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DETECTING FALLS AT HOME: USER-CENTERED DESIGN OF A PERVASIVE TECHNOLOGY

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Abstract: *Falling is the main cause of domestic accidents and fatal injuries to seniors at home. In this paper, we describe the design process for a new pervasive technology (CIRDO). The aim of this technology is to detect falls (via audio and video sensors) and to alert the elderly's family or caregivers. Two complementary studies were performed. Firstly, the actual risk situations of older adults were analyzed. Secondly, social acceptance was investigated for the different homecare field stakeholders. Our results highlight the tensions among social actors towards the tool and their impacts on technology acceptance by the elderly. Also, we show a significant change in the fall process due to the device. In actuality, the social functions associated with CIRDO implementation and the necessity of iterative design processes suggest that the CIRDO system should be more flexible and versatile to better fit the risk behaviors of seniors that evolve using this device.*

Keywords: *pervasive technology, acceptance, domestic activity, elderly people, risk situation.*

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INTRODUCTION

Over the past few years, the home care of dependent people has become a priority in societies, for both economical and societal reasons (Robert-Bobée, 2006). A study called Altivis (Gaucher & Ribes, 2006) explored the concerns of the elderly at home and revealed that the fear of falling ranks second after the fear of dependency. A fall, even a minor incident, can have serious implications, especially at a psychosocial level. The elderly could drastically reduce their activities to avoid accident-prone situations. In addition, falling can lead to further isolation and to the loss of all social ties. New ways to support the aging process and prevent the associated risks are necessary to enable the elderly to maintain their autonomy and quality of life and to delay institutionalization as long as possible. Our gerontechnology study, known as the CIRDO study,[1] takes place within this context. Its objective was to design a pervasive technology disseminated in the home that helps to automatically detect falls via audio and video sensors and to alert emergency services if necessary.

Using a user-centered system design (Norman & Draper, 1986) and a multidisciplinary research approach (associating computer sciences, ergonomics, and social psychology), this article presents the methods and key findings that have led to the development of a social alarm management device compatible with the specific needs of vulnerable people, and one that can be implemented in the user's psychosocial environment. More specifically, we present the analyses that have allowed us to (a) model falling at home among the elderly (falling scripts) and (b) explore the conditions of accepting the device by the various "actors" in the home care environment.

Presentation of the CIRDO System's Technological Device

The objective of the CIRDO system is to provide a relatively discrete technological solution to the issue of falling, often faced by elderly people at home. Technically, the device is composed of camera(s)[2] and microphone(s) distributed in the domestic space and is based on the detection of human activities via video and audio sensors. The system is automatic (i.e., no external human intervention or surveillance) and evaluates, in real time, abnormal, dangerous, or risky domestic situations (falls, immobility, calls for help, accidents, etc.) and then alerts family members or caregivers, if necessary. The vocal interaction between the CIRDO system and the elderly individual is simplified: It asks if the person needs help ("I identified an abnormal situation. Do you need help?") and if there is a positive answer or no answer at all, the system alerts the emergency departments.

The Scientific Objectives of the Study

In an approach designed for use, we sought to provide two types of complementary results:

1. The first results were planned for the scientific partners of the study (image processing and language specialists). Our objective was to provide partners with behavioral (key postures) and verbal (key words) scenarios of risky situations for the elderly in the home to help the technology designers define the parameters for automatically detecting falls with the CIRDO system. To support the design, we devised an innovative methodology for the analysis of falls within the complex and uncontrolled environments where

people live. Indeed, studies previously conducted in the field of gerontechnology are based mainly on quantitative or experimental methods (Wu et al., 2013) that enable researchers achieve cognitive dimensions (e.g., Huang & Dong, 2015). The contribution of our methodology can be found in the better understanding of the details of the elderly's daily lives. The steps taken and the results obtained are presented in Study 1.

2. The second type of analysis, aimed at industrial partners (system manufacturers, institutional prescribers, training institutions for home caregivers, etc.), explored the conditions for accepting this new device by the various "players" in the home: the elderly individual, family members/caregivers, and professional caregivers. It is necessary to reflect on perfecting the approaches to anticipate the uses and the possible impacts of an innovative system that has no equivalent among existing technical devices. This is discussed in Study 2.

The Contributions of This Study to the Links Between Choreography and Gerontechnology

For us researchers, as part of the CIRDO system's design and implementation in the home of the elderly, the choreographic approach (Loke & Robertson, 2010) seemed particularly relevant to consider for our study. Although the concept of choreography mainly refers to an aesthetic and body art experience, we believe that the domestic activity of a person can also be regarded as a choreographed activity in a psychosocial sense. This choreography framework allowed us researchers and designers of the CIRDO system to have a better representation of the movements in, the associated feelings about, and a fuller understanding of falls as a real condition of life, thus supplementing existing data regarding designing interactive computing technologies (Boehner, Sengers, & Warner, 2008; Gillies, Brenton, & Kleinsmith, 2015; Hansen, 2015; Wright, Wallace, & McCarthy, 2008).

More precisely, for elderly people, such choreography of behaviors at home would be structured around these three points:

1. Scenography: The general aim is to organize the space to avoid obstacles and falls and to quickly and easily access the various objects in the home. This speaks to the concept of "setting," in which the situation is built around an individual's activities (Lave, 1988);
2. Gesture and reality: The activities of the elderly tend to be highly ritualized and this leads to efficient conducts (scripts) in order to effectively carry out various daily activities while minimizing physical costs and associated risks.
3. Relatives and others: This staging (with rules and proper behaviors) also aims to reassure the entourage, offering the best possible picture (in the sense of Goffman, 1959) and, thus, showing the autonomy, the risk of institutionalization, and so on, faced by their loved one or care client.

Deploying this domestic choreography, with a set of predefined behaviors and rules, shows the intention to master the risk and exercise control over the unexpected—or any possible accidents. Thus, the ability to detect abnormal behavior by the CIRDO system can be seen as an exception to a typical choreography expected in the home. But a fall can be understood in our research as a conduct that we sought to formalize and, therefore, to choreograph, thereby allowing its detection

by the device. Indeed, one of the main aims is precisely to be able to script a fall as a process (which is unexpected, unintentional, and uncontrolled) to enable designers to develop the suitable detection algorithms (voice and video) for such an event. The creation of these scripts may help distinguish between a normal and an abnormal/dangerous situation. Finally, the introduction of the device to preexisting social and domestic systems inevitably impacted the social choreography (social scenography; Capeto, 2015), in other words, the scripts outlined the roles, places, and functions of each player (caregivers, family members, and the elderly) in the elderly client's management, as well as on the nature of social interactions. Moreover, in order to report as clearly as possible on these different levels of choreographic analysis (i.e., the analysis of the social structure of the CIRDO system setup by behavioral and individual analysis) and associated analytical approaches (e.g., user-centered design and the ethno-methodological approach), we have chosen to present our results in two separate parts.

By integrating more fall analyses in the psychosocial context of their production and management, we had two goals for our research project. First, we sought to provide more insight into the design of the terms and conditions of the CIRDO system's possible uses in domestic situations. And second, we wanted to better guide, via recommendations, the designers and the multiple participants involved in deploying such a technology solution. The research aims for each of these goals are presented in their appropriate subsections in the Methods section.

THE THEORETICAL FRAMEWORK

Risk Factors for the Elderly in the Home

Defined as "the fact of unintentionally ending up lying on the ground, or any other lower-level surface" (Haute Autorité à la Santé [HAL], 2009, p. 18), a fall entails a phenomenon that is not easily characterized. The studies by Ballinger and Payne (2002) showed that seniors underestimate the risks they face. The bias in this self-assessment stems from a sense of superiority or optimism or the illusion of invulnerability. This denial can influence the elderly's perception of the usefulness and relevance of protection devices such as CIRDO. Findings from the study carried out by l'Institut National pour la Prévention et l'Education à la Santé (INPES; 2006) showed that fall risks are significant. In France, almost a quarter of people aged 65 to 75 years old had fallen in the 12 months prior to the study. These falls represent almost 80% of daily accidents. They are implicated in over 60% of domestic accidents and are responsible for approximately 9,300 deaths annually among individuals aged 65 years and above. However, these data are generally underestimated because the elderly often forget that they fell (Cummings, Nevitt, & Kidd, 1988). Moreover, age, gender, and health status can affect the type and gravity of the fall (Todd, Ballinger, & Whitehead, 2007). Falling leads to limited outings and increased isolation that can drive the elderly into a state of relative dependency. They can be drawn into a dangerous spiral that makes it difficult for them to remain at home and increases the deleterious effects of aging (Fontaine & Pennequin, 1997).

However, these impairments are neither ineluctable nor irreversible if the elderly are in a safe and suitable environment, both for them and their entourage. This implies that a different perspective must be considered in the process of senescence among the elderly. The onset of disability does not reside in the individual alone. It also depends on the interaction among the said

individual, his/her environment, and, more specifically, the incompatibility between the living conditions of the environment and the needs of the vulnerable person. If the environment is not modified to help individuals with a "deficiency" adapt, then they will be faced with an impediment. On the other hand, such a situation would be nonexistent if the environment was adapted to the individuals (Newell & Gregor, 2000; Vanderheiden, 1997).

Two models can be distinguished in this perspective (Ebersold, 2002). The first is the integrative model in which reducing disability involves working on the individual through rehabilitation or equipment. The second is a participative model, where the environment compensates for an individual's shortcomings and, therefore, transforms the situation into a source of development and autonomy. The CIRDO system project falls within the second approach, as it is made to adapt the environment to the risk situation of the dependent elderly. This pervasive technology aims to transform a situation with obstacles into a suitable situation. We now turn to show how technology helps to decrease obstacles in elderly's homes.

The Contribution of Pervasive Assistive Technologies to the Protection of the Elderly

New ways to support aging and prevent falls are necessary to enable the elderly to maintain their autonomy and delay institutionalization. The field of gerontechnology has explored innovative solutions for assisting elderly individuals in preventing falls and/or diagnosing unusual behaviors (Chan, Esteve, & Campo, 2011; Kerssens, Kumar, Adams, Knott, & Rogers, 2015; Moget, Bonnardel, & Galy-Marie, 2014; Rialle, Duchene, Noury, Bajole, & Demongeot, 2004; Rouillard & Tarby, 2011; Steenkeste, Bocquet, Chan, & Campo, 2001). However, we note that, typically, the primary focus of studies on falls by the elderly explores only the individual, behavioral, or physiological dimensions. This appears to be at the expense of the social and domestic aspects into which risk activities fit. In addition to maintenance and hospitalization at home and the development of autonomy, gerontechnology also aims to rehabilitate and attenuate some deficiencies (Buiza et al., 2009; Hage, 2008) and to improve the quality of life of older adults (Blaschke, Freddolino, & Mullen, 2009; Bobillier Chaumon, Michel, Tarpin-Bernard, & Croisille, 2013; Bronswijk, van Bouma, & Fozard, 2002). Pervasive assistive technologies are less intrusive than conventional systems of remote assistance or surveillance, as they tend to blend into the living environment (Bobillier Chaumon & Ciobanu, 2009). Thus, they are able to anticipate users' needs by using data from the environment and proposing appropriate solutions (Strong & Gaver, 1996). Moreover, these technologies are less stigmatizing because they do not have to be worn, unlike certain remote surveillance bracelets, known as "markers of old age" (Caradec, 1999), which tend to equate the subjects to their shortcomings and to some form of weakness.

METHODS

Study 1. Understanding Activities to Equip the Home Environment

This initial study aimed to understand and model the falling process by using the analysis of daily and actual activities of elderly individuals within their homes. There were three complementary objectives:

1. Identify the nature of the activities of daily living (ADL) of the elderly individual, as well as the risks at home;
2. Define the various falling profiles and identify the factors involved; and
3. Develop falling scenarios to set the parameters and test the CIRDO system.

We present the methodologies implemented within this first study in Figure 1. A fuller description is provided in the subsections here.

Identifying the ADL and the Risks in the Home Environment

We initially interviewed 63 individuals with an average age of 85 years. The sample comprised 90% women, reflecting the greater proportion of women versus men in individuals over age 65 (Institut National de la Statistique et des Etudes Economiques [INSEE], 2014). Therefore, the results of the definition and analysis of fallings will have to be limited to this specific gender. Respondents lived alone at home or in independent living communities. The interviews sought to understand the informants' trajectories and living conditions with regard to autonomy, need, isolation, and social ties with those close to them. We also asked interviewees to describe a typical day in detail. Specifically, we accompanied them to the different places where these activities took place and asked them to simulate their household chores. Our objective was to place them within their contexts while questioning them on the nature of their daily living activities and on the potential risks they face (falls, accidents). We also used the method of critical incidents (Flanagan, 1954) to identify the specific circumstances of incidents (causes, modalities) and their effects.

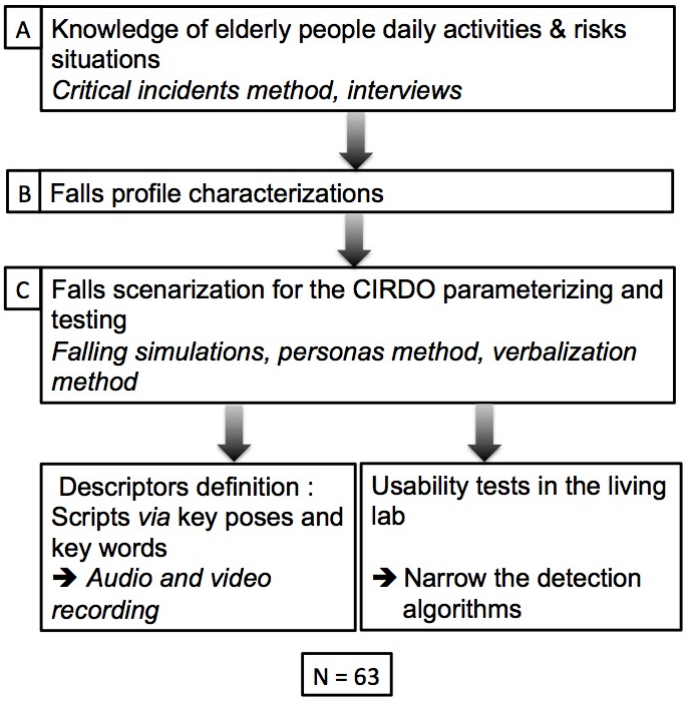

Figure 1. Research protocol of Study 1.

Characterizing and Describing Falling Profiles in the Home

Of all the risk situations that the 63 respondents described, we selected and analyzed 28 falls to identify related factors (see Table 1). Two criteria guided the selection of these incidents. First, a spatial criterion was established to take into account only falls that occurred in the rooms where the device could be implemented and tested: living room, bedroom, kitchen and bathroom. Then, a social criterion allowed investigation into the falls occurring only among isolated individuals. Indeed, the CIRDO system is expected to overcome the isolation and absence of human assistance. The aim of the study was, therefore, to identify how isolated individuals coped after a fall and to determine their assistance needs.

Establishing the Falling Scenarios to Set Parameters and Test the CIRDO System

To describe more accurately the falling process, we asked six volunteers from our initial sample to replay 16 accident situations at home. We selected the most frequent fall scenarios that could be safely simulated by our subjects. The choice of the six volunteers was also dependent on whether they had the psychological and physical capability to reproduce the incidents. Due to the physical and psychological traumatic shocks caused by the falls, it was very difficult to find and involve the elderly in this aspect of the research process.

Table 1. Description of Methods for Data Collection and Sample Characteristics in Studies 1 and 2.

Sample characteristics	Semi-structured interviews	Observation	Focus-groups interviews
63 elderly people Profile: Individual living alone at home; average age (AA) = 84 years old; 88% women. Age range: 82-92 years old.	63 people (reusing Study 1's interviews)	Auto-transfer of the activity of 2 elderly individuals with alert bracelets. 6 elderly individuals: Simulating the use of the CIRDO system using the Wizard of Oz method	1 group with 6 people (senior citizens club)
19 domestic caregivers Children (AA = 60 years old; 75% women) and grandchildren (32.5 years old, 65% women). Age range of children: 55-66 years old.	16 members of the family (children and grandchildren)		1 group with 1 elderly individual and 3 members of her family (children)
19 professionals (domestic professionals/ caregivers). AA = 40 years old; average length of service: 13 years. 100% women. Age range of professionals: 37-44 years old.	9 domestic caregivers	Analysis of 3 domestic caregivers' activities	1 group with 6 domestic caregivers + 1 group of 4 home care nurses

Note: None of the domestic caregivers were involved in more than one research method, whereas the contrary was indeed the case for some of the professionals.

We filmed the falling simulations using both subjective (subcam integrated with glasses or Bluetooth headset) and objective (on a tripod) cameras by the following procedure (see also Figure 2). After reading again aloud the circumstances of the fall, we asked the subjects to replay the scene. Each of them replayed two or three scenes. They were instructed, using the scenarios, to comment out loud on what they did, what they said and how they felt during the fall (simultaneous verbalization). We also intervened (using interruptive verbalization) by asking the subjects to give more details on certain actions, words, or circumstances of the fall (e.g., What did you say at the time? How did you fall? What did you do once you found yourself on the ground?). Finally, after the incident re-enactment, we asked the volunteer to react to the filmed scenes through consecutive verbalization.

All these data allowed us to construct falling scripts using the Personas method (Cooper, 1999). Personas are proposed as an analysis tool of the end user's behavior. The persona is composed of various components[3] (Courage & Baxter, 2005) that improve the user's representation. The purpose is to provide descriptions of fictitious individuals that embody future systems users, thus enabling designers to develop innovative devices and services. Designers can then refer to these fictitious individuals when designing a system.

In our research, the scenarios were used to describe the vocal and behavioral descriptors of falls in order to configure the CIRDO system's audio and video sensors. Additionally, they were used to test the use of the prototype within an experimental environment (such as a living lab) in order to refine detection algorithms.

This method was the first step in generating features and indicators. By giving a first input, this helped in designing the scripts of falling. Although this was prerequisite, a necessary guide for the design, it is not enough. Indeed this first formalization of falling needed to be refined based on the use and experience and contexts of the older adults who would use the device.

Study 2: The Conditions of Acceptance of the CIRDO System

The objective of this second study was to explore the social acceptability of this new pervasive technology, one with no equivalent either in terms of use or existing systems. We sought to identify how various participants in the home—the elderly individual, the family, and professional caregivers—perceived the CIRDO system, depending on the advantages and social functions they attributed to it. Table 1 lists the techniques used to analyze acceptation and the characteristics of the samples used.

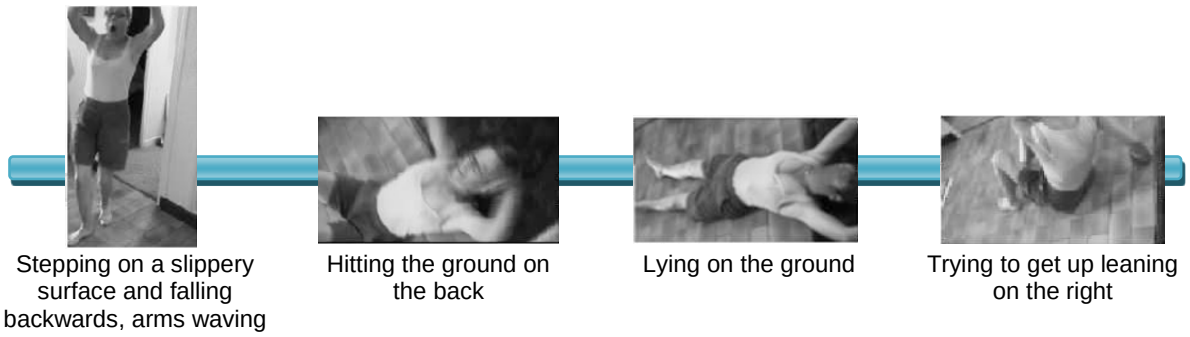

Figure 2. Simulation of an individual falling on a wet floor: Extract.

Our approach was structured around three types of data collection: Semistructured interviews with the various actors in the home, the observation and monitoring of activities of the informants as they sought to achieve different purposes, and focus groups. The goal was to identify, analyze, and characterize the acceptance of a CIRDO system for each group of informants.

Semistructured Interviews with Various Actors in the Home

The objective of this initial step was to better understand how members of each group viewed their activities, the difficulties encountered, and how they conceived articulation of their actions with the actions of other participants. These interviews (lasting approximately one hour) took place in the home of the elderly individuals and were conducted individually with each actor. They were recorded and fully transcribed to facilitate subsequent analysis.

Observing and Monitoring Activities for Different Purposes.

An initial series of three field observations allowed us to better grasp the activities of home care professionals and understand the nature of the tasks performed. We sought to discern how the CIRDO system could influence the practice of these professionals.

Next, we followed the daily activities of two elderly volunteers from our sample who were using other remote assistance devices (a medallion or a bracelet). They noted their activities on a grid that indicated the nature, duration, difficulty, and localization. They were also invited to give information about the conditions when using the alarm devices. We also asked them to comment on these episodes using consecutive verbalization. The objective was to better understand the uses and limitations of these protection systems.

Using the Wizard of Oz technique[4] (Baccino, Bellino, & Colombi, 2005), we sought to evaluate the conditions of using the CIRDO system by six elderly people in their homes. These six volunteers had been selected from among participants of Study 1. They had the psychological and physiological ability to simulate an incident (e.g., using a prosthesis of hips that blocked their mobility and prevented them from getting up from the sofa) and they had to interact with a demonstrator when a risky situation was detected (e.g., “I detect an abnormal situation. Do you need help?”). The CIRDO demonstrator was in the form of a Webcam and microphone connected to a computer. The alerting sentences, prerecorded by the experimenters, were then activated depending on the behavior and appeals of the elderly volunteers. One of the experimenters was present but in another room. In addition to configuring the individual system dialogue and identifying their contact person (the one that the CIRDO system could warn in case of emergency, e.g., relatives, firefighters, police), this approach made possible the initial evaluation of user reactions to this future system.

Focus Groups

Focus groups were conducted to collectively discuss and compare two key elements of our study: (a) How each home care participant perceived his/her role and contribution in helping the elderly stay at home, and (b) how the CIRDO system could affect home care practices. The focus group process involved viewing a short film describing the role of the CIRDO system; then, a researcher led the discussion. The exchange was recorded on video and fully transcribed for analysis.

RESULTS

Results of Study 1: Understand and Specify the Process of Falling

Factors Involved in Understanding ADL and Risks Faced by the Elderly

The first part of the study sought to identify the different activities of daily living to determine how these situations could turn into a fall. We analyzed the factors that could transform an activity that a priori was normal into an abnormal and dangerous situation. The analysis enabled us to identify eight major ADL groups that individuals perform over the course of their day: Household activities, food preparation and eating, recreation, rest, mobility, care and hygiene, communication, and health (see Figure 3). Carrying out these domestic activities requires the mobilization of two types of resources: intrinsic (dispositional) and extrinsic (situational). While intrinsic resources involve the specific characteristics of the elderly person, extrinsic resources refer to what the environment provides to enable an individual to achieve a given objective. The interaction between these two conditions defines the context in which the action takes place.

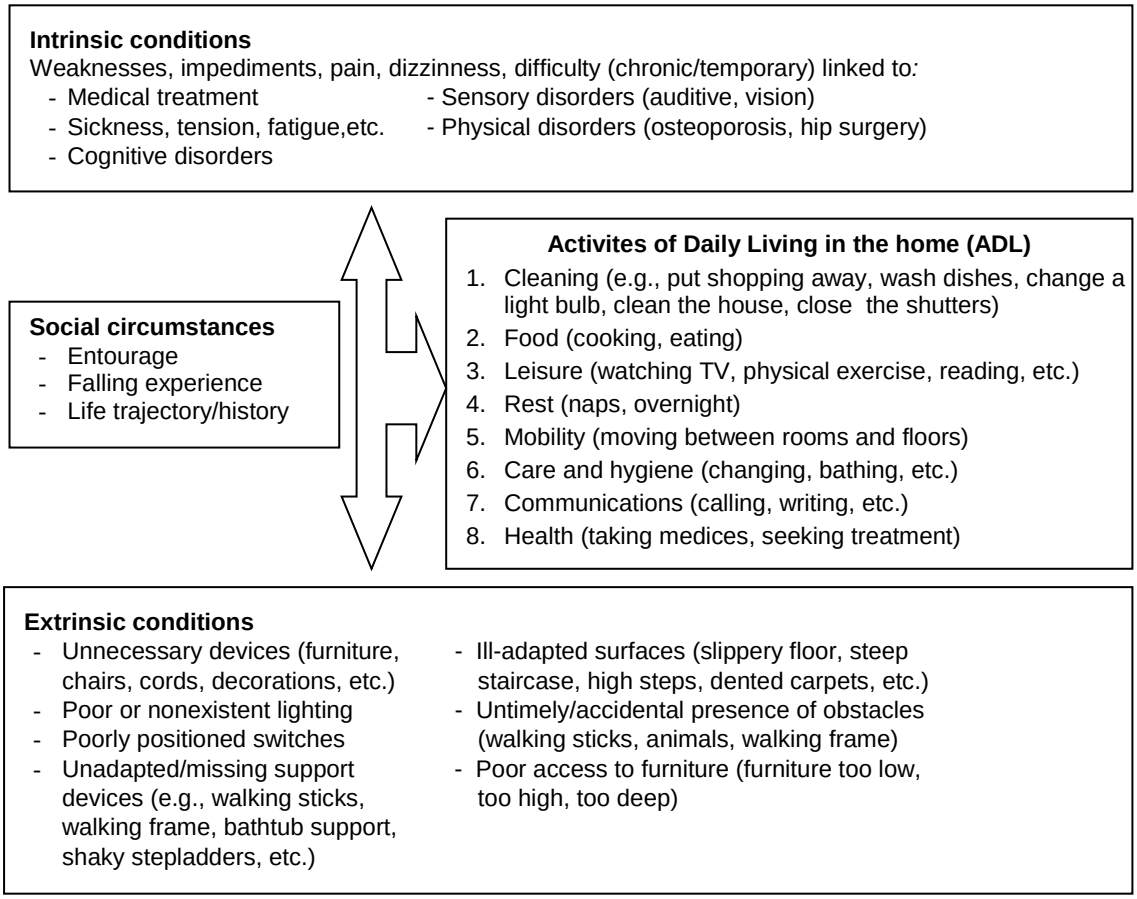

Figure 3. The conditions of a risky situation.

ADL can become risky if at least one of these two conditions is absent. This is notably the case when internal functions (motor, perceptual, etc.) of the elderly fail due to a natural (e.g., generalized fatigue, hip problems) and/or provoked (e.g., prescribed medications) weakness. This has happened, for instance, to one of the people we studied (female, 83 years old), who fell in her kitchen. Conscious, but unable to alert her entourage or trigger the remote alarm device situated in her bedroom, she remained immobilized for close to 36 hours. Her cleaning lady eventually found her.

> *At home, I had taken my sleeping pills and I was taking my juice bottle to the fridge. I was wearing my nightgown. Then, as I approached the kitchen door, I felt myself slip. I said to myself, "Oh, you're falling." I felt my head explode as it touched the ground. I didn't quite feel my leg at the time. I felt it later when I wanted to move it, and it hurt. I couldn't turn; I couldn't go anywhere. The phone was close by, but it was in the entrance hall.* (Informant 3, 83, F)[5]

The physical resources of the situation could also be limited (e.g., insufficient lighting) or inappropriate (e.g., rumpled carpets, high stairs) and thus can be dangerous. These resources then could become obstacles to the normal performing of activities, creating a second example of risk situations, as in a case of an 89-year-old woman who fell in her kitchen: After her slipper caught on a screw protruding from the parquet floor, she remained on the floor for a long time, stunned, before managing to get up after several attempts.

> *I caught on something. There was something protruding, a screw. Incidentally, it's still slightly protruding because it was fixed askew. So after eating, I took my tray and, as I was passing—I had soles with laces—so the tip of the sole caught, and I glided against the doorpost and found myself lying down.* (Informant 4, 89, F)

Moreover, the social circumstances that include individuals' trajectories, and the experiences of the elderly individuals and their entourage, can also impact falling. These factors can condition risk-taking or, on the contrary, restrict it. Consequently, if a fall is experienced or shared by a third party, these other elderly individuals may implement strategies to avoid or prevent them from happening to them. This was the case of an 88-year-old woman who removed all visible cables in her home following a friend's accident.

Accidents can also occur due to noncompliance with the allocation of chores in the home. In such cases, the elderly individual takes on the task of the absent professional helper, thus exposing him- or herself to risk. This was the case with a 78-year-old woman who decided to move the plants in her living room because her helper was late; her head hit the edge of the fireplace and she was knocked out.

Finally, elements in one's individual and social history can also increase the risk of accidents, as the following example shows. An 80-year-old woman who wanted to clear the table got her foot caught in the stairs leading to her bay window and fell, cracking a rib. As she mentioned in the description of her story, she could have let go of the plates she was carrying in order to recover her balance. However, she preferred to protect the plates as "*They were part of the family history, passed down from generation to generation*" (Informant 1, 80, F). This fall thus stemmed from situational circumstances (i.e., stairs too high, a pile of plates reducing mobility), dispositional conditions (i.e., reduced motor skills, lack of attention linked to fatigue), and social circumstances (i.e., desire to preserve family assets). In this case, social factors took precedence over the woman's own safety and protection.

The Characterization of Falling Profiles

The comparative analysis of 28 falling situations (selected based on spatial and social criteria discussed in the Methods section) revealed three broad categories of falls: *Falling* (flopping onto the ground from a static posture, whether standing, sitting, or lying on a couch), *slipping* (loss of balance as one is moving), and *stumbling* (loss of verticality induced by stumbling on an obstacle, such as a cane, carpet, or stairs). Table 2 provides additional information gathered within these three key categories.

Table 2 also shows that falls primarily occurred in the living room (13 falls). Various activities are centralized in this room (e.g., meals, rest, recreation, relaxation, telephone conversations.). Frequent actions and moves also took place in this room. Some falls (8) took place more particularly in areas where the elderly person does activities more personal or private: like cooking (kitchen), the care and hygiene (bathroom) or rest (bedroom). Other falls (7) occurred in transitional spaces (i.e., corridors, stairs, or the door between the living room and kitchen or balcony) that had to be crossed and required mobility. This confirms the need to evaluate the CIRDO system only in living rooms. Falling represents more than half of the risky situations (57%). Slipping (17) and stumbling (19) are almost on par. These results provide some interesting insight into the kind of falls that we researchers and designers had to analyze and formalize to allow the CIRDO device to detect them.

Situational conditions were the most common factors responsible for falls (20 cases); only eight cases were related to individual weaknesses. These results seem to suggest that accidents are more likely the consequences of inadequacy in the environment rather than in individual weaknesses. However, as said before, we think that falls result more often at the intersection of the intrinsic (dispositional) and extrinsic (situational) characteristics of the elderly.

Indeed, older bodies, typically stiffer (but also with other physical conditions), will have decreased likelihood of avoiding or managing a fall situation. Respondents spoke of their behavior and their level of consciousness after the accident. In 13 of the cases reported,

Table 2. Main Characteristics of Falls in the Home.

		TYPES OF FALLS			TOTAL
		Falling	Slipping	Stumbling	
PLACES	Living room	6	2	5	13
	Kitchen	3	-	-	3
	Bathroom	2	2	-	4
	Bedroom	1	-	-	1
	Stairs/ corridors	4	2	1	7
FACTORS	Dispositional	7	1	-	8
	Situational	9	4	7	20
BEHAVIOR AFTER FALLS	Active	7	2	4	13
	Passive	2	1	1	4
	Stand up straight	7	3	1	10
TOTAL		48 (57%)	17 (20%)	19 (23%)	84

the elderly people were quite conscious and active. They crawled, attempted to get up, clung onto furniture, or called for help. In such a context, the CIRDO system would be able to identify this behavior and engage in dialogue with the individual in need (via a microphone). In five cases, the elderly individuals were rather inert and unconscious. This would entail visual detection and a CIRDO diagnosis with an automated alert. Finally, in 10 situations, the people were able to immediately get up without any specific repercussions or trauma. In this case, CIRDO would be able to detect that the fall had no harmful effects on the individual and/or prompt the individual to validate orally that all was well.

We now turn to the procedure we used to analyze the falls and determine the different gestural and verbal indicators that allow the CIRDO device to detect an abnormal situation. This process involved scripts related to falls.

Scripting Falls to Set the Parameters and to Test CIRDO

Based on the falling simulations by the six subjects, we were able to develop 12 scenarios of falls, according to the Personas method. We provide a brief overview of these scenarios in Table 3.

For each scenario, we described the conditions of the fall (the individual's characteristics, the activity performed, the location, the circumstances of the fall, etc.), as well as the modalities of this fall. We paid particular attention to which limbs were mobilized in the fall (upper/lower limbs), the direction and the magnitude of each movement (arm lifted upwards/downwards, body to the right/left, etc.), the speed (velocity and direction of the body in motion), the elderly individual's reaction while on the ground (trying to get up, crawling, etc.), and the approximate time of action/inaction (duration of immobility on the ground). Phrases of alarm were also identified at different moments of the fall (e.g., *"AAhhh," "zuuut," "What's happening to me?"* and *"Oh no!"*). For example, this is a scenario of a fall using a brief notation of the Personas method):

> *She gets up in the middle of the night to drink a glass of water in the kitchen. She is walking in the dark when suddenly her foot slips on the floor. She loses her balance and her whole body swings backward. She exclaims, "Ouaahhhhhhh!!!" Her body bends to the right. First her right knee hits the ground forcefully, then her whole body. She finds herself on her back, arms extended behind her head.*

These scenarios were used for two types of application. Using falling scripts, we first were able to identify and to provide specific details on the different actions and postures that lead to falls. We defined these as "key postures." We also identified the key words and sounds verbalized. The designers used these indicators to calibrate CIRDO's video and audio sensors (see Figure 4). All these descriptors are clues that enable the camera and microphone to identify and distinguish fall situations from normal behavior.

The second application was used to perform the scenarios with 22 volunteer actors, both elderly adults and younger people, with these latter individuals equipped with an old-age simulator (see Figure 5). This device hampers the wearer's mobility and reduces both vision and hearing.

Table 3. Falling Scenarios for the Living Lab.

	Slip	**Stumble**	**Falling**	**Other**
Falling backward, loss of balance in the continuity of a movement	**Scenario #1**: *Slipping on a wet floor in a corridor* **Scenario #2:** *Sliding with a slipper*			
Forward fall, loss of balance, tripping over an uneven surface		**Scenario #3**: *Tripping over a rug* **Scenario #4:** *Tripping with arms full of items* **Scenario #5:** *Tripping over an object (e.g., a cane, a walker)*		
Backward fall, loss of verticality, loss of footing *(Loss of footing when there is less than total contact between one's foot and the ground or floor)*			**Scenario # 6:** *Falling while closing shutters, cupboards* **Scenario #7:** *Climbing and falling from a kitchen chair* **Scenario #8:** *Avoiding a falling object*	
Side fall			**Scenario #9:** *Falling from the couch or chair*	
No falls but trouble				**Scenario #10:** *Being stuck on the couch (when hip prosthesis locks)*
"False positive" cases ***(are movements that CIRDO could considered as falls, while they are not)***				
Speed that can be taken for a falling	**Scenario #11:** *Picking up* the *newspaper rapidly from the floor*			
No falls and no trouble				**Scenario #12:** *Trying to catch the remote control*

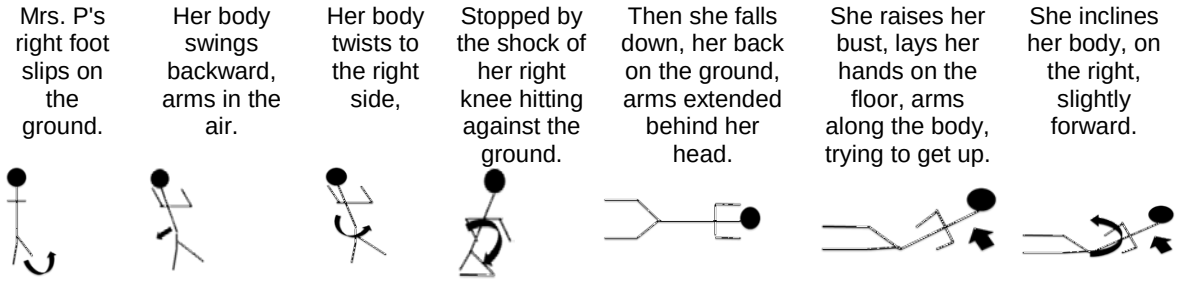

Figure 4. Sample fall script used to set the CIRDO device with key postures, based on Informant 1(78, F).

Figure 5. CIRDO actor employing old-age simulator.

The simulations were conducted in an experimental platform similar to a living lab (the Domus platform at the University of Grenoble). Equipped with audio and video sensors and a two-way mirror, this room was configured to resemble an independent living residence. We thus were able to reconstruct incidents by adapting the living environment to the different scenarios that we sought to simulate (e.g., rumpled carpet, falling from a sofa). The purpose of these experiments was to test the first version of the CIRDO demonstrator in order to improve the parameters of detection and validate the detection algorithms (see Figure 6).

Image front	Foreground extraction	Segmentation of the background/body parts	Comments
			Presence of shadows and lights reflected on the ground
			Camouflage case: trousers color/seat color
			Monitoring body parts

Figure 6. Example of the registering of a fall by the CIRDO demonstrator: Description of the different extractions of the body falling.

Results of Study 2: The acceptance of CIRDO by the Various Home Care Participants

The results—obtained by the focus group and the individual interviews—show that elderly individuals have a specific use of the remote alarm systems that could influence the acceptance of the CIRDO system. For the professionals, the acceptance depends on the visibility this system allows regarding their own activities. For the family, the CIRDO system should not decrease the quality of care assistance and caregivers' commitment.

For Elderly Individuals

We first tried to determine the use of the remote alarm systems by elderly people and the related issues or benefits they encounter while using them (by writing down their activities). Our goal was to identify the potential intakes that the CIRDO system could provide.

This auto-transfer of activities concerning the use of remote alarm systems revealed contrasted situations. In one case, the remote alarm system (medallion) was used at the discretion of an 86-years-old woman . The system was used depending on the risk she associated with the activity performed. In other words, her subjective assessment of risk determined how she used the system. This assessment is not without risk, as falls are unpredictable. However, the CIRDO device would offer continuous and discreet supervision and make it possible to

overcome erroneous judgments associated with risk-taking. In the second case, an elderly woman, aged 85 years, was extremely dependent on her medallion and did not carry out any activity without wearing it. In this case, the discretion and unobtrusiveness of a pervasive environment such as CIRDO could paradoxically result in its rejection because people would feel inadequately protected by a perceived passive system. Its intangible character would therefore restrict its acceptance. Although these results convey some interesting trends, they nevertheless must be kept in perspective, given the very small sample size.

Simulations of the CIRDO system using the Wizard of Oz method also revealed that the elderly were afraid to make their homes more accessible or to lose their ability to manage the situation on their own within an accident. Notably, they worried about who would be contacted in case of a fall, who would intervene, and how? These elderly people who lived alone not only lived in apprehension of internal domestic risks (falls and accidents) but also in fear of external intrusions (theft, sellers taking advantage of their gullibility, etc.). "*If the firefighters break down the door, what will they do*?" (Informant 2, 86, F), or "*If they break down the door and take me away, I can't and won't leave the house open to the street*" (Informant 5, 82, F). Perceived in terms of a break-in, the sudden emergence of a CIRDO system in the home also was seen as intrusive. These representations are forcing elderly individuals to redefine the compromise they were willing to make with regard to security and domestic and protection priorities.

Our interview results also revealed that the elderly people often would like to keep certain aspects of their lives secret (e.g., falls), and the CIRDO system could weaken their social position with those close to them. Put differently, by managing the risk of falls, CIRDO does not simply protect the elderly but it also provides personal information to their entourage, thus reflecting a senior person's weakness and/or potential inability to maintain his/her autonomy. *"I fell but I did not tell anyone, except my friend. I said nothing to my family"* (Informant 2, 86, F). The CIRDO system could thus weaken the social position of the elderly by revealing what they would rather keep private. The device must therefore address the challenge of safeguarding the elderly people's physical, psychological, and social integrity without compromising their personal sense of independence, agency, and privacy.

For Professionals

Analyzing the performed activities reveals that home care professionals essentially undertake not only technical tasks (cleaning, cooking, care, etc.) but also provide emotional and relational support that addresses the psychosocial needs of the elderly (e.g., support, listening, attention, assistance). This is what makes it possible to give meaning to professional intervention and shows why this intervention is significant. With respect to the CIRDO system, the professionals questioned the possible risks regarding intensification and modification of their activities. Fearing that the device would supervise their work (although the CIRDO system does not), they assumed that they would have to choose between purely technical tasks (prescribed position determined by the job description of employer: *Cure*) and the more empathetic personal support (the reality of a service activity: *Care*). Nurses also mentioned the risk of seeing their scope of action reduced. They felt that the automated remote assistance that the CIRDO system was expected to achieve could substitute the regular visits and diagnoses they carried out. During interviews, the professional users suggested improvements and ideas to develop services more appropriate to their needs and activities.

Optimizing professional coordination with the CIRDO system: Even when professionals work alone, they can call on other professionals to help with difficult tasks. This type of task approach was perceived as an enhancement of skills that offered psychological support in difficult situations for the care givers. Therefore, the members of impromptu collective became protective of each other in light of difficulties due to the tasks**.** Coordination appeared to be crucial to many home care professionals, as was the coordinated divisions of intervention over time. In this context, even though the CIRDO device does not keep archives of audio and video, the system could play a crucial role by composing an event book, a separate logbook in which stakeholders would rate their activities (by writing a message or filling in a grid). This kind of digital diary could thus be a means to link the different activities they carry out. Keeping a voluntary written record of their actions could thereby ensure better follow-up care and greater complementarity of the actions of the whole system existing around the elderly person. According to these professionals, such a diary would significantly facilitate and reinforce cooperation among them. It could support how they work together and select the best care option: Who should intervene? When? For which activity? With whom? For instance, in a future version of the CIRDO system, we can imagine that a nurse can tell (in a voice or written message, for example) to the domestic professional to avoid giving the elderly individual meals in preparation for a blood test.

Making activities more visible using CIRDO: Recognizing the profession vs. refocusing activities. Our interviews and focus groups showed that CIRDO aroused ambivalent feelings among the professionals. On the one hand, professional caregivers recognized that a system like CIRDO could enable the valorization of the professional activity within the home visit. In addition, CIRDO could ensure professionals' control of the home care goals through what the system revealed with regards to the professional's activity. Indeed, despite the fact that the tapes are confidential, the professionals felt that CIRDO would enable their activities to become better recognized by making the reality, complexity, and challenges of their home visits visible to their managers, as well as to the elderly individuals' families. The device could also protect them from abusive behavior from their clients (such as, e.g., situations when domestic cleaners are asked to provide house cleaning in the nude) or monitor their own behavior (i.e., abuse from professionals against elderly people). Enhancing the visibility of the elderly's daily activities could also reconfigure professionals' practices. On the other hand, the nurses argued that several tasks, such as bathing, which some elderly people already have difficulty accepting, would become unrealizable if these are monitored by such a system.

It appears the CIRDO project could raise the image of professional domestic cleaners. In fact, these professionals could assist, through their in-depth knowledge of the habits, risks, and practices of elderly individuals, in setting or refining detailed system parameters during the implementation of the device. For instance, they could help determine the choice of video or audio sensors and in which room and at which angle they should be placed. Similarly, they could be more involved in defining the parameters of an event book. In addition to providing their expertise,

these professionals could also become essential mediators to help the elderly and their families accept the device.

These contributions, therefore, could significantly reposition the home care profession through the enhancement and expansion of professional activities. Beyond operational tasks, these professionals could participate in activities related to employing a CIRDO device, such as system set up, change support, and usage guidance. However, this would require an upgrade in qualifications and training.

For Family Members/Caregivers

The analyses conducted with family caregivers revealed different views. These perspectives address the quality of assistance provided by the family and the place of the CIRDO system in the assistance relationship.

The type of assistance provided by the family. Even though it is supposed to be "natural," the assistance provided by the family was experienced as a time constraint for many family members, and even a considerable liability because some those who provided the care could also have used the assistance. Indeed, some of the children respondents were more than 65 years old. This multipurpose assistance included psychological, administrative, management of daily activities, financial and individual care assistance, as well as cognitive and affective "stimulation." The family caregivers reflect upon the level of assistance they need to bring to their relatives to avoid aggravating the dependence by excessive care assistance and presence. In the same way, they wonder if the CIRDO system, by partially replacing them (in terms of attendance time, for example), will not affect the quality caregivers' commitment.

The place and meaning of the CIRDO system in the assistance relationship: Families perceived CIRDO as a potential "competitor." Family respondents pointed out that the automatic triggering of the alert robbed family caregivers of the ability to evaluate the gravity of the incident and the resulting alertness level. They also felt guilty at the thought of not being present or involved if these situations occurred, and thus they could not assist, support, or reassure their loved ones. These concerns can also be interpreted as the fear of being replaced by the device, as one 55-year-old man noted: "*This does not mean that it will replace my visits to her place on Thursday evenings*!" Nevertheless, the family caregivers interviewed did not consider that the CIRDO system would induce modifications toward or weaken their commitment to their loved ones.

The value of the CIRDO system lies in the fact that it more effectively watches over the elderly, especially when the family is busy, unavailable, or far away. Thus, the CIRDO system shifted the role of the family caregiver to a different status: The remote caregiver status. By keeping watch over elderly individuals, the device freed family caregivers from the perpetual constraint that involved remote monitoring, being ready just in case, modifying lifestyles accordingly, and adjusting schedules. This device thus reassured both the family and the parents. In this sense, the CIRDO device seemed to respond to the request of family caregivers—that their elderly family member is protected during their absence or from their inability to intervene.

DISCUSSION

As a reminder, we conducted two studies: The first was about understanding and specifying the process of falling, while the second one concerned the acceptance of the CIRDO system by the various home care stakeholders. Both of these studies shared the same aim, that is, designing the CIRDO system. The results of these studies are the outcome of two approaches. The first, "descriptive" approach determined the fall choreographies detectable by the device, although a possible pitfall is that they were conceptualized from rather disembodied situations (i.e., controlled simulations in a limited space of the home, specifically, the living room and test protocols in a laboratory). Our second "comprehending" approach sought to take account of the social framework in which the CIRDO system could be integrated. It was then interesting to consider the social scenography at home and how the latter could be altered with the introduction of the device.

We also needed to include the automated falls analysis within the actual sociotechnical achievement context. The goal was to prevent a decontextualized analysis in favor of an embodied analysis of these risk behaviors in a pre-existing domestic and social organization. By this comparison between our studies, we could easily identify potential sources of improvement, vigilance points, or types of recommendation that designers and various participants of the CIRDO technology implementation would be provided.

Redefinition of Domestic Falls

Analyzing the choreography of a fall (Study 1) through the prism of social acceptance (Study 2) allowed us to question the meanings given by seniors to their accident and the special status taken by a fall within this mediated monitoring environment. Specifically, we wanted to articulate who or what would recognize the reality of the fall. In other words, would priority be given to the triggering (or not) by the CIRDO device, the word of the elderly person, or the testimony of the entourage? And, depending on the priority, what would this say, and how does it show the fall—once identified by the device—regarding the elderly's state of health, the system's ability to take responsibility, or the way the others perceive the elderly people and have to assist them, and so forth?

We found that a highlighted domestic accident, outlined (for oneself and for others) by the CIRDO system, led the elderly individual to relate to the falls in other ways than they had previously. They suddenly attempted to further regulate and control their behavior, sometimes by risking a profound change of behaving that may not be detected by the device.

More specifically, in our various studies (simulated CIRDO system use and the focus groups), it was observed that the elderly informants developed two opposing conducts in managing their fall monitored via the CIRDO system. Some of them chose to boost their falling movement or exaggerate the cry to make sure the device would recognize the danger. However, these individuals were also the same elderly informants who, as noted in Study 2, used tangible remote monitoring systems. They doubted the ability of the new ambient system to detect their accident. On the opposite end of the spectrum, however, some elderly informants wanted to hide their incidents of falling from their entourage. As a result, they tried to control the fall: They did not scream and attempted to recover at all costs, even though it possibly exacerbated the deleterious effects of the fall.

In both cases, we see that the falling movement choreography (falling is unintentional by nature) will be intentionally modified by the subjects, whether to be seen to fall, and, hence, be better recognized, or otherwise to be hidden from the technology and its supervision. Thus, the presence of technological artifacts changes the dynamic of the fall because this conduct will be addressed/directed toward a target (technology object) and to other involved individuals. As mentioned by Clot (1999), the movements of the falls are not only directed by the conduct of the subject but also they are directed through the use of the technical object and toward others (the representation they have of the system and the possible recipients of the alert). The fall choreography is influenced by what the individual wants to show to, or hide, from the device. Therefore, the risk of not detecting these movements is possible because the movements sometimes may veer too far from programmed scripts.

Another more symbolical consequence involves the status and the legitimacy that the CIRDO technology will give the fall. In the past, the word of the victim, or of a third party, was enough to prove the occurrence of a fall. However, these days, surveillance technologies are used to validate the occurrence of an incident.

We could even add that these technologies also assess whether this fall conforms to predefined scripts. In other words, the lack of detection (i.e., nonrecognition) of a fall by CIRDO system may mean that (a) the individual has poorly conducted the choreography of the falling or (b) the movement cannot be categorized as a risk movement. This therefore can lead to a denial of risk or recognition of the elderly individual's status as a "victim," thereby throwing suspicion on their statements.

As a result, CIRDO device implementation may operate a transfer of the risk recognition: It is the technology that gives official status to a fall in a domestic incident, as opposed to the elderly person. In other words, this is the technology that overrides the declaration of the elderly person. The system establishes credibility and legitimacy. Thus, technological reliability supersedes the word of the elderly victim; the latter then can be discredited, for example, if the user talks about incidents not recognized by technology with the logic of "If the system is not triggered, then the fall did not occur." In both cases, setting the CIRDO technology within the domestic social system can either redefine the falls choreography or redefine their status. These reasons may be caused by malfunction or rejection.

From these findings, several recommendations can be directed toward the CIRDO designers. As noted in the literature (e.g., Hwang & Thorn, 1999; Kujala, 2003), designers must continue reassuring, involving, and properly training users of the new system by including demonstrations and updates in real situations adapted to users' habits and lifestyle practices (to demonstrate that the system works efficiently in detecting falls and avoiding any worsening of condition because of movements). In addition, designers should create more flexible programs and fall-detection algorithms to cover a wider spectrum of fall choreography and not rely solely on fixed scripts in risk behavior. In the same way, the researchers should also ensure more effective articulation between the audio and video detection components to allow better recognition and validation of falls.

As part of a participatory-design-through-use protocol (He & King, 2008), it would be valuable to adjust the system according to feedback from the field regarding the location of the sensors and the level of fall-scripts detection. This can be achieved by taking into account conduct adjustments and daily risk evolutions from the moment the technological artifact is introduced. This requires a situated analysis of the device's effectiveness in real-use

applications and redesigning it according to its usage (e.g., Norman & Draper, 1986). This reinforced monitoring system will ask the elderly to make an oral (confirmatory) emergency call to an outside third party. The alert then is triggered only in case of a positive response or a lack of any response from the individual, thereby enabling the user to properly control the system (and to avoid false alarms). Finally, this new device for monitoring the risky activity will be meaningful only if it serves and supports its users' quality of life. Therefore, designers and researchers must involve and assist the various participants during all phases of CIRDO system's redesign in an inclusive approach (as in the living lab approach of Pino, Moget, Benveniste, Picard, & Rigaud, 2015). Such an approach is particularly important in anticipating any reconfigurations at work within the social framework, as we shall now see.

Supporting the Reconfiguration of Social Contexts

A second level of discussion is about the roles and responsibilities of the various people involved in the care of elderly people at home. One important aspect of this involves the relationships among the various parties and how this control can be shared among them. For example, will the professional caregivers and the family be there only to repair (in other words, as per the system's request once the accident is identified and people alerted), or will they continue to act in a more preventive mode, while maintaining vigilance toward the conducts and practices of the elderly? Will the family members be less present, less attentive vis-à-vis the elderly and instead relegate the supervisory activity to the device? What will be the function of and place for each participant? Will we see a repositioning and/or a redistribution of levels of intervention, support and assistance from these participants?

From the acceptance perspective, it is essential to see how the CIRDO technology affects the activity systems of the different actors involved, and how it destabilizes their articulation and a reconfiguration of their position. The analysis of these impacts on the actors' social setting at home leads more directly to the sharing of tasks and responsibilities following the integration of the CIRDO system. Specifically, in terms of user support, this refers to the who-does-what context: the device parameterization, training in use of the tool, the choice of rooms covered, and and the nature of activities that the device should analyze . These tasks definitions and divisions, marked by the appropriation or divestiture of certain tasks by the actors, thus reshape the areas of power and control over the home, expressed through some fears:

- Withdrawal of actors at the elderly's homes, and entrusting the monitoring exclusively to the device. In this case, the CIRDO system works as a new remote control support.
- Exclusive management of technology by relatives and professional entourage. In this case, the senior is submitted to the system but is not player. The senior is relieved of his/her ability to act on his/her environment and both are under the control of a third party.
- Legitimization of the elderly's dependency likely to take the status of a monitored object, wherein the senior is considered and treated as a weak individual, with restricted power to act. In other words, the elderly individual is under the control of an imposed system on which he/she has no control. This generates a feeling of heightened dependence.
- The exclusion of certain professional caregivers, who, until the introduction of the CIRDO technology, occupied a privileged position with their elderly clients. In this

case, the elderly persons are partially deprived of some human relationships on the pretext of being secured by a monitoring device.

The difficulty in designing, and consequently implementing, the CIRDO technology is caused by the necessary adjustment to a social-and-home care system that changes frequently. This evolution in care exists not only because of the diversity of the elderly individuals' risky activities, but also because of their mobility changes, or their current state of health, and the interests of various actors in the home.

Integrating the CIRDO system or other generally ambient technologies into the home is not possible without questioning our conception—as researchers or designers—of intimacy and privacy through those multiple variations and ongoing iterations of the technology: What we want to see, what we aim to see without necessarily assessing the scope, what we aim to see "in spite of ourselves," and their potential use of these images. How will this trivialization of the privacy relayed by environmental features participate in changing our representation of privacy overall? How will the benefits of the system (e.g., one's ability to maintain independence at home, to secure the home's upkeep, and to reassure members of the entourage under pressure) enable the acceptance of a potential psychologically distressing technology? It is not so much the actual use of these images because guarantees and safeguards can be given. But sometimes the real fears of psychological and social weakening by the elderly (e.g., loss of freedom, greater control by the entourage, enslavement to a "reassuring" behavior) can become paramount. The privacy of an individual can involve "everything that is wished to be kept secret (at one point), as well as all that expresses individuality, identity, and the depths of being" (Arnaud, 2011, p. 6). The risks of noncompliance and threats to the privacy of the elderly or professional caregivers may, therefore, cover both dimensions and consist of (a) an attempt to investigate and/or disclose what the individual would rather keep secret (e.g., complicity in relations between the professional and elderly people, knowledge of what one does not wish to disclose, or avoiding being dispossessed or judged), and (b) a breach in this individuality, with what expresses, composes, and develops it (e.g., habits, ways of behaving that may raise fears of an institutional placement). These fears are largely related to the place of the elderly, variable according to the society and culture.

IMPLICATIONS FOR APPLICATION

The CIRDO study highlights the essential role of the humanities in an innovative technology design approach for an audience of users with specific needs. The commitment of Humanities and Social Sciences (HSS) researchers cannot be limited to the trimming functions of the artifact. This article questions not only the researchers' place within a multidisciplinary team, but also the integration of their contributions in the design process. The designed artifact is a social product, a compromise between more or less converging visions, into possible ranges of uses and actions. Thus, the contribution of HSS is not only to allow the integration of experience of the final user in the CIRDO project, but also to take into account of the feelings, the perceptions of people (family, friends) and/or professionals gravitating in the environment of the elderly. The broader inclusion of the "user activity system" also generates more political debates, aiming to question the place and the support we think and give the elderly. This ethical design conveys important values to preserve (e.g., social, family, legal), but also others to give

up through certain design choices and uses. If the domestic support of the elderly is a social issue, the given answers using widely technical devices give rise to multiple questions that are little discussed, if at all. They are often hidden within an idealized representation, or a technicist vision, capable of meeting all needs. As such, we believe that the activity of design, specifically the artifact itself, could become an "analyzer" of the social system in which the elderly live. Specifically, we believe it is feasible to consider the CIRDO system as an instrument of social mediation, enabling collective discussion and reflection about the places and roles that various participants (and their coordination) hold or should have as regards elderly homecare.

CONCLUSION

The purpose of the article was to present the approaches and key results associated with the design and analysis of the CIRDO[1&2] system—a new pervasive technology for social acceptability in the care of the elderly. The approach we used mainly concerned the daily domestic activities of and potential falls by elderly persons living at home or in an independent living environment. It also described how home care stakeholders (e.g., family members and/or home care professionals) might consider the impact of the new device on their respective activities and relationships with their elderly relatives or clients. Because the system can contribute to a significant change in the process of falls, we propose to develop an iterative design of this device. Specifically, we believe the CIRDO system should be more flexible and versatile to better fit to the evolutions of risk behaviors of older people that are linked to the use of ICTs.

We demonstrated that, depending on their experience, trajectory, and needs, home care stakeholders have differing visions of the objective of their activity (e.g., support, assistance, care, prevention) and therefore specific expectations and fears with regard to the CIRDO system. The function and outcomes of this system, therefore, are (implicitly) heterogeneous, as participants interpret them differently. Moreover, their visions are incomplete, conflicting, or partially contradictory.

From our research, we suggest that the falls choreography, in its meaning and expression, is likely to change depending on the sociotechnical environment. All these issues lead us to adopt a critical perspective on this type of device. Nevertheless, our initial reflection was made possible regarding the place that the elderly hold and the more-or-less humanized support measures that should be proposed. The CIRDO system is one of many environmental technologies positioned in the boundaries between public and private spheres. As such, it would lead to a greater porosity between the private and public areas (i.e., what is hidden as opposed to what is shown) and consequently affects the various choreographies deployed at home (private and social). Alternatively, if the CIRDO system becomes a "boundary object" (Star & Griesemer, 1989) in the sense that it involves articulation and coordination between and among different social worlds (i.e., the professional caregivers, the family, and the elderly), then questions arise regarding the concrete use of the technology and each actor's actual investment and ownership of the device regarding both in his/her own activities and in relation to his/her particular issues or concerns. These areas warrant exploration.

By distancing ourselves from a techno-centered vision that intrinsically associates technology and well-being, we have used a rather anthropologically centered, psychosocial approach. We believe that this approach can reveal a social need, question it, and,

consequently offer support to design a device that better fits within the entire committed human system by taking into account the needs and concerns of every stakeholder.

ENDNOTES

1. CIRDO is the acronym of *Compagnon intelligent qui réagit au doigt et à l'œil*, a French concept that translates in English as "Smart, fast-reacting companion." The CIRDO study is a global research project relying on the device known as the CIRDO system. The CIRDO system (device) is a passive technology system implemented into an at-home environment to identify situations in which an aged resident has fallen or has a similar incapacitating outcome. This device can be used by individuals or by institutions.
2. In this scientific step of the design process, the CIRDO system is a technology demonstrator. The cameras used to allow a proper identification and tracking of falls are therefore very similar to surveillance camera systems. These cameras are not supposed to be integrated as such into the living environment of seniors; their presence may disturb people. When implementing the CIRDO system as a working technology within the living environment of the elderly, cameras should be better integrated by using discrete cameras such as gyroscopic cameras or intrusion detection systems.
3. Courage & Baxter (2005) defined 10 components of personas: Identity, general profile, goals, scenarios, knowledge and experience, relationships, psychosocial profile and needs, attitude and motivation, expectations, and special needs.
4. By using the Wizard of Oz technique in the research protocol to evaluate the use of the CIRDO system, the researchers wanted to convince individuals that the system they are interacting with is autonomous, when it is actually fully or partially controlled by a human. In other words, the researcher simulated the same services and functionality as the CIRDO system normally performs. Therefore, apart from this step of the research, the CIRDO system will be autonomous in the real conditions of use and will not entail human surveillance.
5. The quotes from the participants of our studies were originally in French and we researchers have translated this material into English for this report. We have provided an identifier to describe briefly the individual who spoke these sentences. For example, Informant 3 represents the third person on our list of participants, 83 is the age of the individual, and F or M is her/his sex (Female or Male).

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