that users rediscover their aging process as well as technology while interacting in a co-design process. Taking a phenomenological and anthropological perspective, while talking with older users in co-design processes, the processes of aging, technology, and their interrelations come about and innovate.
Conclusion: This analysis draws on focus group dynamics carried out while identifying the context and then re- and de-contextualizing as design methods. By these means, the users become co-creators of value and influence both design and function of the App by being test persons and by improving new ideas and value offerings within the service network.

Keywords: value co-creation, service App, older customers, technology design, user studies, fall prevention

Introduction

As life expectancy increases globally, researchers and engineers are shifting their focus to the development of innovative technologies for effective health care service delivery to older age users who now constitute a huge potential market (Coughlin 2017). Currently, technology from daily Apps and devices like smartphones, tablets, and social robots integrate into the lives of older people (Heerink et al. 2010; Yamazaki et al. 2020; Peine and Neven 2020; Katz and Marshall 2018; Mazuz et al., 2020). With the increasingly strong emphasis on active and healthy aging in place comes a need for technologies specifically designed for older people – commonly described as gerontechnologies (Fukuda 2015). This has led to the emergence of a great diversity of prototypes, pilots, and early-stage businesses (Peine and Neven 2020) engaged in the co-design process. According to Östlund et al (2020), co-design is based on a collaboration between (older) users and designers and is one

of the main concepts used in technological innovation and development to increase the users' impact by involving them in the design process. As Östlund (2015) argues "far too little attention has been focused on older people's capacity for innovation, and on how their life experience can contribute to the development and redevelopment of products and technologies. However, it is insufficient to simply talk about older people or to categorize them in accordance with what we already assume. We need to talk with them" (Östlund 2015, p.16). Thus, in actively engaging and talking with older users, they have become more involved in designing and testing technological products and services, articulating their experiences, needs and preferences, and contributing to 'mutual learning' (Fischer, et al., 2021). These engagements may assist the understanding of how technology is adapted and accepted by older adults (Mannheim et al. 2019) and help to close the gap between what designers and engineers think older users need on one hand, and what older users ask for or how they want to be treated on the other. This effort has led to a flurry of conceptual and methodological results, such as human-centred design, experience-centred design, participatory design, and co-design (Fischer et al., 2021). Additionally, it has been found that the outcomes that can be achieved with user involvement differ significantly based on how the method is implemented. Fischer et al (2021), reported findings in four countries (Canada, the Netherlands, Spain, and Sweden) to illustrate how different types of learning occurred in relation to methods, power relations, and socio-material arrangements that structure these design practices in particular ways.

This literature indicates that learning in co-design practice is far more than the simple transmission or exchange of available expert knowledge about aging and technology. Peine and Neven (2020) describe a theoretical perspective called the co-constitution of aging and technology (CAT-model) that views aging and technology in terms of constituting each other. The CAT model refers to the way aging and technology mutually shape each other as they stress that *"design produces ideas about aging and older people as much as it produces technology. Such ideas can include ideas about aging bodies, ideas about adequate role models, proper actions to be taken in relation to the technology, and so forth"* (Peine and Neven 2020, p.12). Based on the CAT model, we understand that in co-design it is usually assumed that what technology can do and mean for older people is an inherent and stable property of only these technologies while the life-worlds of older people are usually not considered to be sites that define technologies in relation to the changing experiences of aging. Peine and Neven (2020) coined the term 'interventionist logic' to describe how aging is conceptualised as a target for technological design. Designers and engineers, often with the help of social scientists, refer to aging as a target for interventions or as a set of problems to be solved, thus they primarily study Age-tech in terms of the impact or acceptability and usability in the lives of older people.

This article builds upon these conceptual and theoretical findings regarding co-design and the CAT model to offer an interpretive framework to contribute to our understanding of the dynamic and innovative relations between aging and technology that arise during co-design interactions. These interactions are significant both empirically and theoretically, specifically with the ways in which older users make sense of their lived experiences and the aging process while using and designing technology. When designing innovations for older adult users, it is not sufficient to assess only their expressed problems, needs, and demands within co-design procedures and workshops. These assume that aging problems and needs exist in advance and with no relation to the technology being discussed in the workshop. It is also important to enable users to rediscover their new (real or imagined) roles as older adults. This means that users rediscover their aging process as well as technology while interacting in a co-design process. Taking a phenomenological and anthropological perspective, while talking with the older user through co-design processes, aging and technology and their interrelations unfold and become clear and maybe innovated. Aging and technology are continuously evolving as a cyclical relationship, as pointed out by Peine and Neven (2020). So as a result, designers may select and reflect on these aspects alongside the designed technology without presuming the significance of aging comes before the interactions have begun.

This assumption refers to co-design interactions as an emergent phenomenon. According to anthropologist Handelman (2005), emergent phenomena develop through time from within themselves - they begin to come into phenomenal existence from the moment persons begin to interact. In this emergent phenomenon, the very process of interaction has the potential to generate something other, something different, something unexpected and innovative. In that sense, aging as well as technology is discussed and experienced in a co-design workshop, which is a site of innovation formed through the interactions between - real and imagined - users, designers, and technological objects that shape this interaction as it occurs. Therefore, interactions in general simply are not reducible to work-

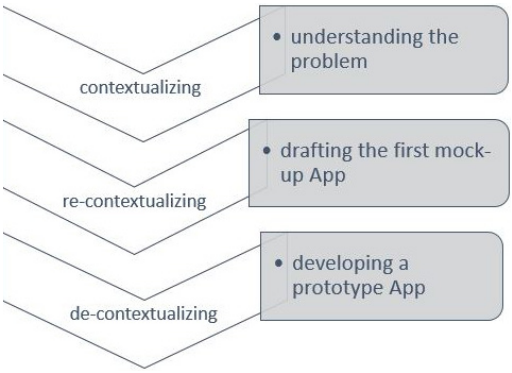

Figure 1. The interpretive framework composed of three levels with three outcomes

shop conditions, scripts, strategies, or the participants' skills, needs or problems. Otherwise, how would co-design sites enable innovation and the emergence of something new? Moreover, the complexity and diversity of older users cannot be fully encompassed in a co-design - no matter how familiar the designer is with the older lifeworld or how well the designers interact with different user personas - because aging is a changing and emerging phenomenon with real and imagined aspects. This point of view focuses on the social aspect of the co-design process and interactions and suggests an interpretive framework of how to interact and interpret the emergent interactions with older users while engaging them in a co-design process of an App service called 'Age TechCare' for the prevention of falls (Mazuz, Biswas, and Lindner 2019).

The interpretive framework

Anthropology theory and methods play valuable roles in the innovation of technological services and products because they probe the emergent social and cultural context of how things work, for whom they work, when and why, and motivations that manage how people use technology. Anthropologists examine through interviews and observations how people use, discuss, and imagine technology so that users may become a significant source of innovation. The following approach proposes an interpretive framework for understanding how older users innovate technology as well as their own aging process while designing in a service network. Such a framework may prove vitally important for developing innovation when the outcome, the technological artifact, or the prospective target users, are not yet known or are difficult to model analytically.

Based on the interdisciplinary approach, we propose an interpretive framework for understanding the context in which older users discuss, use, and imagine technology as well as their needs and routines. In the following case, falls (whether they occur or the fear of falling) play an important part in older adult daily routines. Thus, the following framework is a model of an App design that will engage with their routines and service network.

The interpretive framework is composed of three levels that can be implemented along with different phases of co-design interactions (it can be implemented at the beginning of an iterative or sequential design cycle in general and/or as part of a specific test in a series of tests and redesign cycles) as seen in *Figure 1.*

This framework intersects with the CAT model which theoretically "relaxes implicit notions of stability inherent to the interventionist logic" (that assume aging is a stable target for technology interventions) (Peine and Neven 2020, p.5). Identifying the context and then re- and de-contextualizing as design methods assume aging, as well as technology, can be innovated:

Contextualizing

At this level, we openly talk with the older users using a focus group dynamic to identify how the users co-create value and integrate resources while trying to solve a problem within a specific context (i.e., fall prevention). The co-creation of value in this article, is based on the McColl-Kennedy (2012) definition of *"benefit realized from integration of resources through activities and interactions with collaborators in the customer's service network"* (McColl-Kennedy et al. 2012, p.370). The concept of customer participation acknowledges other sources that input the customer's value-creating processes (Vargo and Lusch 2004, 2008, 2009), including from the customer's own activities as 'value-in-use'. Values are types of knowledge and skills that embody interactions and perceptions that people learn throughout their lives while handling everyday tasks and solving problems (also known as practical wisdom or tacit knowledge by Nonaka and Takeuchi (2009)). Through practices of co-creation of value, the problem is posed and presented in a specific context. The context conveys an answer as to why someone is likely to value or not value a service, such as an App or other technology, and with whom it is being valued within the service setting (for example, the users' caregivers, physicians, or family members). Thus, the focus group discussions at this level should identify practices of value cocreation and service setting from which the context of the phenomenon emerges.

Re-contextualizing

At this level, we openly talk and interact with actors from the service setting that were identified at the previous level using a focus group dynamic. When users co-create value they are identifying their practices, behaviors, expectations, and gains with other actors within the service setting

Table 1. The three phases in the development and assessment of the App in relation to the interpretive framework

Phase	Methods	Outcome	Level of interpretive framework
Phase 1	In-depth interviews and 2 focus groups Older individuals (n = 12) Older individuals (n = 12)	Defining the problem Item drafting of the first mock-up App	Contextualizing
	In-depth interviews and 1 focus group Health care professionals (n = 8)	Drafting the first mock-up App	Re-contextualizing
	In-depth interviews and 1 focus group Older individuals (n = 12)	Developing a prototype App	De-contextualizing
Phase 2	Pilot test of the App Older individuals (n = 51)	Usability test	
Phase 3	Focus groups and data retrieval Older individuals (n = 51)	Satisfaction survey and focus group feedback	

(for example, health professionals who work with older adults to prevent falls). At this level, we map and capture how certain aspects and ideas about the phenomenon (i.e., fall events or the users' aging process) shape the service setting where older users interact, and how certain aspects are inscribed into aging and technology, while others are sidelined or ignored. In that way, we deepen our understanding of the broad and dynamic context from which the older users interact and derive meanings and values. So far, based on these two levels we gain a partial picture of the "micro" (contextualizing) and "macro" (re-contextualizing) components of the phenomenon. Due to the continuously evolving cyclical relationship between aging and technology and their real and imagined dimensions, we always gain a partial picture at this point. The important point is that this partial picture is a shared one in a service setting, that may bring together different understandings that make sense of the lifeworld, and in which particular features of the lifeworld become evident.

De-contextualizing

At this level, we synthesize the two previous levels while preserving their meaning by item drafting and developing a prototype using focus group dynamics. It is important at this level not to prefer one level over the other, no level is more important than the other (whether we consider the "micro" level of the lives of the users or the "macro" level of the social setting). Synthesizing between them while letting new meanings about technology and aging emerge is the act of innovation. Innovation, in that sense, is to visualize through a mock-up that synthesises together diverse levels and knowledge and relates between them. De-contextualizing is not a deductive or inductive process. This synthesis should be reflected in the mock-up App and points out how the technology developed enables the users to co-create value in the specific service setting, and what this means for both the users and other actors to age (or to fall) in relation to the technology. Thus, the mock-up is a powerful tool that constructs meaning and enables us to imagine reality before it is realized.

Methods

Ethics approval

Ethics approval for all phases of this research was granted by the Ethics Committee of Hadassah Academic College in Jerusalem, Israel. All participants received verbal and written information about the research and gave signed written informed consent to participate.

Data collection

The research and development projects were performed between July 2017 and September 2019 (Mazuz, Biswas, and Lindner 2019). The interpretive analysis draws on various methods collected in three phases as illustrated in *Table 1*. This article focuses on phase 1 only to illustrate the interpretive framework analysis.

As part of the open innovation paradigm, this research was managed and funded by CDI-Negev in collaboration with the Israeli National Insurance Fund of the National Insurance Institute (Bituach Leumi), JDC-Joint (the American Jewish Joint Distribution Committee), the Israeli Ministry of Health's National Program for Fall Prevention, WizeCare Technologies and Uniper Care Technologies.

The Centre for Digital Innovation-Negev (CDI-Negev) living laboratory (https://www.cdi-negev.com/project/the-healthy-aging-simulation-center/), works with older adults in Beer Sheva, Israel, to promote digital literacy and healthy aging in collaboration with local social, educational, health care and senior citizen advocacy organizations. CDI-Negev develops and tests technological innovations that support healthy aging among senior citizens who receive training in their use in the laboratory, at home, and in nearby residential homes.

Participants in this research were recruited through the CDI-Negev SeniorTech program. Uniper Care Technologies offer artificial intelligence (AI) based in-home assistance platforms for older

Table 2. Four themes describing fall events as a social problem within older adult activities as parts of contextualizing levels

Order of themes	Why a fall event is a social problem?	What does the older adult do after a fall? Value co-creation activities	The context
1	*An event has happened – a fall or near-fall*	- Request and receive initial assistance from others or use devices such as pendent alarm - Try to make sense of what happened - Try to resolve problems alone as quickly as possible	Fall events are silent events (fall events that are not disclosed, reported, or treated) due to social problems
2	*Feelings of embarrassment*	- Refuse ambulance assistance in spite of physical pain - Non disclosure of event to carer, health professional or loved one - Afraid to be labelled as "at risk of a further fall" - Self-denial (forget to wear pendent alarm when at home) - Acknowledgement of a series of fall events that have occurred - Rationalization of outdoor fall event as a "legitimate fall". The outdoor environment is regarded as more unpredictable and beyond a personal realm of control	
3	*Fear of loss of independence and restrictions to daily routine and mobility*	- No use of a walking stick or cane within the home - Fear of falling - Attempts to recall fall events and make sense of what happened - Afraid of exposure of personal vulnerability	
4	*Dilemma in disclosure of fall event*	- Trying to navigate care - Feeling patronized by health care professionals - Lack of confidence in the medical system - Avoiding Emergency Room visits - Risk management at home - increased awareness and caution, personal assessment of dangerous environments - Disclosure to trusted individuals such as a physiotherapist or nurse	

adults, producing Android-based set-top boxes that transform any television into a smart television (smart TV). In addition to entertainment, the interactive TV platform features several holistic services including social engagement, assistance in performing daily activities, and management of medical needs to facilitate independent living for older adults in their own homes. WizeCare technologies designed the exercise video which was embedded in the App. WizeCare (https://wizecare.com/) provides all-in-one solutions for telerehabilitation physiotherapy. The video comprises static and dynamic balance exercises combined with strength, flexibility, and aerobic exercises.

Phase 1 of research: In-depth interviews and focus group dynamics

This phase included the recruitment of older users aged 62 years and over (n=36) and health care professionals who are Key Opinion Leaders (KOLs) from the users' service network (n=8) for focus group dynamics and input into the design and assessment of a mock-up App. The older users were invited via email and telephone to join the co-design process. Those interested were asked to complete a registration form and were then invited to participate in phase 1 focus group discussions and open interviews aimed at item drafting and design. Four focus group sessions were undertaken, each group was up to 2 hours long and had 12 participants. The focus group dynamic began with one main open-ended question - asking to describe in detail a fall event they or a relative or friend had experienced in or outdoors. Additionally, to stimulate a group dynamic we requested that participants ask other participants questions to find similarities and differences in their narratives and behaviours. We encouraged group dynamics and interactions between the participants to avoid self-testimony (as in an in-depth interview) and to enable sufficient interaction for new perspectives about fall events to emerge (all the focus groups sessions were led by a medical anthropologist).

This method assumes that the group facilitators do not know all the questions in advance (let alone the answers). The aim of the focus group was to understand the context of fall events or how fall events are imagined and experienced in their everyday life and how participants co-create value in a specific context and service setting. The focus groups were recorded and then analyzed and interpreted to examine the participants' co-creation of value practices and how they make sense of their aging process. Through group interactions and discussions, we were able to underline the interactive and shared experience of falls as a contextualized experience. Thus, the co-creation of value is more visible through group interactions.

Phase 2 of research: Pilot test of the App

Based on the process of App drafting from Phase 1, this second phase involved testing the App for acceptability and usability in a 10-week pilot study. A total of 51 volunteers were recruited (15 volunteers were Uniper Care smartTV users and 36 were from the CDI-Negev SeniorTech community).

Phase 3 of research: Focus groups and data retrieval

In Phase 3 the data accumulated in the App, survey and focus group were transcribed, anonymized, and stored in a password-protected file available only to the researchers for analysis. SPSS (Statistical Package for the Social Sciences) program for

t-test and Anova associations was used for statistical analysis. Phase 3 concluded with a satisfaction survey and focus group feedback. Phases 2 and phase 3 are explained in detail in a previous article (Mazuz, Biswas, and Lindner 2019).

Findings

During Phase 1, four focus groups were conducted for open discussion and draft item writing of the mock-up App. In the following sections we analyse Phase 1 findings to illustrate the three levels of the interpretive framework:

First level: Contextualizing

Based on the two group discussions (n=24), we identified the context of fall events as a social problem. Older users unanimously described falls in their narratives as a social problem. We analyzed the discussion based on value co-creation practices that were identified, and as a result the context was understood in the terms described in *Table 2* which illustrates the users' fall journey within the context of four themes. Based on this analysis, a new meaning emerged, describing fall events as a "silent event" (i.e., all types of fall events including near-falls and fear of falling, that are not disclosed, reported, or treated) within the context of a social problem.

First theme: An event has happened – a fall or near-fall

In one of the focus groups sessions, a 75-year-old woman described an outdoor fall event. She was walking down the street when she suddenly felt pain and realized she was lying face down in the street. A few minutes later when onlookers gathered around her to assist her, she looked around and understood she had fallen because the pavement was uneven. She refused ambulance assistance despite her pain. She reassured everyone that she was fine and was able to mobilize without assistance. Only later, when she returned home, did she notice the bruises on her knee and her swollen hand (she had a fractured wrist).

Another participant, a 73-year-old woman described herself as a *"serial faller"*. She started her dialogue imitating the opening of a Narcotics and Alcoholics Anonymous opening at a group meeting, *"Hi, my name is … and I am a serial faller"*, the other participants smiled, and one answered, *"we love you …, we know the feeling"*. She told the group that ten days earlier she fell in her living room at home. She had an alarm pendant, but it was far from her (on a kitchen table). She usually keeps the alarm in the kitchen and or the shower because of the risk of a slippery floor. As a result of the fall, she felt pain and numbness in her legs and was not able to lift herself. She was on the floor for several minutes - *"half an hour or so, I can't recall exactly"*. In the group dynamics, all the participants' narratives included at least one instance of a near-fall and/or a fear of falling, whether in the shower at home, or outdoors on steps or a bus.

Second theme: Feelings of embarrassment

When one of the participants described her embarrassment and shame after a fall resulting in a fractured wrist, all the participants in the group nodded their agreement and empathized with her, agreeing that any fall event, whether indoor or outdoor, is an embarrassing event, especially if it is a recurring event. This group dynamic provided a place to share their stories of embarrassment.

All the participants (n=24) agreed that they have a fear of falling and acknowledge that this is *"part of getting old"*. Only five participants (especially those who had previously fallen twice or more) admitted to using a pendent alarm at home. They described a pendent alarm as only a partial solution as it is not effective outside the home and they frequently forget to wear it while at home. Other participants also admitted that they do not use a walking stick or cane within the home, even if they need it. They admit that these solutions make them feel old, frail, and always at risk. This sense of being at risk is powerful in shaping aging images and the self-perception of what it means to age to all participants (no matter what their age, gender, or health status).

All the participants agreed that falls outside the home are more *"legitimate"* as there are more unpredictable risks outdoors and fewer factors within their control to mitigate. They agreed that they are more inclined to tell others and ask for assistance when they fall outdoors.

Third theme: Fear of loss of independence and restrictions to daily routine and mobility

Another participant, a 78-year-old man, agreed with the rest of the participants and described the same dilemma - whether to tell family members. He described a fall while gardening in his house. He climbed a ladder and fell on his back and head. He recalled *"fainting"* for a few minutes. He felt ashamed and was afraid to tell his wife, fearing he would be prevented from gardening. His fears extended to being prevented from continuing other activities affecting his independence, *"I have a good life with meaningful activities that I love, such as gardening. I don't want anyone to take that away from me, not even my clumsy behaviour. I was shocked and annoyed with myself because I am clumsy. I often bump into furniture or drop things"*. He, in common with other participants, said he does not understand what causes the falls, and after each fall, tries to recall and make sense of what happened. He told the group that since the fall he has been trying to practice *"risk management so this event*

won't happen again". This involves an increased awareness of his surroundings and caution to avoid dangerous situations. This presents a challenge - *"It is hard to change behaviour. We are used to certain ways of doing things."*

Fourth theme: Dilemma in the disclosure of a fall event

The participant who fell and fractured her wrist felt too embarrassed to tell her daughter of her fall. The day after the fall, she saw her physician and found out she had fractured her wrist. She clearly remembers the physician saying to her *"You must be more careful on the road next time, even at home. Be careful! It is not safe for you"*. This made her even more embarrassed, as though she were responsible for the fall – as though she had been careless. After the meeting with her physician, she admitted to the group that she had promised herself not to consult the physician again. With a feeling of a lack of confidence in the medical system, she concluded *"they don't know what to do with us, or how to help us. If all the older people who fell in a day were to come to the Emergency Room, the system would collapse. There are too many people with injuries for the system to assist or to prevent a fall"*. She continued *"I don't want to think of my home, the place I have lived for the past 30 years and raised my children and now my grandchildren, as unsafe, a place that puts me at risk. How would I be able to live then?"* Falls at home, where individuals believe they can mitigate risk, therefore, create the greatest dilemma in disclosure.

She was upset because she felt the physician treated her as a child, especially when she could not recall exactly how she fell, even though she was conscious throughout the experience. She concluded, *"I guess that some events we need to keep secret and not tell others"*. Some participants agreed with her and disclosed that they have friends who keep some fall events secret because they trigger doubts among their children about whether their parents are safe at home and precipitate negotiations about the installation of alarms and monitoring devices.

Another three participants described their experiences and agreed that they had decided not to tell their physician but to tell others such as a physiotherapist or nurse because they perceived them to be on their wavelength and did not try to educate them as if they were children. One of the participants suggested that disclosing an ache or pain to the physician was a way of avoiding disclosure of the actual fall.

One of the participants described a fall at home after which, with considerable effort, she was able to get to the telephone to call her daughter who answered in frustration *"Oh, again... another fall!"* She was immediately embarrassed and ashamed, feeling a burden to her daughter. *"I am becoming more ashamed from one fall to the next. I feel like I am losing control, so I have stopped counting how many times it happens. I stopped trying to understand why, whether there is a connection between all the falls. I was so afraid for my future that maybe I am in denial. I usually don't talk about all my slips or when I have almost fallen while walking outside. You can't track all of them [the fall events]. You must not tell anyone about them, otherwise, it will become a problem and stop me from doing the things I want to do"*. She promised her daughter that she would be careful, but she doubted she would call her daughter should she fall again.

Analysis of the value co-creation activities: how does a fall become a silent event?

All the participants concluded that they do not regularly report fall events to their caregivers or physicians due to social problems that may arise from the reports. This means that they do not share or co-create value within their service network (family members and physicians). They feel embarrassed to share the details of every fall event and are afraid of losing their independence by exposing their vulnerability. Also, they do not want to be a burden to their caregivers by reporting every fall event. Moreover, every participant perceived that no effective intervention exists after the report of a fall (whether it is a fear of falling or a near-fall), thus, there would be no value in reporting a fall event, which then remains a silent event. For example, reporting a fall to their physician entailed referral to physiotherapy which they were reluctant to attend as this was an additional cost and trouble.

The social impact of a fall is significant. Far from the perception of a fall as a medical event, in the participants' narratives falls were described in terms of their social implications. The societal connotation of a fall, the loss of independence, and the cultural connotation of care synthesize the two meanings into one event. Based on the value co-creation practices that were identified, we interpret the context. Three practices of value co-creation were identified and analyzed:

Recalling the details, organizing the narrative

Even though the questions were open-ended, all the fall event narratives were composed with the same structure including a timeline with a beginning, middle, and end (this is one part of the emerging group interactions). The participants described in detail the events following this specific timeline and tried to recall all the details. They described where the fall event happened, when and how it happened, why they thought it

had happened, and what they had done just before and after the fall event. In this manner, they tried to relate what they did before the fall and what happened afterward to make sense of their reactions, what had just happened, and how they would act as a result. This emergent structure of their narratives was followed by all the participants in a *"match and complete"* manner, as though they were organizing their private event in one volume. The organization of the story into one structure with an effort to recall all the details required some effort to connect the dots within each story and between all the stories (something which individual interviews could not capture). Repeating the story with the same structure co-created the social value of validation (that they can remember the details although they do not know exactly how or why they fell) and achieved social acknowledgment through sharing of the event in the group dynamic. The participants were actively seeking information, sharing, advising each other, and providing feedback, this dynamic enabled them to learn for themselves more about their aging process.

Communication
In each story, the main dilemma was whether or not to tell anyone about their fall. This decision was linked to the participant's perception of the value in sharing this information, and the perceived risk in telling anyone where the consequence may include a restriction on their movement, activity, or independence. The perception of being a burden to their families was significant (crucial in their decision to keep the fall event a secret).

Emotional labour
All the participants shared their self-practice which demanded emotional labour during the fall events, after the fall events, and while talking about it with others. For example, keeping the event a secret, screening when and whom to tell, feelings of embarrassment, losing control, being old, and mistrust of medical offerings. Their purpose in sharing the details of fall events was not just to report each event but to make sense of their lived experiences in relation to their peers and to the technology (i.e., pendent alarm). This is a site where the aging process is rediscovered and redefined.

From the focus group discussions and interactions, we learnt that there are more fall events than what is reported to others within the service setting. The dynamics of the group facilitate discussion of those *"secrets"* openly (in the individual interviews that were conducted before the focus group this issue was either not mentioned or given less focus). These events include all types of fall events from slips, missteps, a loss of balance, near falls to the fear of falling. Based on the discussions, we learnt that the type of a fall event is determined by several indicators: First, every individual interpreted the significance of their fall differently (depending on the outcome, their injuries, underlying physical and mental health, and, in particular, their fall history); second, the social hurt, and especially the shame and embarrassment associated with the fall; third, their level of trust and confidence in medical personnel and health care services; and, fourth, their personal perception of what it means to get old. This last factor enables them to evaluate and manage risks for themselves (as one of the participants argued *"We are at risk all the time, from medication to falls, but we need to manage this and determine what is important for us now. To me feeling independent is worth much more than reporting a fall event"*).

All these factors were key to individuals' decisions in what to do after a fall: whether to tell anyone, whom to tell, how to ask for urgent assistance, what assistance to seek in the longer term, what lifestyle adjustments they think need to be made and what they are prepared to do to avoid a further fall. In this context, a fall event is better understood within a social context rather than regarded as a physical injury with a physical cause.

Based on this context perspective, we asked the participants their thoughts about the role of technology in the perception of fall events and the realities of aging. We asked what type of technology would be valuable and suit them best in this specific context. The participants focused on TV and smartphones as the best technology to use because they were already familiar with the operating systems and, more importantly, the smartphone and TVs were considered private and personal tools – their possessions and technology to which they can already relate. They were against monitoring devices being installed in their homes such as cameras or sensors that gather information because they increase their sense of vulnerability and loss of control.

Second level: Re-contextualizing the fall event
As part of the co-design and assessment of a mock-up App in Phase 1, we brought the findings from discussions at the previous level to another focus group conducted only with health professionals who are Key Opinion Leaders (KOLs) who also work as advisors for the Ministry of Health's national policy regarding fall prevention (doctors, nurses, and employment therapist, social worker, and a physiotherapist working with older adults and treating fall events). All KOLs are part of the service network of older users. In the contextualizing level, while the participants describe how they co-create value, they describe their service networking with whom they interact, just as all the KOLs who participated in this focus group. The

aim of the discussion was to re-contextualize the fall events and to allow new meanings to emerge. Also, in this focus group we requested of the participants that they ask each other questions because they usually work in silos in their different professional positions and different organizations.

Meeting with health professionals about fall events presents potential pitfalls as falls become a medicalized issue from which pre-conceived images of frailty in aging derive. Based on the context we identified in the previous level, the discussions in this focus group were not about fall events but rather about the social context of the events. The older participants made it clear that they did not recognize themselves in images that emphasized frailty and dependence which constitute the immediate image when talking about falls with health KOLs. As it is almost impossible to avoid these pre-images, the aim at this level is to capture, map, and critically question the often simplistic and negative aging images and myths discussed so that we are aware of how to reflect these when designing the App.

To the question of what a fall event is, the KOL participants refer to the medical literature, in which falls are a common and alarming geriatric syndrome among older individuals (Rubenstein 2006) and a major cause of morbidity and mortality (Ambrose et al. 2013). Resulting from the cumulative effects of the cognitive, musculoskeletal, and sensory decline on postural control in the activities of daily living, falls constitute an important antecedent of restrictions in daily activities, lower quality of life, and cause physical injury (Boyd and Stevens 2009; Dunsky 2019).

The discussion reflected the "interventionist logic" (Peine and Neven, 2020) that describes falls as a problem in terms of risk and safety that should be solved using technology and described the use of an App as an example of technology that increases or decreases the frequency of falls as a means of fall prevention (this was deemed the main clinical method of evaluating success in fall prevention intervention). At this level, we do not want to ignore this medical aspect but to link it to the social context the older users brought to the fore at the previous level. Ultimately, the aim of the technology developed is to serve all participants in the service network.

When we presented the KOL participants with the ways older users describe fall events as silent events, the health professionals were surprised because in their practice they had not given enough thought to the different types of falls and how these affect the older adults socially. In this discussion, the participants were confronted with their own images of aging and agreed that they need to critically analyse their own perceptions regarding the effects of technologies on the lives of older people and the definition of vulnerability. From their perspectives they pointed out four reasons why seniors do not disclose fall events: the time elapsed between the actual fall event and meeting with the physician or nurse is too long; patients are not always able to recall exactly what happened; patients forget about falls and do not discuss these during routine appointments; and consultations are rushed, leaving no opportunity to ask about unreported events. Their perception is that older adults fail to connect the dots between all their fall events. They think that each event happens *"in a vacuum"*. Thus, they refrain from talking about fall events and these become irrelevant to their overall functional state. This insight shaped our understanding of the importance of the reporting function of the App which the older adults use for their own records and self-evaluation (which is related to the emotional labour the older users are dealing with after a fall has occurred, as described above).

Third level: De-contextualize the fall event: developing the App prototype

At this last level of the interpretive framework, we invited the older users who participated in the first focus group and new users as this was their first time to interact with this project. The participants in the focus group interacted with paper drafts of the App screens. Based on their feedback, modifications were implemented iteratively until a prototype App was built to operate on smartphone (Android and IOS operating phone systems) and smart TV (Uniper Care Technologies) platforms.

Based on the findings from the previous two levels, we drafted and designed the primary function of the App to be a reporting tool – a personal digital diary beginning with the main question: *"what happened to you?"* The diary format served as a self-report question with answers available to select from a digital menu. During the de-contextualizing process, we *"designed out"* the images of frailty in aging and *"designed in"* items relevant to the ways older users co-create value within their service network.

As described in *Table 3*, the structure of the App and the users' navigation in the digital diary reflected the users' reporting narrative, including the time of the event (when did it happen?), the location of the event (where did it happen? indoors or outdoors?), what caused the fall (what did you do before and after the event?) and whether assistance or medical treatment was sought after the fall (which was an important aspect at the medical re-contextualizing level). These questions, put together from participants' narratives within their service network com-

Table 3. Co-created App screens with questions

Screen page	Concepts/Purpose	Diary question with options
Screen #1: The home screen	Scale/severity of fall event	"What happened to you?" 1. I fell 2. I nearly-fell 3. I had a fear of falling 4. I had a good day
Screen #2	Time of event	When did it happen? 1. Day 2. Night
Screen #3	Location of the event	Where did it happen? 1. Indoors (move to screen #3A) 2. Outdoors (move to screen #3B)
Screen #3A	Specific location of the event outdoors	If the event happened outdoors, where did it happen: 1. On the bus 2. In a street 3. In a building 4. On the stairs
Screen #3B	Specific location of the event indoors	If the event happened indoors, where did it happen: 1. In the kitchen 2. In the shower/toilet 3. In the bedroom 4. On the stairs
Screen #4	Awareness	What do you think caused the event? 1. Slippery surface 2. Tripped 3. Dizziness 4. Unsafe behavior 5. I don't know
Screen #5	Lifestyle management	What had you just done before the event? 1. Got up from seat 2. Taken medication 3. Used the stairs 4. I don't know
Screen #6	Outcome of the event	Did you seek medical treatment after the event? 1. Yes 2. No
Screen # 7	Preventative intervention	Thank you for joining us, let's begin a balance exercise. This series of activities can help reduce the risk of a fall. The lesson will take up to 10 minutes so wear comfortable closed footwear and choose a suitable place to do your exercises. If you feel weak or dizzy stop the activity. Enjoy! Let's begin
Screen #8	Acceptability of the intervention and confidence (after the video exercise session)	How was it? 1. Good 2. Not good

prised seven multiple-choice questions with the option to select only one answer to each question and the facility to navigate backward or forward through the App.

The flowchart in *Table 3* shows the design logic through the questions in the App which combine the two levels. While interacting with the mock-up App, participants suggested the phrasing of questions and responses in terms they found acceptable based on their aging images (some of the participants related to accessibility and design features such as color or font size). For example, in the first question on the home screen *"what happened to you?"* they suggested four answers: *"I fell"*; *"I nearly fell"*; *"I fear falling"*; *"I had a good day"* (meaning *"no fall"*). The phrase *"I had a good day"* was used instead of *"no fall"* at the insistence of focus group participants who perceived this a more positive description of their daily activities. Another phrase the older participants offered was *"I don't know"* instead of *"I don't remember"* so that there was no agist implication of memory loss. The participants suggested that automated notifications to complete the diary be sent three times per week as a helpful friendly reminder and a habit-forming refrain at an hour of their own choice. These suggestions relate to their personal perception of what it means to get old. After finishing the report, they asked for practical recommendations and preventative interventions they can immediately undertake, such as balance and coordination video clip exercises. This was an aspect that co-creates value with the KOL health professionals who wanted to promote fall prevention interventions; this is one aspect toward acceptability.

Co-designing the App with the participants alongside the three levels contributed to the contextualizing and understanding of the meanings of fall events in the everyday life of older adults and, as a result, shaped the design logic. The design premise was to create a feedback loop between the self-reports (*"what happened to me?"*) and the intervention (*"what can I do?"*) with one action linking to and driving the other, so self-reports became the driver to increase awareness and motivate the implementation of the preventive intervention (balance and coordination exercises). And by that, they could co-create value with the KOL health professionals.

Based on the value co-creation activities described above - recalling the details, communication, and emotional labour - the App delivered, at once and in one click, both the self-reporting diary and the prevention intervention, downloading and performing fall-prevention exercises. Instant reporting of the events allows later *"joining of the dots"* as discussed with the health professionals, without losing control and independence. The digital diary could be the basis of further and mutual discussion among the users within their service network.

Extending the use of this App for smart TV users was crucial in understanding the value of self-management tools among older adults because watching and using TV is a lifelong habit that is deeply rooted in everyday routines as opposed to the new smartphone devices.

Smartphone texting and App notifications were important requests of the participants during the focus group discussions. Three times weekly notifications were considered a motivator to use the App. Additionally, a text message was very much valued for older users because texts are easy to read and respond to and are not perceived as invasive or a threat to their privacy. The details they record are essential for their own perusal and analysis – available to review at their discretion. One user requested distinct ring tones or sounds for the text App messages.

Discussion

The interpretive framework exposed what users do, discuss, and how they imagine themselves with technology when they co-create value. This is of particular importance when technology is not yet developed and known and where there exists a gap between what designers and engineers think older users need, and what users ask for or how they want to be treated. Understanding the context of the problem and then re-contextualizing and de-contextualizing it as an interpretive framework that enables co-designing a valuable App for users within their service network. Technology is not a singular object, in the sense that it has only a well-defined and measurable impact on the lives of older users but integrates the lives of older users and changes the ways in which they are able to co-create value in a service network. The 'Age-Techcare' App cannot be expected uniquely to prevent falls as if this were the only outcome to measure. The prevention of falls is a major need and interest for both the older adults and the health care profession; thus, co-design focus groups are necessary in order to realize and acknowledge this need. At this point, we understand how technology becomes meaningful in this specific context and within the service network. As a result, new meanings emerge.

Thus, technological artifacts are not neutral objects but present meaning about aging through the specific way in which they are imagined, designed, used, and marketed. The focus groups described fall events in relation to the way they imagine their role as older users within a service network. The App, therefore, carries with it the context of falls as silent events that emerge from the users' ways to co-create value (regarding disclosure, fear of a loss of independence, and interaction with health care professionals and family). Eventually like every other technology, the App (whether on the user's smartphones or smart TV) enters the lifeworld of the older users together with the technical objects, social meanings, and values they co-create.

The digital diary on the App was designed based on the three practices of value co-creation identified and described above: recalling details and organizing the narrative, communication, and emotional labour. In this way, the App engaged with the ways older users make sense of their daily life and needs while interacting within a co-design process. The App enables the co-creation of new values (i.e., *"Whom to inform of a fall event"*), practices (i.e., *"What is the proper use of the App?"*), and subjectivities (*"Am I healthy or at risk? Am I embarrassed?"*) – all of which are dynamic ongoing negotiations between themselves and their surroundings over time.

The users compared the App with other devices currently in use for fall prevention, such as smartwatch sensors and alarm pendants. They described a pendent alarm as only a partial solution as it is not effective outside the home and they frequently forget to wear it when at home. Thus, the pendant alarm may be described in this context as a non-compliant device. In this context, the App serves as a *"pre-alarm pendant"* because its value lies before rather than during a fall event. Moreover, the App has value in coping with the social problems described above that lead to silent events.

The App data can become a resource for users and health professionals to integrate information and co-create value in a service network, for example, in the recollection of exactly what happened during a fall event (and not discussed at routine doctors' appointments). By using the App, the users can choose when and with whom to share the details of the fall events they document on the App (the de-contextualizing level may bridge the gap between the older user and the health professional through an understanding of the value of co-creation).

When identifying the context and meanings of fall events, the potential in facilitating older adults to exert control or to build self-confidence and competence and to take responsibility for their own health is valuable for accepting and utilizing the App. More precisely, they highlight how aspects of aging and technology achieve specific values only in relation to each other.

The self-management App, comprising a self-reporting and exercise promotion tool, constitutes healthy aging as a contextual phenomenon for older adults related to their surroundings, behaviours, and positive and negative life events. This contrasts

with the alarm pendant which conveys a specific version of aging where older adults feel vulnerable and continually aware of risk and danger. The ability for older adults to co-create value, negotiate ideas and practices of risk and safety is crucial to older adults in their acceptance of technology.

In the sequential 2nd and 3rd phases (as described in the Methods section), we continued to test the prototype to explore aspects of acceptability, usability, and impact on the daily lives of the users (Mazuz, Biswas, and Lindner 2019). And as suggested by the CAT-model, the best way of understanding acceptance, usability and impact are to start from a model that does not presuppose what aging or technology means.

Processes of co-design are sites of innovation. What is being innovated is not only technology but also new ideas, new roles, new users which in turn shapes technology development and so the cycle continues with other factors and actors playing a role in a service network. The interpretive framework enables entering this ongoing cycle of innovation to select some aspects and values that are reflected in the technology developed and user roles.

This also reflects the research limitations. When to enter the ongoing cycle is a challenging decision to make which is also affected by financial and time constraints. For example, we may choose to re-contextualize with the users' family members in addition or instead of health KOLs. Thus, it is important to investigate co-design processes alongside iterative and redesign cycles and with different stakeholders from the users' service setting who co-create value with them. Practical questions concern the duration of the process, the number of cycles, the sum of focus group findings, the role of stakeholder opinions, with whom to interact in the service network, and how to measure the success of the design logic. All are difficult to answer in advance due to the complexity of technology and the diversity of the aging population and are beyond the scope of this article.

Conclusion

With this framework, we hope to foster a deeper and systematic understanding of the way older users and technology co-constitute each other. Our study suggests focussing on how users make sense of their life-worlds through practices of value co-creation, resource integration, and knowledge exchange. Thus, it is important to co-design with older users from the beginning and continue throughout the development process. By contextualizing, re-, and de- contextualizing we facilitate the emergence of innovation - innovation of aging and of technology. In this framework, the user is not a passive recipient and technology is not a stable agent, both change in relation to one another. Also, the individual narrative about his/her fall event is not only anecdotal data but serves to contextualize, re-, and decontextualize to generate new images and ideas.

At a theoretical and methodological level, the article offers a new framework for co-design processes. As part of co-design and open innovation processes, the user's role and images are also developed. This is a crucial first step to incorporating the ongoing aging process into the provision of effective service Apps tailor-made for older adults and the creation of a collaborative service network and market.

Future research should seek to shed light on how co-design interactions emerge and can lead to the development of more meaningful and valuable technologies for older people within service settings. The interpretive framework offers a structure of how to talk (open-ended questions and group dynamics) and how to interpret the discussion (through contextualization, re and de-contextualization of the co-creation value) as an emergent phenomenon to allow innovation to emerge.

This framework should be examined across different service settings and times to analyze the *"outcomes"* in terms of the resulting technology and new users' roles, and to compare whether something else emerges across time. Future research should map how different service networks produce different versions of aging and technology as another dimension of acceptability. Another recommendation for future research is to investigate this framework with all types of technology (Apps, devices, social robots, software, and more) and different users. If aging is the outcome of a co-design process and not a condition, we could test technologies also with users who are not defined as older. It is important not to let the sociodemographic categories that older users represent (i.e., age, gender, health status, ethnicity, and more) determine what is aging and how technology should be developed in relation to these representations. These representation categories are only one map but not the entire territory of aging that may emerge and innovate.

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