HOUSEHOLD APPLIANCES CONTROL DEVICE FOR THE ELDERLY

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ABSTRACT

An evaluation of musical earcons was carried out to see whether they are an effective and efficient method of delivering information about household appliances to elderly people. A test was carried out to explore the ability of the elderly subjects in remembering and learning the musical earcons. This test indicated a poor rate of recognition of the earcons. A second test that included the presentation of information in three modes (audio, visual and multimodal) was performed to determine which modality was preferred to deliver certain types of information among this group. We hypothesized that the multimodal interface would be the best in terms of speed and accuracy of response, and this was supported by the data. The results showed the need for a redesign of the earcons.

1. INTRODUCTION

In recent years there has been a noticeable increased use of computers in everyday life [3] which can help in many tasks such as the monitoring of our surroundings as well as other activities that are not directly related to the office environment. Although computers nowadays offer a wide range of possibilities this also has to be adapted to a very varied population, where small groups with different physical, sensory and cognitive capabilities make use of them or would use them if it were possible for them to gain access to their applications and functionality. We propose the use of sound as a step forward towards achieving this universal usability.

2. MULTIMODALITY

The important benefits of auditory display have been highlighted by Kramer et al [6]. Particularly relevant to this study are eyes free use and alerting capabilities of auditory display as well as parallel listening. We think that by introducing the audio modality into an application users will benefit from the extra output channel. We hope elderly users especially will benefit from the multimodal interface as with the aging process most sensory capabilities decline and the presentation of information via more than one channel assists it reaching the intended receiver thus improving the elderly users' ability to use such devices.

The inclusion of sound in the interface can help to prevent representational errors that sometimes happen in situation awareness, as the sound reinforces the information provided by the visual image thus adjusting the mental model the user has of the surrounding environment. Auditory icons or the use of a speech interface could be use to deliver the same information to the user, but to convey information of a temporal nature, such as filling the bath, earcons seem very appropriate, as manipulating sound parameters can give an accurate representation of the process on course.

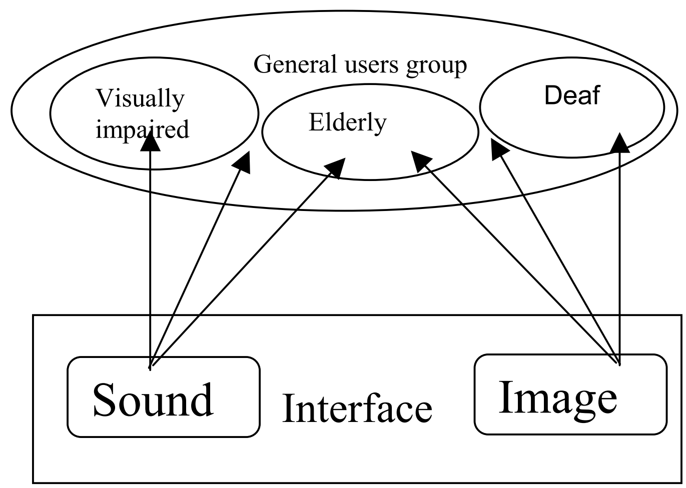

Figure 1: *Multimodal User Interface: Theoretical Principles Model of the proposed interface in relation with various users groups.*

In addition, the research would also help people with various degrees of visual impairment, and not just the elderly.

Much has been done on the research of the use of sound to display data, monitor system and provide enhanced user interfaces for computers, but the research done so far has not been aimed at elderly people in household situations.

Even considering the difficulties encountered with auditory displays, such as lack of absolute values, lack of orthogonality, absence of persistence [6] etc, we found that the integration of sound (in the form of musical earcons) for a multimodal display can greatly improve the interface and its usability among the elderly and visually impaired people.

2.1. Musical earcons.

The idea of using musical earcons for an interface aimed at the elderly came from reading previous research in the area [8] and personal experience with elderly fragile patients which suggest music and musical memories tend to stay intact in the last period of our lives, even through major cognitive decline. To our knowledge, musical earcons have not been used in any interface intended for the elderly, neither for the visually impaired, despite the possible advantages. We used western musical structures as they are widely accepted and used around the world [9], to design compound earcons that represented the appliances and their status at any time, (see Figure 2).

Earcon composition. An example

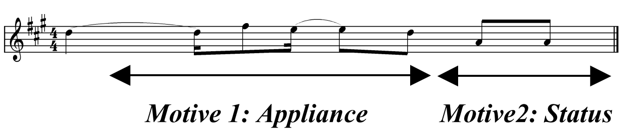

Figure 2. *Earcon design. Motive 1 represents the appliance, Motive 2 represents the status (e.g. on/off). The sequence of the 2 motives indicate the status of the appliance at the moment.*

The use of musical language offers great possibilities of expansion where more complex meaning can be added as the system expands. Musical earcons offer great flexibility and adaptability to different demands. In a sense musical earcons combined the advantages of earcons and the properties of the musical language.

2.2. Elderly and aging population

The elderly population in the (mainly developed) world is increasing rapidly. Data from the United Nations indicate that this trend is going to continue. The course of population ageing is now worldwide and flows freely into social and economic support systems [11].

Certain characteristics that define this segment of the population are also the cause of impairments that we can experience at any point during the course of life, and that are therefore unexpected a priori. Sensory losses don't occur as a homogeneous process and individual variation is very large. The combination of audio and visual display could mitigate the effect of this loss and help in getting all the information to the subject.

New technology can play a very important part in the quality of life for elderly and disabled people who wish to continue to live autonomously. Technology can assist with daily routines thus helping them regain some control and very psychologically valuable independence [3].

3. RATIONALE

Domotics, the application of information and communication technologies for more comfort and convenience in and around the home [12], is an area of research that is growing fast and can benefit from this research. The household appliances field seems to be a good area to test the use of sound. The house environment with its universality among variations makes an appropriate frame for testing the musical earcons. Disabled and elderly people can find problems with some of the appliances used in the home. The appliances chosen for the test are the most common ones chosen for smart homes and safety systems, (e.g.: lights, door, blinds, bath, hob and radiator) and the ones that could, in certain situations, cause a danger or concern.

4. PILOT STUDY

To test the possibilities of non-speech sound we propose a system where feedback is delivered via sound (musical compound earcons), images (icons) and a combination of both. A hypothetical situation is created and users will be tested on the performance of a task.

4.1. Design

To gain as much as possible from the prospective users and the knowledge we have on the subject we used a combination of techniques that will maximize the resources available to the project. This includes the use of participatory design, a user pyramid approach and universal design as part of a broader range of methods and techniques.

4.2. Aesthetic issues.

Aesthetics not only refers to the perceived attractiveness and beauty characteristics of the interface, but also to its non-stigmatising value as a product designed for the general population and not just for a small (and fragile) part of it. Participants chose the icons they liked the most to be used in the interface.

4.3. Techniques applied to the design process.

There are many techniques developed to help in the design of devices for people with impairments, as well as even more to be applied to the design focused on the general population. All of the approaches have advantages and inconveniences that prevent them from becoming a definite design that can be used in any circumstance for any design [5]. The limitations of each approach come from different aspects of the process, from its target users, to its methodology.

The earcons were designed so a balance is achieved between familiarity and obtrusiveness so users will not find them annoying or so common that they don't have any effect on the listener. We decided to use a piano as the instrument producing the earcons as it has been proved before that its harmonically complex sounds are perceived easily [1] and also because *western musical forms based around the seven-diatonic scale are readily recognised around the world* [9].

Participatory design helps in getting the requirements right from the intended users from the beginning of the process, increasing the chances of a successful design story [8]. The group of elders was involved in the design process from the very beginning of the process.

We opted for a proactive design. This implies that prospective users (subjects) would feel more engaged in a designing process where the end product is aimed at them. User-adapted interaction techniques are more popular in industry where the adaptation to small numbers of users is quite expensive due to the number of potential customers [4]. We have adopted a proactive approach conscious of its limitations, especially those concerned with the highly individual differences in the elderly population, but due to problems getting volunteers we are aware of the limited conclusions of the study and possible generalizations.

Cognitive knowledge provided important information on how the elderly have specific necessities due to the aging process, but there are also solutions to this particular circumstance. The design takes into account the idiosyncracy of old age and especially their cognitive and perceptual capabilities [11]. First we followed clear general ideas on design principles for the elderly in the visual and audio senses: enhancing contrast between stimuli, increase signal intensity. We also tried to follow Brewster et al.'s [1] guidelines for the creation of earcons, modelling the compound earcons according to the recommendations on rhythm, pitch, intensity, duration and tempo, making the earcons attention grabbing.

5. EXPERIMENT

Participants should be able to listen to the earcons and see the icons representing the status of the different appliances on the hypothetical room, and be able to notice any change and act accordingly. The objectives were achieved as the participants pointed to:

- reasons why they didn't work
- possible alternatives to the earcons
- general opinion of the interface

5.1. Apparatus

Custom software was built for the study of the three experimental conditions. The software was implemented in Visual Basic and Cakewalk. The earcons were saved in MIDI files and the icons as JPG, GIF and BMP files. The experiments were carried out on a Windows computer with an AOC Colour monitor model 7vlr, an Accuratus ™ model ACK-210 keyboard, and Typhoon model PS-301B speakers with adjustable volume and bass.

5.2. Subjects

Participants were 6 female volunteers between 60 and 65 years of age, all with little or no musical training. 3 wore corrective lenses and 1 suffered from sinitus and 1 from arthritis. 3 reported to have a "little" computer experience (casual use in relatives' homes). There were no signs of technophobia and all were keen to use the computer.

5.3. Procedure

First all users were introduced to the 12 earcons -which represent another 12 status appliances- by a ten-minute presentation in a common room. Afterwards an identification task was performed in which 12 earcons were played in random order. Participants were instructed to try and select the sounds accurately. After an interval of around 30 minutes participants were asked to perform the computerized tasks individually in a different room. Due to the high level of errors found on the first task, participants were asked to say out loud the sound they thought they heard, so the experimenter could check the mistakes in identification. When the tasks were completed a focus group was set up for all participants to comment on the issue of the interface.

5.4. Data Collection

For the identification task users were given an identification sheet on which they marked the sounds according to their recognition skills. There were 12 identification trials. All participants listened to the 12 sounds and signalled on the identification sheet the name of the earcon.

For the second test subjects were placed in front of a computer. They were asked to pay attention to the interface and notice any change ocurred. In the audio modality an earcon will signal the change of state in one of the appliances. In the visual modality the change in one of the icons will signal the change of status in one of the appliances. For the multimodal interface the change will be noticed by the appearance of the earcon and change in icon at the same time. When they noticed any change they press a key to revert the system to its original position. Reaction time was measured by calculating time lapsed between stimuli presentation (earcon, icon or both) and response (pressing the key), whether the subject gave a correct or incorrect answer.

5.5. Results

We collected data to explore the hypotheses that participants would be able to remember the earcons and that the multimodal interface would prompt fewer mistakes and be quicker. We suggest that the earcons didn't have a good audibility [4] to the intended user group as the results showed that the performance on the recognition tasks was poor and users were not very satisfied with them. Memory overload could also have been an important factor to explain the results.

5.5.1. Performance

Errors, in the First test, were differentiated between:

- Total error: wrong identification of appliance and status (29%)
- error Type 1: wrong identification of appliance (31%)
- error Type 2: wrong identification of status (11%)

The number of errors was greater than expected, with 71% of the identifications being incorrect (leaving only 29% as correct). This forced us to change the second part of the experiment.

5.5.2. Post experiment data collection.

A focus group was carried after the experiment. Although users may eventually learn the earcons, they did suggest they didn't like them, as they have to make an effort to associate them with their meaning. It seems auditory icons, or even extracts from songs that directly connect to the appliance, such as door: "*open* *the door my darling"*, or door close*: "It is cold outside…"*), would have been more natural and easy to remember. This is in tune with Leung et al.'s [7] findings, where it was shown that abstract sounds were more difficult to remember than warnings or auditory icons.

The second experiment task consisted in the representation (either aurally, visually or in a multimodal mode) of a change in the status of one of the appliances and the demand to revert to the previous status by operating the interface (pressing a key on the keyboard). Time was taken by an in-built chronometer in the program. To avoid possible learning effects all presentations were randomly assigned. For the experiment, and due to the previous results on the identification task, subjects were ask to press the appropriate key after identifying and saying out loud which appliance they though had just change state.

Condition	Minimn.	Maximn.	Mean	Std. Devin.
Multimodal	1.71	10.90	4.078	3.3814
Audio	2.88	6.23	4.390	1.2495
Visual	1.95	8.94	5.383	2.9744

Table 1. *Test 2 Descriptive statistics, time in seconds.*

From Table 1 it can be appreciated that the maximum and minimum times are both in the multimodal condition. The mean was smaller in the multimodal condition and the standard deviation was more than double than on the other conditions. We can not suggest that any of the modalities was superior in presenting the information, although the multimodal condition appears as a slightly more efficient mode. We note that the sample size was small.

6. CONCLUSIONS AND RECOMENDATIONS

The results show that the audio interface was not performing as well as hoped and thus changes need to be made. Earcon recognition was the cause of the poor performance, and the subjects complained about difficulty in remembering the earcons.

Although the system is not difficult to use the auditory component has proved to have a steep-learning curve thus making it inappropriate for its integration on the system. Modifications are needed to make the whole interface more suitable. We plan to carry out further experiments that will test the efficiency of the different interface modalities when subjects are occupied in primary tasks other than monitoring the state of the house. For this situation, we also expect the multimodal interface to promote better results.

The necessity of users to learn the functioning of the device and their ability to remember it is an important issue that can only be addressed after the first trials. Our concern is that the time spent to learn the earcons may have a negative effect on the opinion potential users have about them and, by extension, about the devices. The learning and retention of the earcons may result in a negative perception of the auditory feedback, while there is a comparatively irrelevant need of cognitive resources for the learn and retention of the meaning of the icons.

The fact that so many errors appear on the experiment can be explained by a series of factors. The gap between the earcons might have been not long enough for users to differentiate thus confirming Brewster et al.'s [1] recommendation to leave 0.1 second gap between each earcon component.

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