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Design Studies in Adapting Interactive Computer Interfaces for Elderly Users

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Introduction

Computer technology and the Internet have become inseparable parts of our daily lives. They are essential elements in the work environment, the household, schools, commerce and healthcare. Interactive health services are expected to become an increasingly integral part of the "knowledge society" in this century, which has been characterized as the era of the aging population (Drucker, 2002).

Interactive health services (E- Health, E-care) are a developing area of major social, medical and economic importance (Gomez, Del Pozo, and Arredondo, 1999; Eysenbach 2001; Robinson et al, 2001; Morrell, Mayhorn and Bennett, 2002). Interactive health services are expected to improve the chain of treatment, decrease healthcare expenses, enhance quality and efficiency of healthcare, and increase the fairness and equality of the distribution of medical services, particularly for citizens living in remote areas and for the elderly population.

The elderly are becoming increasingly exposed to computers and information technologies, either out of interest or necessity (Morrell, Mayhorn and Bennett 2000; Lindberg, 2002; McConatha, 2002; Morrell et al., Bitterman and Shalev, 2004).

Interactive computer systems and home health care systems can significantly assist elderly patients in self-monitoring, collection, storage, and retrieval of personal clinical data (especially for chronic diseases), including feedback and decision capabilities. However, most of the existing interactive computer systems and health care web sites (even those oriented for the older population) do not take into account the sensory, motor, and cognitive changes that are part of the aging process, and therefore limit the use of the technology in reaching its fullest potential.

Recently there have been an increasing number of studies on the compatibility of human computer interfaces (HCI) for elderly people (Czaja, 1997; Rogers, 1997; Morrell and Echt, 2001; Czaja and Lee(2001); Bitterman and Shalev, 2004). However, only a few of them were controlled studies, which specifically address the compatibility of **medical** interactive (web-based) computer systems for elderly users.

Taking into account the importance of interactive (web based) computer systems in the coming "knowledge society ", and their inherent benefits for senior citizens and for the entire community, we initiated an ongoing research activity to study how well they meet the specific needs of the elderly. Three studies examining the compatibility of interactive computer systems for the elderly will be presented: one general study on link configuration preferences, and two studies related to retrieval and display of clinical data (nutrition and coagulation control) and continuous personal follow up by elderly computer users.

METHODS

Participants

The studies were carried out on volunteers of two age groups: elderly (65+ years) and young people (20-50 years), with an equal number of male and female subjects in each group. All participants had previous experience with computers and the Internet. The participants were asked to navigate through experimental web sites, perform realistic tasks and answer specific representative questions, based on information supplied in the web sites. Each study was conducted by a different team (research students) and performed on different participants (volunteers).

Experimental setup

For each study, three different experimental web sites (realistic web site simulations), equipped with hidden tracking programs, were constructed, to fully record the participants' steps and navigation routes.

The three studies were:

Study 1; Link configuration design (N=24 subjects)

Three tourism web sites (Rome, Prague and London) with up-to-date travelers' information and images were constructed. Nine different configurations of links were introduced into the three web sites, three on each web site. Participants were asked to obtain nine pieces of information available in each web site (total of 27 tasks).

Study 2: Interactive computer nutrition system (N=40 subjects).

Three nutrition web sites based on different user models for follow-up of food intake and nutritional management were constructed. The first two web sites were organized according to alphabetical order, or by "food groups"; the third was a 'structured' web site based on a recall dietary protocol. Participants were asked to list their daily breakfast food intake in each of the different experimental web sites.

Study 3: Interactive computer system for self-control of coagulation function (N=50 subjects).

Three experimental web sites based on three different visualization models for data entry and follow-up of personal clinical information were constructed. The different displays were organized by tables, time line graphs, or integrated display with graphical representations. The participants were asked to fill in their personal and clinical data and then search the experimental web sites for specific medical information such as finding a specific value, recognition of trends and locating abnormal values.

The three web sites in each study were similar in their level of complexity and color-scheme, and differentiated only by their user's models and/or design display.

Experimental Parameters

The different web sites were evaluated by parameters of time for task completion and accuracy (e.g. errors), derived from the integrated tracking program. Satisfaction and personal preferences were determined from questionnaires and interviews completed at the end of each experiment.

Physiological monitoring

All participants in Study 3 (coagulation factors) were simultaneously equipped with miniature sensors for continuous recording of physiological parameters indicating stress and anxiety: heart rate, sweat and skin temperature) (Fig 1) (AR7- Stress Management Monitor"; Atlas Res. Ltd., Israel).

Fig 1. A participant equipped with miniature sensors for continuous recording of physiological parameters indicating stress and anxiety: heart rate, sweat and skin temperature) (AR7- Stress Management Monitor"; Atlas Res. Ltd., Israel).

Statistical analysis

Continuous variables were expressed as mean ± SD, and categorized variables as percentages. The chi-square (X^2) or Fisher's exact test were used for comparison of categorized values. Comparisons between age groups in each study for each display configuration were carried out by t-test or non-parametric test.

Differences between web sites within each age group were carried out by repeated measures, followed by ad hoc testing using a Duncan or Tukey test. Pearson correlations were performed between physiological parameters and performance. A value of $P < 0.05$ was considered significant.

Results

Differences between age groups

The time for task completion was statistically longer for the elderly compared to the younger participants in all the different experimental displays of the three studies (links, nutrition and coagulation functions). Fig 2 presents typical results for duration of time for task completion taken from Study 2.

A positive correlation was demonstrated between time for task completion and age in the elderly group in all web sites in the three studies, as can be seen in a representative graph taken from Study 2 (Fig 3).

In all studies, there were no significant differences in accuracy between elderly and young participants as reflected in number of errors.

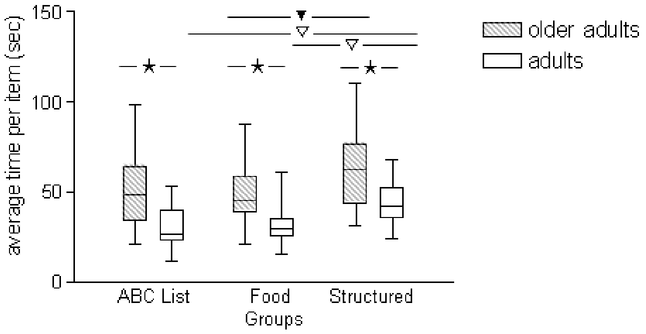

Fig 2. Average time for task completion (listing food intake) in the three experimental web sites (sec) of Study 2. Data are presented by boxplot demonstrating extremes, interquartile range (25% - 75%) and median. N=20 for each group.

★ p←0.05 in Mann-Whitney test, comparison between age groups

▽ ▼ p←0.05 Tukey-Kramer test comparison within age group.

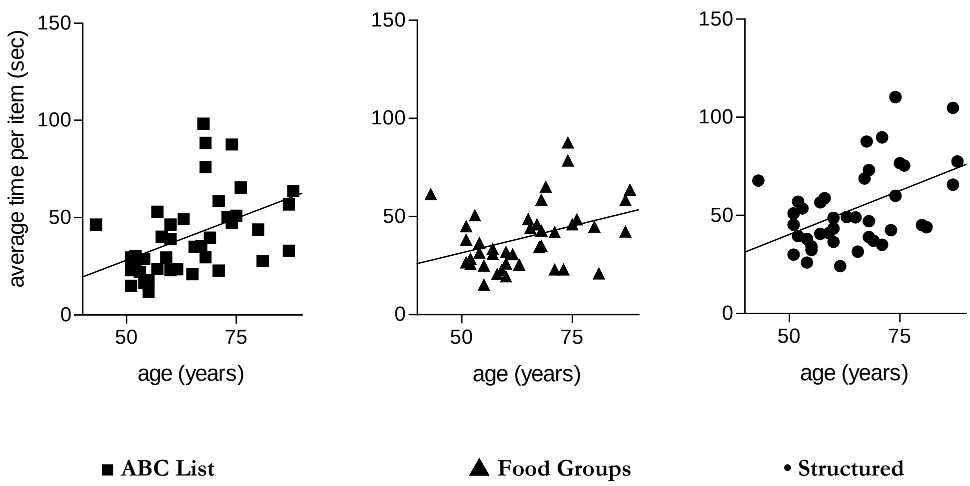

Fig 3. Correlation between participants' age and average input time (sec) per food item in the three experimental web sites (study 2).

r^2=0.2286, p=0.0018; r^2=0.1359, p=0.0193; r^2=0.2063 p=0.0032, respectively, N=40.

Difference between web sites

The main differences measured between specific web sites for each study were:

- The highest scores were measured for "icon" or "horizontal text list" links and the lowest for "bulleted list" and "list box with "go" button" links ($P< 0.05$, Duncan test) (Bitterman and Shalev, 2002).
- The shortest total task time and duration for entering food items were measured in the 'food groups' web site in the two age groups, and the worst performance was obtained at the 'Structured' web site by both age groups ($P<0.05$ Tukey test)
- Table display was the best design for locating a specific clinical value, and the graph presentation was the worst (Duncan, $P< 0.05$). For locating abnormal values, the graph was the best design and the table was the worst visualization method (Duncan, $P< 0.05$).

DISCUSSION

Our results based on three different studies suggest that older adults can perform Internet tasks as well as, albeit slower than, younger people. However proper link selection, user models and appropriate visualization methods are needed in order to facilitate the use of interactive computer systems by the elderly.

Several general conclusions drawn from the three studies:

- A positive, significant correlation was found between total time for task completion and age in the elderly group, which was not seen among the younger participants, with no difference in number of errors. These findings suggest age-related functional deterioration and possible special care taken to avoid mistakes among the elderly (Morrell, 2002). The findings from the continuous monitoring of physiological parameters also support the possibility of slight changes in stress and anxiety levels.
- No correlation (and even an occasional negative correlation) was found between satisfaction and preferences rankings and performance scores, suggesting that the users do not always know what is best for them (Andre and Wickens 1995). This discrepancy between function and preferences emphasizes the need for specific studies, using specially-constructed, novel clinical web sites, with relevant users' models and visualization aids, rather than relying on questionnaires and interviews to gauge user satisfaction and preferences.
- The use of continuous monitoring of physiological parameters adds objective measures of anxiety and stress as an additional objective measure for evaluating web functions. Yet, a better understanding of the correlation between physiological parameters (mostly of the autonomic system), functional HCI measures and subjective satisfaction criteria is still needed.
- Based on the variations between age groups, it is suggested to choose display configurations that are suitable for the elderly and young users as well. Therefore, the final web version should take into account the needs of both the elderly and the young users.
- Interactive computer interfaces should be fully accessible not only for the elderly, but for people with functional limitations related to disabilities. One should also remember that circumstances and external situations (such as background noise, dim light, stress, unsteady and moving environment, etc.) place ordinary people in a position comparable to that of a disabled person (Vanderheiden, 1997, Murphy et al., 2000).

The results of these studies will help to establish principles and guidelines for interactive medical computer interfaces for elderly people and people with disabilities.

We expect to establish some general models and concepts for the design of interactive medical computer system interfaces compatible for elderly people, that could be modified and tailored (personalized) according to different diseases, changing needs of the patients, and possibly gender.

Our belief is that personalization and tailoring of interactive medical computer system interfaces, according to the capabilities and limitations of elderly patients, based on the results of the presented experiments, will make this technology more accessible for a large population of elderly people, along with upgrading and improvement of home -care services

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