IASDR 2019
International Association of Societies of
Design Research Conference 2019
DESIGN REVOLUTIONS

Manchester School of Art
Manchester Metropolitan University
02-05 September 2019

A framework to understanding factors that influence designing for older people

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There is a considerable amount of research literature that is focused on the importance of inclusive design. There is a steady increase in research that is also focused on understanding how to design for older people. However, most of the research available focuses on ageing as a variable in understanding patterns of technology usage, preferences and difficulties. What is more necessary is research that explains why the age differences occur. For this reason, it is essential to investigate mediating factors such as cognitive abilities and experience. In this paper, we did an extensive literature review to understand various factors that explain why age differences occur and how these factors are interrelated. Based on which we propose a framework that will help other researchers and designers to provide a quick map to investigate inclusive design problems.

Keywords: older people; cognitive ageing; inclusive design;

1 Introduction

Research suggests that many older adults have difficulty using contemporary consumer products due to their complexity both in terms of functionality and interface design. Moreover, studies have found a strong correlation between age and the time taken to use modern electronic devices (Lewis, Langdon, and Clarkson 2007, Reddy, Blackler, and Popovic 2018).

Use of technological products in older users is a complex issue mediated by technology prior knowledge, cognitive capabilities, sensorimotor function, technology anxiety, perceived technology self-efficacy and socio-demographic factors (Czaja et al. 2006). This paper discusses several of these important factors of ageing that influence use of technological products in older adults and to understand interdepended nature of these issues. The objective of this study is to provide a framework for both researchers and designers to help address problems related to design for ageing population.

2 Sensorimotor function and ageing

Ageing progressively impairs various cognitive skills and sensory-motor abilities. Some abilities decline more markedly than others, and some may remain intact till the late 70s (Mynatt, Essa, and Rogers 2000, Salthouse 2010). This decline is not constant and varies widely between individuals (Gregor, Newell, and Zajicek 2000, Czaja and Lee 2007). Baltes and Lindenberger (1997) found a strong correlation between visual acuity, auditory pure tone threshold and different measures of intellectual functioning. In other words, degraded sensory impairment implies degraded intellectual functioning (Li and Lindenberger 2002). However, it is not clear which is the cause, and which is the effect.

2.1 Vision

Problems with vision start in the early forties and it deteriorates progressively as people grow older (Fisk 2004, Fisk et al. 2009). One of the most noticeable declines in vision is the loss of ability to focus on close objects (presbyopia), which is mostly caused by reduced reactivity of the lens. Among many others, some common ageing-related vision problems include: decline in visual acuity (the ability to see fine detail), contrast sensitivity, colour discrimination and detection, and glare sensitivity. Most of these problems are results of clouding of the lens. Reduced reactivity of the pupil over time degrades vision in dim light. Degradation in visual information processing reduces the ability to detect flicker, and creates difficulty in estimating depth and visual searching (Hawthorn 2006, 2000, Fozard and Gordon-Salant 2001). While older people seem to cope with age-related vision decline quite well, the middle-aged are more concerned about their vision-related problems (Kosnik et al. 1988).

2.2 Hearing

Decline in hearing is one of the most frequently noted problems of the ageing process. Older people with mild to moderate hearing problems have reported difficulties with speech comprehension especially under stressful conditions (Corso 1977). Hearing declines with age, and around 20% of those aged between 45 and 54 have some hearing impairment. This rises to 75% for those between 75 and 79 years of age (Hawthorn 2000). The most noticeable decline in hearing with age is an inability to detect tones over 2500 Hz (Schleber 1992). Age-related cognitive decline further contributes to deterioration in speech understanding, particularly in difficult listening conditions. However, older people compensate for most of these declines by using their knowledge of language and available contextual cues (Fozard and Gordon-Salant 2001).

2.3 Motor control

Response time on complex motor tasks lengthens with ageing. Proprioception, the ability to perceive (without visual monitoring) the position of body segments in space, also declines. There is a lack of substantial research data on the learning of new motor skills in older adults, but the available information suggests that they do not learn as well as the young (Ketcham and Stelmach 2001). Overall, fundamental neural events become slower for all cognitive and motor functions. Slowing of movement is evident, ability to reach and grasp diminishes, and older adults have difficulty in coping with the demands of repetitive speed, such as double clicking a mouse (Kroemer 2006).

However, ageing does not diminish performance on all types of tasks. There is little effect of ageing on older adults' ability to perform single, discrete actions that are planned in advance of the stimulus. On the other hand, negative effects of ageing become apparent when the task is complex, unfamiliar and uninteresting (Vercruyssen 1997). Many researchers have found that older people are more concerned with accuracy than speed. They tend to slow down their movements to attain accuracy in tasks related to movement. This also explains why older people are slower than younger people (Goggin and Meeuwsen 1992, Goggin and Stelmach 1990, Larish and Stelmach 1982).

3 Ageing and cognitive processing

It is generally agreed that old age causes a decline in cognitive skills which, in turn, affects the learning of new information. Some research points out that this decline is not global, as not all skills are affected by ageing (Bäckman, Small, and Wahlin 2001). For example, crystallised memory (such as vocabulary) remains constant or improves with age. Fluid intelligence (such as problem-solving, learning, and pattern recognition abilities), on the other hand, declines markedly. Other researchers have shown that age-related memory impairment is a result of damage to some parts of the brain, such as the hippocampus (Marighetto et al. 1999) or the frontal lobe (Rabbitt 1997). These changes take place at a sub-clinical level and are part of the normal processes of ageing.

However, the brain compensates for this diffuse neuron loss by recruiting other unaffected parts of the brain. This recruitment is not universal, as it is only evident in high performing older people; lower performing adult brains do not show this flexibility (Cabeza et al. 2002). This adaptability of the brain gives credence to the maxim ‘use it or lose it’ for successful ageing (Hawthorn 2006).

To summarise, Salthouse (2004) suggests that cognitive processing speed affects almost all measures of performance in the aged. However, some research challenges the idea that cognitive slowing is global and suggests that it depends more on the task being performed (Ratcliff, Thapar, and McKoon 2003).

3.1 Memory and ageing

Memory is more than just a simple storage facility: it lies at the core of thinking and learning (Howard and Howard 1997). It is also a very complex phenomenon, which is not yet completely understood. In general, literature suggests an overall decline in memory performance with ageing (Old and Naveh-Benjamin 2008, Howard and Howard 1997). However, this decline is not linear and there is ample evidence that age-related memory impairment varies greatly between individuals.

Memory is broadly categorised into five major systems. Of these, four are particularly important for research that involves older people and interaction design: 1) working memory, 2) episodic memory, 3) semantic memory, and 4) procedural memory (Fisk and Rogers 1997). Episodic, semantic and procedural memory systems all deal with long term storage of information and are hence clubbed under long-term memory. Working memory, on the other hand involves holding a limited amount of information for a limited time for processing. Of these four memory systems, working and episodic memory are most affected by age-related degradation, while semantic and procedural memory are relatively un-affected (Howard and Howard 1997).

Episodic memory deals with the ability to retain and consciously recollect information that is acquired at a particular place and time. Extensive literature on ageing shows that episodic memory performance declines with age (Fisk and Rogers 1997). Episodic memory deficits lead to older adults’ difficulty in recalling events and faces. Source memory, another important aspect of episodic remembering, is also affected by ageing (Bäckman, Small, and Wahlin 2001). Source memory refers to the specific conditions and context that was present when the memory was acquired. Its deficit leads to difficulty in recollecting where knowledge was acquired and can also lead to false memories resulting from a confusion of imagined and real experiences (Howard and Howard 1997).

Semantic memory deals with facts about the world and knowledge of language, including the meanings of words, concepts and symbols and their associations. This system of memory, in general, is not affected by age. However, age-related deficit in information access makes the retrieval process slower (Bäckman, Small, and Wahlin 2001). Both episodic and sematic memories are termed as 'explicit' or 'declarative' knowledge as they are involved with information, such as knowing that or remembering something.

Procedural memory is non-declarative, or implicit, knowledge. Procedural knowledge is not directly accessible to consciousness and its presence can only be demonstrated in action (e.g. driving or walking). Ageing only affects the speed of acquiring this knowledge. However, once the knowledge is acquired, there is no significant difference between the old and the young (Fisk and Rogers 1997). Priming, like procedural memory, is referred to as 'implicit' and refers to the facilitation of the processing of a stimulus as a result of a recent encounter with the same or related stimulus (Schacter 1987). In general, ageing-related deficits in implicit memory are relatively small.

Working memory operation can be broadly placed into two functional categories: one that deals with holding information in consciousness, and the other that is involved in processing this information while keeping task-relevant goals and strategies at a conscious level. In general, ageing has little impact on the amount of information held in consciousness. However, the information processing function deteriorates with ageing. Moreover, age-related working memory deficiencies become more prominent as the complexity of cognitive tasks increases, such as when a task requires the simultaneous storage and processing of information (Bäckman, Small, and Wahlin 2001). However, manifestation of working memory deficiencies in ageing can be mediated by coping mechanisms adopted by older individuals (Brébion, Smith, and Ehrlich 1997), especially when the task is simple.

One of the dominant theories of working memory was proposed by Baddeley and Hitch (1974). According to this theory working memory is not a unitary system; rather, it is a multiple component system that emphasises functional importance rather than just storage. This system has three components (later expanded to four): the central executive (a limited capacity attentional controller or processing component); aided by subsystems, the phonological loop; the visuospatial sketchpad; and the most recent addition the episodic buffer (Baddeley 2002).

The central executive is engaged in reasoning, decision-making and co-ordinating the activities of other subsidiary systems. It also plays a critical role in storing, coordinating and updating information in the long-term memory. Age related decline in working memory is mostly due to slowing down of the central executive component (Salthouse and Babcock 1991). Phonological loop is a temporary store for phonological information. Similarly, visuospatial sketchpad is a temporary store for visual and spatial information. The function of episodic buffer is to combine information from phonological loop, visuospatial sketchpad and long-term memory.

These four important memory systems give a clearer understanding of prior experience in the context of this study. Use of product interfaces involves both procedural (implicit, non-declarative) knowledge for knowing how to do something, and semantic (explicit, declarative) knowledge for understanding and interpreting a product's interface features and functions. Recent research on interaction design (Reddy et al. 2010, Blackler, Mahar, and Popovic 2010) also shows that, more than chronological age, domain-specific prior experience and central executive function is important for fast, intuitive and error-free use of product interfaces.

4 Attention and ageing

A variety of behavioural inefficiencies are attributed to age-related changes in attention. In general, attentional capacity is conceptualised as a limited supply of energy that supports cognitive processing. The central executive is thought to play a key role in directing and controlling attention (Baddeley 2002, Norman and Shallice 2000). ‘Attention’ is a term used to describe a variety of cognitive functions, and is usually defined in literature by its various functions. For example, ‘selective-attention’ is processing of one source of information at the expense of another; ‘divided-attention’ is simultaneous processing of two or more sources of information; ‘switching-attention’ is alternately processing one source then another; and ‘sustained-attention’ is maintaining a consistent focus on one source (McDowd and Shaw 2000). However, these descriptions of different functions of attention are used to organise and present information in research literature. In reality, there are no clear boundaries between various functions of attention, a complex cognitive task, at a time, may employs more than one attentional function for its processing.

Age-related decline is most noticeable in selective-attention and divided-attention functions. Selective-attention, the ability to attend selectively to relevant information and ignore irrelevant information, is considered a prerequisite for extracting relevant information from distracting or irrelevant detail (McDowd and Shaw 2000, Kramer and Madden 2008). Some researchers argue that age-related decline in selective-attention is due to the inability of older people to inhibit task irrelevant information (Hasher and Zacks 1988, Morrison 2005). This inability to suppress irrelevant information is also known to affect divided-attention in older adults.

Ageing shows one of the clearest declines in the ability of older people to divide their attention between two sources of information, to attend to one source of information while holding onto another, and to hold and respond to both the sources (Craik 1977, McDowd and Craik 1988). For example, when driving a car, divided-attention ability involves scanning the road for other vehicles and pedestrians and, at the same time, performing other unrelated tasks such as taking directions from a global position satellite navigation system or talking on a mobile phone. However, age-related decline in divided-attention is only apparent when the task is complex, and it is not evident when performing automatic tasks (Kramer and Madden 2008). For example, performing a familiar divided-attention task such as driving a car and keeping it in the centre of the road while maintaining a set distance from other vehicles on the road, is not affected by ageing. However, when this familiar task is changed – as in a study conducted by Korteling (1994) where the polarity of the accelerator pedal was reversed so that faster became up - the divided-attention deficit is more prominent in older people. Interestingly, Korteling found that when the accelerator pedal polarity was reversed, the older people had difficulty with steering the car rather than the accelerator pedal. It was concluded that the complex task had overwhelmed cognitive resources, leaving little capacity to deal with the second, less complex task. Some researchers argue that this deficit in older people is a result of overall task complexity, rather than of divided attention per se (McDowd and Craik 1988).

5 Ageing and technology adoption

A common belief is that older people are unwilling or reluctant to use contemporary technologies. Contrary to this assumption, available data suggests that older people are, in general, open to the use of technology (Czaja and Lee 2007). However, they exhibit more anxiety about their ability and confidence in using these systems successfully; this in turn, hampers their adoption of new technologies (Marquié, Jourdan-Boddaert, and Huet 2002).

The usage of new technologies by the present generation of older people is low, especially by those who are less educated and come from a lower income bracket (Tacken et al. 2005). Tacken et al. (2005) also suggest that age-related cognitive decline is a major contributing factor to the low use of technology by the older people. However, some researchers view new technology adoption by older people from a different perspective, suggesting that the low adoption and use of technology could be viewed more as the reaction of older people to generational changes in technology rather than to age-related declines. Furthermore, the way people handle current technology could be based on the kind of technology they were exposed to during their formative years from age 10-25 years (Docampo Rama, Ridder, and Bouma 2001). People who have experienced certain technology of consumer products in their formative years show similar technology usage behaviour in their later life (Sackmann and Weymann 1994). This group of people can be identified as belonging to a certain ‘technological generation’ (Docampo Rama, Ridder, and Bouma 2001, Lim 2009).

It is also observed that a digital divide exists for certain segments of the population, such as those belonging to minorities, those who are older and those who are less educated (Czaja et al. 2006). However, adoption of technology is a complex issue that cannot be explained by just socio-economic factors, attitudinal approach, age and education alone. There are other psychological factors, such as self-efficacy and technology anxiety that could influence the attitude of an individual towards technology (Czaja et al. 2006).

6 Prior experience and ageing

Prior experience with technology is a strong predictor of performance for a variety of computer-based tasks (Czaja et al. 2001); the more experience a user has with related technology the faster they will learn to use new technology (Lewis, Langdon, and Clarkson 2008). Prior experience or familiarity is also the backbone of intuitive interaction (Blackler 2008, Hurtienne, Weber, and Blessing 2008, Blackler, Popovic, and Mahar 2010). Moreover, literature on interaction design and usability stresses the need to design products based on users’ experience, familiarity, and prior knowledge (Preece, Rogers, and Sharp 2002). Also, interactions that exploit a user’s prior knowledge are significantly faster and are less prone to errors (Langdon, Lewis, and Clarkson 2007, Lewis, Langdon, and Clarkson 2008, O’Brien 2010).

There are two facets to prior experience – exposure to technology and competence with technology (Hurtienne, Horn, and Langdon 2010). Exposure to technology is a measure for duration, intensity and diversity of technology use, and competence with technology is a measure for skill and knowledge required to interacting with the product. The outcome of this study suggests that a measure of competence with technology, compared to exposure, might be more predictive of usability of a product in older adults.

A much more comprehensive study by O’Brien (2010) also supports Hurtienne et al. ‘s (2010) finding. O’Brien (2010) investigated the role of prior experience in the use of technology in users of different ages and experience levels. Results show that prior experience was often cited as the reason for successful use of technology. The most common approach for resolving problems in technology use was to use a combination of prior experience and the *knowledge in the world* (affordances). Older people also reported more problems than younger people due to insufficient knowledge. Further, participants who had reported higher relevant experience generally performed better. Interestingly, younger participants performed better on all technologies compared with the high-tech older age group. Although the younger group and the high-tech older group shared similar technology experience, the age differences were still significant. Older group were also more variable in their performance. In other words, older participants with higher technology prior exposure performed much more slowly than younger participants with the same level of technology prior exposure. Similarly, other studies found that, although prior experience with related technology improved the performance of older adults, age-related differences in processing speed and memory are still important factors that influence the usability of a product (Blackler, Mahar, and Popovic 2010, Reddy et al. 2010, Czaja et al. 2001, Czaja and Sharit 1993).

All the literature reviewed here agrees that both domain-specific prior knowledge and cognitive abilities are important for successful use of complex technological product interfaces. However, depending on the sample size, age groups and measures used in a particular study, there appears to be some variation in identifying the most influential factor among prior knowledge, age or cognitive abilities. One of the reasons for these variations could be that all three factors are interrelated.

Prior experience is acquired knowledge, and efficiency in acquiring new experiences is based on existing knowledge. In other words, the greater the knowledge base of a person, the easier it is for them to understand and integrate new knowledge. However, due to generational effect, older people tend to have a low knowledge base for contemporary technologies (Docampo Rama, Ridder, and Bouma 2001). Moreover, the knowledge thus acquired, both explicit and implicit, is stored in the long-term memory. Use of prior experiences involves procedural memory (implicit) to recollect the process needed to accomplish a task, and semantic memory (explicit) to understand how a task needs to be performed (Lim 2009). However, working memory facilitates both acquiring and using of knowledge. Both procedural memory and working memory are affected by the process of ageing. This could be one of the reasons why older people, although they are exposed to relevant technologies, find it difficult to use new technological products intuitively.

In summary, age, cognitive abilities and generational (or cohort) effect are some of the important factors that influence prior knowledge of older people. This prior knowledge, in turn, affects the process of acquiring new knowledge. In other words, all of these factors - prior knowledge, age, and cognitive ability - are interdependent.

7 Anxiety and cognitive performance

Many studies have shown that anxiety impairs cognitive functioning by reducing the amount of resources available for task accomplishment (Eysenck and Calvo 1992, Eysenck et al. 2007, Eysenck and Derakshan 2011, Wetherell 2002). People in an anxious state worry about threats to their current goal and try to develop effective strategies to reduce anxiety to achieve the goal. These worrisome thoughts interfere with their attention to task-relevant information, thus competing with cognitive resources available for task-related information processing activities (Eysenck et al. 2007, Eysenck and Calvo 1992). While this interference of worrisome thoughts with the cognitive process results in the individual taking longer to accomplish a task, it does not necessarily result in more errors (Darke 1988). A brief look at basic theories of anxiety gives a better understanding of its impact on performance.

Conditions of anxiety and danger produce stressful circumstances that increase physiological arousal. Razmjou (1996) defines arousal as ‘a hypothetical construct that represents the level of central nervous system activity along a behavioural continuum ranging from sleep to alertness’ (p. 530). An optimal level of arousal is needed to perform any goal-oriented tasks successfully. Researchers have found that there is a strong relationship between the arousal state and a person’s performance. The cornerstone of this anxiety-performance research for many decades has been the inverted-U hypothesis. It originated from a study by Yerkes and Dodson (1908), cited in Hardy and Parfitt (1991). The study, of habit strength formation in mice under different conditions of punishment stimuli, states that for any given task, optimal performance is achieved at some intermediate level of arousal. In other words, performance is predicted to be poor at low levels of arousal, good at moderate levels, and progressively worse as arousal increases beyond this optimal level.

However, the inverted-U hypothesis has been criticised by many for its lack of rigour in terms of empirical support. Fazey and Hardy (1988) suggest that the inverted-U should not have a symmetrical shape as it is usually presented. They suggest a ‘catastrophe model’ which states that, when performers ‘go over the top’, performance appears to drop dramatically rather than gradually. Once this happens, it is very difficult to achieve even a mediocre level of performance (Hardy and Parfitt 1991).

Stress impacts both physiological and cognitive functioning of a person. People under stress seem to be less capable of using working memory effectively (Wickens et al. 2004, Eysenck et al. 2007). Almost all functions of working memory - processing, storing and rehearsing - are affected by stressful conditions. However, long-term memory is relatively unaffected by these conditions (Wickens et al. 2004). This causes a person under extreme stress to access most available thoughts/actions and to linger on them due to the unavailability of the information processing function of working memory. This could impact effective accomplishment of tasks that involve the central executive, processing component of working memory.

One of the dominant theories from recent research on effects of anxiety on cognitive functions is Attentional Control Theory proposed by Eysenck, et al. (2007). Eysenck, et al. (2007) suggests that anxiety interferes with the cognitive processing centre of the central executive component (Baddeley 2007), more specifically, attentional control resources of the working memory system (Eysenck and Derakshan 2011). According to Attentional Control Theory, anxiety adversely effects the functioning efficiency of the goal-directed attentional system and increases the influence of the stimulus-directed attentional system. The goal-directed (top-down processing) attentional system is driven by expectation, prior experience, knowledge and current goal, while the stimulus-driven (bottom-up processing) attentional system is more influenced by unexpected, conspicuous stimuli (Corbetta and Shulman 2002). In other words, anxiety increases the allocation of attentional resources to threat-related stimuli at the expense of reduced focus on the current goal.

The core assumption of Atttentional Control Theory is that anxiety impairs processing efficiency more than performance effectiveness (Eysenck et al. 2007). For example, in a typical usability study, response accuracy is a measure of performance effectiveness and response time is a measure of processing efficiency. In effect, what this theory suggests is that high-anxiety individuals, when compared with low-anxiety individuals, will likely take more time to complete a task; however, they may not necessarily make more errors. In other words, high anxious individuals, under stressful conditions, trade time for accuracy in achieving their goal. They also use increased effort and working memory resources.

Overall, Attentional Control Theory makes various predictions of the effects of anxiety on the goal-directed attentional system. Some of these effects are: a) reduced ability to inhibit incorrect prepotent responses, b) increased susceptibility to distraction, c) impaired performance of secondary tasks in dual-task situations, and d) impaired task-switching performance. (Eysenck et al. 2007, 348). On the other hand, some have found that high trait anxious individuals' performance was comparable to, or even superior to that of low anxious individuals (Hayes, MacLeod, and Hammond 2009). Eysenck, et al. (2007) suggests that high anxious individuals perform by increasing effort and by using processing resources in a manner that can overcome functional restrictions resulting from worrisome thoughts. Moreover, Attentional Control Theory also contends that when the task is demanding and task goals are clear, high anxious individuals exhibit a high level of motivation.

7.1 Older adults and anxiety

Older people can experience more anxiety when it comes to interacting with new technologies (Czaja et al. 2006, Eisma et al. 2004). This may stem from an assumption that it requires considerable effort to learn to use them (Eisma et al. 2003). Ageing also diminishes attention capacity (Craik 1986), in particular, the ability to inhibit irrelevant information (Hasher and Zacks 1988) and dual-task performance (Stawski, Sliwinski, and Smyth 2006). An anxious state interferes with attentional resources available for task-relevant processing activity (Eysenck et al. 2007). With age-related decline in attentional resources, the compensatory mechanisms of using more effort and resources in highly anxious individuals could result in substantial impairment in the performance of older adults. Compounding this, research also suggests that higher anxiety in older adults results in poorer performance on tasks that require divided attentional resources (Hogan 2003).

On the brighter side, greater anxiety in older adults does not seem to have a significant effect on performance when it is measured as rate of errors in accomplishing a cognitive task. However, older adults did take more time to complete the task compared with younger ones (Delgoulet and Marquié 2002). On the other hand, this study involved participants from only younger and middle age group of ages, 25 to 49 years.

8 Perceived self-efficacy

Self-efficacy can be defined as a judgement of 'how well one can execute courses of action required to deal with prospective situations' (Bandura 1982, 122). In general, individuals with high perceived self-efficacy are determined and show more effort across a broader range of tasks than people with a lower level of self-efficacy. Bandura (1986) also suggests that decreased levels of self-efficacy, resulting from low levels of exposure to related stimulus, is also associated with higher levels of anxiety. In other words, self-efficacy beliefs can be influenced and manipulated by many factors. People who are younger and better educated or who have higher levels of crystallised and fluid intelligence have higher computer self-efficacy and lower levels of computer anxiety. These people also tend to use more types of technologies (Czaja et al. 2006).

Computer self-efficacy is an important predictor of the general use of technology. People with lower computer self-efficacy may be less likely to engage with technology in general (Bandura, Freeman, and Lightsey 1999). The effects of computer self-efficacy are mediated by computer anxiety, which, in turn, is linked to the breadth of computer experience.

However, some researchers found no significant relationship between experience and computer anxiety (Mahar, Henderson, and Deane 1997, Bozionelos 2001, Wilfong 2006). Mahar et al. feel that the relationship between computer anxiety and computer experience is much more complex than there simply being a general reduction in anxiety with experience. Furthermore, the research of Bozionelos (2001) and Wilfong (2006) suggests that more than computer experience, low perceived self-efficacy has a significant relationship to computer anxiety.

9 Discussion

Age-related declines in cognitive and sensory-motor function occur slowly and at varying intensities from individual to individual. In other words, compared to the younger population, variability in older adults is significantly larger (Fisk 2004, Zajicek 2001). Central executive function, a component of working memory, is most affected by the process of ageing (Bäckman, Small, and Wahlin 2001). Central executive also facilities the acquisition and use of new knowledge; age-related decline in this function not only slows down the acquisition of new knowledge, but also slows the use of existing knowledge on demand (Czaja et al. 2006). This could be one of the reasons why some older adults, even with high domain-specific prior knowledge, find it difficult to use contemporary technological products intuitively.

People with low technology self-efficacy exhibit higher levels of technology anxiety and may be less likely to engage with technology in general. This, in turn, may result in low domain-specific technology prior experience. Thus, technology self-efficacy is mediated by technology anxiety; which in turn, is linked to prior experience (Bandura, Freeman, and Lightsey 1999, Czaja et al. 2006).

In short, the literature identified complex interrelationships between the use of technological products in older people and domain-specific prior experience, age, cognitive aspects of ageing, and technology self-efficacy.

Figure 1 illustrates this relationship: Domain-specific prior knowledge is the key to intuitive interaction; age-related cognitive decline slows down the acquisitions of new experiences, resulting in older people having low prior experience with contemporary technologies; low prior experience with contemporary technologies, in turn, could result in low perceived technology self-efficacy; low technology self-efficacy could result in technology anxiety; and anxiety could interfere with intuitive use.

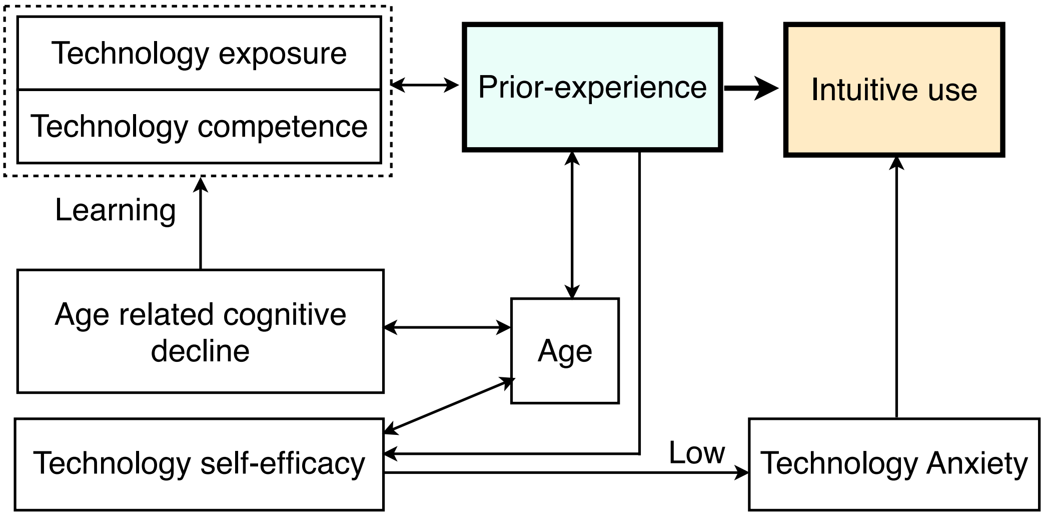

Figure 1: Interrelationships from the literature review

The above framework explains different issues one encounters when researching or designing for older people. Such as:

How to design an intuitive to use product: Design for intuitive use basically involves two steps: 1) to understand domain-specific prior experience and competence of the user; and 2) to design interfaces that reflect this prior experience. (other influencer- cognitive capability)

Ageing and diversity: Normal process of ageing slows down acquiring new knowledge. A significant factor for diversity associated with ageing. (other influencer- technology self-efficacy)

Bad design and how it contributes to the problem: Inability to use a product due to bad design in a critical situation can contribute to technology anxiety. Which can result in low technology self-efficacy and reluctance to use and learn new technology. Thus, low technology prior-experience, more diversity, etc.

In conclusion, we hope this framework will help other researchers and designers to address ageing issues in a comprehensive fashion. Most importantly, provide a foundation for people who are just stepping into this area. Finally, this is still in development we hope to develop it further to increase its granularity to capture more mediator factors.

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