Intuitive Interaction and older people

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Older people often struggle with using contemporary products and interfaces. They show slower, less intuitive interaction with more errors. This paper reports on a large project designed to investigate why older people have these difficulties and what strategies could be used to mitigate them.

The project team found that older people are less familiar with products that they own than younger ones, while both older and middle aged people are less familiar with products that they do not own than younger ones. Age-related cognitive decline is also related to slower and less intuitive performance with contemporary products and interfaces. Therefore, the reasons behind the problems that older people demonstrate with contemporary technologies involve a mix of familiarity and capability.

Redundancy applied to an interface in the form of symbols and words is helpful for middle aged and younger old people but the oldest age group performed better with a words only interface. Also, older people showed faster and more intuitive use with a flat interface than a nested one, although there was no difference in errors. Further work is ongoing in order to establish ways in which these findings can be usefully applied in the design process.

Keywords : Intuitive interaction; older people; observational analysis

Introduction

Intuitive interaction involves the use of knowledge gained from other products and/or experiences (Blackler, 2008; Blackler, Popovic, and Mahar, 2002, 2010b; Hurtienne, 2009; O'Brien, Rogers, and Fisk, 2008a). Therefore, products that people use intuitively are those with features, functions and/or processes that they have encountered before.

Several different researchers on three different continents using a variety of products, interfaces and experiment designs have all found that prior experience is the leading contributor to intuitive use (Blackler, 2008; Hurtienne, 2009; O'Brien, 2010), and intuitive interaction has become strongly linked with familiarity or prior experience (Blackler, 2008; Blackler, et al., 2010b; Hurtienne and Blessing, 2007; Hurtienne and Israel, 2007; Marsh and Setchi, 2008; Mohs et al., 2006; O'Brien, et al., 2008a; O'Brien, Rogers, and Fisk, 2008b).

Our first three experiments with people performing set tasks with camera and remote control interfaces showed that intuitive interaction is based on past experience with similar products and product features. Technology familiarity (TF) was used in all three experiments to gauge past experience with relevant interface features. It was measured through a questionnaire, in which participants provided details of their experience with products with similar features to those they would encounter during the experiment. More frequent and more extensive use of the products in the questionnaire produces a higher TF score (Blackler and Hurtienne, 2007; Blackler, et al., 2010b). Familiar features were used more intuitively, and people with higher TF completed tasks more quickly, with more intuitive uses and less errors (Blackler, 2008; Blackler, et al., 2010b).

However, these experiments also suggested that older people use complex products (cameras and universal remote controls) both more slowly and less intuitively, even when they report equivalent levels of prior experience (Blackler, 2008; Blackler, et al., 2010b). Drawing on our initial experiments, O' Brien (2010) conducted two studies into prior experience and its effect on technology use for older people. She showed that prior experience was the most common reason for successful technology use, but was not always sufficient on its own. O'Brien also found that High TF older adults using a video camera, digital radio alarm clock and e-reader did not perform as well as younger adults, and prior experience was important for technology use, but it did not explain all the differences between age groups. Other researchers have also found that older people use interfaces more slowly and with more errors (Langdon, Lewis, and Clarkson, 2007; Lewis, Langdon, and Clarkson, 2008).

As a result, we have spent the past four years investigating intuitive interaction for older people. This large Australian Research Council funded project, based at the People and System (PAS) lab at QUT, has investigated several themes related to intuitive interaction and ageing. These were: technology familiarity, cognitive decline, and design approaches. This paper offers a cohesive overview of the whole project. All data were analysed using Noldus Observer and SPSS, although full statistics are not reported here due to space constraints. Full results of each experiment can be found elsewhere (Blackler, Mahar, and Popovic, 2010a; Lawry, Popovic, and Blackler, 2011; Lawry, Popovic, and Blackler, 2009; Lawry, Popovic, and Blackler, 2010; Reddy, Blackler, Mahar, and Popovic, 2010; Reddy, Blackler, Popovic, and Mahar, 2011; Reddy, Blackler, Popovic, and Mahar, 2009).

Microwaves Experiment

This experiment was designed to investigate the differences between three different age groups and two different microwave interfaces. This was a matched subjects 2x3 experiment design. Independent variables were age group and microwave interface. There were 36 participants, 18 in each microwave group and 12 in each age group. Age groups were Younger (20-39), Middle (40-56) and Older (57+). Participants were matched for TF, education and gender. Dependant variables were time on task, percentage of correct uses, and percentage of intuitive correct uses. Participants were video-recorded performing three set tasks on touchscreen microwave prototypes in the laboratory while delivering concurrent protocol (Figure 1). They also completed a TF questionnaire and follow up interview.

The central executive is the component of working memory that controls cognitive tasks like attention, reasoning, problem solving and language (Baddeley, 2000; Morrison, 2005a). There is a growing body of research evidence pointing to age-related deficits in central executive functioning (Fisk and Sharp, 2004). Based on Baddeley's model of working memory (Baddeley, 2000), we devised a battery of computer-based tests to measure a range of Working Memory functions. They were all administered on the touchscreen. The software recorded reaction time and accuracy (Blackler, et al., 2010a; Blackler et al., 2011).

Figure 1. Using microwave prototype on touchscreen

Analysis

The audiovisual data were coded using Noldus Observer software. Correctness and intuitiveness of feature uses were determined by a process we have used successfully over the past several years (Blackler, 2008; Blackler, Popovic, and Mahar, 2004). This involved coding each feature use, using a set of heuristics based on the literature. Intuitive uses show less evidence of conscious reasoning in the verbal protocol, are typically fast, have low latency, participants are fairly confident they are pressing the right button, and they may mention that they have seen or used the feature before (Blackler, et al., 2011).

Results

Results of a multiple regression analysis showed that time to complete tasks was most impacted by reaction time and accuracy on the phonological transform test (Figure 2). The next most significant variable for time on tasks was TF (Figure 3), followed by hits on the sustained attention test. The percentage of intuitive correct uses was impacted most by sustained attention accuracy, and also by TF. Percentage of correct uses was most related to phonological transform accuracy, followed by TF (Blackler, et al., 2010a).

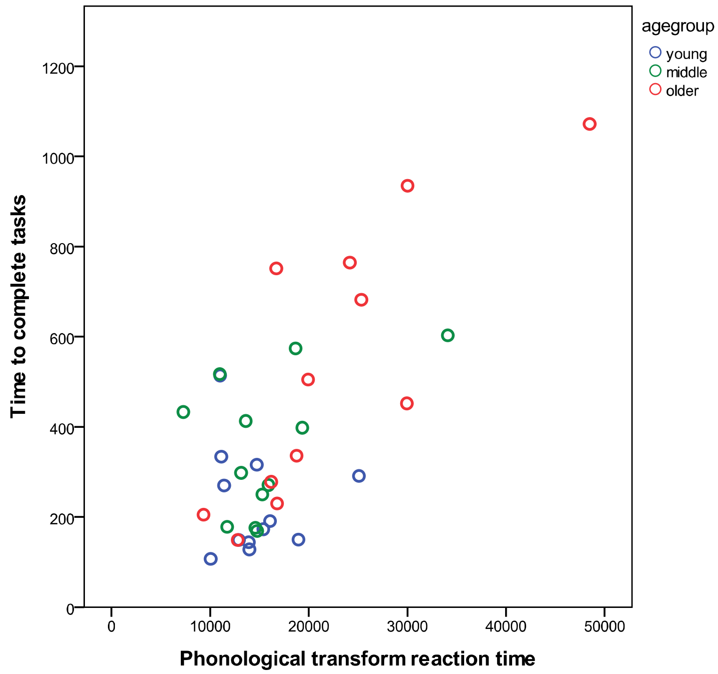

Figure 2. Time to complete tasks and phonological transform RT

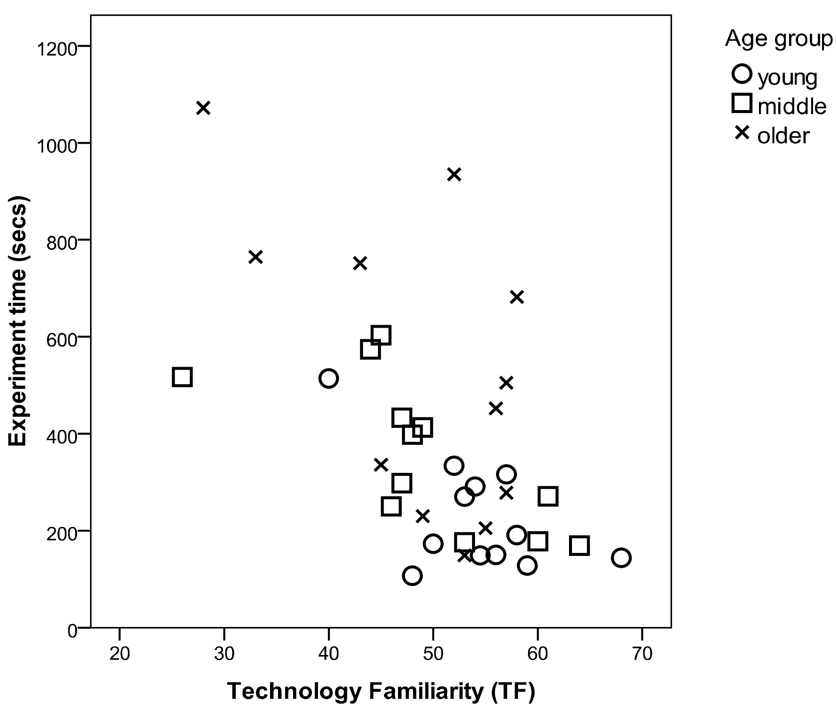

Figure 3. Time to complete tasks and TF

Discussion

As we had found previously (Blackler, 2008), this experiment showed that TF is a vital factor in fast, correct and intuitive use of an interface. The other variables that had the most impact all require use of the central executive (phonological transform and attention). These results could explain some of the differences between younger people and high TF older people that O'Brien could not, as differences between age groups appear to relate to cognitive decline as well as TF.

Familiarity Field Experiment 1

Because intuitive interaction is based on past experience, familiarity with relevant products or interfaces is essential. Familiarity Field Experiment 1 was designed to investigate participants' familiarity with products that they owned. The Independent Variable was age, with 32 participants in four age groups (18-44, 45-59, 60-74, 75+), balanced for gender. The dependant variables were measures of familiarity identified through the coding process (Lawry, et al., 2010). Time to complete tasks was not relevant as all participants were completing different tasks with different products.

The experiment was conducted in the participant's home with a product that s/he considered him/herself to be familiar with. A semi-structured interview was conducted, going into depth about the product the participant chose as familiar. The participant was then required to describe how s/he performed a common task with the product (we called this "task recall"). S/he then performed that task with the product, while delivering concurrent protocol ("observation"). A retrospective protocol was completed after the observation.

Analysis

The semi-structured interviews were transcribed and then scored. The more familiarity demonstrated by an answer, the higher the score. All audiovisual data were coded for accuracy and also with three levels of familiarity: (1) very familiar, (2) moderately familiar and (3) not familiar. Some of our earlier heuristics for coding intuitive interaction were integrated into this coding scheme. Familiarity was identified by relatively fast and flowing interactions, pre-emptive movements, low levels of verbalisation, and high levels of situational awareness (Lawry, et al., 2010).

The task recall was transcribed and compared to participants' actual behaviour during the observation. Noldus Observer was used to code actual behaviour in relation to the way the participant described how s/he would do the task. By comparing the steps the participant described to perform the activity, with the steps that s/he actually undertook to execute the task, it was possible to identify the level of familiarity the participant had with the product. Each step observed during the execution of the selected task was coded. The 'grouping' code was used when participants described multiple steps together as a single step or sentence. Groupings were hypothesised to demonstrate higher levels of familiarity.

In addition to these relational codes, 'procedures' were coded within the observation. Procedures were coded when participants demonstrated high levels of familiarity with two or more steps in a process during the observation, suggesting that they are grouped cognitively. This differs from the grouping code as the grouping code applied to the description made beforehand, whereas the procedure code applied to steps performed during the execution of the task.

Results

Findings suggested that there was a significant difference in familiarity between the youngest age group (17-39) and the two oldest age groups (60-74 and 75+), in terms of interview score (Figure 4), percentage of time in procedure (Figure 5), steps coded as grouped, percentage of steps in procedure, and grouped steps in procedure (Lawry, et al., 2009; Lawry, et al., 2010).

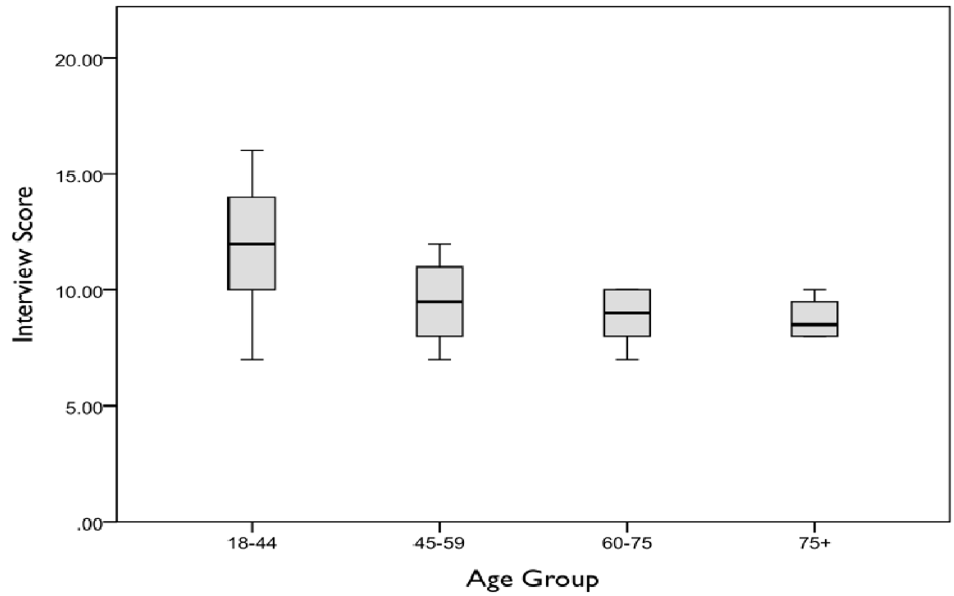

Figure 4. Age group and interview score

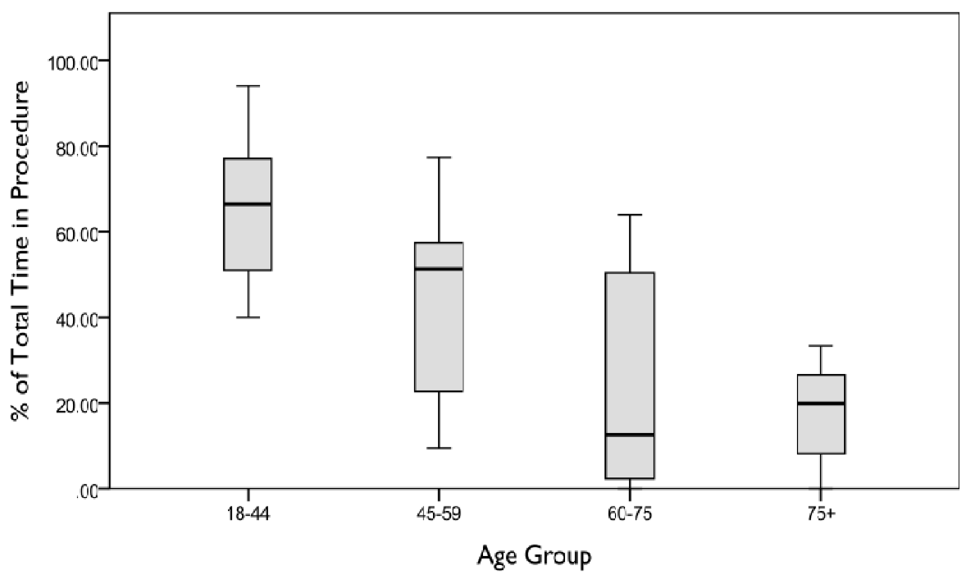

Figure 5. Age and time in procedure

Discussion

This experiment showed that older adults have a significantly different relationship to familiar contemporary products than younger adults. The findings suggest that this is primarily a result of a much higher level of knowledge of contemporary products among younger adults. For example, in the Semi-structured Interview, the youngest age group provided more comprehensive answers to questions relating to comparisons between products, and answered questions about the potential for expansion of functionality. The youngest age group also used their familiar products for more activities that any other age group, thus suggesting a high knowledge of product functionality.

The observational data showed that younger adults were the most familiar with their selected product and that familiarity differed significantly between the youngest and the oldest age groups. Also the differences in familiarity among the three oldest age groups were negligible. These results suggest that a generational difference in familiarity with contemporary products may be occurring between the youngest and oldest age groups. Docampo Rama (2001a) and her colleagues (Docampo Rama, de Ridder, and Bouma, 2001) conducted research into technology generations. Docampo Rama et al. (2001) describe the effect of generation as a discontinuous effect, while the effect of age is continuous, or linear. The results of this experiment demonstrate a discontinuous effect, suggesting that the differences in performance are a result of different prior knowledge. Docampo Rama (2001a) also found no significant differences between the three older age groups when generational effects were present.

Familiarity Experiment 2

Familiarity Experiment 2 focused on the use of products that the participants were not already familiar with. Independent variables were age group (18-44, 45-59, 60-74, 75+) and product (four products). There were 32 participants, balanced for gender. The dependant variable was level of familiarity, assessed through a coding scheme. This was a mixed 4x4 experiment design with a repeated measures condition (product), so each of the four age groups was split into two smaller groups to counterbalance and control for any order or training effects. Groups were also balanced for education and gender.

The four products were two alarm clocks and two cameras. There were several tasks to be completed for each product. The participant read a task sheet, and was then shown the product briefly. The participant then explained how s/he thought s/he would perform the specified task (“primed task recall”), and then performed the task while delivering concurrent protocol (“observation”). After the observation a short interview was conducted, asking about what aspects of the task the participants found difficult and why. This process was repeated for each product. The experiment was conducted in the laboratory and in two senior citizens centres, with conditions controlled as much as possible.

Analysis

All audiovisual data were coded for accuracy and also with three levels of familiarity as in Familiarity Field Experiment 1 (Lawry, et al., 2010).

Each action in the primed task recall and observation was coded. The list of actions was specified beforehand, and some actions were made up of several steps (e.g. inserting the SD card into the digital camera), while others were a single step (e.g. turning the camera on). In the Primed Task Recall, the task sheet provided a certain amount of knowledge of the process, so if a participant simply verbalised the process as it appeared on the task sheet, it was coded as not familiar.

The Retrospective Interview was coded based on the nature of what the participant discussed. Comments that were positive in nature, such as “…it was easy to use”, suggested higher levels of familiarity. Comments that were negative in nature, such as “it wasn’t obvious how to turn the flash off”, suggested lower levels of familiarity.

Results

Findings from Familiarity Experiment 2 suggested that, with products that participants had never used before, there was a significant difference in familiarity between the youngest age groups and all three of the older ones, as measured by the primed task recall (Figure 6), the observation (Figure 7), and the retrospective interview.

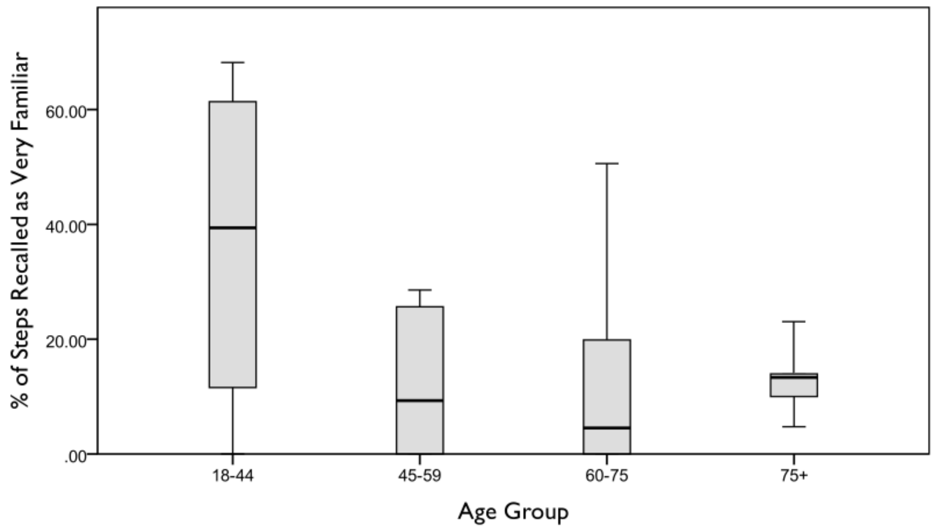

Figure 6. Age and percentage of familiar steps during primed task recall

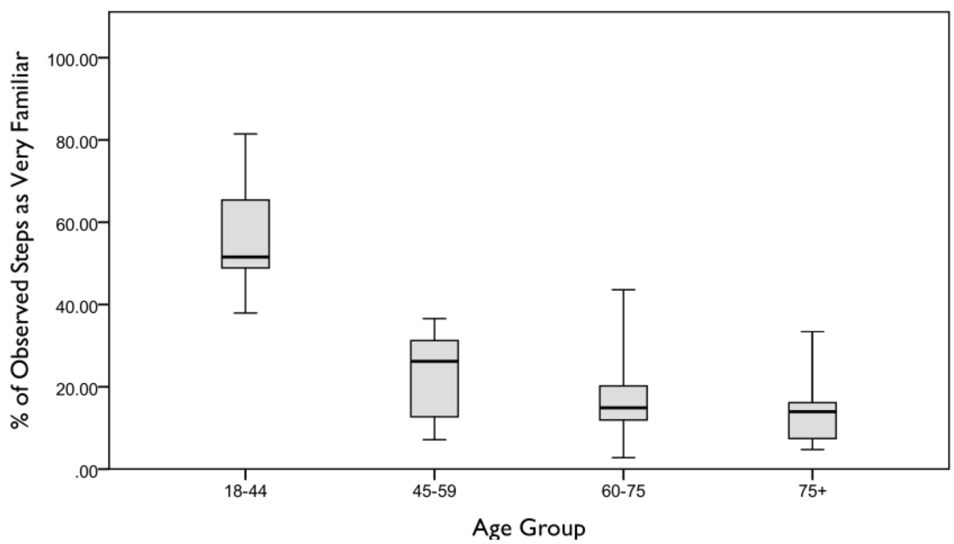

Figure 7. Age and percentage of familiar steps during task performance

Discussion

The results show that there are very significant differences between older and younger adults, and that there are not significant differences among the three older age groups. These results differ from those found in Familiarity Experiment 1, where the youngest groups differed from the two oldest group but not from the middle aged group, and this implies that middle aged people (40-59) are able to become familiar with products they own but, like older people, show significantly less familiarity with new products than younger people (Lawry, et al., 2011).

These findings show that familiarity with contemporary products does not decline linearly with age, but drops around the mid-40s. This suggests that the findings from this experiment are the result of differences in prior knowledge, rather than any age-related declines in cognition or other abilities.

Redundancy Experiment

This experiment was designed to investigate whether the problems older adults experience with new technologies could be mitigated by employing redundancy in interface design. The Independent Variables for this experiment were interface design (Words only, Symbols only and Redundant [both words and symbols]), and age group (18-39, 40-64 and 75+). Of 50 participants 40% were males and 60% females, ages ranging from 18 to 83 years (M = 51, SD = 21). Groups were balanced for gender. The dependant variables were the time taken to accomplish the two set tasks, percentage of intuitive events observed and errors. We also measured working memory function and TF. This experiment was conducted in the laboratory. The data collection methods included observation of set tasks, concurrent verbal protocol, interviews, a TF questionnaire, and a working memory test battery similar to that as used in the microwave experiment. A Go/No go task, a measure of sustained attention, was added to the cognitive test battery for this experiment. A software prototype of a body-fat analyser, a non-invasive self-care health product, was used to complete the tasks on a touchscreen (Figure 8).

Figure 8. Body fat monitor with redundant interface

Analysis

For this experiment, we coded events. A task comprises a set number of events, and each event needs one or more actions to complete. For example, inputting participant's age is an event, and this event includes the actions pressing up or down arrow and pressing the OK button. There were 8 "events" embedded in the set tasks.

Coding heuristics were based on those used previously (Blackler, 2008). Coding was done based on observation in conjunction with verbal protocol using Noldus Observer software. When participants performed an action quickly, with ease and did not verbalise (or at times verbalised after, instead of while, performing the action), that interaction was coded as an intuitive event. All videos were coded by two independent raters to validate the data.

Results

As expected, results suggested that a negative correlation existed between TF and time to complete the task. Younger people also tended to score higher on TF and were more likely to use interfaces faster than older people. An analysis of variance showed a significant main effect of Age on time to complete task. The effect of age was much larger for the Redundant and Symbols only interface than it was for the Words only interface. The difference was reflected in a significant Age x Type of interface interaction. Older people took lot less time on the Words only interface compared to the Redundant interface (Figure 9). Older people also made more errors on the Redundant interface when compared with the Words only interface. This was reflected in a significant interaction between Age x Interface on percentage of errors made. Older people also used the interfaces significantly less intuitively than younger ones and found the Words only interface more intuitive to use (Figure 10).

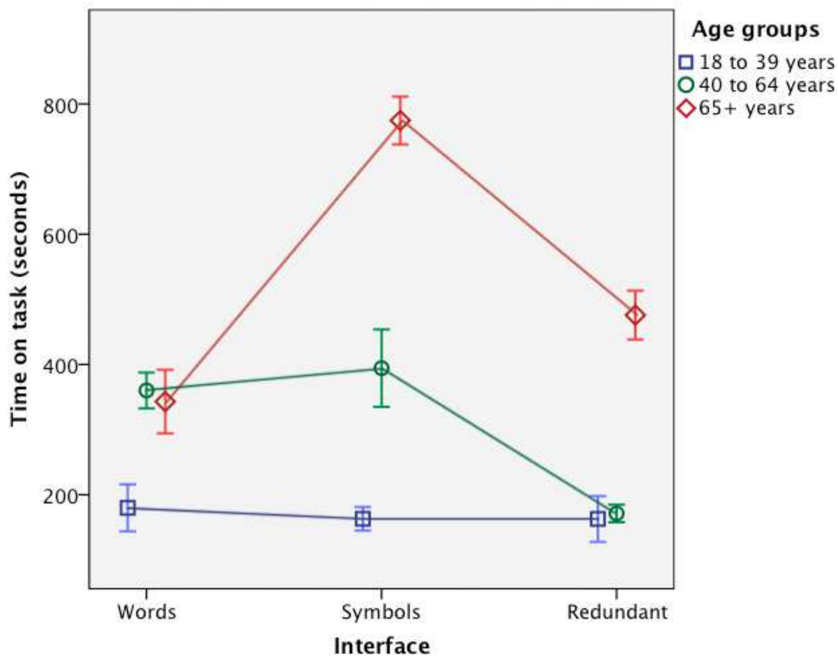

Figure 9. Interface and time to complete tasks

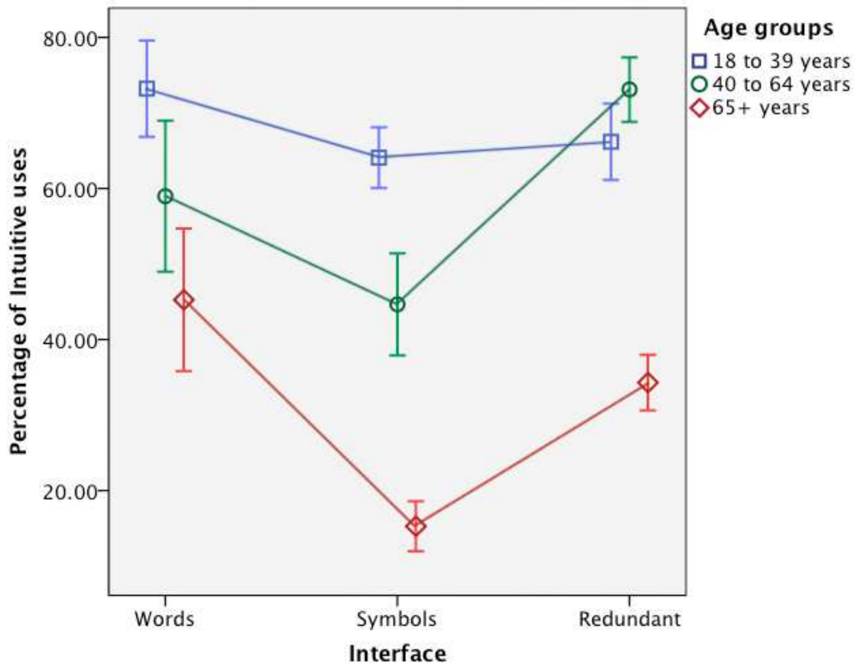

Figure 10. Interface and Percentage of intuitive uses

Multiple regression analysis of the data showed that Visuo-spatial sketchpad capacity and Phonological transform response time significantly correlated with time to complete the task. Score on the Go/No go task had most impact on number of intuitive uses and errors. As the Central Executive plays a key role in controlling and directing attention (Morrison, 2005b), this data supports results from our microwave experiment.

Discussion

Surprisingly, redundancy in interface design resulted in faster and more accurate performance for younger and middle aged people, but a words only interface worked better for older people (65+). Also, we again found that components of CE function impacted on time, intuitive uses and errors, suggesting that cognitive decline as well as familiarity are affecting older people in their use of new technologies.

Interface complexity Experiment

This experiment was designed to investigate the relationships between age, interface complexity, anxiety and intuitive use. This experiment used a mixed between and within-participants design. Independent variables were complexity of interface (nested or flat – repeated measure), induced stress (high or low – between groups) and age group (17-34, 35-49, 50-64, 65-72, 73+). 50 participants (10 each in five age groups, balanced for gender) participated in this experiment, ranging in age from 18-84 years (M = 54, SD = 18). The dependent variables were time on task, errors and percentage of intuitive interactions.

In the laboratory, participants were asked to complete two real-life style tasks with a virtual pet on a touch sensitive tablet (iPad). They completed one task using a nested interface and the other using a flat interface (Figure 11). The tasks were counterbalanced to avoid training and sequencing effects. During the tasks they received either positive or negative feedback about their performance via the screen, in order to control the induced stress variable. Data collection methods were observation of interaction, TF questionnaires, and cognitive measures.

Figure 11. Flat and nested interfaces

Analysis

The coding scheme for this experiment was the same as that used for the redundancy experiment, except that we coded each "use" (every time a participant touched the screen), rather than groups of uses, or "events".

Results

Low TF participants took significantly more time to complete the task, compared with Mid TF and High TF participants, on both types of interface and both stress conditions. There was a significant effect of Interface type on time to complete the task (Figure 12). The participants took significantly more time to complete the task on the Nested interface when compared with the Flat interface. Age also had significant effect on time to complete the tasks, with the 73+ age group taking significantly more time when compared with the four younger age groups. The 65 to 72 group also took significantly more time than the youngest age group, 17 to 34. There was a significant Interface type x Age interaction. Type of interface had a significant effect on the 73+ and 65 to 72 age groups. Both of these groups took more time to complete the task on the Nested interface than the Flat one. There was also a significant Interface type x Stress interaction. The time to complete the task on the Nested interface differed significantly between High and Low stress conditions, whereas on the Flat interface there was no significant time difference between Low and High stress conditions. Interestingly, on the Nested interface participants took significantly less time in the High stress condition.

A 3 way mixed ANOVA revealed a significant effect of type of Interface on percentage of Intuitive uses (Figure 13). This indicated that the participants used the Flat interface more intuitively when compared with the Nested interface. Age also had a significant effect on percentage of Intuitive uses. The age effect was significant between age groups 17 to 34 and 65 to 72, 35 to 49 and 65 to 72, and 35 to 49 and 73+.

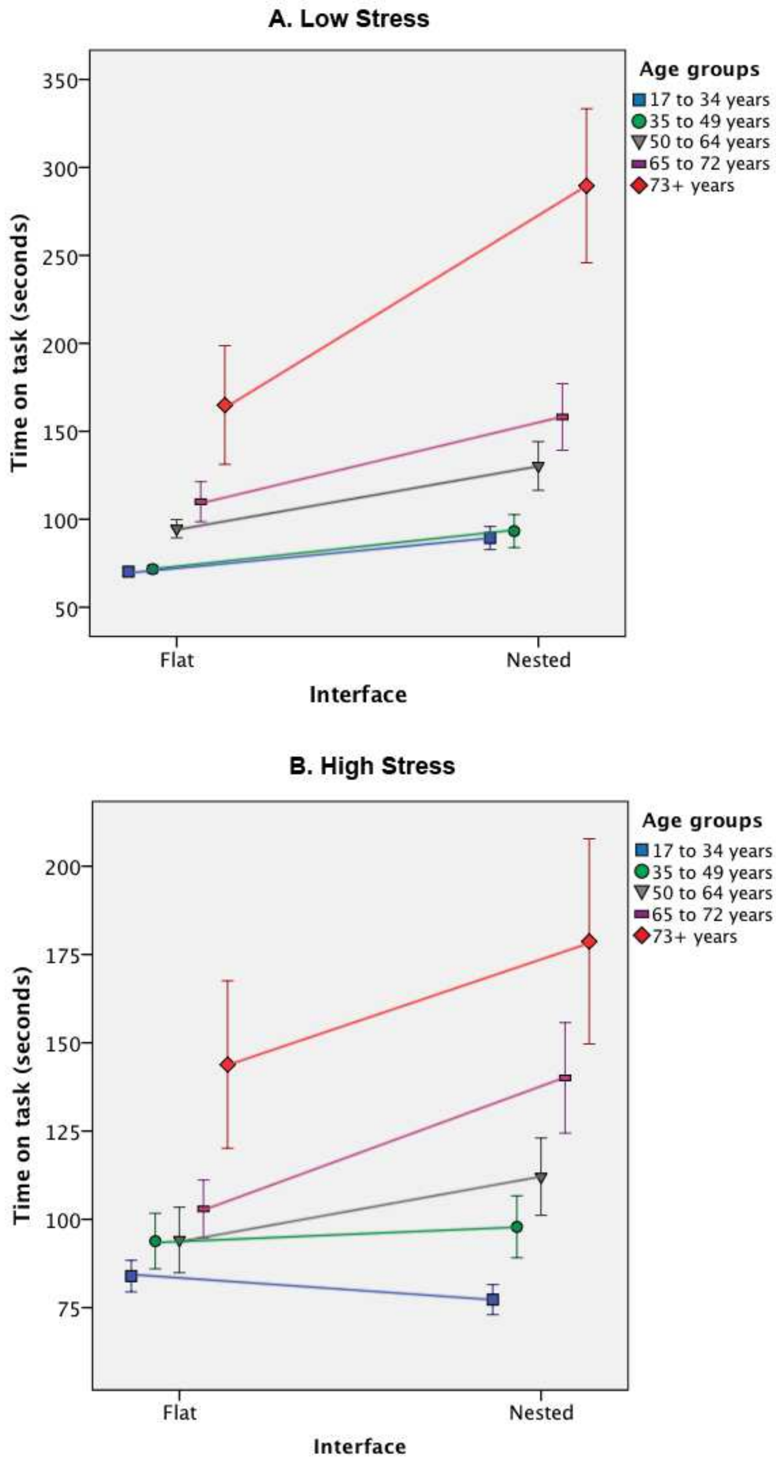

Figure 12. Time on task by age and interface under A. Low Stress and B. High stress

There was also a significant three way interaction between Interface x Age x Stress for percentage of intuitive uses. In the Low stress condition, Age had significant effect on intuitive uses using both Flat and Nested interfaces, with a significant difference between 35 to 49 and 65 to 72 on Flat interface, and a significant difference between 35 to 49 and 50 to 64, 65 to 72 and 73+ on the Nested interface. Age also had significant effect on percentage of errors made. Overall, older age groups made more errors on both types of interfaces when compared with younger age groups. However, type of interface had no effect on errors.

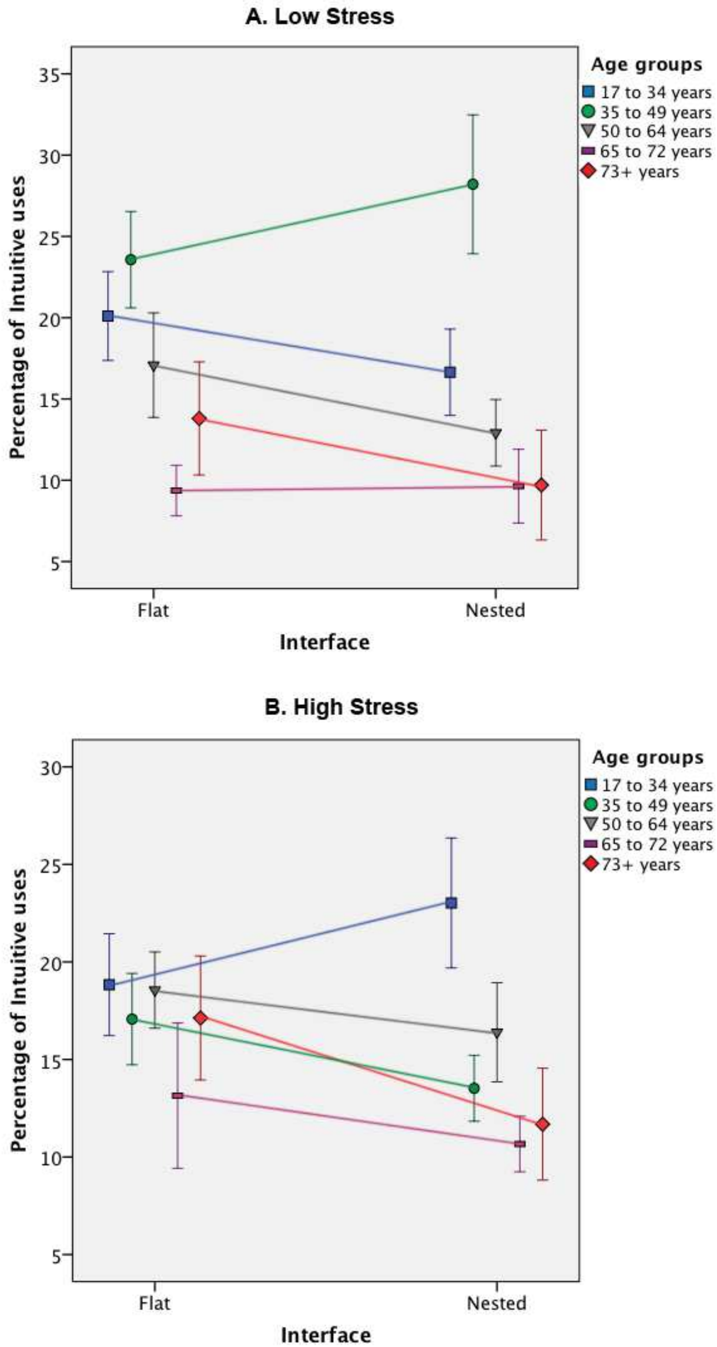

Figure 13. Percentage intuitive uses by interface and age under A. Low Stress and B. High Stress conditions

Results of a multiple regression showed that visuospatial sketchpad capacity and Phonological transform response time significantly correlated with time to complete the task on the Flat interface. Phonological transform response time and Attention also had significant influence on time to complete the task on Nested interface. Sustained Attention had a significant effect on Intuitive uses on Flat interface, and sustained Attention Reaction time and Visual transform response time had significant effect on

Intuitive uses on Nested interface. Visual transform had a significant effect on number of Errors on Flat interface, and sustained Attention had a significant effect on number of Errors on Nested interface. These results suggest that these aspects of CE function, which are affected by age-related cognitive decline, have again had an impact on the performance of older people. It would also appear that attention in particular is more important in using the nested interface than the flat interface.

Discussion

As expected, older people scored less on TF questionnaire, took more time to complete the tasks and used interfaces less intuitively. Furthermore, all age groups took significantly more time to complete the tasks on the nested interface, possibly because it required more actions to complete the tasks. On the flat interface only the oldest age group (73+) had significantly less intuitive uses than the younger groups, whereas on the nested interface all three age groups over 50 had significantly less intuitive uses. This finding supports existing data that suggest older people find nested interfaces more difficult to use (Detweiler, Hess, and Ellis, 1996; Docampo Rama, 2001b). The impact of attention on performance with the nested interface could provide an explanation for this. However, older people did not make significantly more errors compared to younger groups on both types of interfaces. This supports Processing-speed theory (Salthouse, 2010), which suggests that older people tend to trade speed for accuracy.

Surprisingly, the older age groups completed the tasks faster and used the interfaces more intuitively under the High stress condition. It could be that the High stress condition was inducing only an intermediate level of arousal, which can improve performance, rather than high levels of stress, which can decrease it (Yerkes and Dodson, 1908).

General Discussion

Our research has concurred with that of others (Langdon, et al., 2007; Lewis, et al., 2008; O'Brien, 2010) in showing that older people do indeed have more problems than younger ones in using contemporary products and interfaces. They are slower, make more errors and show less intuitive uses.

This research has begun to unravel the reasons behind these differences in interface use between older and younger people. We have found that older people are significantly less familiar with contemporary products than younger ones. However, when products that participants have not seen before are used, Middle aged people (40-59) as well as older people (60+) are significantly less familiar, whereas with products they own only older people (60+) differ significantly from younger ones (18-39). This suggests that middle aged people are able to become familiar with their own interfaces, but can still struggle when presented with a novel interface (Lawry, et al., 2011). Therefore, lower familiarity affects people from middle age onwards for novel products (Lawry, et al., 2011), and from early old age for products they own. We have developed a Familiarity Identification Tool (FIT) to assist designers and researchers in discovering familiarity of target users during the design process. This has been trialled and showed some success and is now undergoing further development.

The performance of older people with various interfaces (microwaves, body fat indicator and virtual pet tasks) is affected by decline in central executive function as well as lower familiarity (Blackler, et al., 2010a; Reddy, et al., 2010). This means that the older groups are struggling with two factors that make interface use more difficult – not only are they less familiar with contemporary interfaces, they also are less able to process information in working memory whilst using them.

Various design approaches have been recommended and used to attempt to make interfaces more usable for older people. We investigated two of these – redundancy and simplicity. Redundancy was less effective for the oldest age group, although it did make the tasks faster and more intuitive for middle aged people. The oldest group did better with the words only interface, while the youngest group was hardly affected by the different interfaces. This may be due to increased clarity and lack of clutter in the words only interface as compared to redundant interface, or it may be related to familiarity of different age groups with the mainly contemporary symbols used, or familiarity with use of symbols in interfaces per se.

Simplicity showed more expected outcomes – a flat interface was faster and more intuitive for all age groups to use, and older people were significantly slower and had less intuitive uses on the nested interface. However, there were no significant differences in error rates between the interfaces, and low level stress does not appear to have a detrimental effect on performance and may in fact be helpful. Therefore, while flat interfaces would appear to be the ideal, in a non-time critical task and when a flat interface is not possible due to space or other constraints, a simple nested interface that uses words only may be a suitable compromise. This may not allow fast and intuitive use but could be low in errors. However, the nested interface used in our experiment used only two options with up to three levels in each. This may be the level of simplicity required to get this kind of compromise to work.

Conclusion and further work

Designers need to stop assuming that all target user groups are familiar with all the interface elements that they may wish to apply. Older people are significantly less familiar with contemporary interfaces than younger ones, and they form an increasingly important group in the marketplace. Designers need to adequately understand the familiarity of all target users with potential interfaces. Our FIT tool should help them to do this.

Then they need to apply the users' knowledge to suitable interfaces. Redundancy, although often applied, may not be the answer to making interfaces more intuitive for the older age groups. Flatter interfaces may help as all participants in the interface complexity experiment used the flat interface more quickly. However, these may not always be possible and a compromise on a simple nested interface may not have too much impact on error rates, although it could impact on time and intuitive uses.

Further work is ongoing. More tools that can assist designers and researchers in discovering familiarity and applying it to interfaces are under development. These need to be more extensively tested in industry before they can be released.

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