

A study on the accessibility of touch and gesture interaction with senior users through a prototype game based on the activity of "vindima"

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Abstract— At a time when there is the widespread use of new applications with touch and gesture interfaces, it is important to question whether these have a positive differential to the accessibility of the senior population or whether they are one more excluding info artifact. The purpose of this article is to present preliminary results for the potential and limitations of touch and gesture interfaces, through the proposal of usability heuristics for this audience which subsequently will be proven, rebutted and calibrated by means of a prototype game for tablets with features based on cognitive and motor rehabilitation. The Intention is that the game prototype based on the activities of harvest, collect bunches of ripe grapes, carrying baskets and crushing grapes to make wine, prove or refute the following proposed heuristics.

Keywords—senior users; multitouch; heuristics, game prototype

I. INTRODUCTION

The ageing of Society is an eminent reality, due to the improvement of public policies and the increasing of multidisciplinary research through new medicines or implementation of assistive technologies. One of the populations that show considerable demographic growth is the senior audience. Statistics [25] in 2011 show that they can go from the current 650 million plateau to 2 billion over the next 20 years. In Brazil, IBGE data [14] show that this growth is associated with the progressive decline of birth and mortality rates, resulting from improved nutritional, employment, sanitation and housing conditions, as well as new discoveries in medicine such as antibiotics and vaccines. In Portugal, for example, the proportion of elderly people was 19% in 2011. This figure contrasts with the 8% recorded in 1960 and 16% of the preceding decade. Portugal, according to the 2011 Census [5] has more elderly than young people. In view of this situation, experts from various technological areas, including computer science, telecommunications and engineering have been seeking means to remedy the problems faced by the elderly, mainly to ease the interaction with these new technologies. After all, according to Kachar [18], "Computers and information technologies offer the potential to improve the quality of life of the elderly, providing them information and useful services to their daily life".

However, this is not a simple task because of the fear of

the public in using electronic means. The elderly – opposed to the generation born in the universe of icons and Internet – have revealed serious difficulties in assimilating the meaning of metaphoric language imposed by the electronic media. Everyday actions like handling menus for televisions, answering a mobile phone or operating ATMs become difficult tasks to be carried out, due to physiologic and cognitive challenges that define human ageing.

Coordination skills with the mouse, for example, are one of the most obvious difficulties observed in the elderly' interaction with interfaces called GUI (Graphical User Interface). Tasks that involve placement on a target or a double click to start some action are challenging for users with problems of accuracy.

Within this technological context, it is relevant to emphasize the consolidation of TUI (Tangible User Interfaces), characterized by touch-based interaction with representations of the interface and multiple forms of information control. In the case of this technology it is assumed that the elimination of traditional input mechanisms, such as the mouse, keyboard, or joystick, would provide a more direct, natural and intuitive interaction with a computing device. However, this becomes a controversial convention, when we relate it with elderly people. At the same time that there are studies that consider the potential of these devices, there are strands that assess them as just one more excluding info artifact.

Multitouch Interfaces, as the currently most common example of TUI, may be more effective in reducing cognitive load and in fostering a better interaction experience. However, they can be inadequate for tasks that involve precision, in cases of accidental activation caused by Parkinson's or arthritis. The issue of complexity of gestures and the minimum amount of space required for carrying them out may increase this difficulty.

This dichotomy raises the formulation of hypotheses about the potentials and limitations of this technology for the elderly population; this is relevant, at a time when there is a tendency for interactive projects that include the concept of universal design. Within this approach the scope of this research will focus on the creation of usability heuristics for applications

based on multitouch interfaces according to the physiological characteristics of the senior user. Subsequently, these proven heuristics will be rebutted and calibrated by means of a prototype for a multi-touch interactive game with a rehabilitative character.

Overall, it is expected that this research contributes as a basis for other related studies and serves as a reference for the development of multi-touch applications that suit the needs of the elderly, empowering them to make use of these for the improvement of their quality of life and inclusion in society.

A. Physiological aspects of third age

In relation to general aspects of the elderly audience, psycho biological features of old age, involving questions about visual, hearing, motor, and cognitive acuity, have been investigated. Visual acuity problems cause the loss of autonomy of the elderly in the environment in which they live, as they fail to perform or reduce daily activities such as reading or driving, becoming, in the most extreme cases, dependent on other people to help them.

Kachar [18] reports that from the age of twenty-five people start to feel that it is difficult to read and identify nearby objects. There is also a decrease of color and light perception, as well as difficulty in seeing at night. Pak [25] emphasizes that fact when he says that the night vision of the elderly resembles the permanent use of sunglasses. Neto [21] shows some common diseases to the senior citizens: Presbyopia, for instance, is characterized by the accommodation of the lens, i.e. there is a loss of elasticity of this component of the human eye, making it inflexible and unable to distinguish shapes and colors. Another kind of problem related to the vision of the elderly is cataracts, characterized by gradual lens opacity of the eye, resulting in a hazy vision highly susceptible to reflected light. Glaucoma (neuropathy in which the intraocular pressure is one of the various elements related to its pathogenesis), macular degeneration (injury or decomposition of the macula) and diabetic retinopathy (ocular manifestation of diabetes mellitus) are also related to loss of visual acuity.

The above factors must be considered in the development of interactive applications, as the elderly may have difficulties in decoding information represented by visual signs of the interface such as typography, colors, pictures and instructional elements. In the design of interactive applications auditory aspects should be considered. Filho [8] states that the ear canal compensates for the visual impairment reinforcing the information captured by the sight. When selecting hearing signals the purpose of the sound and the hearing capabilities of the user should be considered, in addition to the conditions of the environment in which the interaction will be held. Ideally, the sound quality of these application types should be balanced, considering that both low and extremely high sounds can lead to unsatisfactory experiences for the user. This balance is necessary because – as well as in vision – hearing aspects also suffer the influence of ageing and become quite unstable. Grandjean [11] shows that in men, for example, hearing losses are greatest in the high frequency range. In general, it is expected an average hearing loss in the 3,000 Hz at the age of 50 (10 dB), 60 years (25dB) and 70

years (35dB).

Motor control refers to the accuracy and response time of human movement. Degenerative diseases, such as Parkinson's or Arthritis, are related to the difficulty raised by these conditions in what concerns the triggering of buttons or dealing with precision mechanisms. Pak and McLaughlin [25] say that arthritis is related to pain, swelling and stiffness of the joints, resulting in the possibility of bone malformations, which may cause difficulties of direct manual interaction with screens. The same author emphasizes this by stating that "in general, users with arthritis will have difficulty with tasks that require fluid finger movements, or specific pressure: small buttons are bad choices for users with this type of disease".

In relation to the cognitive aspect, there is a natural decline in the ability to acquire and recall information. Kachar [18] shows that there is a gradual increase in complaints of memory loss with the advancement of age: less than 10%, when below the age of 50, to more than 42% in the age of 80 Group. "This characteristic forgetfulness of the third age is defined by Iida [15] as the inability to retrieve stored information." Cybis [7] extends this concept, stating that oblivion is raised by the increase in number and similarity of declarative knowledge (concepts), and by the mismatch between the encoding and retrieval contexts of procedural knowledge. Criteria of organization, categorization, differentiation and discrimination of information are essential for good interaction of the elderly with interactive systems. It is essential that the memory of users is not overloaded with irrelevant procedures. Consistency of elements, coherent encodings and volume segregation and chromatic aspects are indispensable. Such factors may contribute to the proper use of the system.

B. Elderly and new technologies

New technologies have invaded homes, businesses and society, becoming an increasingly vital need. However, despite this revolution in technological means, a large portion of this population is unfortunately unable to follow this trend, at the risk of being excluded out of this phenomenon. It must be taken into account that there are heterogeneous user groups handling information systems. The young audience, for instance, learns to live with these new technologies from an early age, making computer handling something intuitive and common, as their curiosity provides a rapid learning. The elderly, however, are afraid of using computerized system for believing they will mishandle the computer and damage it.

Some researchers, however, argue against this stereotype to say that 65-year-old adults refuse to be unaware of technological innovations. Pak [25] shows that more or less half of the elderly between 65 and 74 years are mobile phone subscribers and onethird of those who have more than 75 years old pay for this service. Tanaka [34] shows that in Japan bank lending services through interactive television for the elderly public are already a reality since 2004. A study carried out in 150 homes confirmed this technology has good possibilities as a significant increase in the number of bank transactions has been proven.

In addition, it is worth noting that the computerized procedures and their different media (audio, video and text)

become fundamental elements to support elderly rehabilitation. One of the possibilities is the use of games, not only for entertainment, but also for educational, social and therapeutic purposes. Commercial web services such as Lumosity aggregates games that exercise the cognitive aspect and that rely on an audience of 20 million regular players who sign the equivalent to \$ 10 dollars a month.

The use of tablets and smartphones is also a reality among this audience. Data collected by Whitney [40] show that the public better accepts larger devices. Bhalla [2] shows that this acceptability is due to the ease of use of touch interfaces, because users can find information more easily with just a touch. Umemuro [35] reinforces this idea when he proves in his study that the anxiety level of users who use the screen as an input mechanism decreases in relation to those using the keyboard.

C. Specificities of use in tangible interfaces

It is clear that there has been an evolution in electronic means; it is notorious the breaking of paradigms of point-click technology for products based on interaction through gestures. This action of "removing" traditional input mechanisms such as the mouse, keyboard or joystick provides a greater range of possibilities for system activation when using all the human body. Gestural interfaces can be categorized into touchscreens or free-form. Touchscreen Interfaces require direct "touch" contact with the devices, while free form gestural interfaces are characterized by the use of the human body as an input device for interaction; a classic example of this is Kinect.

One of the first approaches deals with a few requirements that must be considered in the development of gesture-based interfaces. Saffer [30] gives priority to some of these features; the first, named discoverability shows the importance of the evidence of affordances in interactive system. Affordance refers to one of several properties of an object that gives some indication of where and how it can be accessed. This concept was popularized by Norman [22] which criticizes [23] the inefficiency of gestural interfaces as he considers them retrogrades in relation to usability, saying "[...] Apple specifically recommends against the use of menus, the Android UI team takes the opposite position, even providing a dedicated menu key, though not activated. In addition, swipes and gestures cannot be readily incorporated into menus. Unfortunately, so far no one has figured out how to inform the user on the ways he can access the application".

Two other qualities proposed by Saffer [30] are reliability – based on the aspects of security and privacy to the user – and responsiveness, related to instant response time in up to 100 milliseconds. Every action performed by a human on a gestural interface, no matter how small, should be accompanied by some recognition of the action, wherever possible. The fourth quality refers to the appropriateness of this technology towards culture, location and context. Some gestures are offensive in some cultures. An "OK", quite common in North America and in almost all Western Europe, is regarded as offensive in Greece, Turkey and Russia, for instance. Complicated gestures, that involve sudden movements of the arms and legs or fingers, are unsuitable for the elderly or those who have some kind of physical disability.

Studies conducted by Saffer [30] and Jacko [16] suggest tangible interfaces have a number of advantages over traditional graphical interfaces. However, when it comes to the elderly, the subject divides opinions, because some issues related to motor features are inaccurate, in spite of relying heavily on intuition. Saffer [31] says that touchscreen devices need to be accessible to different users of all ages; therefore, simple gestures such as pushing buttons are suitable to the interactive context. It is, however, desirable to use simple and elegant gestures for solving complex tasks. The "ideal gesture" and the proper use of multitouch interfaces are not always achieved, because there is the possibility of inherent feedback, the risk of inadvertent activation or difficulties with precision. And as this is much more critical in the elderly, similar gestures for different actions on the same system should ideally not be developed, to prevent the users accidentally firing other affordances. Stoessel et al [32] contributes to this discussion stating that the increased complexity of gestures and the reduction of the space for their performance tend to generate errors during the interaction.

II. GOALS AND METHODS

The goal of the research is the composition of usability heuristics for applications based on multitouch interfaces according to the physiological characteristics of the senior user. Subsequently, these heuristics will be evaluated by means of a prototype for a multi-touch interactive game with a rehabilitative character.

Research within the context of design is an analytical process and, according to Silva [31], it searches, through different areas of knowledge and other research methods, a basis for the creation of its own methodology. This new methodology will then generate a body of knowledge which, in turn, will lead to relevant theoretical construction for the solution of a specific problem.

The intent of this study was to propose a set of guidelines as a basis for future studies on the elderly, interaction and multitouch devices triad. To empirically study these relations we opted for the Design Research (DR) methodology, as it supports the production and study of artifacts through which theoretical constructs can be tried and tested. Hevner [12] has proposed the DR methodology can be structured in five stages: problem identification and awareness (awareness of problem); proposal of solutions to this problem (suggestion); prototyping (development of artifacts); evaluation; and statement of learning, which can be characterized as the phase of knowledge production.

In his studies, Rusu et al [29] propose four stages that support the production of new heuristics from existing ones that were inserted within the scope of the solution proposal in Design Research. The first stage, called exploratory phase, was characterized by the collection of bibliographic material related to the main topics of research on heuristics. The second stage, heuristics synthesis, and highlights the most important features of the information previously collected, in order to formalize key concepts associated with this research. The third stage, or correlational stage, was relevant to identify the characteristics that usability heuristics should have for specific applications, based on studies of traditional heuristics.

At the end of the problem identification and contextualization stage, the offer of solutions has been stipulated through an explanatory component to specify the proposed set of heuristics through a standardized model. Each new proposed heuristic was presented as follows: the most important references of the information previously collected; synthesis text; nomenclature; and definition.

After the six proposed heuristics have been defined they had to be studied and calibrated by means of a prototype that implemented these heuristics. This prototyping phase is part of the fourth stage of the Design Research Methodology, called development.

For the development of the interactive prototype, we also used Garret's user experience design method [10]. The justification of the option for Garret was based on the focus of this method on variables associated with usability, navigability and information architecture. Once the prototype has been set implementing the relevant heuristics, to assess their applicability, we proceeded with an evaluation phase to assess the effectiveness of their application.

This comprises a comparison of the goals of a solution with the results obtained with the use of the artifact, in this case, the game prototype. According to Hevner [12], "Depending on the nature of the problem, the assessment can take many forms: it can include quantitative measures of performance, such as budgets or items produced, results of satisfaction surveys, feedback from users or simulations; and also quantifiable measures of system performance, such as the response time".

For this evaluation stage, two methods of analysis have been proposed: prototype Design Walkthroughs with people knowledgeable in usability and digital game design; and monitoring specific tasks within the game, through systematic testing with elderly users.

Preece et al [28] states that Design Walkthrough is an alternative approach to heuristic evaluation, in order to predict user problems without performing tests on them. As the name suggests, it involves traversing tasks or use scenarios with a low or high fidelity prototype and annotating problematic aspects. Most of the techniques that follow routes do not evolve end users.

The intention in this first stage of tests was:

- a) To explore the technical possibilities in terms of components and their arrangements in each screen;
- b) Check the effectiveness of the conceptual aspects of the interface such as metaphors and graphical structure; and
- c) Seek contributions on the gameplay aspects of the prototype.

The contributions of expert users will serve as basis for the development of the high-fidelity prototype aimed to the elderly, and will be later assessed through formal lab testing. At the end of the evaluation activity, there is the possibility to return to the previous stages of the DR methodology in order to improve the effectiveness of the artifact and finally calibrate, verify or refute the heuristics initially proposed.

The last stage, or statement of learning, will be characterized by the dissemination of the knowledge acquired during the research. Highlighting the problem of heuristics for senior users and the way they were calibrated based on an interactive game prototype may be relevant for other researchers and practitioners in field of interaction design, more specifically, interested in the proposal of new design heuristics.

III. HEURISTICS PROPOSALS

Following the methodological plan of activities, the first activity involved synthesizing a proposal of usability heuristics for use on design for multitouch platforms targeted at elderly users. In this way the following six heuristics have been proposed to operationalize the cited body of knowledge.

A. *Bimodal Feedback*

According to Cybis [7], feedback is an essential criterion to any interactive system. The quality and speed of response to the user's actions are essential to the success of their tasks performance. Preece et al [28] reinforces this idea saying that the proper use of feedback can provide the required visibility for users' interaction.

This premise becomes more evident when we deal with the elderly. In this case, any kind of inappropriate or lengthy response of the system can generate frustration and fear, either due to the feeling of having performed an inadvertent task or the feeling of having caused physical damage to the unit. Stoessel et al [32] support the assertion that older users have a special interest in security and protection during the interaction, and are often afraid to get lost within a system or to damage it through improper use; this loss of feedback can be seen as particularly damaging among this group of users.

In relation to multitouch interaction it is usual on all systems to provide some kind of feedback. However, as there is the natural decline of sensory aspects at this age, it is assumed that unimodal feedback based on visual aspects is not sufficient to meet the needs of senior users, being also necessary the encouragement of tactile and auditory senses. Pak and McLaughlin [25] show that a feedback more suited to the elderly should involve combined auditory visual and haptic components, but as the proof of concept will be held on an iPad tablet, this haptic variable will not be no considered. Caprani [5] found however that the use of two components is sufficient to promote a good interaction.

Pak and McLaughlin [25] argue for a special attention to the response time of the system in relation to the senior user. In this case, an appropriate time response to the user interaction should be prioritized, because what is reasonable for the younger ones may be too short for older adults, due to the deficit of perception and attention constraints. Ingram [14] stresses that this feedback should be intermittent in all stages of action with the application when we deal with users, but with caution not to overload the system with too many visual and auditory stimuli. With regard to the quality of feedback in NUI systems, Wigdor and Wixon [39] advise that in systems based on single touch a set of visual states – and transitions that would ensure minimal coverage of several errors by providing visual interactions, and unique transitions for each

one of these states by removing the ambiguities of unexpected behavior – should be developed.

In this way it is proposed:

H1: The use of bimodal feedback (sight and hearing) within a response time suited to the specific needs of the senior user throughout the all process of interaction with multitouch applications.

B. *Appropriate spacing and sizing*

According to Pak and McLaughlin [25], degenerative diseases of the motor system – such as Parkinson's and arthritis – affect the interaction of the elderly with multitouch applications, especially when sensitive controls are required or those that demand precision. Juxtaposed buttons are, for instance, a bad choice for elderly people with arthritis, since they cannot conduct fluid movements with their fingers. In addition, gestures complexity decreases users' accuracy within a reduced space of interaction.

To avoid these unsuitable designs, Jin [17] considers that minimum parameters of 19.05 mm for buttons or icons, icons and a 6.35 mm spacing 12.7 mm should ideally be considered if the user's dexterity is critical, including using only simple interaction movements (tap, wave, click, press). Saffer [30] mentions another uncertain dimension parameter for users with motor impairments: "Although there still aren't guidelines to make the interaction more accessible, it is important to consider larger targets than usual, about 150% or 1.5 cm more than the standard". These parameters can be compared during the proof of concept. Wigdor and Wixon [39] consider that in minor touch areas, in which users use the hands or thumb to make a selection, a target with 9 mm is sufficient.

In addition to the question of sizing, the spacing between elements is another factor that undermines accuracy; one example is the QWERTY keyboards that have minimum spacing which hinder people with thicker fingers, especially the obese. Stoessel et al [32] hypothesize that the growing complexity of gestures and the reduction of space between the targets contribute to the decrease of accuracy, especially among older users.

Pak and McLaughlin [25] consider that the Gestalt theory can contribute to the design of adequate spacing between elements, especially when proximity and similarity laws– to create harmonious visual categories and which are understandable to the user – are applied in the display.

Summing up, the proposed guideline is:

H2: Development of Touch targets and spacing appropriated to the motor deficiencies or characteristic of the senior users.

C. *Graphics and interaction consistency*

The heuristic criterion of consistency is perhaps one of the most relevant to the elderly population, since they, when interacting with sign or graphic standardization, create mental models that will be later used with other elements of the interface. One of the benefits of consistent interfaces is that they are easier to learn and use. According to Preece et al [28],

users only learn a single mode of operation applicable to all objects.

Chen [6] shows that color, positions or functions alternation or changes affect older adults. These effects include performance and the learning time. It is interesting the use of the criterion of consistency in a single application, as it reduces the user's memory load and the risk of errors.

It is understood that the variation of screen patterns can reduce the performance of the senior user, because the gesture patterns thought at the beginning of the interaction might be diverted, causing the elevation of cognitive and motor load in the fulfillment of tasks. Stoessel et al [32] states that the number of unnecessary screen changes is an estimate of navigation inefficiency. Ideally, the gestures made by users should be consistent throughout the interface, being perfectly simple and not complex.

Guideline proposed:

H3: Consistency and stability of graphic elements and their composition in the touch interface, in order to preserve the patterns of gestures across the space of possible interactions with the application.

D. *Appropriate metaphors*

Seniors are often "afraid" or discouraged to use computerized means, because as opposed to the Internet generation their understanding of interface's graphics is complex and far from the actual representations already assimilated by users more familiarized with digital technologies.

Kachar [18] exemplifies this noting that older users identify the icons relying on their own references and contexts. The floppy disk in the toolbar of Microsoft Word software is identified as a television and the printer icon as a toaster". Preece et al [28] note that emulating real-world activities in the interface can be a powerful design strategy; since the new incorporated functionality extends or provides support to users' tasks in ways that are not possible in the physical world.

In this case, metaphors are essential to provide cognitive shortcuts to users through pre-existing templates in memory when they learn to cope with new systems, according to Yang [37]. The application of this concept, according to Yousef [38], minimizes the cognitive effort of the elderly during the use of any system, thus offsetting some limitations. In this way, the use of interface metaphors based on pre-existing mental models provides users a reduced cognitive load and the consequent confidence and motivation to explore a new system. Additionally, as these are tangible interfaces, it is necessary that the gesture input matches the real context, making the interaction as natural and intuitive as possible.

Moggdrige [20] suggests the development of a standardized system of sign language related to manageable elements of the world, with controls that are intuitive and easy to remember.

In this way it is proposed:

H4: To develop patterns of gestures and metaphor-based interface elements which are consistent with the cultural identity of the elderly.

E. Interfaces consistent with visual acuity

Visual acuity problems lead to the loss of autonomy of the elderly in the environment in which they live, because they fail to perform, or reduce, daily activities such as reading or driving, becoming dependent on other people to help them.

According to Kachar [18], there are several changes in vision that evolve naturally over the years. From the age of thirty-five people begin to have difficulties to read and to identify nearby objects. There is also a decrease on light and color perception, as well as difficulty in seeing at night.

Pak and McLaughlin [25] report that color perception alters with the normal wear and tear of eye "lenses", which change its transparent appearance to a yellowish one. This provides a greater absorption of blue light, giving the perception that the colors are less blue and more yellow, so there is a greater difficulty of distinguishing between shades of blue. In several cases, the differentiation between red and purple tones becomes more difficult.

In relation to the perception of the visual elements of the interface, it is also natural that there are difficulties in perceiving icons in computer terminals, since it takes longer to understand and select information when the icons are more abstract or very similar, and this is related to the loss of visual acuity.

Cybis [7] concludes that readability is one of the most important interface ergonomic criteria for the elderly or people with vision problems. In this case, there must be concern about the readability of graphical elements; factors such as character brightness, contrast between background and main information may compromise the immediate perception of information.

The issue of brightness intensity in screens, according to Pak [25], should also be addressed since the process of adaptation to darkness occurs more slowly for older adults. A solution may be to avoid rapid changes in the screen glow and provide quickly accessible controls to brightness to allow the user to choose a comfortable level.

Since much of the informational aspect is related to the use of texts, questions about the proper use of types must be considered. Phiriyaokanon [27] states that older people can benefit from the use of sans-serif types of size between 12-14 point, normal view (72 dpi), short line lengths and left-justified text.

In this way it is recommended:

H5: Interfaces focused on the aspect of readability, which are consistent with the elderly' visual acuity needs.

F. Amount of affordances / points of interaction

Another issue suggests limiting the number of screen interaction elements so that there is a decrease in cognitive load. According to Kachar [18], in addition to the motor coordination problem, the cognitive deficit interferes with the

performance of the users, because they do not organize information into categories and do not form visual images as easily. This impairment makes users' memorization difficult, decreasing their ability to manipulate and organize information on a short-term basis.

In this way, using only information relevant to the application context is recommended, because there is a possibility that a crowded screen hinders the process of memorization of the elderly and thus the assertiveness of the interaction.

Cybis [7] points out that it is important to consider that the user' performance is decreased when the information density is too high or too low. This information retention capacity relates to shortterm Memory (MCD), where the average retention capacity is commonly explained in Cognitive Theory to be around seven independent units [15].

Depending on the circumstances and the degree of attention, this ability can vary between five and nine concurrent units. This means that in general there is a 100% hit when remembering up to five units related to each other, and from there, errors begin to increase rapidly.

Thus we proposed:

H6: To limit the number of interaction elements and affordances in specific multitouch screens, so that there is a decrease in cognitive load by the senior user.

IV. STATEMENT OF APPLICABILITY OF PROPOSED HEURISTICS

One of the intentions for the development of the game prototype is that it is not just an instrument for applicability analysis and calibration of heuristics but an artifact that refers to cultural aspects, to the daily life of the elderly, so that they do not feel taunted during the interaction. Design as an interdisciplinary area can contribute to this purpose concatenating technological, visual and anthropological aspects in search of a product that suits the specificities of this public.

Therefore, before the development stage of the application interface it was necessary to develop a concept for the game prototype composition. In this way, one of the steps was to seek, within the Iberian culture, for a theme reflecting back on some movement or popular festivity whose essence involved the friendship between different generations. Within this context Christmas, New Year, Easter, Magusto (chestnut roast), employers' parties, Weddings, Baptisms, Communion were all referred; however, the choice was for the Grape Harvest.

The Grape Harvest is the harvest of bunches of grapes, intended for the production of wine, when these reach the right degree of ripening. This event is usually characterized by the arrival of workers from neighboring places to contribute to the harvest. In this way, it starts one of the most characteristic moments of European Ethnography. Complete families often go to work on the Grape Harvest, a tradition that spans generations.

At the time of the Grape Harvest festivals are organized in

different lands or regions, a historic tradition where generations of families get together for wine production. This festive moment attracts tourists, as it happens, for instance, in the region of Douro, in Portugal, the oldest demarcated wine region in the world. According to Pinto [26], this kind of family festivities has a special meaning for the elderly, as it gives the family group and each of its members an opportunity for personal, familiar, social and moral growth, raising challenges to educational, social and therapeutic action. Activities idealized for the game prototype were inspired on common harvest activities. Moreover, this ideation involved making sure these game activities would serve as an instrument for the calibration of the proposed heuristics, as well for the stimulation of the synesthetic, cognitive and motor senses, through multitouch interaction.

As the first game activity we proposed the collection of ripe bunches of wine growers. The challenge is to identify along the green plantation small color differentiations (affordances) that indicate the location of shrubs with bunches of grapes ready for harvesting.



Fig. 1. Targets taping and sizing activity

This part of the prototype enables measuring the effectiveness of two heuristics: appropriate dimensioning and spacing and interfaces consistent with visual acuity. The elderly have difficulty in distinguishing chromatic tones, thus, the first task is to identify and "pinpoint", along the extensive green shrubs, visual cues (affordances) that indicate the location of harvesting sites. These indication points can change its positioning, color and size. Alternatively varying the size and coloring of affordances can highlight or disguise the target for the senior user.

When the user "taps" each affordance the game shows a popup screen that is a representation of a shrub comprised of bunches of grapes, inserted in a tangle of leaves. This will be the basis for another activity combining visual acuity and motor skill.



Fig. 2. Visual acuity motor skills exercised through the prototype

This activity intends to further promote the exercise of visual acuity. Appropriate dimensioning and spacing heuristics will be exercised through the task of separating bunches from the bushes through the "flick" gesture as shown in Figure 3. The thickness of the "cable" and its distance from the bush can be used to calibrate the proposed heuristic.

The second prototype activity is to lead the workers with the grape baskets to the trucks, with a continuous drag motion. The challenge of this game stage is to take their baskets, duly identified by colors, to their vehicles with the same color. The player cannot touch the edges of the tracks; otherwise, the racks are lost. This game activity exercises motor acuity.



Fig. 3. Exercises scuity motor activities by drag

This activity intends demonstrates the heuristics of graphics and interaction consistency. By definition, the elderly prefer templates; a drop in the learning curve may result in errors and, consequently, in the abandonment of the system. The purpose is to study senior user's touch interaction

behavior in relation to placement and chromatic aspect alternation of prototype graphics along the screen.

The last activity called "grape stomping" is related to one of the main problems faced by the elderly audience: difficulties in Short Term Memory management. The intention is to use some strategies to mitigate this problem, as for example, information consistency, pattern repetitions and hearing assistance in addition to visual information. This activity includes "filling" with a minimum percentage of grape juice the wooden barrels of wine presses. For this the challenge will be to "stomp" in sequential numerical order each of the grape berries that appear on the screen.

The berries are shown within a short period of 05 seconds so that the player memorizes the sequence in which they appear. In an ascending order of difficulty, the berries will appear in greater numbers. To study the effect of multisensory stimulation a combination of color and relative size of berries can be used to help perceive the order.



Fig. 4. Game activity proposal for mental exercise of elderly users

This prototype aims at establishing activity metrics regarding the amount of interactive areas noticeable to the elderly user, as well as to verify their effectiveness through the use of auditory feedback in addition to visual information.

Prototyping [36] is an efficient and cost-effective way to test design results and validate the functionality proposed. This is an iterative process, because designs are usually created to identify issues or validate the user's experience. The result of the prototyping process can be the evaluation of design concepts that can further be used to improve proposed designs.

According to Bryer [3], the planning of the game design is one of the main activities that concern the formalization of ideas through models that ensure the potential of fun that a game can provide. Prototypes are useful in this initial development phase to demonstrate concepts, plans and other mechanical aspects.

For the first development stage of the application the paper prototype has been chosen. Fullerton [9] argues that low-res prototypes work essentially as sketches whose purpose is to

provide a field for testing the mechanics of the game and the operation of certain features. Lewis & Rieman [19] consider that relevant information can be obtained through the use of paper prototypes discussing among the members of the design team can reveal serious aspects or bad performance of the tasks can be revealed by discussing among the members of the design team.

The paper prototype adopted at this stage can be classified as of low fidelity; its characteristics are low cost and quick production. These were indispensable for the identification of elements that pervade the mechanics of the game. For this simulation the following materials were used: a cardboard sheet of paper for the composition of the tablet fairing; six sheets of A4 size for the screen and interactive elements production; and paper overlays mounted on wood sticks to support the affordances (touch elements) as depicted in Figure 5. After the production of the prototypes it was necessary to test them with users familiar with interactive game design. The intention in this first testing stage was to explore the conceptual and technical possibilities in terms of components and their arrangements in each screen, check the effectiveness of the heuristics in realizing the conceptual aspects of the interface, the metaphors and graphical structure, and seek contributions on the gameplay aspects of the prototype. The contributions of expert users will serve as basis for the development of an high-fidelity digital prototype for testing with senior users.

This type of contribution where developers and experts work together in order to go step by step through a scenario [task] is called known as a Design Walkthrough [28] apud Nielsen and Mack (1994). The advantage of these pluralistic routes includes a strong focus on users' tasks.

In this context six users were selected for this test. Nielsen apud Cybis [7] states that at least five evaluators with some level of expertise in interactive systems and interface ergonomics are able to identify about 95% of software problems, while the same number of novice evaluators can identify 50% of these problems.

During the initial contact the individuals were contextualized as to the nature of the project and its intention, and from there on they were free to interact with the prototype, assess, criticize and contribute with suggestions. The evaluation process was done by observation, dialog and recording the issues raised during the walkthrough.

Results from this evaluation were as follows. On the first screen, where the user selects the game activities, suggestions addressed naming issues and positioning of graphic elements. The "collect" icon label, according to two experts, would be more contextual to the purpose of the game if their nomenclature reflected more traditional terms such as "harvesting"; similarly the "crushing" label was suggested to be changed to "stomping", this being the usual term for the grape maceration. Still on the main screen, the main question was the senior user's ability to interact with the interface; clearer and larger instructional areas were suggested. A way to gain space for these changes would imply modifying the proposed layout. Some proposed the insertion of a previous screen, with just the logo, which would leave more space on the game

activity selection screen. Another relevant factor was the criticism of the imposed sequentiality of gameplay activities, as the numbering of the icons implied. It was suggested that we remove this constraint allowing users to choose any activity.



Fig. 5. Design Walkthrough with the experts

The first game activity raised questions about the appearance of interactive affordances and the metaphor underlying this activity. The suggestion was a popup that would explain the significance of this grape harvesting stage. The idea of harvesting grapes that were left over or forgotten in the bushes emerged as proposal for justification of the activity. As this first activity is divided into two parts, clearer instructional areas and the insertion of a tutorial on how to play the game have also been suggested. This division of activities, the insertion of the temporal challenge and the counting of the amount of grape bunches inside the baskets were criticized by the assessed individuals as factors that can overload the cognitive aspect of the elderly, instigating them to make mistakes. The grape bunches cutting activity by "flick" was regarded as interesting. Two alternative options were suggested for this interaction; one would be the insertion of a cutting "tool" (pliers) that would be handled by "drag" and manipulated by "spread" and "pinch" and rotated by a "rotate" movement; and the other option would be to show the "cutting" order on the cables to separate the bunches from the bushes.

The second activity was criticized as to the static positioning of the wicker baskets. The suggestion, to measure the behavior of users as well, was to make the racks more dynamic, making the game more challenging. There was discussion regarding the preview of the trucks before one of these would reach the dock: some users would like to know what comes before, to try to "plan" their movements; and others consider this a "facilitator" for the carrying-out of tasks, which would reduce the challenge. The insertion of "blocked lanes" has been suggested by the individuals assessing the prototype, as this would make the activity of "drag" more interesting, since fingers flexibility would be exercised.

In relation to the third activity, "stomping" of the grape bunches within the clusters was recommended, since the majority believes that this makes the process more realistic. Questions about the coloring of the grapes and the order in which they would be crushed were also raised. The insertion of three layers to the challenge was also suggested; crushing could follow numerical order, or according to colors or dimensions.

V. CONCLUSION AND FUTURE STUDIES

This article has shown the preliminary steps of a study on the access of the elderly to multitouch devices. The research started from the hypothesis that there is a fine line between good possibility of use and the info exclusion of the users from the device. The plan for development of the project was divided into two parts: proposal of heuristics, step already achieved; and their demonstration through a game prototype.

One of the challenges of the first stage was the extensive state-of-the-art collection related to guidelines, because much of the work reviewed was based on adaptations of heuristics for web.

Therefore, the proposition of new guidelines for touch technologies directed to the elderly has made research challenging. All six proposed heuristics try to contemplate cognitive sensory and motor exercise. The intention is that all are assessed through the prototype – which will calibrate position and sizing related aspects of affordances, feedback quality, interface metaphors and gestures patterns and readability of graphical elements.

In relation to the prototype, more than just a tool for verification of heuristics the intention behind the game design was consideration of cultural aspects of the elderly' daily life, so that they would not feel taunted during the interaction. The insertion of the grape harvesting context, as a popular and family festivity, highlights the concern with the appropriate metaphors heuristics proposed in the study. Pinto [26] points out family festivities as these have a special meaning for the elderly; after all, the function of the party is to give the family group and each of its members an opportunity for personal, familiar, social and moral growth, raising challenges to educational, social and therapeutic action.

The first prototype paper test carried out with the experts in electronic games and usability has guided some issues related to the game mechanics and interface usability, and all of them will be considered in the development of the high-fidelity prototype that will be subsequently tested with the users.

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