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Elderly centered design for Interaction – the case of the S4S Medication Assistant

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Abstract

Several aspects of older adults' life can benefit from recent technological developments, but success in harnessing this potential depends on careful design and accessible, easy to use products. Design and development must be centered on the elderly and adequately consider interaction. In this paper we follow this design approach and put it to the test in developing a concrete application, aimed to contribute to lower the high levels of non-adherence to medication in the elderly population. The "Medication Assistant" application was developed following an iterative method centered, from the start, on the elderly and interaction design. The method repeats short-time development cycles integrating definition of scenarios and goals, requirements engineering, design, prototyping and evaluation. Evaluation, by end-users, of the increasingly refined prototypes, is a key characteristic of the method. The evaluation results provide information related to strengths and weaknesses of the application and yield suggestions regarding changes and improvements, valuable support further development. Results regarding evaluation of the second prototype of "Medication Assistant" are presented.

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1. Introduction

The impact of using advanced technologies has been very positive for the general population. Due to the continuous increase in the elderly population worldwide [1], development starts to contemplate this group, taking into account the significant contribution that new technologies may provide to improve the quality of life of these population. This meets the guidelines of the EU countries for the elderly population, which highlight active aging and independent living, by the development of services based on the specific needs of the population, helping them to live in community [2].

Developers know the importance of involving the target users in the design process [3] and this is even more important when the target users are elderly [4]. Throughout the design process of products suitable for and usable by elderly it must be taken into account their unique needs, limitations and capabilities [5]. To accomplish this, it is essential to know and use effective approaches for interaction and gather data on how they are used. This data will give information about the features and attributes that elderly prefer, and consequently allow an understanding of which factors can improve the usability of the product [6].

The design process in this perspective arises in the literature as User Centered Design (UCD), but the traditional user centered design provides little guidance on how to involve the elderly [3]. UCD is a collection of methods that aim to involve the users in an appropriate way during development. The basic principle of this approach is placing users in the focus of the design process through the use of various techniques, first to collect information from them and then to initiate the design of prototypes which they will be asked to test [7]. “Needs assessment and requirements analysis are the most important activities for initiating system improvement because, done well, they are the foundation upon which all other activities build" [5].

With the continuous progress and sophistication of the prototypes, the user should be asked to perform tasks with minimum guidance by the testers. The results of this tests, according to the iterative process inherited from UCD, are analyzed and will guide the design of subsequent prototypes [7].

Product development based in UCD should adhere to the following principles [8, 9]: knowledge gathering concerning users’ needs, capabilities, attitudes and characteristics; active involvement of users; prototypes redesign, as often as necessary; iterations of design solutions (repetition of a cyclic process of design, evaluation and redesign as often as necessary); multidisciplinary design teams.

According to the international standard ISO 13407 this process should be developed through four stages in the following order: specify the context of use, define the requirements, design and evaluation [8].

One of the important contributions to guide the process of product development according to the principles of UCD, particularly at an early stage of requirement definition, is the creation of Personas [10]. Personas are fictional persons, with name, occupations, age, gender, socioeconomic status, hobbies, stories and goals and are used to personify the principal characteristics and functions for the product design [11, 12]. There are various data-driven Personas for elderly based on European statistics, which should be followed by teams that intend to develop products to the elderly [13]. Personas are an important and valuable tool, mainly if the objective of the team is to test and evaluate the usability and effectiveness of a product. The Personas “allow us to see the scope and nature of the design problem. They make it clear exactly what the user's goals are, so we can see what the product must do" [13].

Despite the general applicability of the UCD development method, it must be tuned and adapted when developing applications for older adults. With the increased use of new interaction modalities (e.g. touch), multimodal interaction requirements, design, development and evaluation must also be part of the development process.

Considering the elderly population, one important issue affecting their daily life and health, concerns medication non-adherence [14]. This is often due to the increasing number of medicines to take, to age related changes (such as memory loss, or different levels of physical and cognitive impairment), to lack of information on its usefulness and transient side-effects and to demotivation. The impact of medication non-adherence on the quality of life and associated costs dealing, for example, with reduced or unwanted therapeutic effects (e.g. antibiotic resistance and longer treatment timespans) [15], configure this as a very important problem to tackle in which mobile devices and adequate interaction design can play an important role. This, we argue, is a context were the UCD development method can prove its mettle.

In this paper, we present an UCD development method centered on the elderly and interaction, aimed at increased usability and accessibility [9], and its application to the development of a concrete system, the "Medication Assistant", that allows voice and touch interaction to facilitate the access by elderly. The main features of this system are the alerts of medication to intake, the visualization of information of each medication and the advice service that allows users to obtain information about what to do in case of forgetting to take a medication. The prototype of this application has been already evaluated in two tests, with two different groups of users, in order to detect problems and collect opinions and suggestions to further meet the needs and specificities of the users.

This paper starts by providing an overview of the proposed development method. After, a description of the primary Persona, context scenarios and application requirements for the "Medication Assistant" are presented. It is also discussed how the application meets the requirements, followed by the evaluation method, main results and the conclusions.

2. Elderly Centered Development Method

The proposed development method is aligned with the methodology described in [16]. After obtaining the requirements (phase 1), a prototype is proposed (phase 2) and evaluated (phase 3), in order to refine the requirements. This iterative methodology continues with additional prototypes and evaluations towards an increasingly refined application. In order to get system Personas, the context scenarios and the system requirements for phase 1 we adopted a five stages method aligned with Cooper and collaborators [17].

The first stage aims at identifying the behavioral variables, such as age and demographic localization, activities, attitudes, aptitudes, motivations and skills and significant behavior patterns, by analyzing the interview results. Following these guides, it is possible to synthetize the characteristics and relevant goals for the Persona. After, the description of the Persona is expanded in order to have a small story about the Persona and its daily life. Finally, Persona types are designated. At the beginning only the primary Persona should be created.

On the second stage, to get the requirements and context scenarios a problem and vision statement must me produced.

The third stage consists in brainstorming with people from different domains and end-users. The brainstorming should last a couple of hours and comprise a few questions in order to stimulate the ideas flow. After the brainstorming the main ideas should be filtered.

On the fourth stage Persona expectations are set by the same people who brainstormed earlier. This is very important in order to understand the main end-user and its expectations. At the end of this stage, context scenarios are defined, typically as a group of short stories. They should be simple and represent use of the application by end-users. Finally, the requirements analysis should be made. To create the requirements it is important to be aware of the information gathered in the previous stages. It is important to note that the Persona and the scenarios should always be present during the development process (phase 2) and not only in requirements elicitation.

Towards the development of an application designed taking into account the accessibility and usability features of end users, the application is evaluated along all the development process (several iterations of phase 3). The evaluation method adopted is based on a methodology recently proposed [16]. This methodology is adapted to the characteristics of the application and its end users. The evaluation consists of three phases: conceptual validation, prototype test and pilot test. These three phases are connected, in a cyclic process, as the results of the several evaluations will influence the development process of the application.

The first phase of evaluation aims at collecting information to verify the viability of the application interface and functions. The second phase comprises a test performed by the users through interaction with the application prototype, with the presence of an evaluator to register opinions and suggestions of the user. The pilot test is similar to the prototype test, but it adds the assessment of the impact the application has on the lives of its end users.

3. Application to a Medication Assistant for the Elderly

In this section, after the generic presentation of the method in the previous section, we show how it can be applied in a real scenario using, as an example, the development of a new multimodal application for Smartphones, named "Medication Assistant". The main purpose of this application is to make elders become healthier, addressing the problem of medication non-adherence due to age related factors such as the inherent medication increase, cognitive losses and demotivation. It helps them with medication management, providing multimodality and context awareness, fully advising and supporting with the medication.

3.1. Personas, Context Scenarios and Requirements

As already explained, Personas and Scenarios have a key role in supporting requirement analysis. Information on the Persona and scenarios developed for "Medication Assistant" are presented below.

3.1.1. Persona

Our Persona should live in Portugal, does not need to have the aptitude to use electronic devices, must be an elder person with health problems (although it is not necessary to have regular doctor appointments), and should have the desire to control its own medication. Furthermore, the Persona does not need to have a family, but commonly speaks with friends and family through a computer or mobile device. In the first phase we are developing our application in order to respond to the requirements of the Primary Persona. The Primary Persona is the Persona at which the application should address all the requirements. We identified the following expectations: the Persona wants to be able to use the same application with arthritis; the application should help prevent gaps in medication, report medication, report side effects, and provide alerts. Furthermore, the Persona wants to use the application even with little aptitude for working with electronic devices. Thereafter, we created the context scenarios, after which we identified the requirements.

Primary Persona, Mrs. Emília, lives in Coimbra with her husband Filipe Rodrigues. She's a housewife and does not have experience with electronic devices. She is right handed. She is diabetic and has arthritis in her right superior member. Her health condition requires a regular and daily medication. Mrs. Emília has the habit to call her daughter during dinner preparation. However, she has some difficulty in doing the two activities simultaneously due to her limitation in the right superior member. She has weekly appointments in her local health center for surveillance. Mrs. Emília would like to buy equipment that facilitates the contact with her daughter and allows her to control her medication, which she often forgets to take.

3.1.2. An example of a context scenario

Our context scenarios intend to describe several scenarios of application usage. These scenarios outline different ways to interact with the application, as well as its features. Each scenario is represented by a short story. Two scenario examples are presented below.

Mrs. Emília waked up to prepare breakfast. The application showed an alert (with the medication names and dosage) warning that Mrs. Emília needed to take her medication in the fasted state. Mrs. Emília, warned that she had to take the medication, took it immediately and then prepared breakfast.

After a while, the application asked Mrs. Emília if she had already taken the medication. The application interacted through speech, since Mrs. Emília hands were busy. She answered "Yes, I took my medication".

A few hours later Mrs. Emília starts to feel unwell. She felt concern and, through speech, she asked the application if that condition was normal. In order to answer that, the application explained that she took a medication that could induce a feeling of being unwell, also giving information about what is the reason to take the medication and what are the side effects of it. Thereafter, Mrs. Emília felt relieved and returned to her tasks.

Table 1 - Context Scenario

Mrs. Emília Action	Action on smartphone application	Output from smartphone application to user
Wakes up and prepares breakfast.	Prepares an alert to show	The application triggers an alert: "You need to take medication in the fasted state"
Takes the smartphone and read the alert. The user opens the alert [IM=Touch].	Opens the alert.	Shows the list of medications to take [IM=Text and Images]
Takes the medication and lock de mobile.	Closes application and lock.	Locks Screen
Eats the breakfast.	Needs to know if the medication was taken. Prepares a speech message.	Shows a message: "Did you take the medication in fasted state?" [IM=Text and Speech]
Answers "Yes, I took my medication" [IM=Speech]	Recognizes the answer. Notes the take of the medication. Locks.	Locks Screen.
A few hours later, starts to feel unwell. The user unlocks the mobile and asks "I'm felling unwell, is it normal?" [IM=Speech]	Recognizes the sentence. Find if any medication taken has side effects and prepares the response.	Shows a message: "Yes, the MEDX could induce a feeling of being unwell. It can induce nauseas too. But you should take it for arthritis." [IM=Text and Speech]
Feels relieved.		

3.2. Main requirements

The requirements were divided in two main groups: the functional requirements and the user requirements.

The main functional requirements are: (1) the application should provide medication insertion and management by third parties, so that seniors do not need to perform this task since it can be complicated; (2) the application should provide medication alerts to remember users about medication schedules; (3) the application should provide medication advice to help elders in daily medication questions. It must be able to respond to commands given in Portuguese expressing questions such as "What should I do if I forget to take

my medication?", "Plan the day because I'm leaving" or "I'm with headaches. Is it a side effect?"; (4) the application should provide configurable interaction; (5) the application should provide multimodal interaction; (6) the application should allow registry of medication taken.

The main user requirements are: (1) the application should inform users in an everyday language since technical language could be misunderstood; (2) the application should provide touch and speech interaction for everything in order to facilitate user interaction since some users may have physical or cognitive limitations; (3) the application should be reliable and credible because the user must trust its advices and alerts; (4) as elders usually have low proficiency with technology and vision problems it is crucial that the application avoids overloading content and small icons; (5) the application should have extra care with language and dimension; (6) the application should adapt to the user and the context; (7) the application should provide personalization; (8) the application should avoid information overload; (9) the application should be able to provide more information when the user wants it; (10) the application should provide help to the elder when they present difficulties interacting with the application; (11) the application should provide a group of "how to use guides".

3.3. Prototype 2 – Meeting the requirements

After completing one development cycle, which resulted in a first prototype, the data gathered during its evaluation was used to feed the following development cycle. Furthermore, beyond the consideration of user feedback, existing features have been expanded and new features added, resulting in a second application prototype.

In order to enable the insertion of medication and its management by third parties, we created an external service. The smartphone uses the service to get all the information related to the medication. When the application is open for the first time it will ask for a login that will be used to get the elderly medication plan. In the second prototype the insertion was made by a formal or informal caregiver, i.e., the elderly didn't need to perform this task. This has the advantage of preventing the elderly from getting bored and demotivated to use the application, since this task can be tiresome and time consuming. However, this feature needs to be improved in order to simplify the insertion process.

The application provides medication alerts using both Windows Phone push notification and local notification. If the application is connected to the Internet, the user can receive push notifications. However, when the application opens, it creates local notifications for the next four alerts and informs the push notification service that it only needs to work for the fifth alert. This process is executed whenever the application opens. Therefore, the push notification service is only required when the elderly do not open the application for the next four straight alerts. This way it is very likely that the application will inform the user in the need of taking the medication in a timely fashion, even without constant access to the Internet, creating a high level of credibility and reliability, very important for older adults. Furthermore, the application allows the elderly to see the next alerts list.

When the elderly forget to take medication, or want to know what its side effects are, they can refer to the application. All the medication should have information about what to do if the user forgets to take it, what are the side effects, and why the elderly needs to take it. In this way, the application can give that information to the elderly when needed. In the prototype, it is possible to know the reason of taking that medication, what are the side effects, the expiration date of the medication, and what to do if a medication intake was forgotten. We will add additional information to the medication in order to allow the elderly to get more advice about it. This information is based on the medicines leaflets, increasing the credibility and reliability of the information given.

The application provides a set of options so the elderly can change the application settings. The user can allow noise control features, change the font size, change between dark and light mode and activate the help mode. Regarding the noise control feature, for example, if it is activated the application will automatically

Fig. 1 - Medication Assistant example views: (a) application starting; (b) main menu; (c) advice menu; (d) next alerts; (e) about the medication.

detect the user context noise and adapt its volume.

The user can also change interaction features such as how speech commands are input (touch-to-speak or use of speech by voice activation) and activate the auto-zoom. The touch-to-speak feature will allow elderly to touch a button and speak to the application. The application can also be configured to automatically detect speech inputs without any type of touch interaction. However, this alternative is not so precise and has not yet been carefully evaluated.

The auto-zoom feature adapts the size of text and images to the user distance to the smartphone. If this feature is activated, the size of the items on the screen will automatically increase when the user moves away or closer to the smartphone depending on the user context: if the user has nearsightedness, when approaching the screen the size of the images/text will increase; if the elderly has astigmatism, when moving farther from the screen the size of the images/text will increase too.

Furthermore, when the elderly needs to know more information about a specific medication, the application will adapt to the needs. Thereby, the application provides personalization, configurable interaction, extra information and user/context adaptation.

The elderly can use touch or speech as input in order to interact with the application. The speech can be used to get advice (e.g. “I forgot to take the lunch medication”) or to get extra information (e.g. “What are the side effects of this medication?”). The advantage of speech is that it normally provides a faster and more intuitive way to get response from the system than touch. As output we use text, speech and images. Thus, in the second prototype we already used multiple modalities both for input and output, making it really multimodal [18].

As the elders usually have low proficiency with technology and vision problems, we created a User Interface based in big text and big items/images. The UI follows the Metro Style guidelines, avoiding extra bars, icons, buttons, etc. [19]. The application has a simple and clear layout that gives the user the opportunity to get more information when required (through speech) to avoid information overload in the views. Furthermore, the auto-zoom feature will be aware of the user difficulties and adapts the UI to it. On the other hand, the application tries to give information in a common and informal language avoiding the technical one. However, this is a requirement that needs more improvement since it is hard to replace the medication names and side effects by informal and common names.

Lastly, the application provides auto adaptable help. When the elderly are inexperienced, the application offers many suggestions, but when they learn to interact with the application it will stop providing them. However, if an expert user starts to show some difficulty (e.g. increasing time to perform tasks) using one of the features, the application adapts and starts offering suggestions again. In addition, the application provides a

group of "how to use guides" composed by some example phrases about how to interact with it through speech. In the future, we will add video guides in order to help inexperienced users.

3.4. Evaluation

3.4.1. Methodology

As mentioned, the evaluation method adopted for "Medication Assistant" is based on a methodology proposed recently in [16]. A first evaluation of the prototype was conducted with a heterogeneous group of engineers and health professionals, with the intent of gathering an extended number of opinions and suggestions to validate the general design options and guide the following development. In the first prototype test the user was accompanied by an evaluator, member of the project, to explain the test and respond to user doubts. During this test the think aloud method was used and the audio was recorded. The group was composed by three women and one man with age ranges between 25 and 60 years. The results of this first evaluation of prototype was presented in [20] and used to support the development of a second prototype, for which evaluation results are presented in this paper.

The second evaluation was made with a group of end users and followed a previously defined structured plan of evaluation with a set of tasks.

The evaluation consisted of two phases: the interaction assessment phase and the usability evaluation phase. In both phases the user is accompanied by an evaluator to explain the evaluation method. The interaction phase is composed by a set of tasks requiring the user to interact with the application: for instance "See the list of medications to be taken at breakfast" and "Inform the application that you missed the last medication". In this phase the think aloud method is used and the evaluator takes notes regarding users behavior and their main difficulties, comments, doubts, suggestions and problems during the completion of the tasks. In the second phase, pertaining usability, the evaluator applies a questionnaire about the user interaction experience with the application. In this stage the user answers some questions about the application, such as "In your opinion what are the strengths and weaknesses of the application?" and "What would you change in the application?". The user should give an opinion about some aspects of the application such as the layout, font size and color, the features and the interaction.

The second evaluation of the prototype was with a group of three women and one man, with ages between 57 and 76 years. Accordingly to [21], the sample size is appropriate to a qualitative evaluation, considered adequate for a second prototype evaluation.

3.4.2. Results

In this section we present the results of the evaluation.

Regarding usability evaluation, through the analysis of the opinion questionnaires, the results that stand out are the strengths and weaknesses of the application and the suggestions of changes to be made. Fig. 2 shows the strengths and weaknesses of the "Medication Assistant". In the tag clouds the words with larger font size are the most referred by the users and the smaller ones are the least identified by the sample.

Fig. 2 – (left box) strengths of the application; (right box) weaknesses of the application

The changes suggested by the users are presented in the following table (In each type of alteration are presented the object and the action to be taken, accordingly to the user suggestions. The last column presents the priority of the alteration, according to the development team opinion.

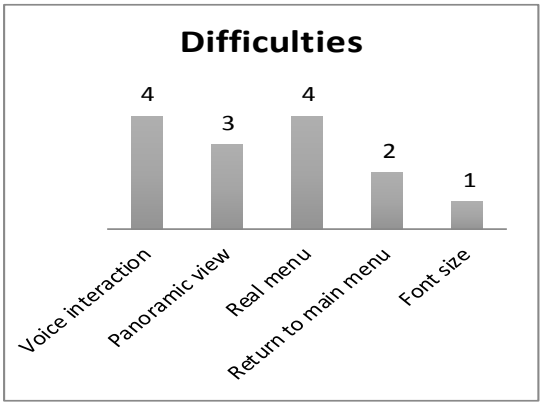
Regarding interaction evaluation, based on the data collected from observation and notes of the evaluators several features were identified that users considered more difficult or easier to use. The overall results presented in the two graphics depicted in Fig. 3, showing the number of users that considered each feature difficult or easy to use.

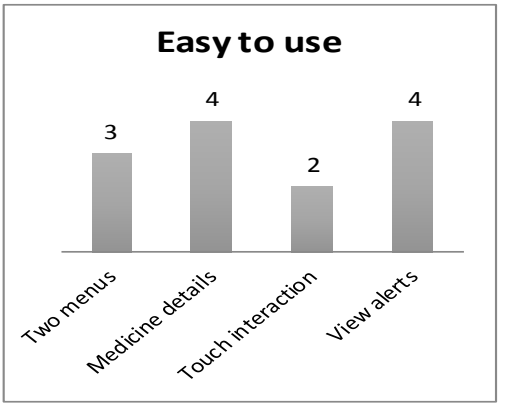
) and organized by types. In each type of alteration are presented the object and the action to be taken, accordingly to the user suggestions. The last column presents the priority of the alteration, according to the development team opinion.

Regarding interaction evaluation, based on the data collected from observation and notes of the evaluators several features were identified that users considered more difficult or easier to use. The overall results presented in the two graphics depicted in Fig. 3, showing the number of users that considered each feature difficult or easy to use.

Table 2 - Application improvements suggested by users on the evaluation questionnaire

Type	Object	Action	Comment
New features	Tutorial	Add	Priority
	Register	Add	Priority
Interaction	Speech input	Improve	Priority
Design/Layout	Panoramic view	Improve	Nonpriority
	Real menu	Improve	Nonpriority





4. Conclusions

Since the beginning of the "Medication Assistant" application development, one of the main focuses was the inclusion of end-users. User intervention is crucial since the initial phase, mostly with their participation in brainstorming sessions to generate ideas and support the definition of Persona and scenarios. During the continuous development process of the application users have an active role, by participating in the process of evaluation, thus enabling the application to be shaped accordingly to the users' needs and capabilities, suffering a continuous process of redesign. In this paper all this process is explained and the results of the second prototype are presented.

The data analysis was qualitative, taking into account the size of the evaluation sample. In the data analysis priority was given to the questionnaires, which provide information related to strengths and weaknesses of the application and give suggestions of changes proposed by users.

By analyzing the strengths of the application we can say that the application is already useful, even being on

Fig. 3 – Application features and corresponding number of users who considered them difficult (left) and easy (right).

a prototype development phase. Features like forgetfulness support, medication images and the expiration date were proposed in the brainstorming, and as we can see they seem to be of interest for the end-users. The Help menu feature is a result of the first prototype evaluation. It shows that our method can lead to the development of useful applications for end-users.

The weaknesses can provide important information too. First, they provide basis for the next iteration and prototype. Second, they show that interaction is really important as we defend in our proposed method. Since we are in the second prototype, the interaction features are only in the initial phase of development, unlike other features of the application, being the reported weaknesses expected.

With the intent tackle the needs identified in the evaluation of the second prototype, the future work should focus, mainly, in the development of a new prototype, considering particularly touch and speech interaction.

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