Cognitive Aspects of Ageing and Product Interfaces: Interface Type

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Abstract. Twelve users with a range of ages between 20 and 70, were assessed for their cognitive capabilities and degree of experience with microwave cooker features and then trialled with two microwaves, one with a dials interface and the other with a buttons interface. The users were provided with a set of tasks to complete with each microwave. It was hypothesised that all users would perform better with the dials model but that the difference in performance between dials and buttons would become more pronounced as age increased. This was found to be the case in comparing the performance from the trials, with the strongest correlation occurring between the users age and the time taken to complete the tasks.

Keywords: inclusive design, product design, cognition, learning, product experience.

1 Introduction

A previous study examined the effects of ageing, generation, cognitive ability and previous experience on their ability to use both a motor car and a digital camera [1]. The products were deliberately chosen to be significantly different. Performance of the products was measured by the time taken and errors produced by a sample of users completing set tasks. There was evidence to support the theories of deterioration with ageing and step changes for generational effects but the strongest evidence indicated a relationship between degree of previous experience and performance.

The experiment discussed in this paper addresses the conclusions reached from this previous study [1] as well as a background understanding of inclusive design and cognitive psychology to examine the age-related effect of type of user interface.

1.1 Inclusive Design

In 2020, more than half the population of the UK will be over the age of 50 and the over-80 range will be growing the most rapidly [2]. In order to meet the ideals of inclusive design, a designer must create a product that minimises the number of people excluded or who experience difficulty with a product [3]. Whilst inclusive products reduce the difficulties suffered by the elderly and those users with

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disabilities, the products often attract those without either. Work from similar fields to inclusive design has characterised specific impairments as well as produced guidelines for specific product types [4], [5]. However evidence exists that product designers will ignore this form of guidance in favour of more concise advice [6].

Researchers in inclusive design have found helpful the use of simulation kits in conveying the effects of physical and sensory impairments to designers [7]. However, by their nature, cognitive impairments are significantly more difficult to accurately simulate than motor or sensory impairments. A primary area of concern, for example, is how the properties of memory affect the learning of a products use and the ability of individual users to transfer learning from prior experience. Inclusive design theory promotes consideration of both the properties of the products' interfaces and the users' capabilities, when seeking design improvements.

1.2 Memory and Learning

The development of the knowledge a user brings to a new product is provided by their ability to acquire, store and retrieve past experience. An overview model based on the human information processing approach to cognition would include memory functions such as Sensory memory; Short term memory (STM), Working Memory (WM); Long Term Memory (LTM), as well as LTM memory models implying organising processes, such as Schema; Semantic, Episodic, and Prospective Memory. Following current models, such as that of [8], it would also assume an Executive function as part of working memory. According to generally accepted theory, [8] the WM has a duration of between 10-15 seconds, has a limited capacity for information of around five to seven items and is organised by different modalities of storage such as visual-spatial and auditory-verbal. The WM can hold sufficient, separate items for further consideration from either perception, memory or other input sources. It is thought to consist of three components:-

- a central executive to divide attention amongst the required tasks
- a phonological store and articulatory loop for verbally based information
- a visuospatial sketch pad for organised, visual information.

1.3 Previous Experience and Training Transfer

New products rarely are designed that make no reference to products that have gone before and of which users will have no experience. The more experience a user has of similar products, the quicker they will learn the operation of a new product.

Training transfer research has looked at the relationship between the similarity of a user's training to the actual task to effectiveness of training. For example, a flight simulation will provide an improved training performance over studying a video of a pilot at work [9]. This can be counter productive if the training product is too similar to the actual product and acquired accepted behaviour on the training product represents an error on the actual product. In the product design world, the designer may change the function of a button on an interface from one model to another causing experienced users proactive interference, or failure to learn the function of that button when using the later model.

1.4 Generational Effects

Previous work has shown that ubiquitous, existing symbolgies across product families are only noticed by some generations [10]. Studies in the Netherlands have explored this further by outlining technological generations. These consist of the time era during which one was born and the interface technology that was experienced untill the age of around 25 [11]. The electro-mechanical era can be considered for people born pre-1928, 1928-1964 sees the remote control era, 1964-1990 is dominated by displays and post 1990 layered menu systems are generally prevalent and popular.

1.5 Past Work and Research Questions

Furthering the work of the previous study [1], individual interface elements were to be examined in anticipation of further evidence of ageing and generational effects. Two functionally equivalent microwave interfaces were chosen to be examined; one with a dials interface and the other with a display-button interface (fig. 1). It was anticipated that all age ranges would perform better with the dials interface due to the reduced complexity offered by this model. However, the difference in performance between the two models would increase with age with a possible generational effect in the over 70 age group.

Capability variation with task difficulty was expected to be subject to the following influences:-

- An experience effect: The degree of previous experience with the same and similar products;
- A generation effect: The age of the users and specific technology generations;
- An ageing effect: The gradual decline of learning and cognitive abilities with age;
- A cognitive capability effect: The ability of users as measured by a variety of tests of individuals' general and specific cognitive capabilities.

Fig. 1. The interfaces of the microwaves tested (a) dials and (b) buttons

2 Method

The users were selected to cover the age spectrum with a representation in each age decade band. Six male users and six female users ranging from 21 to 68 were tested. Users were informed throughout the trial that it was the purpose was to test the products' performance through different age categories and not to comparatively measure their personal performance. They were also informed of their entitlement to stop the trial at any stage and have any records deleted. The detailed methodology followed the codes of practice of the British Psychological Society [12].

2.2 Cognitive Assessment

The users each completed a short, 15-minute cognitive test [13] that provided sub scale scores for: Verbal, Mathematical ability, Spatial, Logic, Pattern Recognition, General Knowledge, STM, Visualisation and Classification. For convenience these were amalgamated into five categories: Perceptual, Reasoning, STM and LTM and a Combined-Cognitive-Score (CCS). Users were informed that should they not know the answer to a question they could either pass on it or guess at a solution. The assessment contained a normalising age correction factor on the sub-scales. Since one of the factors under investigation was ageing, this factor was deemed inappropriate and each solution set was calculated without correction. This combined, uncorrected scale is denoted by the acronym CCS20.

2.3 Experience Testing

Users also completed a short experience test to quantify their microwave knowledge. The test comprised five questions on symbol recognition with symbols taken from the both the microwaves tested and also other products. This was followed by 10

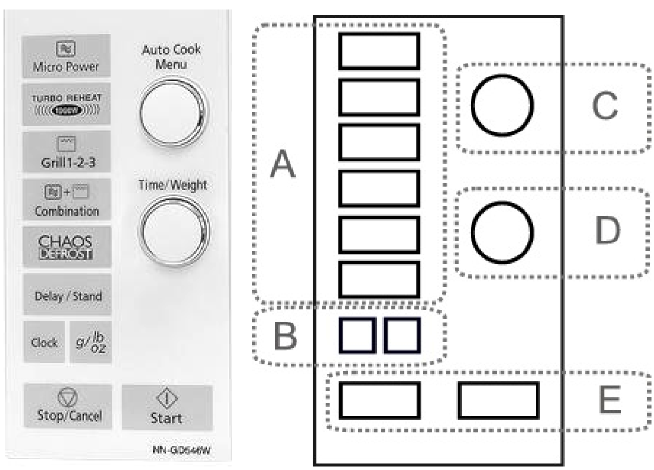

Fig. 2. Sample from Microwave Experience Test showing Interface and schematic

questions relating to button position and symbol recognition combined. A picture of a microwave was shown alongside a schematic diagram of the button layout (fig. 2). The schematic diagram grouped the buttons into lettered regions and five questions were asked relating to which button group the user would select for a particular task. This was repeated for a second microwave, both different from those tested. The test was not under timed conditions and the different sections were completed separately.

2.4 Products

The microwaves tested were both Goodmans, models; M20S and ME20S. They were essentially the same microwave with the exception of the control panel interface that for the former was two circular dials and for the latter, a buttons interface with ten numbered buttons, three function buttons and two further buttons representing activate and cancel (fig. 1). They were priced at the lower end of the range offered by a UK chain electrical retailer, with the buttons model slightly more expensive.

2.5 Segmentation and Errors

The time required for each user action was recorded by studying the video recording and managed on the basis of: retrospective protocols; observation of the video recording; observation of evident task boundaries. Users were provided with the different tasks on different pages of a paper folder. The tasks times were easily determined by recording the times upon which the pages were turned. Further information was gained from comments in the retrospective protocols.

Additionally each user action was assessed as to whether it constituted an error. An ideal sequence of events was created and users' actions were compared to this. Actions that changed the state of the microwave further away from a status than that requested by the current task were deemed errors. Unnecessary actions were also recorded as errors.

2.7 Trials

The task list supplied to the users is shown in fig. 6. The users were asked to complete the two written tests before the trials. The order of the testing microwaves was alternated to avoid any ordering effect. Task 1 was the only task that had an identical procedure for successful completion as it relied upon the user noticing the handle which is true for both microwaves. After the completion of the trial the users were shown the video recording of their trial. They were asked to provide a spoken protocol describing their performance and explaining their interpretation of their mental process during the task. The researcher remained silent during this but asked follow-up questions relating to anything that remained unclear. The users were debriefed after the follow-up period and offered to opportunity to discuss the study.

3 Results

3.1 Cognitive Ability Analysis

Figure 3 shows the relationship of CCS20 with Age. As anticipated CCS20 declines with increasing age, this is more prominent as the age correction factor had been removed.

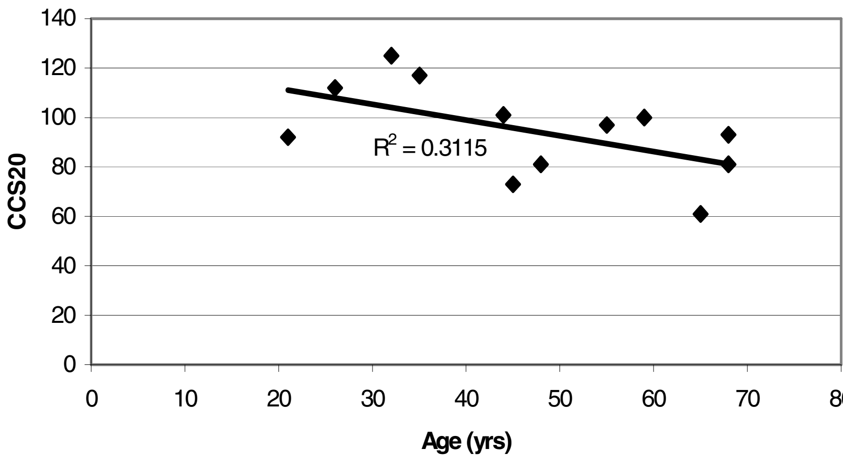

Fig. 3. CCS20 Distribution with Age

3.2 Experience Analysis

The Experience scores were weighted so that the results from the symbol recognition were worth twice the value of the combined symbol recognition and position questions. There was no significant correlation with either Age (R= 0.405) or CCS20 (R=0.286).

3.3 User Performance

The users' performances were analysed by examining the completion times and the number of errors for the trial. Users were limited to 3 minutes per task and in the situation when a user gave up, this resulted in them being awarded the full 3 minutes as their time taken. This penalty was not added where the user had falsely assumed they had completed the task. Completion of tasks was also recorded as a separate measure.

Time taken and age produced good correlations with both microwaves (fig. 4) as indeed was the case for time taken and CCS20 correlation (Dials R=-0.539, buttons R=-0.626). Errors produced no significant correlation with either age (Dials R=0.306, buttons R=0.235) or CCS (Dials R=-0.424, buttons R=-0.014).

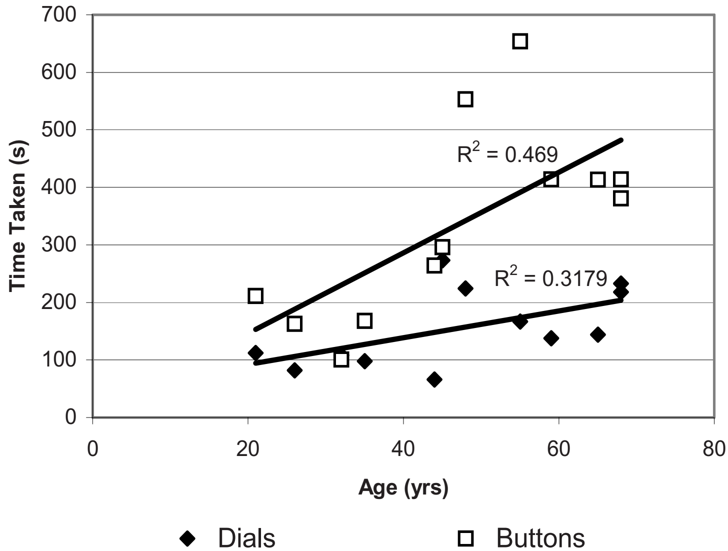

Fig. 4. Relationship of Time Taken (s) with Age

Figure 5 below shows the far lower correlation of the time taken performance measure with the experience score.

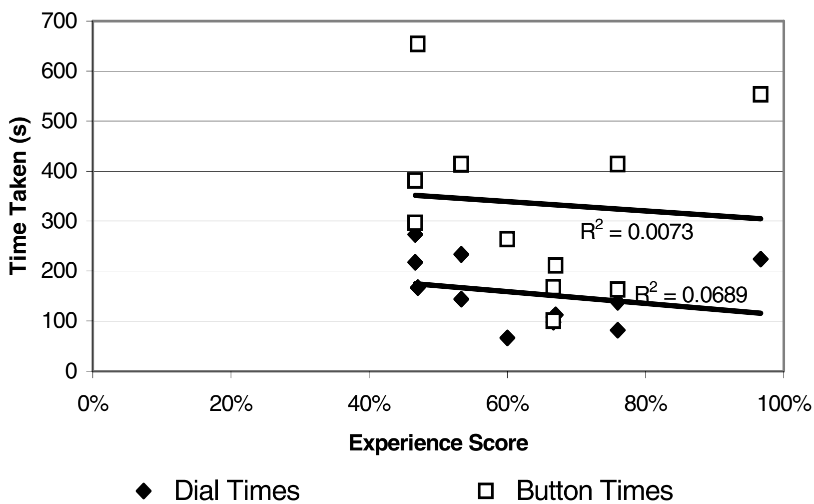

Fig. 5. Distribution of Time Taken(s) with Experience Score

A task breakdown is provided in Figure 6 for the averaged task times;

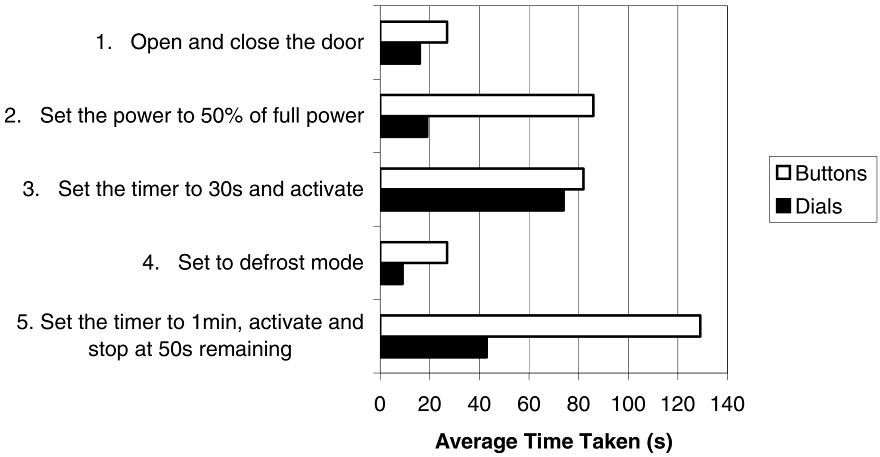

Fig. 6. Average Task times (s) for the dials and buttons

4 Discussion

The users' cognitive scores are as expected with the cognitive ability declining with age. In previous work this has offered a closer correlation [1] but there is a clear downward trend in Fig. 3. Fig. 4 shows the relationship between time taken and experience. In the previous study [1] the relationships between experience and the time taken offered the strongest correlations. Either the relevance for previous experience when using a new microwave is less than for digital cameras and cars or the differences in testing procedure have cause this result. Whereas previously an experience questionnaire had been used to assess product prior experience, for this trial users are subjected to a more specific interface features test. It is conceivable that a user may have shown a high knowledge of microwaves but perform badly in the trials. Indeed, the highest experience-scoring participant did not own or regularly use a microwave.

The strongest result from the trials is the relationship of time taken and age. The lower complexity in the dials model provides predictably shorter times for completion and a higher completion rate. The steeper trend line for the buttons model shows that the ageing effect predicted is present with an increasing difference between users' dials and buttons times.

In the previous study [1] it was noted that with no time pressure to complete the task there was no evidence of users trading speed against accuracy. In that study there was positive correlations of task times with errors. However, in these trials there is very little correlation. This may be accounted for by considering users' strategies. Some users were noticed attempting as many solutions as possible in the hope that they would chance upon the correct one. Others tended to rely on a more systematic strategy, studying the interface, looking for cues to the correct option. Both approaches can be seen to be effective but overall result in a poor correlation of times and errors. Those users with a higher overall cognitive score were faster at achieving the correct sequence of actions. Considering the sub-scales and time-taken; LTM offered no correlation, Perception and Reasoning provided reasonable correlations and STM provided a very strong correlation (Dials R=-0.701, buttons R=-0.773). The buttons model makes high demand on WM as sequences of buttons need to be remembered as well as the effects of sequences already attempted. The higher complexity of the buttons model fits the higher correlation for this model and STM relationship.

Fig. 6 shows that not all tasks fit the same pattern for the two microwaves. Task 1 was identical for both microwaves and the slightly higher result for the buttons model is likely to be due to chance. For Task 2, the dials model has one of its two dials dedicated to setting the power and users very quickly established a 50% setting. The buttons model required the user to recognise the power symbol and then press it repeatedly to decrease its displayed value. Many users opted for the incorrect solution of entering a numerical setting. This, therefore, took them notably more time to successfully complete. Task 3 took the longest of all the tasks for the dials model. The dial labeling was in minutes and many users struggled to accurately select the short time of 30 seconds. For the buttons model, the user had to first select the power and then enter a numerical time in a digital display.

Task 4 required a similar solution as task 2 for the dials model as the “power” dial needed to be moved to the lower setting adjacent to a defrost symbol. On the buttons model there were two buttons marked with the defrost symbol and simply pressing either provided the solution. Task 5 represented the hardest task to complete for the buttons model. Few users had learnt the procedure from task 3 for setting the time, most had chanced upon the solution by accident and had been unable to recall it. For the dials model, setting the minute was found to be easy but stopping accurately at a particular second, or even the nearest ten seconds, appeared to be more difficult.

There is no evidence for a generational effect at this stage in the experiment, but further trials will sample the 70+ age range where this effect was anticipated to be strongest. This would appear as a step change in graphs of time taken for the higher ages (fig. 4). In the next stages of the experiment, a sufficient number of older users will be trialled for this effect to be tested.

5 Conclusion

The time taken and age relationship is the strongest result and supports the hypothesis in showing that whilst the dials model would be quicker for all users, due to lower complexity, the extent of the difference between buttons and dials would become more pronounced with increasing age. A generational effect may still appear when further users over 70 have been trialled. It is clear that the experience testing produced no correlation with task duration, number of errors, age nor CCS20 yet in the previous study [1] this produced the highest correlations. The difference in method of experience scoring may be the cause of this since an experience questionnaire was used previously while a symbol and position recognition test was used for the current trials. Future work will consider a combination of both measures. Data collection will continue to extend this study to cover more and older users. Further analysis will classify the nature of errors made into a scheme based on a simple cognitive model used in the previous study [1].

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