The use of domestic appliances by cognitively impaired users

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Abstract: Domestic appliances, especially those that are complex and unfamiliar, may bewilder older adults suffering cognitive decline in attention, perceptual encoding, memory (cueing and recall), and self-efficacy. Successful use of technology depends on a user's mental model of operation. For older adults, transfer of understanding from similar, more familiar technologies can help their encoding of new mental models for unfamiliar devices. Leveraging established mental models provides affordances for new devices, but may constrain discovery and use of advanced functionality. Interference from existing mental models may also affect development of newer, more fitting mental models or interaction behaviour. Extending the cognitive abilities of older adults through adaptive product design provides opportunity to sustain their independence in the home. Empirical evidence from gerontology studies and concepts from human factors and cognitive psychology are reviewed to explain age-related behaviour towards technology and to open discussion on focused product design.

Keywords: cognitive impairment; domestic appliances; elderly; human-machine system; mental model; cognitive performance; working memory; gerontechnology; attention; affordance; interference; product design; psychology; geronotology.

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1 Introduction

Labour market support for an ageing world population is diminishing, with the proportion of available workers decreasing by half between 2000 and 2020. Concomitantly, the number of senior beneficiaries drawing on social welfare relative to the workforce is increasing (Anderson and Hussey, 2000). Therefore, reduction in welfare dependency by the elderly has become a social imperative.

Maintaining independence in the home is a priority for older adults. Lack of ability to perform independent activities of daily living will create dependence on family, friends, and service providers for assistance, possibly leading to premature admittance to care facilities. The likelihood of strain on social systems is great given the large cohort of baby boomers set to retire over the next few decades.

Personal independence of the aged is contingent on their ability to perform Instrumental Activities of Daily Living (IADL). Their independence may be compromised by cognitive impairment. Cognitive decline can weaken both learning and skill acquisition by affecting fluid intelligence, spatial ability, perceptual speed, and working memory. Incidences of Mild Cognitive Impairment (MCI) will dramatically increase with the expanding aged population. Furthermore, the proportion of the aged population with MCI is expected to expand also: doubling within four decades (Alwin et al., 2008).

Self-reliance in the home depends on competent use of domestic appliances. As MCI advances, seniors' adeptness in using familiar appliances may wane. When confronted by unaccustomed products, their problems in preserving independence may be exacerbated.

While technology innovation has extended lifespan, there has been little effort in creating technologies that support cognitive decline (Alwin et al., 2008). Research into advancing technology that can sustain independence during cognitive decline is needed to address this disparity (Vaupel and Yashin, 1985).

The discussion of the difficulties encountered by persons – cognitively impaired due to age – in using domestic appliances is organised as follows. It begins with a discussion of appliances that maintain self-sufficiency of the elderly and then leads to experimental evidence concerning the effects of cognitive decline on behaviour. Findings from neurophysiology are also presented as corroborating evidence. We postulate that bringing to the fore the nexus between neurophysiology and cognitive behaviour provides additional insight into the perceptual and cognitive abilities of the intended users. Having set a basis for determining how interaction with domestic appliances is affected by MCI, discussion leads on to the proposition that appliances designed for interaction by persons with MCI should draw on cognitive resources that tend not to decline and the elimination of features affected by cognitive decline that reduce performance. The case is presented for establishment by users of mental models that are functionally valid through the inclusion of adaptive appliance control, in which the interface adapts to the current needs of the users – in terms of both the task undertaken and cognitive abilities of the users.

2 Appliances for self-sufficiency

Appliances designed with an eye for seniors are scarce. Invariably, those that exist are the product of designers schooled in disciplines such as engineering, computer science or industrial design. In their creativeness they tend to rely on common understanding of the needs and limitations of users. Pak and McLaughlin (2011) see the application of scientific evidence as a means for rebutting stereotypical prejudices for explaining why persons use or avoid particular products. In their recent book on designing displays for older adults, they focus on the effects of changes in perception, cognition and movement with age on the use of displays and interfaces. Their intention is to move designers from compliance with accessibility to evidence-based research.

The creation of new appliance technologies that compensate for declining abilities requires the integration of behavioural science and engineering. Standard texts on human factors engineering, such as Wickens et al. (2004), discuss human-machine systems in terms of human-information processing. Interaction with appliances is a two-way process in which users send signals to the technology with input devices, commonly called controls, and receive information displayed to them by the technology through their visual, auditory and tactile senses. Information processing is affected by the communication medium: the motor ability of humans in manipulating controls and the performance of visual, auditory and tactile senses in receiving signals from displays. Issues arise regarding the ability of users to signal using the controls (e.g., dexterity in manipulating a control) and in their ability to perceive signals from the technology. Extraction of meaning from the signals received is the process of perception, in which the attribution of meaning derives from experience formed over time. Perception depends on attention and associations drawn from memory. The process of perception concerns bottom-up processing of signals (an ability to resolve the signals relating to factors such as contrast sensitivity and visual acuity) and top-down processing from the users experience, depending on cognitive processes relating to memory and attention.

Persons who are cognitively impaired due to age are affected by declines in motor control and visual, auditory and tactile senses. Effective design for age-related cognitive impairment must therefore cater for declines in motor control and visual, auditory and tactile senses. However, in focusing on the relationship between cognitive impairment and the features of appliance design, we consider this given and draw the attentions to readers to the design guidelines by Pak and McLaughlin (2011) and Schieber (2003).

Competency in using a technology varies from novice to frequent user. Proficiency depends on capacities and capabilities of working and long-term memory and attentional resources. The strength of these cognitive resources lessens with age, significantly because of neurological deterioration.

3 Cognitive impairment

Age-related declines in cognitive abilities are well documented (Schaie, 1994; Schieber, 2003). There is evidence to show that even healthy older adults exhibit impairment on cognitive tests (Balota et al., 2000). For abilities associated with attention and working memory, reduced functional status of older adults measured by IADL is positively correlated to reduced functional capacity of the prefrontal cortex: for a review of the literature see Kane and Engle (2002). The volume of white matter in the prefrontal cortex develops and declines with age in the form of an inverted 'U' shaped function, with the maximum around the mid-forties (Bartzokis et al., 2003). Development is characterised by steady growth, peak, and decline in structural *complexity* and computational power. From 30 years of age, there is a gradual reduction in blood flow and loss of neural tissue.

However, there is a caveat: decline in structural complexity of the prefrontal cortex cannot comprehensively account for increased incidence of MCI.

Carlson et al. (1999) found that executive tests of planning, organisation and flexibility is selectively associated with performance of IADLs. They found mental flexibility was more consequential than motor dexterity for completion of many complex, everyday activities. Also, selective attention depends on a control process that inhibits extraneous information cluttering working memory (Hasher and Zacks, 1988; Hasher et al., 1999; Rabbitt, 1965). Hasher et al. (1999) found that inhibitory control over interference from well-practised extraneous, goal irrelevant, actions decreases with age. In discussing age-related deficits in cognitive function, Schieber (2003) decomposed attention into four categories: attention span, sustained attention, selective attention and divided attention. The latter two concern the design of appliances and home technology that support age-related cognitive impairment.

As they go about their daily life, seniors engage in goal-directed activities, such as cooking a meal or choosing a programme to watch on television. In performing these activities, they usually have to cope with stimuli not allied to their current task; perhaps the telephone rings, a guest asks a question, or the oven alarm sounds. Their performance in carrying out the prevailing task depends on competing limited attentional resources and the modality of the input and processing codes, whether numerical, spatial, verbal, or combinations of these (Wickens, 1991). Verhaeghen and Cerella (2002) demonstrated that older people find difficulty inhibiting distractions from stimuli that are irrelevant to the prevailing task. If the imposing stimuli concern other tasks that need addressing, they will switch between tasks. However, if there is insufficient time for task switching, they must undertake the competing tasks concurrently. For concurrent tasks, performance may be influenced by confusion between task elements, cooperation between task processes and competition for task resources (Wickens, 1991).

Success in using appliances depends on users monitoring performance and actuating controls in response to cues. To respond to a cue, they disengage their attention from the immediate activity and move it to the cue (Posner et al., 1987). A relevant scenario might be a grandmother cooking a Christmas dinner for her extended family. She oversees multiple pots on a stovetop and a roast in the oven. She must respond to cues from sight (bubbling, colour), sound and smell, and intervene when necessary (heat adjustment, removal from stove, beginning another subtask, e.g., plating of meal). The complexity involved may overwhelm someone with MCI.

Behaviour may change to compensate for declines in cognitive abilities. There is some evidence for this from studies of switching tasks using functional Magnetic Resonance Imaging (fMRI). When people switch tasks, areas of medial frontal cortex and the dorsolateral prefrontal cortex become highly active, suggesting extensive cognitive processing (Bunge et al., 2000; MacDonald et al., 2000; Osaka et al., 2003). DiGirolamo et al. (2001) conducted an experiment in which participants undertook both switching and non-switching tasks. Shown a string of digits, with all digits the same value, participants were asked to determine either the value of the digit or the number of digits in the string. For the older adults, the observed cortices were also highly active during non-switching tasks. This result is in stark contrast to the findings for younger adults. The researchers postulated that the high activations were associated with the older adults preparing for the switching task. They claimed the older adults continually retrieved the algorithms for performing the switching task, even when performing the non-switching task. They suggested that older adults may have compensated for cognitive and sensory degradation by recruiting structures from the frontal lobe. If this is so, the behaviour that redresses decline in cognitive abilities places extra demand on cognitive resources. This may also account for the longer response times for the older adults than those for younger adults that DiGirolamo et al. (2001) found for both switching and non-switching tasks.

Increases in response time are also associated with feature integration. Visual features of the displays and controls of appliances consist of various primitives, such as shape, colour and orientation. In using an unfamiliar appliance, users must search for the correct control device for an intended action. Identification of the device depends on their perceptual system extracting the graphical primitives followed by integrating features (Treisman and Gelade, 1980). While extraction takes advantage of perceptual automaticity, the integration process relies on selective attention. If target objects in visual search have simple features, then searchers can detect the features in parallel, without the second serial stage of attention (Treisman and Souther, 1985). In contrast, searchers rely on focal attention to detect targets defined by the conjunction of separable properties. The reaction time for this serial processing is proportional to the number of objects in the search space. Plude and Doussard-Roosevelt (1989) found in an experiment on feature integration using two dimensions – colour and form – that older adults manifested the automaticity of parallel processing during feature extraction. In another experiment the target's form was a conjunction of two dimensions. The target was within a field of non-targets each having the value of one of the dimensions of the target. To identify the target the experimental participants had to integrate features: a serial process for which the older adults had reaction times significantly larger than the young adults. Basak and Verhaeghen (2003) obtained similar results using a modified Stroop task (Stroop, 1935) in which a digit was repeatedly displayed. The number of repetitions either equalled the value of the digit or differed by one. They found the response time for the preattentive extraction process did not depend on age. However, the number of elements a person can grasp decreases with age from around three to two. This suggests that in designing the various controls on appliances used by the aged, designers should use signs that only have a couple of features. See Higgins (2000) for a discussion on the semantics of visual representations at the interface.

Signals from different features may trigger different and interfering responses. Interference is suppressed through inhibitory control, which abates with age. The ability to inhibit interference is measured using the Stroop test. In this test, participants name colours of written words. Where the printed word is itself a colour that is different to the colour of the text denoting it (e.g., the word 'blue' presented in green font), experimental participants must inhibit themselves responding to the word inappropriately. That is, they must suppress inference from ingrained semantics associated with the text. An fMRI study of Stroop testing in older adults revealed higher activation of the prefrontal cortex for inhibitory control in older participants than in younger participants (Langenecker et al., 2004). However, Verhaeghen and De Meersman (1998), in their analysis of 20 studies reported in the literature, found the ability to inhibit the interference between word and colour does not depend on age. They assert that increases in response time for older adults were merely an artefact of general slowing.

Castel et al. (2007) used a modified Simon (1969) task for studying the effects of visuo-spatial attention on the ability of experimental participants to inhibit spatially related conflict. They see the Simon task as a useful tool for examining age differences between attention and control of response. Participants had to press a left or right button that matched the direction pointed by an arrow displayed on a computer monitor. The visual cues (arrows) appeared either at centrally located cross or to the left or right of it. They were told to ignore the spatial location of the stimulus. To respond correctly when cue and location signals were incongruent, participants had to inhibit the location stimulus. When the stimulus from the location conflicted with the required response, participants were slower to respond than when this stimulus matched the signal from the arrow. Comparing performance between congruent and incongruent trials, Castel et al. (2007) found the increase in reaction times for older adults was greater than that for younger adults. Nonetheless, the error rates for both younger and older adults were alike. The inference they drew is that for older adults, the process controlling the automaticity of spatial signals is impaired. They also found that while older adults diagnosed with very mild Alzheimer’s disease had similar reaction times to healthy older adults, their error rates were disproportionately high. A likely cause they proposed was the system for response selection may be “compromised by the onset of dementia”. These results agree with the findings of Spieler et al. (1996) for performance on a Stroop test.

The common findings for Stroop and Simon tasks suggest that the processes for inhibitory control for response mapping (Simon task) and conflict resolution (Stroop test) might share the same regions in the prefrontal cortex. This position is supported by Peterson et al. (2002) from their tests using fMRI.

Age-related deterioration of the prefrontal cortex has a significant effect on working memory. Deficiencies in working memory affect the capability of users to interact with appliances that are functionally complex. The attention-action cycles associated with the usage of complex appliances requires users to reprocess information stored in working memory. In arithmetic tests involving progressively more complex operations, Verhaeghen and Cerella (2002) found younger and older adults displayed increasingly longer response times on arithmetic as the complexity of the task increased. Introducing brackets into the operations forced them to store intermediate results and reorder operations in working memory, thereby increasing the difficulty of the calculation. The longer response times for older adults were attributed to higher ratios of cognitive loading proportional to increases in task complexity. This form of cognitive loading is due to processing information and then temporarily storing it for later processing. Participants must recall operations performed, recognise the current state of information based on operations performed, and further understand what subsequent operations are necessary to achieve the goal. Success and efficiency depends not only on working memory, but on the ability to inhibit irrelevant stimuli that could influence processing or state recognition. These activities become increasingly more complex as cognitive ability declines in older adults.

The Simon task, Stroop test, and the test for feature integration concern distinctly different forms of interference and, therefore, each requires a different form of inhibitory control in the prefrontal cortex.

Verhaeghen and Cerella (2002) studied a counting task. The inclusion of distractors introduced an extra stage to the processing stream – identifying and inhibiting distractors – that contributed to the response time. The extra stage added a fixed amount to the response time for managing the switching between tasks. This extra time was greater for older than younger adults. Verhaeghen and Cerella (2008) point out that for tests of the type discussed above, slowing with age was no longer than for simple tasks, indicating mere generalised slowing rather than specific cognitive factors under test. However, spatial tasks were less affected by such generalised slowing than those associated with verbal or semantic tasks.

The Stroop test assesses inhibitory control of highly practised semantic knowledge of a presented word, which conflicts with the desired colour-based response. For one test condition in their experiment on feature integration using two dimensions, Plude and Doussard-Roosevelt (1989) had half the non targets sharing the target's colour and the other half sharing the target's form. Participants had to inhibit the distraction from the singularly shared property. In the Simon, Stroop, test of feature integration, and arithmetic brackets tests, no additional (secondary) processing tasks were involved but the difficulty of the primary task(s) were increased. Verhaeghen and Cerella (2002, 2008) found that these tasks prolonged each step in the original processing stream.

In situations where there were multiple processing streams, the effects from cognitive ageing on performance were compared by Verhaeghen and Cerella (2008) using the following categories of control: resistance to interference; ability to coordinate multiple tasks or processing streams; task-switching deficiencies; working memory updating. From their meta-analyses, they concluded that there is no age-related deficit specific to inhibitory control. They found that ageing: did not affect lexical tasks; moderately slowed the making of simple decisions. However, the performing of dual tasks concurrently slowed significantly with age. Their most striking outcome was the performance of tasks involving resistance to interference and local task switching are not affected by age. They deduced that "no cognitive tasks appear to show deficits beyond those seen in simple decisions".

Scialfa et al. (1987) found older adults scan within a smaller useful field of view, and at a slower rate, than younger adults. As a speculative example of the effects of these limitations, envision older adults using unfamiliar appliances. In searching for a particular control, say for example, the "fast forward" button on a media-entertainment product, the number of objects they can attend within their useful field of view would be less than attended by younger persons. This decrease coupled with a slower scan rate puts elderly people at an appreciable disadvantage, when searching for a particular control in a busy visual display. However, perceptual training may improve performance (Schieber, 2003).

Users who have an understanding of how an appliance works are more likely to use it more proficiently than those who do not. They refine their understanding of a new appliance through exploration: by playing with the controls. The discovery process is enhanced if the users have a mental model of a similar or related product.

Age-related attentional and working memory decrements affect mental models of operation, which play a major role in the ability to interact with devices. Successful formation and use of mental models of domestic appliances depends on persons holding and working with information stored in memory (Johnson-Laird et al., 1992). In simulating a mental model, a person must operate the mental model while adhering to its constraints. Once formulated, mental models tend to remain static and resistant to change (Richardson and Ball, 2009), until changes to the functionality of the represented system in the real world requires information to be reprocessed in working memory.

Interference may arise where there are similar functions in a new product and a familiar product. Locating and triggering controls depends on the similarity of the surface features between the old and the new. Take for example, a 74 year-old man on visiting his daughter attempts to use a remote control for a DVD. While it looks similar to his, he struggles with an unfamiliar layout of the control buttons. He may become aggravated in using novel products, for instance, an automotive GPS (Global Position System). Richardson and Ball (2009) suggest that difficulty overcoming invalid mental models is due to limitations in the capacity of working memory. Inability to consider, assess and reprocess alternative action sequences in the formation of mental models is exacerbated by MCI. Older adults experiencing declines in attention and cognition, therefore, are at a disadvantage.

For seniors with MCI, learning how to control a new product may be stressful. Cognitive distress arising from the feeling of a lack of control over stressors may contribute to the lowering in self-efficacy and thereby impair cognitive functioning (Bandura, 1989). A vicious cycle of stress arising from inability to control the product, lowering self-efficacy, and addling learning with consequential accentuation of stress. In a study of individuals learning to use computers, Compeau and Higgins (1995) found that encouragement of successful outcomes served to enhance self-efficacy and outcome expectations. For MCI affected older adults using new forms of technology, integrating some form of encouragement of successful action into an interface may positively affect learning by facilitating better encoding, easing the formation of new mental models, and ultimately streamlining control whilst enhancing user satisfaction.

4 Designing appliances for impairment

Effective use of an appliance depends upon users recognising functionality associated with control devices. Realisation depends on a two-stage process in which users first extract the graphical primitives – shape, colour and orientation – and then integrating these features (Treisman and Gelade, 1980). Inefficient integration, based on age-related limitations in selective attention, detracts from encoding. As the number of features older adults are able to integrate is limited, designers of graphical (display and control) objects should take care to make sure each is distinctly different from each other and the background (Schieber, 2003).

As older adults experience difficulties in task switching, industrial designers and product development engineers must take care in designing technologies for environments where users normally perform multiple tasks contemporaneously: kitchens for example. As various cognitive abilities deteriorate at different rates, difficulties in task switching might be countered by moderating the design of interaction controls in a way that accentuates those cognitive abilities that remain stronger across the lifespan. Furthermore, displaying control and response stimuli in more than a single sensory mode may help the comprehension of, and reaction to, presented information (Mayer, 1997; Paivio, 1986).

Cognitive load associated with learning is often very high for older adults with MCI due to difficulties attending displays, discerning device features, and processing information in working memory. As a result, it hinders progressive development of well-formed mental models. However, if they recognise the problems they are trying to solve fit into a familiar cognitive structure, it may be possible to reduce the cognitive workload (Sweller, 1988). That is, designers should exploit users' understanding of familiar technologies, so that they may transfer learned patterns of control between old and new technologies (Schieber, 2003). Demands on working memory can also be reduced through training. Van Gerven et al. (2002) provide experimental evidence that elderly persons benefit more from training in which they study worked examples instead of conventional means-ends analysis. Working memory capacity is spent on task-relevant operations and not wasted on irrelevant operations.

Conversely, anticipation of control structures from past experience may create cognitive barriers that restrain exploration by seniors of new functionality (Moray, 1999). They may even resist suggestions to explore other features. Recognition of new functions requires time and effort. If users can control basic product functions, they may easily ignore additional features. The consequence of such cognitive tunnelling is an undeveloped mental model; the cost is partial use of the product. However, there are less tangible costs: perhaps, awareness of incapability and fear of doing something 'wrong' may lead to a loss of self worth.

Schieber (2003) has put forward some tentative guidelines for improving the design of products. Those that are in concordance with our appraisal of age-related declines in cognitive abilities are: the removal of task-irrelevant information to minimise clutter; design display objects such that users do not have to integrate multiple perceptual features when searching for relevant objects; in cases of multi-tasking, use different sensory modalities for the competing information streams; design the product to meet the attentional and cognitive capacities of seniors, and in particular sufferers of MCI.

One way to address attention and working memory related decrements is to place information in the environment (Zhang, 1997). Many older adults, who wish to remember to perform a task in the future, adopt external memory aids (Maylor, 1990), such as personal notes or intentional placement of objects. Older adults who employ such techniques often outperform younger adults in tests of prospective memory (Schieber, 2003). By externalising information in the environment, sufferers of MCI have cues available to them to prime explicit memory. An externalised appliance interface can cue an operator in a variety of forms. For example, an operator must be cognisant of the goal of the operation, the current state of operation, what tasks were performed to lead up to the current state, and what tasks are necessary to continue navigating towards the goal. Any combination of these forms of cueing may assist an MCI affected older adult in control of a device. The challenge in designing externalised cues lies in defining the method of signalling and determination of singular or combined forms of cueing that are most effective given the state of cognition of the user. In this regard, the process of externalising information requires care.

Designers of appliances can provide externalised cues in the form of Gibsonian affordances (Gibson, 1979) through Ecological Interface Design techniques of Vicente (1999). Affordances in the interface compensate for cognitive deficiencies by transferring information from memory to the world. Existence of affordances depends on users locating the cues within their mental model. By exploiting an individual's existing mental model, an affordance acts as externalised prospective memory. In effect, the cognitive system combines internalised and externalised memory: that in the head with that in the world.

Setting a suitable degree of externalisation is difficult. For each person suffering MCI, its form is singular. As there is no reliable method for measuring cognitive impairment in older adults, quantifying the range of cognitive deficiencies and its advancement is problematic. Studies of cognitive ageing usually only capture a snapshot of performance at a single time by comparing inter-individual differences for different groups. This does not capture variation in declining abilities of persons within and between age groups. However, designers with access to cohort-specific statistical patterns in changing cognitive abilities will have a much stronger grasp on addressing cognitive ergonomics for this demographic. In addition, determining familiarity with certain forms of technology will provide insight into designing applicable internalised and/or externalised control methods that support latent predispositions (known control methods) whilst enabling encoding of extended functionality.

5 Adaptive appliance control

Products requiring users to navigate complex hierarchies of controls to reach desired functionality, may be demanding in regard to attention and working memory, both of which are affected by age-related declines. Demands on working memory could be reduced by placing everything needed in the display, thereby removing the need to manipulate or transform information in memory (Schieber, 2003; Pak and McLaughlin, 2011). Pak and McLaughlin explain that this practice – even if it were feasible – would place excessive demands on visual scanning. They assert that, instead, the challenge is to present information only as needed, thereby minimising clutter. That is, the display adapts to the direct needs of the user, avoiding the capture of attention by irrelevant stimuli (Schieber, 2003). We enhance this stance, by contending that displays should also adapt in concordance with the cognitive abilities of the users.

Limiting control items in a display not only reduces the demands on attention, it may also reduce the demands on inhibitory control during learning and later operation.

However, controls need not remain simplistic in the long run. Ball et al. (1988) found that through practice of target selection, seniors could partially recover their ability to attend multiple objects. This may allow for progressive introduction and expansion of displayed controls as proficiency with the display increases, providing advanced functionality over time without detracting from limited attentional resources.

By integrating into the appliance interface a means for guiding behaviour through cues that aid recall, the technology guides behaviour. We surmise that guided behaviour may: support older adults engaging with appliances that have unfamiliar control structures; alleviate the difficulty that older adults have in self-initiating tasks that are cognitively demanding. As the guidance system introduces a secondary information stream, the use of a different sensory modality may help in segregating it from primary information in the appliance's display. By spreading attentional demands across resources confusion arising from competing information streams may reduce.

To help older adults learn how to use new products that enter their life, instructional design should be crafted to their learning style. A system of instruction or prompting (cueing) that provides user-specific guidance when necessary, lessens or withdraws as users gain proficiency, and occasionally prompts users during lapses in performance, may assist users with varying levels of ability.

6 Conclusion

Some general implications concerning appliance design for older persons exhibiting cognitive decline that can be tentatively drawn from the discursive presentation are:

- the use of spatial relationships in an appliance interface is not problematic
- make use of the lexical abilities of older persons

- as older persons scan within a smaller useful field of view, and at a slower rate, than younger adults, interfaces that require monitoring across multiple objects confine them within limited field of view
- make graphical display and control objects distinctly different from each other and the background
- to evoke an appropriate mental model of its operation, the characteristic features of graphical objects should reflect, where possible, equivalent objects in similar products
- make the objects in a display immediately accessible and limit information needed for the task at hand
- use perceptual training to ameliorate prolonged response times for comprehending complex interfaces, e.g., deciphering integrated features.

For systems with multiple functions, a display that adapts to the immediate needs of the user can remove sources of distraction that may capture attention. By paring back the display to objects for immediate use, the user maintains focus on the current task. Furthermore, adapting the system's operation to the cognitive abilities of the users, cues and instructions can meet the current needs of the user. The degree that the system instructs a user can change with the user's mastery and cognitive capacity.

By embodying instructional assistance within appliances, older adults can be guided in using new technologies, with the ultimate purpose of extending their independence at home and maintaining or restoring their self-efficacy. The objective of our ongoing research is the creation of adaptive guidance control for home appliances. Our challenges are:

- to defined the specific levels of prompting and transitions between levels of support
- to develop the means for recognising the capacities and abilities of users that change over time.

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