Design Recommendations for TV User Interfaces for Older Adults: Findings from the eCAALYX Project

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ABSTRACT
While guidelines for designing websites and iTV applications for older adults exist, no previous work has suggested how to best design TV user interfaces (UIs) that are accessible to older adults. Building upon pertinent guidelines from related areas, this paper presents thirteen recommendations for designing UIs for TV applications for older adults. These recommendations are the result of iterative design, testing, and development of a TV-based health system for older adults that aims to provide a holistic solution to improve quality of life for older adults with chronic conditions by fostering their autonomy and reducing hospitalization costs. The authors' work and experience shows that widely known UI design guidelines unsurprisingly apply to the design of TV-based applications for older adults, but acquire a crucial importance in this context.

Categories and Subject Descriptors
H.1.2 [**User/Machine Systems**]: Human factors; Human information processing. H.5.2 [**User Interfaces**]: User-centered design. H5.m [**Miscellaneous**]: HCI.

General Terms
Design, Experimentation.

Keywords
User interface design, TV, older adults, design recommendations.

1. INTRODUCTION
The work reported in this paper results from the eCAALYX project, a TV-based system that aims to improve quality of life for older adults with chronic conditions. In addition to remote monitoring tools, eCAALYX provides a simple interface for patients to observe the evolution of their health and interact with their caregivers.

It is widely known that for users to adopt a product it must respect their characteristics and needs; a TV-based system for older adults is no exception. Contemporary older adults did not grow up using computers, so what is a routine piece of technology to the mainstream user may be perplexing or even seem like 'rocket-science' to the older adult. Furthermore, many older adults experience some form of age-related condition that impacts their perception, cognition, physical abilities, or socio-psychological situation. An interactive system for older adults must be designed and developed with all of these factors in mind in order to be valuable to them.

Pleasant, usable UIs usually result from a process that includes thorough user research, compliance to device- and audience-specific design guidelines, and evaluation with end users. In newer situations like TV applications for older adults for which specific UI design guidelines do not exist yet, Dumas and Redish recommend applying related Human-Computer Interaction principles to create prototypes, then evaluating the prototypes with users. The results of such evaluations contribute to the formation of guidelines to suit the novel context [1].

Following this advice, the authors began by reviewing related UI design guidelines, which are discussed in the next section. With these guidelines in mind, the authors created prototypes, then tested them with older adults and iteratively improved the design to better suit the end users. The authors later conducted a second evaluation in which they tested the developed system. This paper reports what the authors learned from the eCAALYX project design process and presents a set of recommendations for designing UIs for TV applications for older adults, in order to support future work in this area. The paper first reviews related areas from which authors initially drew guidelines and introduces the eCAALYX project. Then it describes the testing procedures and the results of two main evaluation moments. Building upon the literature review and the results of the evaluation with users, the paper later contributes recommendations for TV UIs for older adults. Finally, the strengths and weaknesses of this work are presented and key conclusions summarized.

2. RELATED WORK
This section briefly reviews the related areas that informed the design of the prototypes. The authors reference the specific pertinent guidelines from these sources when presenting recommendations for designing UIs for TV applications for older adults.

2.1 Web Accessibility
Accessibility is the overarching effort to make products usable for as many people as possible. In information technology, accessibility is usually associated with accommodating people with disabilities like visual, hearing, and physical impairments that make typical input and or output devices difficult or impossible to use. This field is well-established, with the World Wide Web Consortium (W3C) launching the Web Accessibility

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Initiative (WAI) as early as 1997. The WAI offers a set of Web Content Accessibility Guidelines, many of which are applicable beyond the Web context [2]. As Greengard notes, while many accessibility features like text-to-speech and magnification tools were initially provided to enable people with disabilities to use computers, they are also useful for older users [3].

2.2 Web Design for Older Adults

Web user interface design for older adults is also a well-established sub-field. Coyne and Nielsen [4] reviewed 17 websites with products or services targeted at older adults and extracted a number of related user interface design guidelines, for example, addressing navigation or form design aspects[4]. The WAI has also published a document specific to Web accessibility for older adults, which reviews other work in this area and assesses how well their accessibility guidelines mentioned above already address the requirements of older adults [4]. One of the works considered by the WAI's review is [5]. This paper takes recommendations and guidelines gleaned from over 100 academic publications related to Web design for older adults and synthesizes them into 38 guidelines, which the authors arrived at through a focus group and testing. The WAI document also references an article from Redish and Chisnell that reviews research on Web design for older adults and presents a set of heuristics primarily focused on navigation, information architecture, and visual design [6]. Similar sources can be found in [8] [9]. As these sources indicate, much has been written about designing websites that are suitable for older adults.

2.3 iTV Design

Interactive TV (iTV) refers to applications created to enrich the viewing experience of specific TV programs through features like changeable viewing angles, voting on polls, and access to supplemental information about shows. iTV design has been studied extensively in its own right; for instance, Lu conducted a comprehensive examination of the state of the field in 2005 and proposed a set of principles based on existing design patterns and conventions [7]. Many of these principles are generally true for an application on any type of device but are especially important for the TV. Although some knowledge about Web design for older adults also applies to designing for TV, it does not translate directly: TVs have different display characteristics, different input devices, and a different relationship to the user (i.e., they are typically viewed from varying and farther distances, and often while the user is involved in other unrelated tasks) [7]. Chorianopoulos discusses ways that TV design principles differ from Web or desktop design principles, reiterating the fact that whereas users generally approach computers with a productivity perspective, they approach TVs with an entertainment perspective and tend to have a more relaxed, "lean-back" attitude [8]. Bernhaupt et al. contribute the additional point that "while watching TV is easy, being interactive requires knowledge, skill, and competence" [9]. They present findings from a field study of an iTV service, providing recommendations such as keeping text entry at a minimum by using automatic completion whenever possible, and considering users' prior experience with media like mobile phones and computers [9].

2.4 iTV Design for Older adults

To this end, researchers have also addressed the design of iTV applications for accessibility and older adults specifically. Gill and Perera raise the question of what is necessary to ensure the accessibility of iTV, emphasizing the fact that iTV has the potential to empower elderly or disabled people [10]. Carmichael provides a thorough guide to the design of iTV services for elderly viewers that first elucidates the unique characteristics of elderly viewers by describing changes that occur with age [11]. The document concludes by presenting 22 general guidelines, like considering the inclusion of interactive training tools or options to customize the presentation.

2.5 TV-Based Application for Older Adults

Much of this previous work in related areas appeared to be highly relevant to the TV application the authors planned to develop for the eCAALYX project. However, iTV design focuses on enhancing the experience of watching a specific TV show. This system, on the other hand, is not a complement to a TV show, but rather an independent application that is displayed on a TV screen and operated by a TV remote. The system always occupies the complete screen because technical limitations prevent overlaying the TV image, although in the future it is expected that some information, such as the reminders, will be displayed as an overlay while the user is watching TV. While Carmichael et al. developed a similar TV-based system to support people affected by dementia, they did not report on an evaluation of the system [12]. For these reasons, it was necessary to identify the most significant guidelines for TV-based applications designed for older adults. The authors present the results of the study as the recommendations in this paper.

3. THE ECAALYX PROJECT

Enhanced Complete Ambient Assisted Living Experiment – eCAALYX is a European project that aims to create a holistic solution to improve quality of life for older adults with chronic conditions by fostering their autonomy and reducing hospitalization costs. Specifically, the project addresses chronic conditions that severely impact older patients' health, such as cardiovascular disease, chronic obstructive pulmonary disease (COPD), and type 2 diabetes. To ease the burden on these patients, eCAALYX enables them to monitor their own health, receive practical information about their condition, and communicate with caretakers. Technology-wise, the solution utilizes a TV and set-top-box running XBMC installed at the user's home. For monitoring the user health condition, common weight, or blood pressure Bluetooth sensors are used. These communicate with a specific router that pre-processes and sends the data to a central server.

The authors designed the TV UI for this system, which was then called the Health Channel. The Health Channel enables users to (see Figure 1):

- **Check their current health condition** through simple graphical representations of the evolution of their weight, blood pressure, etc.;
- **Communicate with caretakers** using videoconferencing technology;
- **Browse their agenda** of medical appointments and times for taking medication or performing measurements (i.e. checking blood glucose level);
- **Watch educational videos** about managing their disease and dealing with related issues;
- **Answer questionnaires** sent by their doctor to gather more information about their condition; and
- **Make emergency calls**, by audio conferencing the emergency services.

In addition, the Health Channel proactively prompts users to take medications, perform measurements, and attend medical appointments.

The authors followed a User-Centered Design approach fuelled by iterative cycles of user research, design, and usability evaluation in order to design this system. The authors began by designing low fidelity prototypes based on the research on related work described above. The next section details the two main phases of user evaluation.

4. EVALUATING THE HEALTH CHANNEL

4.1 Low fidelity prototypes usability tests

As soon as the first low fidelity prototypes were available, the authors began evaluating the Health Channel with end users. This initial phase of evaluation consisted of a total of eight sessions with four to six users each. The participants' sample consisted of 16 participants from two local senior centers. The participants' average age was 79.4, ranging from 54-92. The participants had diverse backgrounds, with past professions including craftsman, farmer, housemaid, nurse, office worker, and professor. The participants' education level was also diverse, including no education (˜19%), primary school (˜50%), high school (˜13%), and college degree (˜19%). No participant owned a computer, but two had used one in the past.

Most tests consisted of presenting a paper prototype of the Health Channel and asking participants to accomplish various tasks by operating the system with a mock remote control. The TV screens of the Health Channel were hand-drawn on paper sheets of 69 cm (~27 inches) and were placed three meters away from the test participant. To provide better legibility, titles and labels were printed and glued to the paper sheets. Interaction with the paper prototype was performed with a remote control that was crafted using soap and offered Ok, Back and directional, "buttons".

The test facilitator simulated the interactive behavior of the system using the Wizard of Oz technique [13]. Participants were asked to use the think aloud protocol – that is, to verbalize their thoughts throughout the test in order to help us understand their actions better [14]. When participants got stuck, they were invited to explore the interface in search for the right option. If the problem persisted, they were asked questions regarding what the different options would enable them in order to support them identifying the correct one.

These tests asked participants to:

- A1) Watch Arterial Tension – starting from the home screen, to find and review data about their arterial tension.
- A2) See Agenda – starting from the home screen, to find and review their agenda of appointments.
- A3) Call Dr. Eloísa – starting from the home screen, to place a call to a specified doctor.
- A4) Receive Call from Dr. Eloísa – to answer an incoming call from a doctor.
- A5) Appointment Reminder – to read and comprehend an appointment reminder notification.
- A6) Medication Reminder – to read and comprehend a medication reminder notification.

Other tests aimed to find the icons or labels that best fit the users' mental models. In this context, the authors used a modified version of icon intuitiveness tests [15] in which they presented sets of labels or icons to participants and asked them to choose which best represented a described functionality. These tests included asking participants to select from:

- A7) Labels for the main menu options.
- A8) Labels for the video re-play button.
- A9) Icons for the main menu options.
- A10) Icons for the agenda and health videos.
- A11) Icons for the video player.
- A12) Icons to represent times of day.
- A13) Icons for the health measurement charts.
- A14) Icons for medical specializations of doctors.
- A15) Icons for extra info on agenda screens.

4.2 Functional prototype usability tests

Based on the results of the low fidelity usability tests (synthesized in Table 1 and described in the next section) the authors developed a functional prototype that runs on a TV and set-top box and is controlled with an ordinary TV remote control. For the evaluation this system was installed on a TV in a model apartment in the institute's assisted living laboratory and pre-populated with data. Two researchers facilitated the tests, also recording the sessions on video.

Ten older adults from two local senior centers participated in the evaluation. The average age of the participants was 69.5, ranging from 61-78. These participants reported past professions including retail sales, waitress, seamstress, and administrative worker. Their level of education varied between primary school (70%), middle school (10%), and high school (2%). Six had never used a computer before, one had used a computer but did not currently, and three currently used a computer.

In these sessions, participants were asked to complete tasks using the system. These tests included:

- B1) Browse Agenda. Participants were asked to find appointments, then answer specific questions about the date, time, and location.
- B2) Watch Health Videos. Participants were asked to play a specific video, as well as state its length, pause it, resume it, and switch to full screen mode.
- B3) Questionnaires. Participants were asked to answer a set of questions, reading options aloud and choosing the most correct answers.
- B4) Medication Reminder. Participants were shown a medication reminder screen and asked to explain what they understood.
- B5) Draw the main menu. Participants were given a chance to examine a screen, then handed a sheet of paper and instructed to draw it. The goal was to assess if participants remembered the elements in the periphery.
- B6) Watch Blood Pressure. Participants were asked to measure their blood pressure and then locate it in the system. They were also asked to identify several values they supposedly had measured the day before, which aimed to evaluate the system navigation.
- B7) Receive call from doctor. Participants were presented with an incoming call and asked to describe

the screen and options. They were then asked to take the call, and sometime later to end it.

4.3 Font size usability tests

During the evaluation of the working system, the authors also conducted a test to determine the minimum font size for text. This test comprised 19 participants – the ten older adults from the functional prototype usability tests, plus nine additional older adults (eight female and two male, aged 60-89, with an average of 74.2 and median of 74).

To do so, participants sat three meters from a 15" LCD screen and read lines in successively smaller font sizes. Each line contained three words (e.g. Lettuce, Wood, Engineer), starting at 65pt text and progressing by intervals of 5pt down to 30pt.

5. EVALUATION RESULTS

This section describes the results of the evaluation moments introduced in the previous section. Each table outlines the most important results and the guidelines that were enforced by these tests. The initial low fidelity usability tests contributed to iteratively refining the system's design as well as improving our understanding of the target audience. An excerpt of the results of this evaluation phase are expressed in Table 1.

Subsequently, a functional prototype was developed and again evaluated with end users. The results of this evaluation phase are expressed in Table 2. Excerpt of results from tests with the working system and the results of the font sizes tests in Table 3.

Table 1. Excerpt of results obtained in the low fidelity tests.

Test	Key Results	Recm
A1) Watch arterial tension	5/6 understood the arterial tension chart 6/6 successfully chose Watch Arterial Tension 3/6 made errors choosing Watch Health 2/6 did not correctly choose Watch Health	5
A9) Icons for main menu	6/6 understood the telephone for Make Call 3/6 understood the clapperboard for videos 4/6 understood the calendar for See Agenda 3/6 understood the wrench for Personalize 6/6 understood 112 for Emergency Calls 5/6 understood thumbs up for Watch Health	7
A10) Icons for See Agenda and Health Videos	5/8 chose one planner for See Agenda 3/8 chose another planner for See Agenda 4/8 chose a camera for Watch Health Videos 4/8 chose a cassette for Watch Health Videos	7
A11) Icons for Video Player	5/6 did not know the standard icons for playing, stopping, and pausing video 1/6 knew only the standard icon for playing	7
Recm = number of recommendation each test contributed to		

Table 2. Excerpt of results from tests with the working system

Test	Key Results	Recm
B2) Watch Health Videos	5/10 identified Health Videos in 1 attempt 9/10 could tell the video length 10/10 easily played the video 6/10 could not select the pause button (which disappears), while 4 required several attempts 8/10 understood the goal of the full screen button	6 13
B3)Questionnaires	6/10 identified Questionnaires in 1 attempt Moving options required 2.4 reads on average	7 13
B5) Draw menu	10/10 drew something representing a menu 4/10 drew the screen title 1/10 drew the clock	8
B6) Watch Blood Pressure	5/10 identified Watch Blood Pressure in 1 attempt 10/10 identified their last measurement 5/10 understood graphics contained values for different measurements of the day The average number of attempts to reach Yesterday's screen was 1.6 (required scroll)	9
B7) Receive call from doctor	9/10 understood the goal and the available options 10/10 were able to answer the call 10/10 were able to end the call 7/10 used the back button instead of end call button	6
Recm = number of recommendation each test contributed to		

Table 3. Results of the font size tests.

Test	Key Results	Recm
C1) Font size	100% could read text in 65pt, 60pt, 55pt, and 50pt 95% could read text in 45pt font 90% could read text in 40pt font 70% could read text in 35pt font 40% could read text in 30pt font	11
Recm = number of recommendation each test contributed to		

6. RECOMMENDATIONS FOR THE DESIGN OF TV-BASED APPLICATIONS FOR OLDER ADULTS

Following are the recommendations derived from the design and evaluation of the Health Channel. As mentioned above, while many of the recommendations presented here are already guidelines in related fields, the authors have validated their importance for this particular context. The recommendations are grouped into three categories: i. Comprehensive system qualities, related to the overall behavior of the system; ii. Visual presentation, regarding how information is conveyed to the user; and iii. Text characteristics, addressing the requirements for the presentation of text.

6.1 Comprehensive system qualities

1 – Minimize the number of steps it takes to reach a given screen. Opting for a broader, more shallow hierarchy minimizes the amount of navigation users must do. While clicking through too many screens is tiresome on the computer, it can be downright exasperating when the user must make selections with a remote control. The free ranging movement of the mouse is not available [7] consequently, TV design should carefully consider navigation design, minimizing the number of steps from the home screen [7].

Web design guidelines for older adults also suggest utilizing a shallow information hierarchy [5]. While most users tend to perform better with shallow hierarchies, older users are particularly hindered by deep hierarchies because they are more

likely to make erroneous choices and become lost [16] [17]. Moreover, as working memory deteriorates with age, users become less able to maintain focus and consequently can be prone to forget their relative location in a system [6]. In shallow structures the user can never stray far from the starting point, so reorientation is easier.

In the Health Channel the information hierarchy was restricted to three levels. The home screen presents the main menu, which contains all of the primary functions. During the initial tests users often forgot the task they were working on, but were able to trace their steps and regain control because they were never far from the home screen. This emphasized the importance of preventing users from traveling deep into a system, which can prove extremely difficult when users lose concentration. This recommendation is closely related to Recommendation 6, to clearly indicate the current location.

2 – Use consistency to facilitate recognition. Since many seniors have little to no experience with computers [3], they cannot rely on concepts from past usage, meaning they are likely to require a longer learning period; consistency improves this by preventing users from needing to learn every new screen. Accessibility guidelines define consistency as offering the same set of options in the same relative order each time and identifying functionalities that appear more than once the same way each time [2].

A consistent UI is even more important when designing for older adults, as consistent placement of elements supports spatial memory [18] and enables recognition, in this way freeing cognitive resources that allow the user to focus on the task at hand [11]. While the principle of designing for recognition rather than recall is not new (e.g. [19]), it gains particular relevance for seniors because of both the memory limitations common to this audience and their lack of prior knowledge of UIs.

The principle of consistency in the Health Channel is observed in a number of ways: the visual appearance of menus, the components of the UI of each screen, the behaviors of the UI elements, such as the scroll, etc. For an example of menus with a similar visual appearance please see Figure 2 and Figure 1.

3 – Make error recovery as painless as possible. When an error occurs the system should describe it clearly and explain how to recover without implying it was the user's fault. Special attention should be paid to the language used to describe technical issues when designing for older adults. Older adults are more prone to blame themselves for errors because they have less experience with technology [3]. Their lack of experience also makes them more likely to make errors, as does the high prevalence of conditions like arthritis that impact motor skills [20]. Web design guidelines for older adults state that error messages should be simple and easy to follow [5], while Carmichael discusses the need for iTV services for older adults to make errors easy to notice and correct [11].

Figure 1. Selected items are highlighted in yellow.

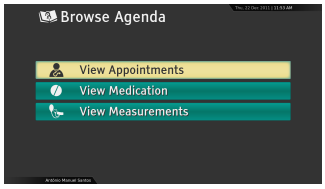

Figure 2. Browse Agenda is similar to the main menu.

The Health Channel explains errors in simple language, without negative connotations or error alert icons that indicate the user has done something incorrect (see Figure 3). Moreover, it presents the user with several options about how to proceed to resolve the situation.

6.2 Visual presentation

4 – Reduce the information presented so users can focus on a single concept at a time. Declining working memory means that older users are more likely to have difficulty dealing with concurrent ideas, or multi-tasking [21]. It is particularly difficult when it requires switching attention between two locations [11]. Moreover, older adults are less able to ignore irrelevant information [11]. Consequently, Web design guidelines for older adults state that all graphics should have a purpose besides decoration and there should be no irrelevant information on the screen [5]. Similarly, in his style guide to iTV for older adults, Carmichael recommended that all information on the screen relate to a single message or activity [11].

The Health Channel uses animations sparingly and purposefully. The only animation currently used in the application is the fading in and out of arrows that indicate the user can scroll left or right to access more information (Figure 4). By showing users possible actions, this animation supports the principle of visibility, one of the authoritative Nielsen usability heuristics [22].

Moreover, the system always facilitates concentrating on a single goal. For instance, medical reminders do not interrupt users during a videoconference call unless the notification is time sensitive.

5 – Clearly indicate the current location. In any application, the most basic requirement for providing visibility is clearly informing users of their current location. Visibility becomes even more important when designing for older adults because of working memory decline, which, as mentioned above, makes them more susceptible to getting lost in an application. Web accessibility guidelines suggest that pages have titles indicating the specific purpose of the page [2]. For older adults, these titles should be even bolder and more apparent [5]. Likewise, iTV systems should orient the viewer, making the relative location clear [7].

Every screen in the Health Menu gives a title at the top, in the same location. The names of the titles always indicate an action, since the low fidelity usability tests showed that a screen title displaying an action or a verb, e.g. "Watch Weight", was more helpful to the users than one simply displaying a name, e.g. "Weight" (see Test A1). In the tests, the authors witnessed participants begin by focusing on the content in the center of the screen, but often forget the task or action they were trying to accomplish. They would then notice the screen title, which if it clearly denoted an action, reminded them of the task they were trying to accomplish.

6 – Show the current selection clearly. Another important way to apply the principle of visibility is making it clear which element on the screen is currently selected. Since seniors tend to lose concentration frequently, they benefit from being able to quickly locate selected elements.

In Web design, Schneiderman recommends that the selected target is significantly different from other elements in the UI, for example, in a prominent color, so users instantly recognize it [23]. Previous work in iTV has indicated the importance of highlighting navigation buttons when they are selected [9].

The Health Channel uses a yellow highlight to distinguish the selected menu item, which is significantly different than the teal color of the unselected items (see Figure 3).

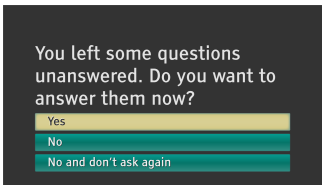

Figure 3. Proposed solutions displayed when users try to quit questionnaire.

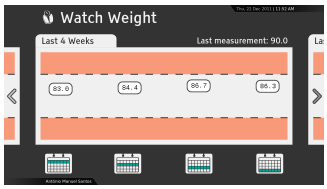

Figure 4. Scrolling capability is indicated by the edges of the item on the next screen.

During Tests B2 and B7, a panel with buttons (see Figure 5) would automatically disappear for having content occupying a larger portion of the screen. However, results have shown that in this situation, users would either forget this option or have troubles using it. Therefore, a more clear indication of the selected should be used.

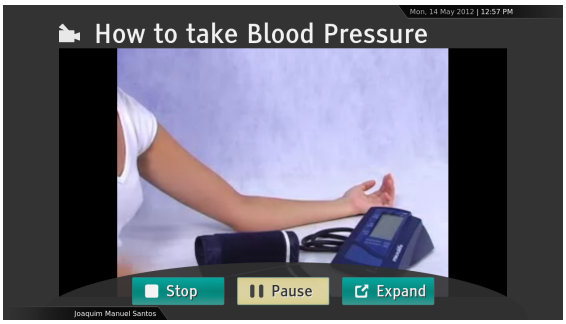

Figure 5. Watch video screen displaying the options panel.

7 – Use meaningful icons and labels. All users benefit from meaningful icons, but they are even more important for users who have trouble reading since they eliminate the need to struggle with words. A large percentage of older adults have low levels of literacy [24], so graphic symbols particularly benefit this audience. Guidelines for both Web design for older adults and iTV systems stress the importance of using icons that are familiar, meaningful, and appropriate for the audience [7] [5]. Special care should be taken when designing for older adults, since the age difference makes it more difficult for the designer to put himself ´in the shoes´ of the user.

In one initial test for the Health Channel, the authors evaluated the effectiveness of the icons for the main menu by requesting users to match each icon with the best corresponding label (see Test A9). Three of six participants did not recognize the meaning of the film clapperboard, a common metaphor in mainstream products (see Test A10).

Figure 6. Five icons shown to users when asked to choose the most appropriate icon for Health Videos.

8 – Concentrate information at the center of the screen. Concentrate important information near the center of the screen and use the margins only to provide context to the user. The peripheral visual field radius reduces with age [21], which makes it more likely that users will miss information near the edges of the screen. In addition, TV programming is typically focused in the center of the screen so maintaining consistency with this convention allows older users to apply what they already know. Also, if information is displayed outside this area users expect it to appear, inattentional blindness [28] is likely to occur. Moreover, web design guidelines for older adults state that information should be concentrated near the center of the screen [5]. Initial testing of low fidelity prototypes indicated that older users tend to miss information near the edges of the screen. In one test, the authors asked participants to return to the previous screen. All did so using the remote control; although participants searched for a button on the screen, none noticed the back button in the top left corner of the UI – probably because it was too near the edge of the screen.

To confirm the notion that users primarily notice elements in the center of the screen, the authors conducted test B5 in which they asked participants to draw a given screen from memory. All ten participants drew some indication of the menu that was at the center of the screen. Only four of ten participants drew the title, which is displayed prominently, but is somewhat near the periphery. Not surprisingly, only one participant drew an element close to the edge of the screen: the clock. Moreover, the participant drew this element in the wrong location.

9 – Use scrolling with caution. Conventional desktop UIs often make use of scrolling to display content that cannot fit on one screen. Declining working memory makes it more difficult to switch attention between locations and to remember options that are not currently displayed [11]. Consequently, Web design guidelines for older adults suggest avoiding scroll bars [5].

In the Health Channel, scrolling was used in order to maintain a shallow information hierarchy, as discussed in recommendation one above. For example, scrolling is used to navigate between different time intervals for graphs displaying health metrics. To compensate for the difficulties caused by scrolling, the Health Channel indicates the fact that additional content is available in two ways: it previews the edges of the content (see Figure 4), and it displays left and right arrows showing which button to select to access these screens. The visual cues of the edges help the user recognize the available options as well as placing the displayed information within a temporal context. This pattern was also followed in other parts of the UI, including the agenda and the health videos.

10 – Use a high contrast color scheme. In order to be accessible to users with visual acuity limitations, an interface displayed on any device must have a sufficient degree of contrast between the background and the foreground (e.g. text) [2] [10]. High contrast makes UIs more discernible for the many older adults who experience greater difficulties distinguishing between colors with a low level of luminance contrast, due to age-related changes [21]. When designing for older adults, UI elements should be highly contrasting, using negative (light text on dark background) or positive (dark text on light background) polarities. Although the two polarities have similar levels of readability, it has been argued that the negative polarity is slightly easier to read on the screen [25].

The Health Channel uses a negative high contrast color scheme throughout the UI. Throughout evaluation of the working system, participants were able to read and comprehend the display without visible or stated difficulty.

6.3 Text characteristics

11 – Use large, sans serif, left-aligned text. It is well-known that visual acuity problems are common among older adults [21]. Moreover, the task of reading becomes more difficult with age due to cognitive changes [24]. Therefore, it is important to ensure text is presented in the most legible, readable way possible. Firstly, text should use sans serif fonts, which are easier to read on the screen [16] [24]. This is also recommended for both iTV and Web design, for users of any age. Secondly, text should be as large as is reasonable. This is among Carmichael's guidelines for iTV services for older adults [11], and is also typically included in Web design guidelines for older adults [6] [4]. In order to make an informed decision about the font size, the authors tested text in different sizes and determined that television font size should be at least 40pt in order to be accessible to the majority of older users (see Test C1 above). Finally, text should be left-aligned text, as justified text does not maintain the optimized spacing between letters and words, and older adults are accustomed to reading left-aligned text [5]. The Health Channel uses Tiresias Screenfont, which was specifically designed to display well on TVs and accommodate visual impairments, as "good design for visually impaired persons is good design for everybody" [26] [27]. Text is always left-aligned and displayed as large as possible, usually above 40pt (see Test C1).

12 – Use simple language. It is always wise to use simple language in text intended for seniors, since while their educational backgrounds vary greatly, the percentage with only a modest academic education is high [24]. Moreover, many older adults experience loss of vision or diminished short-term memory, which also hinder reading comprehension, as noted above. Web design guidelines for older adults advise that websites use simple and clear language [5]. This can be achieved by: i) using common words; ii) reducing noise caused by connection words and slang; iii) avoiding the combination of ideas [28]; and iv) using fewer words. Using simple language not only ensures that content can be understood by an inclusive audience, it also increases the ease of comprehension for users of any reading level.

13 – Give users time to read. Some applications use popups that disappear after a set time. The effectiveness of these popups depends on users' ability to quickly read and understand the text on the screen. Delivering information in this way can create problems for older adults, since they tend to read at a slower pace than younger adults due to age-related changes in working memory [21]. Moreover, as mentioned above, a low literacy level is common among older adults [24]. As older adults are both more likely to have difficulty seeing and comprehending text, it is extremely important to ensure that users have time to read and process any text that is presented. This already exists as a Web design guideline [2] [5]; the authors argue that it is equally salient to TV design.

Instead of popups that disappear after a certain number of seconds, the Health Channel utilizes messages requiring confirmation through a simple 'OK' selection. With this approach the user can take as long as he or she needs to read and process the information displayed.

7. DISCUSSION

These are labeled as recommendations rather than guidelines because of the fact that they derive from only one project. Nevertheless, they are based on a thorough literature review, two phases of user evaluation, and an iterative design process, so constitute a solid basis for guiding the design of TV applications targeted for older adults. As noted in the section on related work, while the recommendations presented in this paper are closely linked to previous guidelines regarding design for accessibility and/or older adults for the Web and iTV, they are specifically intended to guide TV application UI design for older adults. It is unsurprising that many design guidelines that make UIs more usable in these related situations also applied to the Health Channel.

One issue with this work to take into consideration is the fact that it was based on testing with a limited number of Portuguese seniors and therefore it does not claim to apply to all European or international seniors. Nonetheless, this paper contributes a step forward in the context of designing UIs for TV applications for older adults. Moreover, it is important to note that it is extremely hard to access this particular audience, and therefore the authors consider the number of users to be significant.

The results of the evaluation showed that in most cases participants were able to conclude the tasks successfully and contribute to the validation of design recommendations. There is however one factor that might have negatively interfered with the results of the evaluation: the use of a remote. It is widely known that remotes are often not straightforward to use and this is not different for older adults' users. However, the usability of the remote is outside the scope of this paper.

8. CONCLUSIONS AND FUTURE WORK

This paper presents a set of recommendations to guide the design of TV applications for older adults, including references to related guidelines and examples of how each concept materialized in the Health Channel. The recommendations are:

1. Minimize the number of steps it takes to reach a given screen.
2. Use consistency to facilitate recognition.
3. Make error recovery as painless as possible.
4. Reduce the information presented so users can focus on a single concept at a time.
5. Clearly indicate the current location.
6. Show the current selection clearly.
7. Use meaningful icons and labels.
8. Concentrate information at the center of the screen.
9. Use scrolling with caution.
10. Use a high contrast color scheme.
11. Use large, sans serif, left-aligned text.
12. Use simple language.
13. Give users time to read.

The authors arrived at these recommendations through reviewing relevant literature and conducting user research and evaluation during the eCAALYX project. This paper will contribute to further work in this area, providing other researchers with a basis from which to begin designing TV applications for older adults. In the future this list of recommendations could expand to include guidelines that cover other input modalities such as audio or gesture.

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10. REFERENCES

[1] Dumas, J.S. and Redish, J.C. A Practical Guide to Usability Testing. Intellect Books, Exeter UK, 1999.

[2] World Wide Web Consortium (W3C). “Web Content Accessibility Guidelines (WCAG) 2.0”. Available at http://www.w3.org/TR/WCAG/, 2008.

[3] Greengard, S. Facing an age-old problem. Communications of the ACM, 52, 9 (September 2009), ACM Press, 20-22.

[4] Pernice, K. and Nielsen, J. "Web Usability for Senior Citizens: 46 Design Guidelines Based on Usability Studies with People Age 65 and Older," Nielsen Norman Group, Fremont, 2002.

[5] World Wide Web Consortium (W3C). Web Accessiblity for Older Users: A Literature Review. Available at http://www.w3.org/TR/wai-age-literature/, 2008.

[6] Kurniawan, S. and Zaphiris, P. Research-derived Web design guidelines for older adults, in Assets ´05 Proceedings of the 7th International ACM SIGACCESS Conference on Computers and Accessibility (Baltimore MD, October 2005), ACM Press, 129-135.

[7] Redish, J. and Chisnell, D. Designing Web sites for older adults: a review of recent research. AARP.org (December 2004). Available at http://tinyurl.com/d2ttjoz.

[8] Lunn, D., Yesilada, Y. and Harper, S. "Barriers faced by Older users on static web pages: criteria used in the barrier walkthrough method,” RIAM Technical report deliverable 3.1, June 2009, School of Computer Science, University of Manchester.

[9] Sayago S., Guijarro J. M. and Blat, J. “Selective attention in web forms: an exploratory case study with older people,” Behavior and Information Technology, 31(2), 2011.

[10] Lu, K.Y. Interaction design principles for interactive television. Georgia Institute of Technology, Atlanta GA, 2005.

[11] Chorianopoulos, K. User interface design principles for interactive television applications. International Journal of Human-Computer Interaction 24, 6 (2008), 556-573.

[12] Bernhaupt, R., Obrist, M., and Tscheligi, M. Usability and usage of iTV services: lessons learned in an Austrian field trial. ACM Computers in Entertainment 5, 2 (April/June 2007), ACM Press.

[13] Gill, J. and Perera, S. Accessible universal design of interactive digital television, in Proceedings of Interactive Television Conference, Brighton, UK, March 2003.

[14] Carmichael, A. Style Guide for the Design of Interactive Television Services for Elderly Viewers. Independent Television Commission, London UK, 1999.

[15] Carmichael, A., Rice, M., Lindsay, S., and Olivier, P. iTV as a platform for rich multimedia reminders for people with dementia, in Proceedings of EUROITV ´08, Salzburg, Austria, July 2008.

[16] Maulsby, D., Greenberg, S., and Mander, R. Prototyping an intelligent agent through Wizard of Oz, in Proceedings of CHI ´93 and INTERACT ´93, Amsterdam 1993.

[17] Lewis, C. and Mack, R. Learning to use a text processing system: Evidence from "thinking aloud" protocols, in CHI ´82, Gaithersburg MD, 1982, ACM Press, 387-392.

[18] Nielsen, J. Icon Usability. useit.com. Available at http://www.useit.com/papers/sun/icons.html.

[19] Zaphiris, P. Kurniawan, S.H., and Ellis, D.R. Age related differences and the depth vs. breadth tradeoff in hierarchical online information systems, in ERCIM ´02 Proceedings of the User Interfaces for All 7th International Conference on Universal Access: Theoretical Perspectives, Practice, and Experience (Paris, October 2002) ACM Press, 23-42.

[20] Koyani, S., Bailey, R.W., Ahmadi, M., Changkit, M., and Harley, K. Older users and the Web. AARP.org (2002). Available at http://tinyurl.com/6uvgex5.

[21] Dailey, S. Using cognitive aging and vision research to develop senior-friendly online resources, presentation in Usability University (July 2004), AARP.org. Available at http://tinyurl.com/bl74l6x.

[22] Nielsen, J. Heuristic Evaluation. John Wiley & Sons Inc., New York NY, 1994.

[23] Czaja, S.J. Computer technology and the older adult. Handbook of Human-Computer Interaction. Elsevier, Amsterdam Netherlands, 1997, 797-812.

[24] Charness, N. and Schaie, K.W. Impact of Technology on Successful Aging. Springer Publishing Company, New York NY, 2003.

[25] Jakob Nielsen. Ten Usability Heuristics. Available at http://tinyurl.com/aruty.

[26] Shneiderman, B. Designing menu selection systems. Journal of the American Society for Information 37 (1986), 57-70.

[27] Fisk, A.D., Rogers, W.A., Charness, N., Czaja, S.J., and Sharit, J. Designing for Older Adults. CRC Press, Boca Raton FL, 2009.

[28] A. Mack, “Inattentional Blindness: Looking Without Seeing,” Current Directions in Psychological Science, Vol 12(5), Oct 2003, 180-184.

[29] Hansen, V. Designing for Interactive Television v 1.0. BBC, 2005. Available at http://mhp.org/docs/itv-design_v1.pdf.

[30] Tiresias.org. Tiresias Screenfont - a Typeface for Television Subtitling. Available at http://tinyurl.com/c8jdkn7.

[31] Tiresias.org. Text on TV Screens. Available at http://tinyurl.com/6dq47k4.

[32] Miller, C. A. Nursing Care of Older Adults: Theory and Practice. Lippincott Williams & Wilkins, Philadelphia, 1999.