A Qualitative Approach for the Elderly's Needs in Service Robots Design

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ABSTRACT
Service robots will assist the elderly to live independently for long time and improve their quality of life. It is very important to know the older people's needs during product design. This study aims to portray real requirements of older adults to assistive service robots. A five-month qualitative study with 15 participants at a community was conducted to get data. The constant comparative method was used in the analysis interviews and observations. The results show that social, emotional, usability and attitudes of their children play a critical role in the usage of new products.

CCS Concepts
• Human-centered computing → Human computer interaction (HCI) → HCI design and evaluation methods → User studies

Keywords
Human-Robot Interaction; User Needs; Qualitative research; Interviews; Observations; Human factors;

1. INTRODUCTION
The Population Division of United Nations reported that there were 901 million people above 60 years in the world's populations in 2015, and it accounting for 12.3% of the world's population. By 2030 this ration would reach 16.5%. The report said that there were the most elderly people in China, the number is 209 million [1]. There are numerous policies in various countries in the world to tackle the problems and challenges of population aging. The countries would give priority to various research on the aging, the related facilities for the elderly, and how to help the elderly to live a better life independently. Lin et al. [2] have found that although 91.3% of the elderly answered the question "Voluntary choice of pension facility for retirement" when visiting the elderly, the actual result was not. According to the agency staff presents, in fact, most of the elderly did not voluntarily come to the Nursing home and nearly 80% of the elderly people who came here were afraid of "dragging their children." In fact, the elderly people would like to spend their remaining years at their home. It drives the need for innovative solutions to help older adults maintain independence at home longer and foster health. Researchers are looking for solutions to improve the elderly quality of life(QoL), keep elderly active for longer and help them socialize more. Using robotics and related technology is one way to support and assist the elderly in their daily life. There is a growing industry in developing robots for elder care. Robots have been divided three main categories which are personal robot, industrial and professional robots [3]. Assistant robots are a type of personal robot. The International Standards Organization ISO 8373:2012 which defines terms used in relation with robots and robotic devices operating in both industrial and non-industrial environments, and combining the definitions of 'robot' and 'service robot': *'A service robot is a robot or actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, that performs useful tasks for humans or equipment excluding industrial automation applications.*' Currently, there are many service robots for the elderly, such as Smart wheelchair iBot [4], shopping assistance robots RoboCart [5], social robot AIBO [6], Paro [7], ICat [8], Pearl [9], and Care-O-Bot [10] .These robots assistant the elderly daily life in different ways. Most studies have attracted much attention in the level of technology implantation. When developing Robots assisting elderly people, users' truly needs should be carefully considered.

Dautenhahn [11] defines that Human-Robot Interaction(HRI) is *"the science of studying people's behavior and attitudes towards robots in relationship to the physical, technological and interactive features of the robots, with the goal to develop robots that facilitate the emergence of human-robot interactions that are at the same time efficient (according to original requirements of their envisaged area of use), but are also acceptable to people, and meet the social and emotional needs of their individual users as well as respecting human values"* Sheridan [12] notes that probably the most important challenge for HRI is researching in the areas relating to lifestyle, fears and human values. Kidd [13] observed that human-centered design of human-robot interaction needs to look beyond technology subjects and to consider issues such as task allocations between people and robots.

This paper describes a qualitative research method in user research to mining needs for intelligent assistant equipment of the elderly in the daily life. The paper reports the progress made on understanding the user's needs and characteristics that will support the design of the service robot.

2. METHODS
Acquiring needs and desires from older adults is part of a human-centered approach to design and development the assisted service

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robot. ISO standard13407 mentioned "The human centered design (HCD) process is intended to help those responsible for managing hardware and software design, and processes to identify and plan effective and timely human centered activities" (1999, p. 21). Preece et al [14]. mentioned UCD methods were Questionnaires, Diary Study, Observation, Cultural Probe, Focus Groups, Interview Study, Paper Prototyping, Think Aloud Protocol and Questionnaire from Interaction Design. This study used two methods to establish requirements of the elderly, which were Observation, Interview.

2.1 Interviews

Interviews is the most common method of data collection in qualitative research. There are four main types of interviews: open-ended or unstructured, structured, semi-structured, and group interviews [15]. The first three types are named according to how much control the interviewer imposes on the conversation by following a predetermined set of questions. The fourth involves a small group guided by a facilitator. Most of the qualitative research interviews are either semi-structured, lightly structured or in-depth [16]. Unstructured interviews are generally recommended to conduct long-term field work, so that respondents can express their opinions in their own way and pace. The lack of the structured framework allows the participant's view on the issue to be the focus. The use of semi structured interviews makes the collection of rich data on individual experiences and the interviewer gets the intended information.

An unstructured method and semi structured method were used by Jones [17] to study the challenges faced by older adults with schizophrenia and analyze the ways in which older adults with psychiatric disability experience pain and social relations, and to developed a patient diagnoses system. The interview method helps the researcher acquire the expected information in a qualitative form. Structured interview method is often applied for gathering feedback or ratings from older participants on the assistive products or treatment received, and the unstructured interview method is applied for gathering information on the elder's perceptions of illness or the experiences in the daily life. The semi-structured interviews make readers to quickly understand the purpose of the study. making some interviews before the interview can raise the efficiency of the interview.

2.2 Observation

Observation is a qualitative research method, which includes not only the observation of participants, but also the research work of ethnography in this field. In the observational research design, many research points are involved. The observation data can be integrated as an auxiliary or deterministic study [18]. At any stage of product development, observation is a useful data collection technology. In the early stages of the design, observation can help designers understand the background, tasks and goals of the users. Later in development, observations, such as in evaluation, can be used to investigate how development prototypes support these tasks and goals. The researchers can observe users directly as they perform their activities and observe indirectly through the post - study activity records. Observation may also carry through the field, or in a controlled environment. In the former case, individuals are observed as they perform daily tasks in the natural setting. In the latter case, individuals are observed performing specified tasks within a controlled environment such as a usability laboratory.

2.3 Participants

We recruited 15 elders (9 males and 6 females) for interviews and observation, ranging in age from 65-89. The target group of this research is healthy older persons or with light physical or mental health problems who live alone at home or with their spouse. They lived in a retirement community of Xi'an Jiao Tong University. To ensure participants' anonymity and confidentiality, we make use of presidiums in the paper.

2.4 Study Design and Data Collection

The research methods used in this study is semi-interview and observation over 5-month period. Semi-structured interviews have an interview guide before the interview, the interview guide played a leading role. The interview guide allows researchers to get some common results to analyzing the data, and can raise the efficiency of the interview. As in the acquiring needs stage, some open-ended questions are also needed to obtain as much information as possible about older users. All the interviews were complete recorded by a voice recorder, and after the interview, converted the recording to text for analysis.

Before we started the interview, we would inform the elder our aim and process of interview and observation. Making them know that our research results are used only for academics, not for commercial, and we would protect their privacy. The duration of each interview is 1-2 hours. Some questions that have been prepared in advance would be used in the interview in the initial stage. The questions are about demographic, social and general information about the elder daily routines, heath and memory status, what is important, desirable, and improvable in their lives, as well as what products and services they rely on daily, and their social relations. Then according to the elderly's response, some divergent questions would be asked. The interview was used to collected data about technology acceptance, individual value, attitude to service robot, usage of smart product, and inconvenience in routines life.

The observation framework used as shown in Table one was suggested by Robson [19] and modified slightly. Robson [19] encourages observers to pay greater attention to the context of the activity.

Table 1. The observation framework

Observe	Content
Space	What is the physical space like and how is it laid out?
Actors	What are the names and relevant details of the people involved?
Activities	What are the actors doing and why?
Objects	What physical objects are present, in addition to the technology use?
Acts	What are specific individual actions?
Events	What do you observe part of a special event?
Time	What is the sequence of events?
Goals	What are the actors trying to accomplish?
Feelings	What is the mood of the group and of individuals?

Several typical daily activities of the elderly were observed for 3-4 hours per person. All surveys are based on respondents'

voluntariness. A camera faithfully recorded the whole process. After each investigation, the record would be analyzed in time. The activities main includes interacting with a variety of electronic product in daily life, using assistive equipment for going out and communication with children, neighbors and others.

2.5 Interview Data Analysis

The inductive and deductive analyses [20] were used for the interview data. Inductive analysis includes discovering patterns, themes, and categories from a given data. Deductive analysis analyzes the data according to an existing framework. The constant comparative method(CCM) was used for the inductive analysis which makes comparisons at each level of analysis process and comparison is also the dominant principle of the analysis process in other tradition of qualitative research [21,22]. Hennie [23] have developed a procedure for the CMM. The five steps are comparison within a single interview, comparison between interviews within the same group, comparison of interviews from different groups, comparison in pairs at the level of the couple, and comparing couples. Different steps of the CCM procedure in keywords are introduced [23]. The focus of the analysis is to identify and define the properties and dimensions of the related categories and then to use these as the basis for constructing a theory. Corbin and Strauss [24] have observed that coding has three aspects, which are iteratively performed through the cycle of data collection and analysis. Three aspects are open coding, axial coding and selective coding. Open coding is also the primary stage of the whole analysis, which is the process of discovering the categories, their properties and dimensions of data and looking for recurrent words, topics, or concepts. Axial coding is the process of systematically enriching categories and correlating them to their subcategories. Selective coding is a process of refinement and integration of categories, and a larger theoretical scheme has been formed [24].

3. RESULTS

3.1 Demographics and General Information of Participants

This qualitative study lasted 5 months, 15 elderly people were interviewed and observed. Descriptive analysis results are shown in Table 2. User's age was divided into four stages and the division based on the user's physiological age, which is one of the most commonly used classification methods for elderly users. As selecting a community of a university for a research area, the survey accounts for 32% of highly educated elders. As far as possible, more elderly people living alone than with their spouse were selected in the survey because it was found through literature reading of the earlier period that the elderly living alone had stronger demand for technical assistance. The quality of life of elderly people with spouse in later years is generally higher than that of elderly people living alone. The incomes of the elderly are all retired salaries. There is no extra part-time job for the elderly in this survey, so 40% of the elderly earned over 6,000 per month.

As shown in Table 3, 66.7% of the elderly have been used smart phones and 86.7% of them have been used computers. Through the interview, most of the elderly are willing to accept new technologies. The usage rates for the vacuum cleaning robot is only 13.3% and the robot was bought by the elder's children.

According to the interview, the robot was hardly used due to the unfriendly operation and impractical function for the elderly. All the elderly in this study have never been heard service robot.

Table 2. Descriptive analysis

N=15		
	Number of participants	Percentage
Gender		
Male	9	60%
Female	6	40%
Age		
65-69	4	26.7%
70-74	3	20%
75-79	6	40%
Over 80	2	13.3%
Education		
Primary	2	13.3%
Junior	2	13.3%
Senior	1	6.7%
Technical	3	20%
College	7	46.7%
Living Alone		
Yes	12	80%
No	3	20%
Month Income		
<3500	4	26.7%
3500-6000	5	33.3%
>6000	6	40%

Table3. Related Smart Product

	Never heard	**Heard of but never used**	**Have been used**
Smart Phones	0	33.3%	66.7%
Vacuum Cleaning Robot	26.7%	60%	13.3%
Service Robot	80%	20%	0
Computers	0	13.3%	86.7%

3.2 Interview

According to open coding, themes are cataloged for " attaching importance to health", "using smart products" "fearing to be deceived" "learning process" "assistive technology" "social

relations" "attitude to new technology" and “attitude to life". The insightful statements are summarized below.

During the interview, almost every elderly is paying more and more attention to their health. Some elderly people keep their health by practicing Tai Chi and some people have the purpose of exercising through daily walking. In this investigation, we found that the elder people are very assertive and they do things according to their own methods and ideas. The following five participants expressed that the way to exercise.

"I practiced traditional TaiChi and I have a good health. I have no problems with my mind, eyesight, ears and other internal organs. I believe that Taijiquan has brought all this to me. "

"Every week I, I go to the supermarket to buy some food and supplies. I take back goods personally. I think the most important thing is good health and everything else does matter. "

"Every morning at eight I go to practice TaiChi and after the practice, I will buy some vegetables for the day on the road."

"I am the head of the community square dance, every morning and afternoon will go to dance, and all the dance equipment are here with me"

"In most cases, I will choose to walk when I go out. If I have walked for a long time and I feel tired, I would take the bus. I think walking is also a way of exercise."

With the population of smart phones, more and more old people begin to use smart phones. In this survey, only 5 persons use feature phones. There is a learning process for the elder to use phones first time whether it is a smart phone or a feature phone. Initially they have learned some simple operations, such as making a calling phone and answering the phone by their children or other channels. Even many products were used for a long time, the simple several functions were used. WeChat and QQ were frequently applied for communicating with children or relatives, as well as the elderly would watch some interesting videos by phones or computers, which are Taijiquan teaching or square dance videos. There are only two elderly people using computers for playing games which are pre-installed by windows and seeing family photos. Because of the poor operation experience of smart phones, two participants reused feature phones.

The old peoples have a very alert heart and they are worried about being cheated. For example, online payment is very convenient and the elder is also agreeing with it. But they dare not use it, in this research, there is no people to use online payment. The main reason is that they feel the payment process is complex and unknown. They are very vigilant for strange phone calls. The sphere of activity is around their house and they are worried about meeting the evildoer. But the elderly sometimes trusts persons who sale health related products and they don’t want to listen to children’s discouragement.

New devices and technologies can be accepted by the most participants and they would like to spend time on learning. The products which have simple operation and good usability are popular with the elderly. A fixed operation process is easy to master by the elder. Five participants expressed that they prefer to have a try for robots.

Walter et al. [25] shows that the categories of age-related changes are perception, cognition, move control, beliefs, attitudes and motivation. Each age-related change will have corresponding design. Some participants in this research considered that they have a good health, and they would not like to use products which are specifically designed for the elderly such as crutches and wheelchairs which stigmatize users.

Only two participants lived with their companions and one participant lived with his son. Others are lived alone and they feel lonely and do not want to disturb children who are usually busy with work.

3.3 Observation

Trough watching the video taken in the survey repeatedly and the text record, the elderly typically routine activities and research findings are shown in table 4.

Table 4. The participants’ typically routine activities

Activates	Research findings
Getting up	Most participants have trouble with cardiovascular and cerebrovascular diseases, if they got up too fast, they would feel dizzy.
Bathing	The frequency of bath is relatively low as young people. If a bathroom has a slippery ground with water, it is dangerous to slip for the elderly. According to the observation, bathroom for the elderly did not have protective measures.
Using toilet	It is difficult for the elderly to crouch and get up. In the survey, only two persons have installed toilet-assisted devices. It is strenuous to stand up for a long time sitting.
Cooking	The handle of pans is easy to loosen.
up and down stairs	When the elderly went up and down stairs, they moved slowly because of weak legs.
Shopping	They do not buy much things for carrying easily. Smart products or other electrical equipment were bought by their children for the elderly.
Household	It is difficult to bend for a long time. Children will call for household management service for cleaning.
Entertainment	Tai Chi， square dance, mahjong, walking, computer games
Going out	It is not easy to go up and down the bus. Taking a taxi is not easy and the taxi-hailing applications is not used by the elderly.
Get out of the bed during the night	If they go to bathroom hurriedly in the middle of the night, it is easy to fall down.

Typical occurrences are also summarized as follows:

Omron sphygmomanometer is easy to use, and Grandma Chen records her blood pressure by herself.

The old people with strong self-esteem and do not want to expose their own difficulties and illnesses to others. We have observed that many elderly people have a difficulty to walk well. They are reluctant to use age-related products. Even if the ear is not clear, one participant does not want to use a audiphones.

The old people have hand-shaking symptoms in varying degrees, and it is difficult to complete much sophisticated action such as using smart phones to touch the icon.

The elderly does not understand the contents of drug instructions, and small words are not easy to see clearly.

It is very inconvenient for the elderly to go to a hospital. Most of the old people need to regularly go to the hospital for checking.

4. DISCUSSION

4.1 Assistive design

The results showed that older adults need assistive devices to improve quality of life. Walter et al. [25] summarized that age-related changes were shown in Fig1. Functions of an assistive service robot should accord with these changes. The category of participants' activities which were observed refers to the age-related changes to some extent.

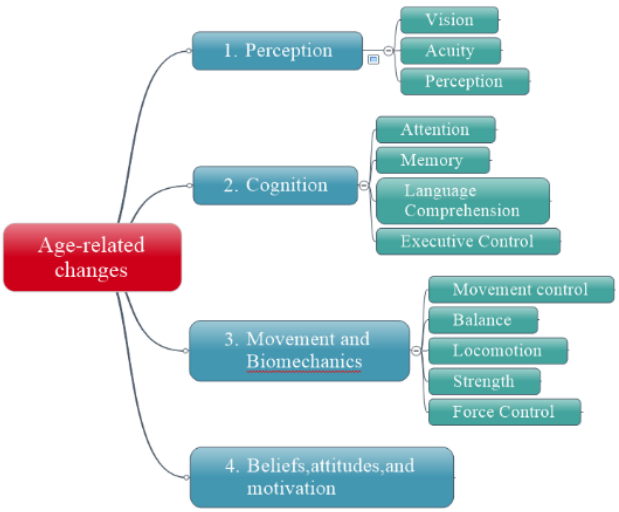

Figure 1. Age-related changes

The results also showed that memory loss has the universality. All of participants have memory loss more or less. The elderly people take some means to assist in memory loss. One of participants put a lot of small notes on the wall and uses a timer to remind him as shown in Fig2. Reminding them to take medicine is necessary. Because of a variety of medicine should be taken every day, the elderly don't remember whether they have taken medicine or not.

Figure 2. Taken in the participant's home

4.2 User Experience

In the present study, it was found that the technical aspect of a product has been implemented to meet the elderly's needs. The point is experience design which includes aesthetic requirements of intended users and usability. Mentioned in results, the participant needs a walking aids to assist him to walk, but he was reluctant to use it because of stigmatizing. Experience design [26] makes people realize that interactive products and services not only exist objectively, but also affect people's life-style and identity. An important component of experience design is pleasure design which includes physical pleasure, social pleasure, mental pleasure and sense pleasure. This is also the focus of future research and design.

4.3 Interaction ways

People perceive the external environment mainly depends on the visual, there are four other senses: taste, smell, touch and hearing. Through the present research and literature shows that the elderly's hearing and vision decline severely with aging. Tactile perception has become an important area of research in recent years. Tactile perception begins with touch, which is sensed by receptors beneath the surface of the skin and at the muscles and joints. High temperatures and vibrations can also be felt by a source that we do not have direct contact with. In the field of human-computer interaction, tactile refers to perception and manipulation through the feeling of touch. Tactile interaction is a direct application of touch.

5. CONCLUSIONS

This paper has conducted qualitative research method to obtain the elderly's requirements. It is obvious that an assistive service robot is an alternative technological solution for the elderly who live alone at home. The elderly need a service robot to assist their independence or social interaction. According to the above results, designing assistive service robots should contain functional, experience, requirements, aesthetics.

We believe that assistive service robots designed for elders could become more and more popular. For example, there are an increasing number of people to use iRobot. Robotic systems have the potential to be accepted by elders as long as they benefit from robots which can improve the quality of elders' life. An application of the qualitative results will not only support service robots design, but also other design for the elderly.

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