Exploring Prior Experience and the Effects of Age on Product Interaction and Learning

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Abstract. The purpose of this research was to investigate the extent to which prior technological experience of products is related to age, and if this has implications for the success of subsequent product interaction. The contribution of this work is to provide the design community with new knowledge and a greater awareness of the diversity of user needs, and particularly the needs and skills of older people. The focus of this paper is to present how individual's mental models of products and interaction were developed through experiential learning; what new knowledge was acquired, and how this contributed to the development of mental models and product understanding.

Keywords: Inclusive Design, Prior Experience, Product Interaction, Learning, Mental Models, User Engagement, User Experience, Ageing, HCI.

1 Introduction

In 2010, more than 20% of the populations of Germany and Italy were over 65, and by 2066 it is predicted half a million people in the UK will be over the age of 100, and this reflects European trends [7]. Ageing is associated with a decrease in mobility, personal independence, and social interaction and, therefore, increasing the accessibility of products and product interaction can have positive effects upon health, well-being, and personal independence. Generational differences with regard to products and technology have been reported in literature [6, 4] and are considered symptomatic of exposure to technology at a particular stage in life (under the age of 25). This may explain the difficulty older individuals experience learning and interacting with various modern products and designs. Similar results were found in previous work that focussed upon the affect of age upon product interaction [10, 11]. Younger individuals completed tasks quicker and also possessed a greater awareness and level of interaction with contemporary technology, and this may have contributed to their superior performance. The aim of this research was to examine how humans learn and interact with products and by understanding more about how learning and mental model development occurs, disseminate this knowledge to influence future design thinking in terms of ease of learning, use, and access to all.

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1.1 Theoretical Background and Mental Models

In Crilly et al.'s (2008) communication-based model of design, the user's and designer's interpretations of artefacts are considered as a form of mental model, being based in part upon user expectation – the existing knowledge and prior experience as to how the product or interface may behave, and their perception of how further interaction is likely to occur. This perception can be influenced by the messages received from product features, visual and tactile cues, and the context within which interaction occurs. The aspect of mental models that this paper investigates is the specific product knowledge acquired that contributes to overall understanding and influences successful interaction. This research utilises novel, new-to-market, products to highlight the intuitive nature of product design. The findings go some way to identify how product features, both functional and aesthetic, can contribute toward successful interaction. There is also an attempt to indicate specific product features that may cause interactional problems, either in terms of physical manipulation or in terms of facilitating learning and the development of correct and appropriate mental models. These findings have been born out of observation and verified through interview material, questionnaire data, and experimental investigation.

2 Experimental Research Approach

30 individuals were recruited and assigned to one of three groups according to age: 16-25 (10 participants), 26-59 (10 participants) and 60-80 (10 participants) on the premise that, by the age of 16, the most significant physical and psychological changes have taken place and stabilise until the age of approximately 60-plus, where natural cognitive degradation often occurs [2]. Participants were presented with a new-to-market product (Figure 1) and asked to discuss their design pre-conceptions of it before being asked to perform 6 interactive tasks.

Fig. 1. Black & Decker 'Laserplus' laser-level

Each participant completed a Technological Familiarity Questionnaire [10, 11] to verify their level of prior experience with various forms of technological equipment, and how frequently they interacted with technology. The Cantabeclipse Cognitive Assessment Tool [1] was also used to assess short-term memory ability, coordination and motor skills, and to afford further post experimentation analysis of differences between age groups, and confirm that age-related differences in performance were not limited to the experiment alone. Participants were asked at the beginning of the experiment what they understood the icons and warning images displayed upon the product's packaging, and interactional features employed upon the product, to mean. They were then asked to review their contributions after product exposure, and in this way, it was possible to observe learning and increased understanding through product interaction.

3 Classification of Interactional Sequences

A key feature of this research approach was to record all the interaction sequences. The methodology involved the use of verbal, concurrent protocol, semi-structured interviews, questionnaire administration, and analysis of video-recorded observation. The concurrent protocol of 180 individual data sets was transcribed and framed according to strict definitions of Rasmussen's (1993) SRK Model of Skill, Rule, and Knowledge-based behaviour. It was then possible to classify each individual's interaction in terms of the activity in which they were engaged.

3.1 Definitions of Skill, Rule, and Knowledge-Based Behaviour

Skill-based activities are often highly rehearsed procedures of behaviour. Increasing the automaticity of behaviour through repetition (making a cup of tea for example) reduces cognitive loading and allows attentional and cognitive resources to be directed toward other aspects of interaction. Such actions can be identified as being highly practiced and fluently executed, requiring a minimal amount of conscious effort in their implementation. Considered almost automatic, these actions are often swiftly repeated or repeatable [5]. Skill-based activity is susceptible, however, to attentional errors – skipping or repeating steps in well rehearsed action sequences or when stimuli trigger an inappropriate automatic response.

The application of rules in the scenario to achieve the desired outcome is indicative of Rule-based behaviour – the scenario may be familiar but to achieve task completion may require the application of conscious attention to execute the associated rule-based response [8]. Rule-based mistakes refer to the application of ineffectual rules or rules that are no longer appropriate. These are often short-cuts developed from experience that work most of the time.

Knowledge-based behaviour is characterised by the exhibition of advanced reasoning [9]. This approach often occurs in novel scenarios, where the situation is unfamiliar: cognitive effort and resources are deployed in understanding the current situation and developing pathways to the desired end-goal scenario which must also be conceptualised. A consequence of exhausting all the options or behaviours at the skill or rule-based level is increased cognitive and situational demand, and resultant interactional response times are usually greater than either skill or rule based interaction activity [9]. Thus, Knowledge-based interaction typically requires greater attention and situational awareness, and is often prone to error. This is loosely interpreted as the utilisation of an inaccurate mental model or the erroneous perception of stimuli adversely affecting understanding. In this instance, it is recognised as elements of the products design or interaction that failed to assist swift and accurate mental model development. Knowledge-based errors are failures in the mental models people use or manipulate, or are based on erroneous perception:

"*...mistakes result from changes in the world that have neither been prepared for nor anticipated…errors arise from the fact that the problem solver has encountered a novel situation for which he or she possesses no contingency plan or pre-programmed solution.*" (Reason, 1990, p61).

3.2 Categorisation of Behaviour in Terms of SRK Activity

Analysis focussed upon differences between age groups in terms of the skill, rule, and knowledge-based activity participants were engaged in during interaction. An additional 'Other' category was developed to allow for situations where there was no observable interaction or verbalised thought, extended pauses in speech, or when participants were merely listening to product feedback. Studying each of the 180 individual reports, it was possible to extrapolate the percentage of skill, rule, knowledge-based, or other activity participants were engaged in during interaction.

4 Experimental Apparatus and Equipment

The Black & Decker laser-level is a multifunctional device contained within a unique and bespoke design that emits a straight level laser line and is also capable o detecting wooden and metallic studs or pipes and electricity cables obscured behind fascias. Users must set the device to detect wooden studs indicated by a wooden block icon, or metal studs/pipes indicated by an icon of a beam representing a metallic object. This is done by pressing a red toggle switch on the front of the device. The device is then calibrated by pressing and holding down a button on the right side of the device. Once calibrated the device emits an audible 'beep' and requires the button remain depressed whilst the user passes the device across the wall surface or fascia. The detector itself is located in a 'Detector Zone' and thus for accuracy it is this area of the device that must be considered during operations of pipe/stud/electricity detection.

As it passes over a stud, vertical lines on the display converge and an audible 'beep' occurs when directly above the stud. The display reflects this by presenting converging lines coming together. Once passed, the beep ceases and the vertical lines retract. The procedure of electrical cable detection is identical, without the need to 'set' the device. The feedback provided is identical with the addition of the electrical warning LED illuminating when the device detects live electrical cables.

The laser-level functionality is accessed by inserting a hanging tool into the rear of the device and pushing the slider button on the left to the 'Laser On' position (Figure 2).

Whilst the devices functionality may arguably be limited, the level of conceptual development required to understand and operate it would appear significant. Its novel nature affords more direct study of the development of user's understanding as the likelihood of prior specific product experience is minimal.

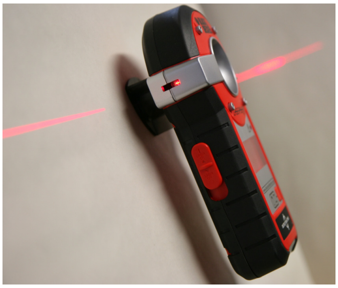

Fig. 2. Laser-level laser projection

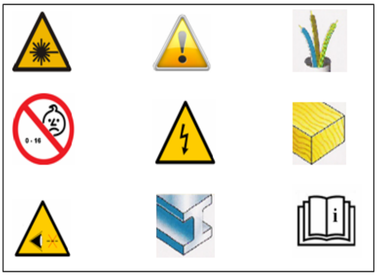

Fig. 3. Icon-warning sheet

In conjunction, an icon-warning sheet was developed that replicated the visual warnings displayed upon the product and its accompanying packaging (Figure 3).

Participants were asked at the beginning of the experiment what they understood the images to mean, then reviewed their contributions after product exposure, and it was possible to observe learning and increased understanding through interaction. This approach also permitted assessment of participants' individual levels of contextual experience or knowledge: participants capable of recognising all the icons presented could be deemed to be more familiar with products used in a similar context.

Participants were then presented with the device itself, and asked to verbally explain what the design of the product expressed about its potential use, what they understood about the product, and to indicate any design features observed. Descriptions and observations of features were recorded on a feature identification sheet allowing subsequent post-experimentation comparison (Figure 4). A total of 34 product features were identified to which participants' pre- and post- experimentation scores were compared.

Fig. 4. Product Feature Assessment Sheet

5 Experimental Methodology and Procedure

5.1 Design

A Between-subjects design was employed, assigning a total of 30 participants to one of three groups according to age: 16-25 (10), 26-59 (10) and 60-80 (10).

Independent Variable: Age: 3 levels: 16-25, 26-59, 60-80.

Dependent Variables: SRK classification, Cantabeclipse performance, icon pre/post exposure identification, task performance (completion time), pre/post exposure product feature identification, technological familiarity questionnaire performance.

5.2 Experimental Procedure

- Administer pre-test assessment using Cantabeclipse Cognitive Assessment Tool
- Assessment of warning icon recognition
- Record initial product exposure; participant understanding, feature recognition
- Record task performance with verbalisation: Fit battery, find wooden stud, find metal pipe, find electric cable, fit hanging tool, hang and operate laser level
- Reassess participant understanding of product and interaction
- Reassess warning icon recognition
- Assess post exposure product feature recognition
- Administer technological familiarity questionnaire
- Perform SRK Classification Analysis

6 Results

The methodology was successful in yielding qualitative and quantitative data, some of which are presented in the table below.

Table 1. Means per age group (n = 30)

Means per age group	16-25	26-59	60-80
Cantabeclipse Completion time (s)	49.2	45.7	50.9
Cantabeclipse Memory Span (number of items)	7	6	5
Warning Icon Recognition (pre-exposure)	4.6	5.5	4.1
Warning Icon Recognition (post-exposure)	8.4	8.3	6.2
Product Feature Recognition (pre-exposure)	8.7	10.8	6.4
Product Feature Recognition (post-exposure)	16.4	15.7	11.7
Number of similar products participants referenced	3.0	2.7	1.1

6.1 SRK Classification According to Age

It is evident from Figure 5 that the overall predominant behaviour type participants engaged in was skill-based in nature. Rule-based behaviour was the second most commonly occurring type of activity with both knowledge-based and other activity showing comparatively minute differences in terms of overall percentages of behaviour participants were engaged in. Differences according to age group membership are also apparent: the 16-25 age group engaged in greater amounts of skill-based interaction (54%) than either of the 26-59 age group (49%) or the 60-80 age group (39%) who indulged in higher rates of rule and knowledge-based activity.

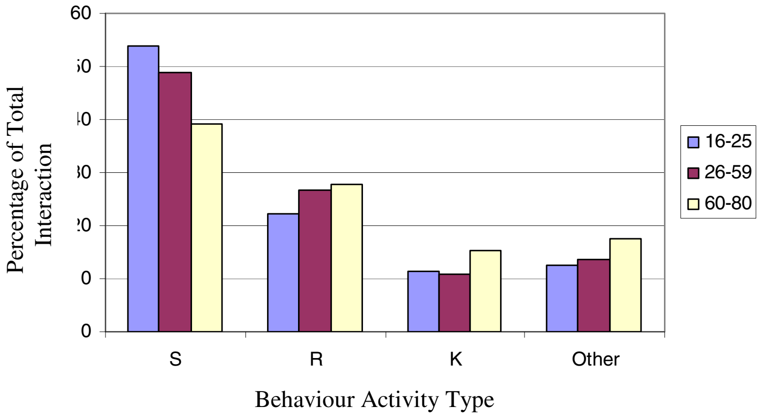

Fig. 5. Behaviour Activity Type Classification according to age group membership (n = 30)

6.2 Warning Icon Identification Comparison

A multivariate analysis of variance (MANOVA) indicated a significant effect of time of assessment and age group on the number of icons identified: F (2, 27) = 415.969, p<0.01. Analysis indicated no significant difference between the age groups at the pre-experiment exposure stage, but a significant difference between the 60-80 age group (M = 6.20, SD = 2.34) and the 26-59 age group (M = 8.20, SD = 1.93) and between the 60-80 age group (M = 6.20, SD = 2.34) and the 16-25 age group (M = 8.40, SD = 0.84) in the post-experiment stage. Thus, although initially age was not a significant factor in identification, it is a factor in the amount of iconic knowledge gained during exposure (Figure 6).

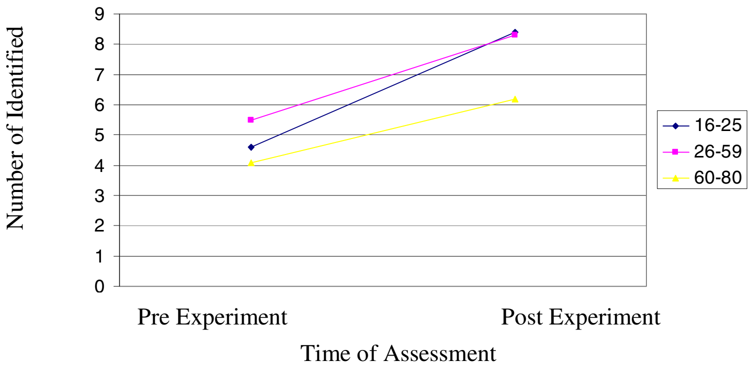

Fig. 6. Comparison of number of warning icons identified pre and post experimentation (n = 30)

6.3 Product Feature Identification Comparison

In the pre-experiment exposure stage, analysis indicated that there was a significant difference between the 60-80 age group (M = 6.40, SD = 3.50) and the 26-59 age group (M = 10.80, SD = 5.18). The 16-25 age group results (M = 8.70, SD = 3.09) did not significantly differ from either of the remaining groups.

However, in the post-experiment exposure stage, analysis indicated a significant difference between the 60-80 age group (M = 11.70, SD = 3.19) and the 26-59 age group (M = 15.70, SD = 6.05) and between the 60-80 age group (M = 11.70, SD = 3.19) and the 16-25 age group (M = 16.40, SD = 2.91). In both stages age was a significant factor in feature identification. Thus, age is considered a factor in the amount of product feature knowledge gained, and the older age groups ability to acquire information and learn appeared to be adversely affected (Figure 7).

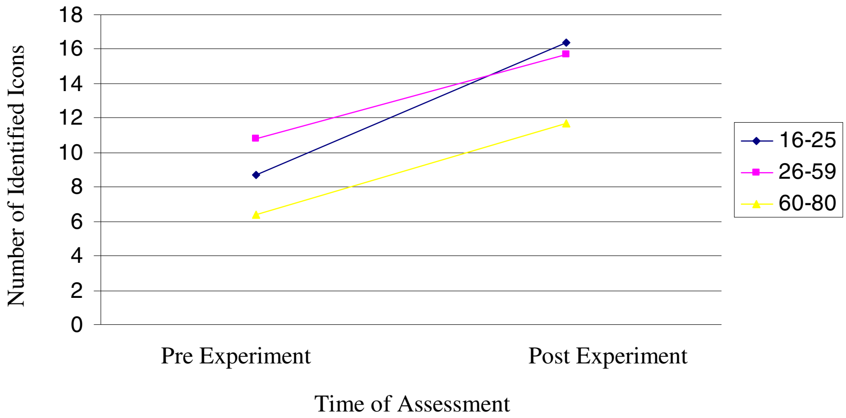

Fig. 7. Comparison of number of product features identified pre and post experimentation (n = 30)

6.4 Identifying Knowledge Acquisition within SRK Classification

SRK Analysis allowed examination of the type of knowledge sought by users when interacting with the product. Reflected within instances of interactional complexity, Figure 8 indicates when users were reduced to a knowledge-based level of interaction. These are key points when knowledge was both required and acquired to continue interaction with the product. Thus, this approach identifies what, when, and where, within interaction, knowledge is sought and learned, as well as identifying the issues causing users the greatest interactional complexity.

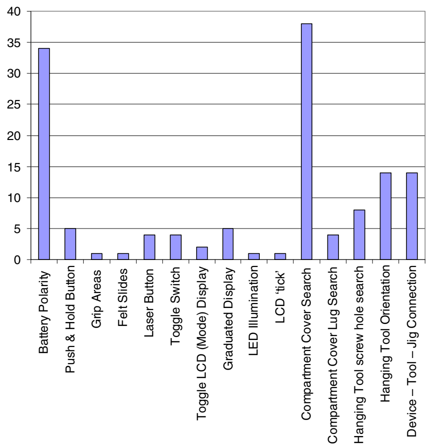

Fig. 8. Instances where interaction was reduced to a knowledge-based level, indicating the features of interaction and areas of learning involved (n = 30)

Clearly the two features of interaction causing the most challenge and greatest interruption to operation at skilled, or rule-based levels of interaction regardless of age or gender, revolve around determining Battery Polarity and the location of the Battery Compartment Cover. The next most frequently occurring design implications centre upon the use of the Hanging Tool that is attached when operating the laser-level function. With regard to learning and ease of knowledge acquisition, the overall analysis indicates that further consideration of particularly how the information regarding battery polarity and battery insertion, and battery compartment cover location and removal is conveyed to users would be well justified.

7 Conclusion

Framing interaction in terms of SRK behaviour assisted the identification of interactional design and complexity issues, as well as analysing learning activity that contributes to mental model development and understanding. Increases in age were found to correlate to a significant decrease in icon recognition at the pre and post-product-exposure stages and correlated to decreases in iconic information acquisition during exposure. Increases in age correlated to significant decreases in feature recognition at pre and post-product-exposure stages, and to decreases in the ability to acquire product feature knowledge. This provides further evidence for generational effects – that as we age our ability to acquire new knowledge and learn from interaction decreases, and the knowledge we bring to interaction also decreases.

The content and creation of mental models appears adversely affected with age; older individuals not only possessed less accurate prior experience and information for effective interaction, but their ability to acquire and consolidate relevant information, also declined with age. The overall conclusion is that products should ideally be designed to facilitate user-interaction at a skill-based level for successful operation and accurate mental model development. This research has highlighted specifically how and when learning occurs during interaction, and revealed precisely what information is required and learned. If this is considered within the design process, it may be possible to reduce the interactional complexity experienced by users regardless of age, making products more usable and accessible to a wider proportion of the population.

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