Ageing, Technology Anxiety and Intuitive Use of Complex Interfaces

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Abstract. This paper presents the outcome of a study that investigated the relationships between technology prior experience, self-efficacy, technology anxiety, complexity of interface (nested versus flat) and intuitive use in older people. The findings show that, as expected, older people took less time to complete the task on the interface that used a flat structure when compared to the interface that used a complex nested structure. All age groups also used the flat interface more intuitively. However, contrary to what was hypothesised, older age groups did better under anxious conditions. Interestingly, older participants did not make significantly more errors compared with younger age groups on either interface structures.
Keywords: Prior-experience; Technology anxiety; self-efficacy; Intuitive interaction; Ageing; Complex Interfaces.

1 Introduction

Many older people have difficulties in using contemporary consumer products that have complex interfaces and extensive functionalities. Past decades have seen a substantial increase in the use of technology in all aspects of daily living. Inability to use contemporary technologies such as computers, mobile devices, the Internet, and ever increasing self-care medical devices puts the older population at a disadvantage in terms of their ability to live and function independently [1]. This research hypothesised that designing technological products that are more intuitive for older people to use can solve this problem. An intuitive interface requires minimal learning as it mostly relies on technology prior experience/familiarity of the users for effective interaction [2, 3].

However, gradual shift of consumer products from hardware-based to microprocessor controlled software-based technologies has brought a higher level of abstraction into interaction with products [3, 4]. Older generations, who grew up with relatively older technological paradigms, have been left behind. Although the use of technologies such as computers and the Internet is increasing among older people, an age-based digital divide still exists [1]. Research also suggests that older people encounter more difficulties when using interfaces that use complex (nested) interface structures compared with simple (flat) interface structures [5, 6]. Despite this a gradual move in product interface interaction towards touch-based input systems with small screens has necessitated extensive use of multi-layered interface structures.

Not being pace with contemporary technology or lack of technology prior knowledge could lead to low perceived technology self-efficacy, which in turn has the potential for causing technology anxiety. Both low domain-specific prior knowledge and technology anxiety can impede successful use of complex contemporary technological products[7]. In addition, some research [8] also suggests that stress, anxiety and oppressive environments are not conducive to intuitive thinking. However, what is not well understood is the impact of these conditions on intuitive use of a product. This paper discusses a study that investigated the impact of anxiety, complexity in interface structure (nested versus flat) and age on intuitive interaction.

1.1 Intuitive interaction

Interaction design professionals often feel that they understand what 'intuitive interaction' is; however, very few really define it clearly [9, 10]. In the context of interaction design, Blackler [9] and Hurtienne [11], based on their literature reviews of the nature of intuition, suggest that - intuitive use of product interfaces involves non-conscious use of user's prior-knowledge related to the product in use. In other words, the user is familiar (based on their earlier encounter with similar products or other relevant experiences) with different features and functions of the product [11, 12]. Intuitive use of an interface can be recognised by the following characteristics: It is fast and effortless, it is generally non-conscious and does not involve conscious reasoning [9].

1.2 Complexity in contemporary product interfaces

There is a gradual shift in most consumer products towards a touch-based interface paradigm. If this trend continues, it will not be long before most of the technology older people encounter in their day-to-day activities will be based on this interface paradigm. On a brighter note, recent research suggests that touch-based products are much easier to learn and older users could successfully use them regardless of their age-related cognitive or physical deficiencies [13-15]. Interestingly, Umemuro's [16] research on older people's aptitudes to computer found that the anxiety factor declined significantly in the touch screen condition. However, further research needs to be done in this regard to clearly establish which types of input devices are optimal for older people [17].

On the other hand, this shift to touch screen has also resulted in smaller screen sizes with little or no tactile feedback [18]. In addition, with increased functionality and small screen sizes, it has become necessary either to decrease the size of interface elements so as to fit them on the small screen, or to resort to some amount of nesting of the interface to fit all the functions of the device on the screen. Decreasing the size of text and icons will result in visibility and readability issues, especially for older people. Then again, a nested design, if its structure is too deep or complex, could increase the cognitive load on the users.

1.3 Breadth versus depth in interface design structure

Fundamental characteristics of menu structures have been well researched over the past couple of decades. In particular, tradeoffs between breadth (the number of options in a level) and depth (the number of levels) in menu structures have been extensively empirically investigated and analysed; for example: [6, 19-23]. Most of these studies agree that broad menu structures result in shorter times and better accuracy.

A flat/broad interface is one that has only one level of menu with all the options arranged in a grid fashion, as shown on the left in Figure 1. A nested/multi-layered interface has more than one level of menu. In a nested or multi-layered interface, menu options for the second level onwards are only displayed when one of the menu options in the first level is activated, as shown on right of Figure 1.

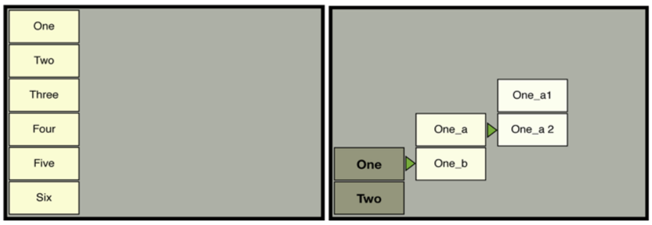

Figure 1: Broad/flat interface versus nested/multi-layered 2-choices and 3-levels menu system

Menu structure on mobile devices presents a different set of problems. Their screen sizes are often smaller and they usually use touch or pen-based interfaces. A study of preferences for menu structure of mobile devices found that participants preferred a layered (nested) rather than broad menu structure [21]. More specifically, they preferred a structured hierarchy with four to eight items per level.

Research suggests that older people encounter more difficulties when using interfaces that use nested/multi-layered structures compared with flat/broad interface structure [5, 6, 24]. They are also much slower using nested interfaces and tend to prefer shallower interfaces that offer better spatial orientation [19]. A nested interface, by its very nature, offers very few cues to the spatial location of different nested functions. Therefore, these types of interfaces impose a greater demand on the user's working memory. In general, working memory function deteriorates with age [1]. Research suggests that broad or flat structured interfaces rely much less on cognitive abilities and, hence, may be much more beneficial for older users [4, 6].

1.4 Anxiety, stress and intuitive interaction

Although anxiety and stress are known to interfere with intuitive thinking [8], there is no research available that clearly points to the impact of anxiety on intuitive interaction. Blackler's [2, 9] research investigating the hypothesis that intuitive use of products is based on prior experience with similar products did attempt to use the presence of anxiety in the participants as an indication of non-intuitive use. However, it was noted in the study that the psychophysiological tools used to measure heart rate and electrodermal activity (to indicate when participants were anxious) did not provide useful data due to latency issues. On the other hand, it was noted that there were occasions when, towards the end of the session, it was observed that the participants were making mistakes with features they had used correctly earlier. While causes of these moments were not ascertained, it was noted that they could be a result of anxiety or fatigue interfering with intuition [2, 9]. Overall, the outcomes of these experiments were inconclusive in terms of establishing a clear relationship between anxiety and intuitive use.

2 Method

2.1 Experiment design

The objective of this experiment was to investigate the relationship between age, anxiety, and intuitive use of complex interface structure (nested versus flat). The following hypotheses were framed to investigation this relationship.

1. Nested interface structure will have an adverse effect on time to complete the task, intuitive uses and errors on older when compared with younger participants.
2. Participants who score low on the Technology Prior Experience Questionnaire will also score low on the Self-efficacy Questionnaire and report high anxiety on the State-Trait Anxiety Inventory (STAI) questionnaire.
3. Anxiety, induced by stressful conditions, will have an adverse impact on the time to complete the task, intuitive uses and errors in both younger and older participants.

Table 1: Experiment design and Independent Variables

Independent variables	Levels of Independent Variables	
Interface type	Repeated measures (interface structure type)	
	Flat interface	Nested interface
Age	Young (17 to 34 years)	
	Older young (35 to 49 years)	
	Younger old (50 to 64 years)	
	Old (65 to 72 years)	
	Older old (73+ years)	
Anxiety	Low stress condition	
	High stress condition	

This experiment used a mixed-factorial design (Table 1). The Dependent Variables (DVs) for this experiment were *time on task*, *percentage of errors* and *percentage of intuitive uses*. Independent Variables (IVs) were, *interface type*, *age* and *stress* with their levels listed in Table 1. *Interface type* -flat or nested – was the repeated factor and *low* or *high* stress conditions were the between subjects factors.

2.2 Participants

Overall 54 participants (29 male, 25 female), in five age groups (17 to 34, n = 12; 35 to 49, n = 10; 50 to 64, n = 12; 65 to 72, n = 10; 73+ Years n = 10), between the ages 18 to 84 years (*M* = 54, *SD* 18) participated in this experiment. They were recruited from different sources to maintain a good sample of the general population. Individuals from organisations (for example, sports clubs, educational institutes, recreational facilities and retirement resorts) were asked if they could volunteer to take part in the study. All the participants were screened for visual acuity (corrected or uncorrected) using a Snellen chart. All participants were given a small gift as a token of appreciation (a $3AU worth scratch lottery ticket or coffee voucher) and were entered into a $200AU shopping voucher draw.

2.3 Apparatus and measures

Technology Prior Experience Questionnaire
This was a two-part questionnaire to capture participants' exposure to, and knowledge of, technologies related to the mediator product used for this experiment.

Self-efficacy Questionnaire
This questionnaire was based on a well-tested instrument to measure perceived general self-efficacy (GSE) that was suggested by Schwarzer, and Jerusalem [25]. For the specific self-efficacy (SSE), a short questionnaire, as suggested by Cassidy and Eachus [26] was used , SSE was specifically designed to measure perceived self-efficacy on using domain-specific technology.

STAI Questionnaire
The State-Trait Anxiety Inventory (STAI) is a self-evaluation questionnaire administered to measure level of state and trait anxiety [27]. A short form six-question questionnaire was used to measure current state of anxiety [28]

Mediator product
A touch-based device (iPad) was used as the mediator platform for the experiment. This decision was based on observing the increasing use of touch-based interfaces for consumer products. The mediator interface for this experiment was designed based on research [29, 30] that suggested that there was a significant negative correlation between visuospatial sketchpad capacity and time to complete the task and the number of errors. The number of controls in the mediator product for this experiment was kept at 5, to keep it within the visuospatial sketchpad capacity of an average older participant [31, 32] . Interface structure was kept at an optimal two levels [23]. At the same

time, the product interface was designed so that, to avoid floor or ceiling effects, it was not too easy for the younger and not too difficult for the older participants. The design of the interface and the task difficulty was established based on the outcome of two pilot studies. Overall 12 participants participated in the pilot studies in three age groups young (20-39 years), middle-aged (40-60 years) and old (61+).

The tasks for this experiment were designed to emulate a real-life, meaningful situation, as Hawthorn [33] suggests that involving the participants in the task is very important to gain meaningful data for the experiment. The task scenarios were based on the real life situation of pet sitting. Moreover, they provided enough interest for both younger and older participants during the pilot study. The tasks that participants were asked to perform were scripted to make sure all participants went through the same number of steps to complete them successfully.

Figure 2 illustrates the layout of the screen with different elements. Interface for the task was displayed only in black, white and greyscale. This was done to control any colour perception issues that the participants might have.

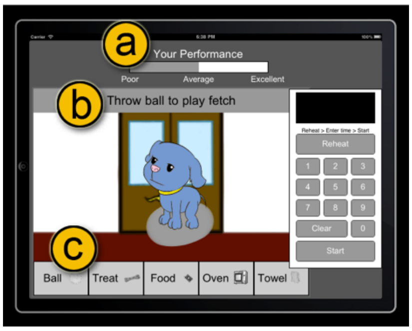

Figure 2: Screen layout: a) performance feedback bar b) message window and c) interface

Figure 3 illustrates the two repeated measures, flat and nested conditions. Each condition has 5 menu options. In the flat condition, all the five menu items were presented in a row at the bottom; in the nested condition, they were nested under two pop-up menus, one located on the right and the other one on the left bottom corner.

Figure 3: Flat and nested interface

Figure 4 illustrates the two between subject factors, *low* and *high stress conditions*. The *low stress condition* was induced through positive feedback provided through a bar located on the top centre of the screen. Similarly, *high stress condition* was induced through negative feedback provide through the feedback bar. Feedback was not tied to the actual performance of the participant. Depending on the condition (*low or high stress*) the performance bar changed its status (towards excellent or poor) at certain pre-determined milestones of the task. In the *low stress condition*, the feedback given was always positive, no matter what the actual performance of the participant was. Similarly, on the *high stress condition*, the feedback was negative no matter what the actual performance was.

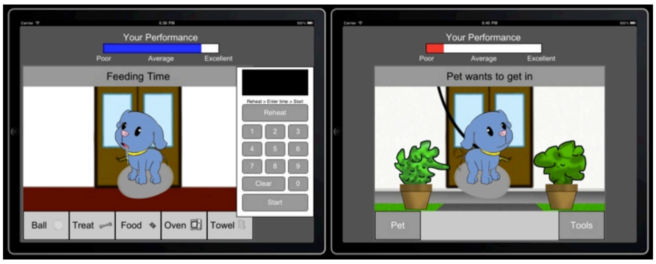

Figure 4: Positive feedback and negative feedback display bar on the top of the task window

Task sheet

Two task sheets were prepared that described the two task scenarios, Play and Walk, for the participants. They were asked to read the task scenario before they were asked to start on the tasks.

3 Procedure

The Experiment was conducted in a controlled laboratory setting. The whole experiment was scripted to make sure all the participants followed similar patterns of events, timing, sequence of tasks and instructions from the experimenter. Participants within each age group were randomly assigned to one of the stress conditions, and each completed two task scenarios (Play and Walk), one each on a flat and nested interfaces. To avoid sequencing effects, the tasks were counter-balanced by alternating the sequence of interfaces (flat and nested) and the two task scenarios (Play and Walk) on the device. Two cameras were used to record the experiment for later analysis using the Observer software. One camera was positioned to record participants' facial expressions and body language; the second camera was positioned to record tasks performed by the participant on the screen.

Once a participant was allocated to a group, they were introduced to the lab environment and experimental setup, and were screened for visual acuity using the Snellen chart. They were provided with the information package and consent form. Participants were also informed that they could stop the experiment at any time and could request the deletion of all the record of their participation.

Participants were then provided with the Technology Prior Experience Questionnaire followed by the combined General and Specific Self-efficacy Questionnaire. As not all participants were familiar with the mediator platform (iPad), they were asked to use a simple calculator application on the platform to get a feel for the device. This was also done to ensure that the seating and the position of the device was comfortable for the participants, as it was observed during the pilot study that some of the older participants were bothered by the glare that could occur when the device was placed at certain angles and positions.

Once the participants were comfortable with the setup, they were provided with the STAI Questionnaire and were asked to complete it based on their current state. Then after this they were given the Task 1 scenario sheet, and after making sure they understood what was expected of them, they were asked to start on the task.

After completing Task 1, they were provided with the STAI Questionnaire for the second time to record their current state of anxiety. Once they completed the STAI, they were provided with the Task 2 scenario sheet. After making sure they understood what was expected of them they were asked to start on the Task 2. Soon after completing the Task 2 they were asked to complete the STAI Questionnaire for the third and final time.

After the participants completed the third STAI Questionnaire, they were debriefed. This was especially needed for the participants in the high stress condition, as some tended to get a bit upset with their performance. It was explained to them that the performance bar was rigged and was not a reflection of their actual abilities or performance.

3.1 Data analysis

The dependent variables *time on task, percentage of intuitive uses, and errors* were central to this experiment. *Time on task* is an important indicator of intuitive use. As 'Intuitive interaction' is defined as fast and generally non-conscious [9]. *Time on task* and *errors* were relatively easy variables to measure. On the other hand, collecting data on actions that are non-conscious was much more challenging. Data on intuitive use was acquired based on observations using Noldus Observer software. Section 3.2 describes heuristics for coding different IVs. The data from the Observer application, the questionnaires and the CogLab application were later exported into statistical analysis software (SPSS) for analysis.

3.2 Coding heuristics

The coding heuristics were based on earlier studies of intuitive interaction [12]. There are altogether seven codes used for coding the tasks in this experiment. Data from four of these codes are presented in this paper.

Time on task: This code records a start and finish time and calculates time on task.

Intuitive use: As intuitive process does not involve conscious reasoning, it is one of the most difficult codes to operationalise [9, 34]. Blackler [12], based on her work on the nature of intuitive interaction, suggests that an intuitive use can be recognised by five indicators: 1) Lack of evidence of conscious reasoning (An intuitive use is often based on very fast decision making with no evidence of reasoning. There is often a lack of verbalisation and, at times, verbalisation follows an action.); 2) Expectation (Participants with very specific prior knowledge about the event are certain about the outcome of their actions.); 3) Subjective certainty of correctness (Confidence of participants executing an event.); 4) Response latency (When a participant executes an event quickly without hesitation.); and, 5) Prior knowledge (When participants indicate their earlier encounter with a similar event). All of this information was extracted from audio video recording of the tasks.

An event was coded as *intuitive use* only when a participant showed two or more of the above indicators [9]. The most certain way of recognising an intuitive use is when an event is executed quickly without hesitation, and when verbalisation follows the action. However, in a study such as this where participants with very diverse sensorimotor and cognitive abilities are involved, it becomes difficult to establish a baseline for both of these indicators. It is well established that ageing slows down motor responses and this slow-down is not linear [35]. In other words, two people might share the same chronological age but may have very different reaction times. These issues were resolved by establishing a baseline response time for each participant. Each participant's observational data was coded multiple times until the differences between *correct non-intuitive use* and *intuitive use* was clearly recognisable. To further minimise coding errors, two independent experienced raters coded the audio-visual recording. An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency of coding *for intuitive use* between the two raters. The inter-rater reliability for coding intuitive uses by the two raters was found to be Kappa = .77 ($p < 001$). Kappa values between 0.60 to 0.79 are considered to indicate substantial agreement between the raters [36].

Correct non-intuitive use: Participant completed an event successfully with the use of reasoning or when they had learnt from earlier error. Use of reasoning is indicated by: hesitation in action, latency between the exposure to the event and response, and verbalisation preceding the response.

Error: This code was used when a participant was unable to complete an activity. Indicated by their using a wrong function or overlooking it.

4 Results

The results are organised into two sections: one will look at the effects of different measures used in this experiment; and other presents the relationship between the *type of interface*, *anxiety* and DVs.

4.1 Effects of different conditions and measures used in the experiment

Technology prior experience

Older people were much more diverse in their capabilities and exposure to the technology. Younger people tended to score much higher on technology prior experience score and were also much more homogenous in their capabilities, 17 to 34 years (*M*= 46 , *SD* = 4 , N = 12), 35 to 49 years (*M*= 43 , *SD* = 6.3 , N = 10), 50 to 64 years (*M*= 36.4 , *SD* = 8 , N = 12), 65 to 72 years (*M* = 36.6 , *SD* = 7.2 , N = 10), 73+ years (*M* = 34.4 , *SD* = 14.8 , N = 10).

Effect of stress condition on reported state anxiety

Before proceeding to analyse the rest of the data it was important to check if the method used for inducing stress had the planned effect on the participants. A two-way ANOVA with 5 age groups and two stress conditions as it factors revealed that there was a significant effect of *age* [$F(4,44) = 3.73$, $p = .011$, $\eta_p^2 = .25$] and *stress condition* [$F(1,44) = 6.45$, $p = .015$, $\eta_p^2 = .13$] on the *anxiety* reported on STAI Questionnaire. There was no significant interaction between the *age* and *stress conditions* [$F(4,44) = 0.75$, $p = .561$, $\eta_p^2 = .064$]. A TukeyHSD post-hoc test revealed a significant difference between age groups 35 to 49 and 73+ years ($p = .016$). Except for the 35 to 49 years age group, all other groups reported more *anxiety* on *high stress condition* compared with *low stress condition*. Overall, the method used for inducing stress appears to have worked to a large extent..

Perceived self-efficacy, technology prior experience and anxiety

As anticipated, participants with low technology prior experience (TP) had reported low perceived specific self-efficacy (SSE) and high anxiety on the STAI. Although there was a significant correlation between perceived general self-efficacy (GSE) and technology prior experience (TP), [r (52) = .453, $p = .001$] between GSE and SSE [r (52) = .526, $p < .001$] and between SSE and TP [r (52) = . 650, $p < .001$] there was no significant correlation between the perceived GSE and *anxiety* [r (52) = -.172, p = .212] or between TP and *anxiety* [r (52) = -.198, $p = .151$]. On the other hand, SSE had a significant correlation with reported anxiety [r (52) = -.269, $p = .049$].

Overall, TP has a significant positive correlation with both the SSE and GSE and, SSE has a significant negative correlation with the reported anxiety. In other words, participants with more TP reported higher SSE and participants with higher SSE reported lower anxiety on the STAI.

Interface structure

It is also important to stress that the nested interface requires a higher number of responses (*M* = 22, *SD* = 7.3, N= 54) from participants, when compared to the flat interface (*M* = 16, *SD* = 4.5, N= 54). The nature of the nested interface is such that the controls are accessed through two pop-up menus and the additional action of using this two menu controls increases the number of responses needed to complete a task.

4.2 Age, Type of Interface, Anxiety and DVs

All ANOVA analyses reported in this section are three-way, *interface type* (flat, nested) x *age* (18 to 34 years, 35 to 49 years, 50 to 64 years, 65 to 72 years and 75+ years) x *stress condition* (Low, High), mixed factorial design, with *interface type* (flat and nested) as the repeated measure factor.

Time to complete the task

Due to the violation of homogeneity revealed by Levene's test, for flat interface [$F(4,49) = 12.72$, $p < .001$], and nested interface [$F(4,49) = 12.09$, $p < .001$], a strict alpha of .025 was used for this analysis [37]. A three-way mixed ANOVA showed that there was a significant effect of *interface type* on *time to complete the task* [$F(1,44) = 24.53$, $p < .001$, $\eta_p^2 = .36$] (Figure 5). Participants took significantly more time to complete the task on the nested interface (M =134 seconds SD = 71) when compared with the flat interface (M =102 seconds SD = 40).

Age also had a significant effect on *time to complete the tasks*: $F(4,44) = 26.69$, $p < .001$, $\eta_p^2 = .71$. TukeyHSD post-hoc test revealed that the 73+ years age group took significantly more time to complete the task when compared with the four younger age groups ($p < .001$). The age group 65 to 72 years also took significantly more time than the youngest (17 to 34 years) age group ($p = .003$). There were no significant differences between the three younger age groups.

There was a significant *interface type* by *age* interaction: $F(4,44) = 3.63$, $p = .012$, $\eta_p^2 = .25$. This shows that the *time to complete the task* in age groups differed between the flat and nested interfaces. To break down these interactions, contrasts were performed comparing different age groups between nested and flat interfaces. *Type of interface* had a significant effect on the 73+ ($P < .001$) and 65 to 72 year age group (p .013). Both of these age groups took more time to complete the task on the nested interface when compared to the flat: 65 to 72 years (flat M = 106 seconds, SE = 10, nested M = 149 seconds, SE = 15) and 73+ years (flat M = 154 seconds, SE = 10, nested M = 234 seconds, SE = 15).

There was also a significant *interface type* by *stress condition* interaction: $F(1,44) = 5.68$, $p = .021$, $\eta_p^2 = .12$. This indicates that the time to complete the task on both interfaces differed between stress conditions. Contrasts revealed that the time to complete the task on the nested interface differed significantly between High and Low stress conditions ($p = .012$). On the flat interface there was no significant time difference between the Low (M = 101 seconds, SD = 47) and High stress (M = 103 seconds, SD = 33) conditions. Interestingly, on nested interface, participants took significantly less time in High stress condition (M = 120 seconds, SD = 48) when compared with Low stress condition (M = 149 seconds, SE = 86).

There was also a non-significant (due to violation of homogeneity) interaction between *age* and *stress condition:* $F(1,41) = 2.78$, $p = .032$, $\eta_p^2 = .21$. Although the interaction was not significant, it is mentioned here as the effect size is very large. This interaction indicates that the effect of stress differed between the age groups. Figure 5 shows these differences clearly. On both stress conditions (Low Figure 5A, High Figure 5B) all age groups took most time to complete the task on the nested interface. As can be seen, the oldest age groups took a lot more time to complete the tasks on both interface types; also, the time differences increased between the nested and flat interfaces. Differences between the other three age groups were not significant.

Interestingly, in the high stress condition, the younger age group (17 to 34 years) took less time on the nested interface compared to the flat interface under High stress condition. Moreover, older age groups took a lot less time to complete the task on both interfaces under High stress condition compared with Low stress condition.

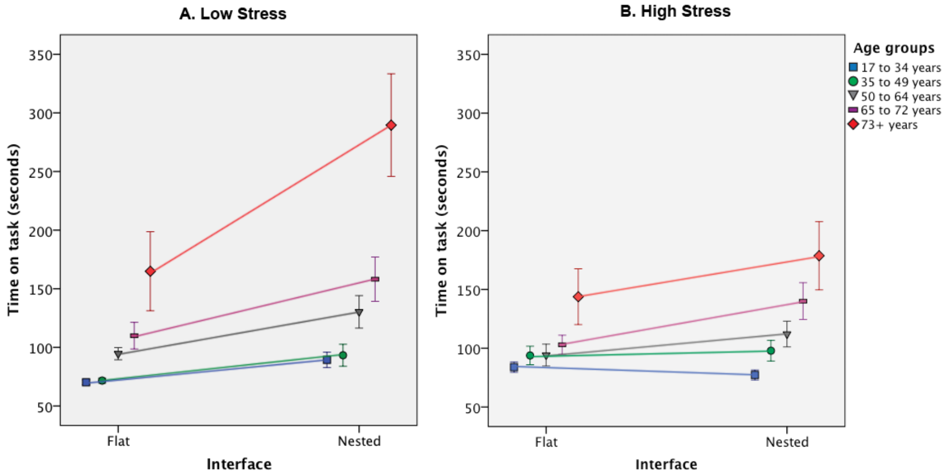

Figure 5: *Time to complete the task* on flat and nested interfaces under A) Low stress and B) High stress condition.

Percentage of intuitive uses

A three-way mixed ANOVA with *percentage of intuitive uses* as one of its factors revealed a significant effect of *type of interface* [$F(1,44) = 4.45$, $p = .041$, $\eta_p^2 = .09$] on *percentage of intuitive uses*. This indicated that the participants used flat interface ($M = 17$, $SD = 7$) more intuitively when compared with nested interface ($M = 15$, $SD = 8$).

Age had a significant effect on *percentage of intuitive uses*: $F(4,44) = 5.33$, $p = .001$, $\eta_p^2 = .33$ (Figure 6). TukeyHSD revealed that the age effect was significant between the age groups 17 to 34 and 65 to 72 years ($p = .008$), 35 to 49 and 65 to 72 years ($p = .004$), 35 to 49 and 73+ years ($p = .048$). There was no significant difference among the older three age groups.

There was also a significant three-way interaction between *interface type* by *age* by *stress condition*: $F(4,44) = 2.97$, $p = .029$, $\eta_p^2 = .21$. This indicates that the *interface type* by *age* interaction was different for Low and High stress conditions. Contrasts were performed to reveal the *age* by *interface type* interaction under Low and High stress conditions. These revealed that in Low stress condition (Figure 6A) age had a significant effect on both flat , $F(4,22) = 3.38$, $p = .027$, $\eta_p^2 = .38$, and nested, $F(4,22) = 6.36$, $p = .001$, $\eta_p^2 = .54$, interfaces.

A pairwise comparison using Bonferroni correction revealed a significant difference between the age group 35 to 49 and 65 to 72 years on flat interface, $p = .031$. There was a significant difference between the 35 to 49 and 50 to 64 ($p = .013$) age groups, and between the 65 to 72 (p = .003), and 73+ (p = .003), age groups on nested interface. Basically, the 35 to 49 age group's behaviour was a mirror image of the rest of the age groups (Figure 6A).

In High stress condition (Figure 6B) the effect of *age* was significant for nested interface [$F(4,22) = 3.85$, $p = .016$, $\eta_p^2 = .41$]. A pairwise comparison using Bonferroni correction revealed no difference between age groups on the flat interface (Figure 6A). However, there were significant differences between the 17 to 34 and 65 to 72 years (p = .025) age groups, and between the 17 to 34 and 73+ (p = .049) years age groups on Nested interface.

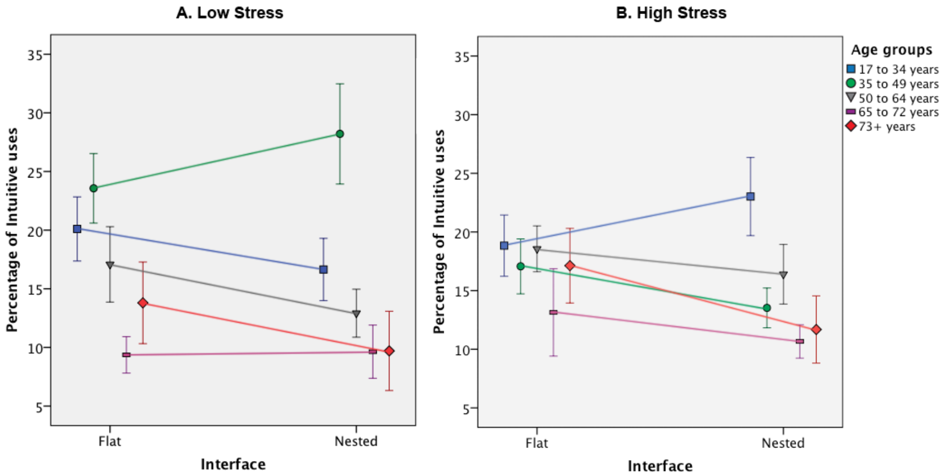

Figure 6: *Percentage of intuitive uses*, *interface type* and *age* under A) Low stress B) High stress conditions.

Interestingly, similar to the results for *time on task*, older age groups did better under stressful conditions. The 50+ age groups used both types of interfaces more intuitively under the High stress condition.

Percentage of errors

Age had a significant effect on the *percentage of errors*: $F(4,43) = 3.11$, $p = .025$, $\eta_p^2 = .22$. Overall, older age groups made more errors on both types of interfaces when compared with the younger age groups. However, the *type of interface* had no effect on errors made (Figure 7).

There was a significant interaction between *age* and *stress condition*: $F(4,43) = 2.64$, $p = .047$, $\eta_p^2 = .20$. This indicates that the *percentage of errors* made between age groups differed between the Low and High stress conditions. Contrasts revealed that in Low stress condition (Figure 7A), age had a significant effect on use of the flat interface: $F(4,43) = 4.94$, $p = .002$, $\eta_p^2 = .31$. A pairwise comparison using Bonferroni correction revealed that significant differences were only observed between the 35 to 49 and 65 to 72 years age groups with the flat interface (p = .001).

Under Low stress condition on the flat interface, the 65 to 72 years (*M* = 17, *SD* = 7) age group made substantially more errors compared to the 35 to 49 year (*M* = 3, *SD* = 2) age group. Similar to other DVs, older age groups appear to have done better under High stress condition when compared with Low stress condition.

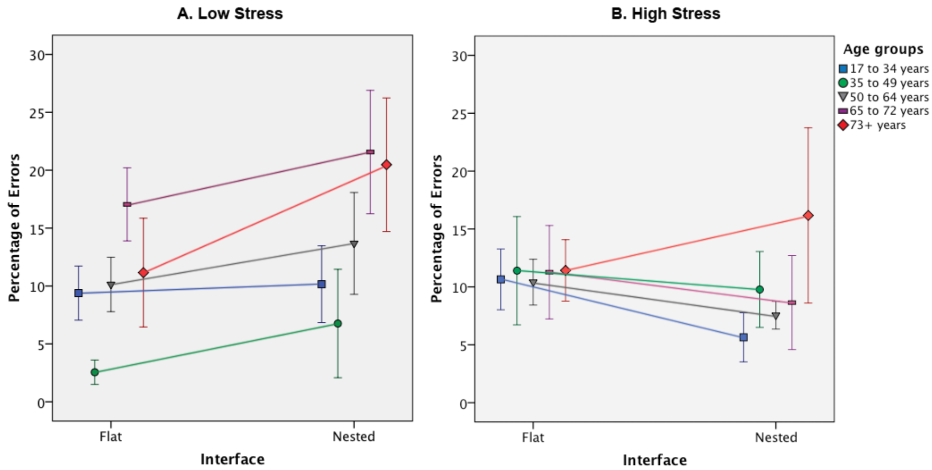

Figure 7: *Percentage of errors*, *interface type* and *age* under A) Low stress and B) High stress conditions

5 Discussion

This experiment was designed to investigate the relationships between *age*, *anxiety*, and *intuitive use* of complex interface structure (nested versus flat).

As hypothesised, people who scored low on Technology prior experience (TP) and Specific Self-efficacy (SSE) reported higher anxiety. This supports the research that suggests a relationship between age, cognitive decline, technology adoptions, self-efficacy and technology anxiety [38, 39]. Similarly, all age groups took significantly more time to complete the tasks on the nested interface when compared with the flat interface, probably because the nested interface needed more actions to complete the task. However, these differences between nested and flat interface use increased with age. Age also had a significant effect on time to complete the tasks on both types of interface. All age groups used the flat interface more intuitively compared with the nested interface. This finding supports existing data that suggests that older people find nested interfaces more difficult to use [5, 6].

Contrary to what was hypothesised, although older age groups made more errors, there were no significant differences in error rates between use of the nested and flat interface types. Similarly, anxiety had different effects on the younger and older age groups. Older people (65+) reported more anxiety than both the younger age groups. This supports Eisma et al.'s [7] research which suggests that older people may experience more anxiety when they interact with new technologies. However, surprisingly, the performance of the two older age groups was better in the high stress condition. These groups completed the tasks faster and used the interfaces more intuitively under the high stress condition.

This supports Attentional control theory [40], which suggests that anxiety affects processing efficiency more than performance effectiveness. In other words, highly anxious individuals, under stressful conditions, trade time for accuracy in achieving their goal. They also use increased effort and more working memory resources. However, if the task does not overwhelm available resources, increased effort on the working memory resources actually enhances the performance. Since the experiment tasks were designed to be only moderately difficult, high stress condition did not induce high enough levels of anxiety to have a catastrophic effect on the older age groups' performance. This could be explained by the inverted U-hypothesis of anxiety-performance, which states that, for any given task optimal performance is achieved at some intermediate level (the peak of the inverted U) of arousal. Performance starts deteriorating as the level of arousal increases or decreases from its optimal level. This could be the most probable reason behind the performance increase in the older age groups under high stress condition.

The behaviour of the 35 to 49 years age group under stressful condition was different to that of the other age groups. Unlike other age groups, they reported low anxiety on high stress condition and high anxiety on low stress condition. However, while they performed better in a high anxiety state as older age groups did, their performance was opposite to that of the older age groups since they experience high anxiety under low stress condition. This behaviour did pose a few challenges in interpreting the results. For example, ANOVA showed that age had a significant effect on number of errors. However, contrasts showed that the difference was significant only between the 35 to 49 and 65 to 72 year age groups. The probable cause of this difference was that the 35 to 49 years age group made a lot fewer errors on low stress condition, whereas the other age groups did not differ that much. One of the possible reasons for the peculiar behaviour could be, as noted by Kosnik, Winslow [41] study of the perception of vision related problems through adulthood, middle-aged people are more concerned about age-related changes that start becoming noticeable at this age. This behaviour of the middle age group needs further investigation.

The findings from this experiment also support Processing-speed Theory [42], which suggests that older people tend to trade speed for accuracy. Although older people took more time to complete the tasks compared to younger people, overall they did not make significantly more errors than younger groups on both types of interfaces. However, as discussed earlier, middle-age groups differed significantly from the 65 to 72 year age group.

Overall, older people scored lower on technology prior experience, took more time to complete the tasks and used the interfaces less intuitively. However, the number of errors is one of the most crucial indicators for successful use of a product interface. This data suggests that when the interface is designed with consideration of the cognitive limitations of older people, the differences in its use among age groups can be minimal. Apart from the oldest age group (73+) the differences in terms of intuitive use of the interface were not significant. This supports research which suggests that working memory deficiencies in ageing are mediated by coping mechanisms adopted by older individuals, especially when the task is simple [43]. Surprisingly, although most of the older participants had never used an iPad (mediator product for this experiment) they were at ease in using it. This supports recent research on touch-based products that has made similar observation [13, 15].

6 Conclusion

This experiment was designed to investigate if complexity of interface, in terms of its structure, has any impact on older users under high and low Stress conditions. The tasks used in this experiment were designed to consider older people's cognitive limitations. The outcome showed that, as expected, older people took more time on the nested interface compared to the flat interface. However, the type of interface structure had no significant effect on errors made. In addition, the age differences in terms of errors made were also minimal, except for the oldest age group (73+), who were significantly slower and used the interfaces less intuitively. Furthermore, contrary to what was hypothesised, older age groups, although they reported higher anxiety levels, did better under high stress conditions.

This research is significant as the findings from this study demonstrated that, age differences are minimal when complex interfaces are designed to accommodate age related cognitive limitations (Section 2.3), Technology anxiety played positive role in use of interfaces in older people and, older people are at ease in using products with touch based interface. Based on these findings and related research, we are currently developing an adaptable interface framework for inclusive design that takes advantage of flexibility afforded by touch-based interfaces.

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