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UNDERSTANDING PATTERNS OF CAPABILITY LOSS AMONG ELDERLY USERS

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ABSTRACT
The objective of this study was to understand patterns of capability loss among elderly users of products and services. Data from a longitudinal, population-based study were obtained for analysis, which recruited a representative sample of 13,004 people aged 65 years and over from five sites in Great Britain. Participants underwent a baseline interview during 1990-1994 and follow-ups at one, two, three, six, eight, and ten years. Those with full vision, hearing, thinking, locomotion, reaching, and dexterity ability at baseline were included in a survival analysis. Locomotion was the first ability to be lost, followed by reaching, thinking, hearing, vision, and dexterity. Women were consistently younger at capability loss than men except in terms of hearing. These findings suggest that capabilities required for product and service interaction follow a hierarchical pattern of loss, which has practical implications for design. Although improvements to reduce design exclusion are likely to require changes that address more than one demand, capabilities lost early in old age should take precedence over those lost later.

Keywords: Capability loss, elderly users, inclusive design

1 INTRODUCTION

When interacting with products and services, people use a range of sensory, cognitive and motor capabilities. Losses in any of these capabilities can make it difficult or even impossible to interact [1]. With ageing, the gap between personal capability and environmental demand becomes wider [2], leading to a greater number of people who have difficulty with the use of products and services. This is compounded by the fact that populations of developed countries are ageing as a result of declining fertility and increasing longevity. The ageing phenomenon particularly affects Europe, where more people are aged 60 years and over (21%) than in any other major region of the world, followed by Northern America (17%) [3]. Taking Great Britain as an example, there are now more people over the age of 60 than under the age of 16. Furthermore, the 'oldest old' (aged ≥80 years) represent the fastest growing cohort. This population segment will increase from 2.4 million in 2000 to 3.5 million in 2025 and, in the longer run, their number will grow even more rapidly (to 4.9 million by 2040) [4]. Such demographic shifts pose challenges to designers because new products and services are required, designed with due sensitivity to older people's needs.

Inclusive design is defined by the British Standards Institute (BSI) as the "design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design" [5]. It is a design approach that aims to consider the variety of needs of the wider population, including older people. Universal design, a concept similar to inclusive design, is popular in the United States (US) and Japan. While the term 'universal' may connote a 'one-size-fits-all' approach [6], inclusive design recognises that this is not always possible or economically viable [7]. Rather, the rationale behind this is to 'counter design exclusion' by systematically identifying capability demands placed upon a user and to re-design features exceeding their capabilities [8]. The outcome should be improved products and services that minimise the exclusion of less capable people, without sacrificing aesthetics and desirability.

Data on the range of human capabilities that are required to interact with products and services is essential for design evaluation [9]. Traditionally, human factors information has been delivered in the form of guidelines and handbooks [10]. Yet designers cannot get information from these sources alone. There is evidence that designers and other decision-makers need quantitative data on the number of people with capability loss [11]. Such information could be used to identify people at risk of exclusion who represent potential candidates for user observation studies. For example, the US company OXO commissioned a design consultancy, Smart Design, to study people at the threshold of losing their ability to perform cooking tasks in order to design their range of 'Good Grips' tools [8]. Previous work done by our group [12] used cross-sectional survey data to estimate the prevalence of limited capability in the older population. While this data can be used to show the range of capabilities, it provides no information about when older people lose them. The current study is based on longitudinal data from the Medical Research Council Cognitive Function and Ageing Study (MRC CFAS) and investigates capability loss prospectively.
The structure of the present paper is as follows. First, user capabilities required for product and service interaction will be reviewed. The data and methods used are described in section two. Section three presents the results and section four provides a discussion, followed by conclusions.

2 USER CAPABILITIES

The information presented in the following paragraphs has been extracted from the Inclusive Design Toolkit [13], which can also be accessed online [14]. Any interaction with a product or service typically requires a cycle where the user perceives, thinks and acts, and is influenced by the environment. Perceiving and acting involve both sensory and motor capabilities; these are controlled by the brain and therefore demand cognitive capability.

2.1 Sensory

Sensory capability describes the combination of vision and hearing ability (taste, smell and touch are not considered in this article). Vision is the ability to see objects and differentiate surfaces; hearing to discriminate sounds from ambient noise and to tell where these are coming from. For example, a person with full vision ability can read ordinary newsprint without difficulty, and someone with full hearing ability can follow a conversation during background noise. The structure and function of the eye may deteriorate with age, resulting in blurry vision, loss of visual field and reduced contrast sensitivity. Hearing loss may also occur as a result of ageing, which affects the ability to understand speech and locate sounds.

2.2 Cognitive

Most processes underlying cognition, or thinking, occur in the brain. Specific regions of the brain are involved in different sensory and motor functions. With age, people's ability to maintain attention generally decreases, while conversely their susceptibility to distraction increases. Well-established memories and skills are often unaffected by age, but it takes longer to learn new things, make decisions and respond to sensory information. Brain disorders are more common among older people, which additionally influence attention, memory, movement, perception, reasoning, and social interaction. Communication is also relevant, yet primarily a result of thinking and will not be considered separately here.

2.3 Motor

A person's motor capability describes the combination of locomotion, reaching and dexterity. Locomotion is the ability to move around in the environment; reaching to stretch out one or both arms; and dexterity to grasp, hold and manipulate objects. Motor capability requires strength, control and balance. As people age, their muscle strength deteriorates and degenerative conditions, *e.g.* arthritis or Parkinson's disease, further reduce mobility and control. A temporary or sudden loss of motor capability can occur due to falls or strokes. Functional training and assistive devices may help to gradually improve motor capability, but complete recovery is rather unlikely.

3 DATA & METHODS

Data from MRC CFAS were obtained for analysis. This longitudinal, population-based study was conducted in Great Britain between 1990 and 2003 to investigate major research areas relevant to ageing, health and well-being. The overall response was 80 percent [15].

3.1 Study design

A full description of the study design may be found elsewhere [16]. Briefly, four study centres in England (Cambridgeshire, Newcastle, Nottingham and Oxford) and one study centre in Wales (Gwynedd) were selected to reflect a heterogeneous sampling frame in terms of socio-economic status and the prevalence of chronic diseases. Eligible subjects were identified from a centralised list of all GP patients with random samples of sufficient size drawn to provide at least 2,500 interviews at each centre. The samples were first stratified into two age strata, 65-74 year olds and 75 year olds and over, to ensure equal numbers from each. Men and women aged 65 years and over on the index date (1990/91) were approached to evaluate interest in participating in the study. Those who agreed to participate provided informed consent (or their proxies where appropriate) and were scheduled for an initial baseline interview over the period December 1990 to June 1994. Follow-up interviews were conducted at one, two, three, six, eight, and ten years with completion in September 2003.

3.2 Variable definitions

Trained interviewers undertook the baseline interviews in the study participants' homes. They were instructed that some probing might be necessary to validate the responses. Proxy interviews (with a family member or friend) were conducted when the participants were found to be very frail or confused. The participants were asked whether they are able to go up and down stairs ('locomotion'), to reach an overhead shelf ('reaching') and to tie a knot in a piece of string ('dexterity'). Individuals scored two for no difficulty, one for some difficulty and zero for not being able to perform at all. Scores of zero and one were grouped together to indicate limited ability, while a score of two indicated full ability. Vision and hearing were assessed by asking "Do you suffer from poor eyesight which interferes with day-to-day living?" and "Do you suffer from hearing problems which interfere with day-to-day living?"; responses of "yes" were classified as full ability and responses of "no" as limited ability. Assessment of thinking ability was based on the Mini-Mental State Examination (MMSE) – a set of 30 questions on cognitive function and concentration. MMSE scores of 25-30 were considered full thinking ability and scores of 0-24 limited thinking ability.

3.3 Statistical analysis

In a preliminary analysis, capability was assessed at baseline ('prevalence') and within two years of follow-up ('incidence'), separately by gender and age group. Prevalence is defined as the number of people with limited capability at a given time, and incidence as the number of people who develop a limitation within a given time. Age at loss of capability was investigated using methods of survival analysis (*i.e.* regression modeling of time to event data) and the log-rank test for differences between men and women. The baseline age was used for those with limited capability at the initial assessment. All analyses were undertaken using the statistical software package STATA version 9.1 (STATA Corp., College Station, Texas, USA).

4 RESULTS

At baseline, there were 12,318 participants with complete data for all of the variables considered; 60 percent were women. Their mean age was 75 years with standard deviation of 7 years. The prevalence of limited capability, as can be seen in Figure 1, was highest overall for locomotion (33%) and lowest for dexterity (7%). After stratifying by gender, almost consistently higher prevalence was found among women (the exception was hearing). The difference between genders was particularly pronounced for reaching, where women had much higher prevalence than men. Increasing trends were observed across age groups, with the prevalence of limited locomotion ability being highest in all groups and that of limited dexterity ability lowest (Table 1).

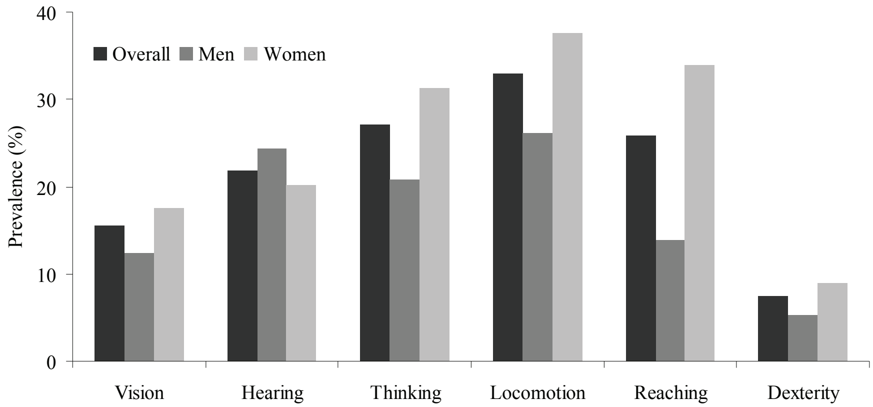

Figure 1. Prevalence of limited capability by gender, 1990/94

Table 1. Prevalence (%) of limited capability by age group, 1990/94

Ability	65-69	70-74	75-79	80-84	85+
Vision	8.2	10.3	15.3	23.0	34.4
Hearing	14.5	16.8	20.9	29.1	43.1
Thinking	14.2	18.3	27.6	40.5	58.1
Locomotion	20.4	24.5	34.5	45.7	61.5
Reaching	14.1	17.6	26.0	38.3	55.0
Dexterity	4.7	4.7	8.0	9.8	16.9

At two years, around 25 percent were alive but not seen ('missing') and 10 percent were deceased. Those with missing data did not differ with regards to their baseline capabilities, but they were more often cognitively impaired. Most people with full capability at the initial assessment lost their locomotion ability within two years, followed by reaching and thinking (Figure 2). Vision, hearing and dexterity were comparable. Incidence was generally lower among men than women, in particular for reaching but very similar for hearing. Loss of locomotion ability was highest across all age groups and loss of vision, hearing and dexterity ability lowest (Table 2).

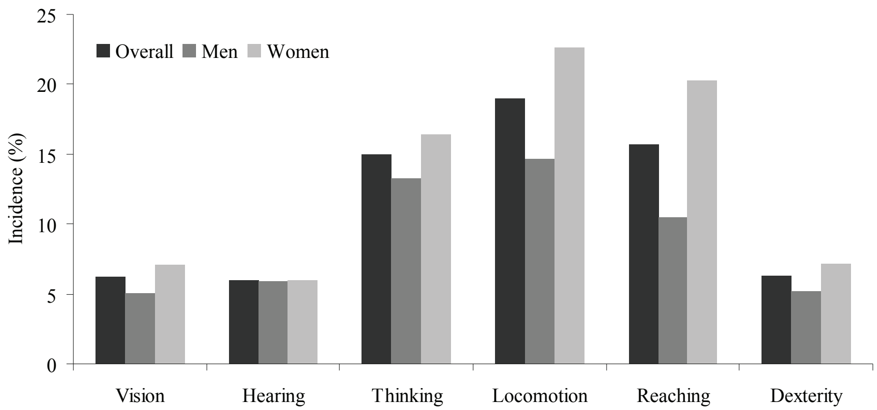

Figure 2. Incidence of capability loss by gender, 1990/94-1996

Table 2. Incidence (%) of capability loss by age group, 1990/94-1996

Ability	65-69	70-74	75-79	80-84	85+
Vision	2.5	4.6	7.1	11.6	15.6
Hearing	4.1	4.2	5.9	9.1	16.0
Thinking	7.7	11.5	17.0	27.4	38.4
Locomotion	11.1	15.4	23.7	29.4	45.6
Reaching	9.0	12.4	18.4	24.7	42.1
Dexterity	3.1	4.3	7.1	11.3	15.4

Figure 3 shows age at capability loss by the 25th, 50th and 75th percentiles. These correspond to the ages at which 25, 50 and 75 percent of the sample were no longer fully capable. Marked differences were observed in the pattern of capability loss. Half of the sample had lost their locomotion ability by 78 years, their reaching ability by 81 years and their thinking ability by 82 years. In comparison, hearing, vision and dexterity were lost later, with the same proportion losing their hearing ability by 85 years, their vision ability by 87 years and their dexterity ability by 90 years.

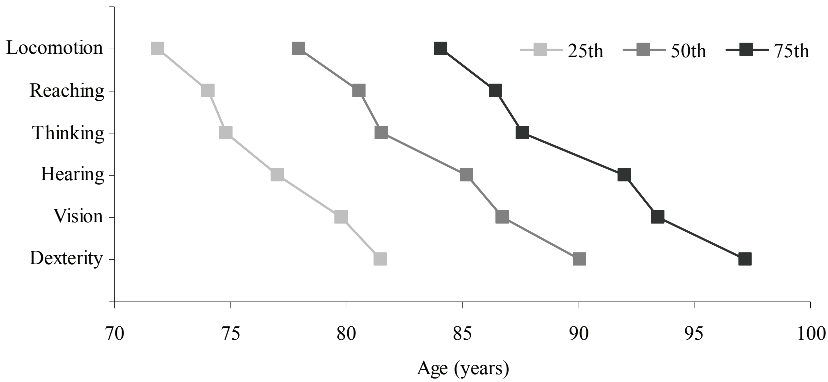

Figure 3. Age at capability loss by percentiles, 1990/94-2003

Gender differences for median age at capability loss were additionally examined (Table 3). There were statistically significant differences between men and women in all abilities except vision (p = 0.108). Median age was generally lower among women, particularly for reaching loss (men: 84 years *vs.* women: 78 years) but not so for hearing loss (men: 83 years *vs.* women: 87 years).

Table 3. Median age at capability loss by gender, 1990/94-2003

Ability	Age (95% CI)		P-value*
	Men	Women	
Vision	87.1 (86.2-88.3)	86.5 (85.7-87.2)	0.108
Hearing	82.9 (81.8-83.8)	86.7 (86.1-87.3)	<0.001
Thinking	82.5 (81.8-83.3)	81.1 (80.5-81.5)	<0.001
Locomotion	78.6 (77.8-79.2)	77.6 (76.9-78.1)	0.005
Reaching	84.1 (83.4-85.0)	78.3 (77.7-78.9)	<0.001
Dexterity	91.4 (90.3-92.3)	89.3 (88.4-90.1)	0.003

CI, confidence interval
*P-values were obtained from the log-rank test; a value <0.05 indicates a statistically significant difference between men and women

5 DISCUSSION

This analysis has provided evidence that capabilities required for product and service interaction follow different patterns of loss among elderly users. Data from MRC CFAS were obtained for analysis, which has several strengths. First, it is a large multi-centre study with a heterogeneous population and high overall response, suggesting good external validity (*i.e.* the results can potentially be generalised to the population). Second, repeated measures of vision, hearing, thinking, locomotion, reaching, and dexterity ability permitted the investigation of capability loss among participants with full capability at baseline. Third, due to the sampling design, robust estimates could also be provided for the very old population.

A potential drawback, however, is that the variables used to represent the capabilities may not be good proxies. The way in which vision and hearing were assessed ("Do you suffer from… which interferes with day-to-day living?") seems reasonable as well as thinking based on the MMSE – the most frequently consulted tool to assess cognitive functioning in research [17]. Locomotion can alternatively be measured by asking whether people are able to walk half a mile (the equivalent of a city block) [18]. Climbing stairs requires greater strength, mobility and balance than walking, and aids such as sticks or trolleys are no longer effective. Reaching does not only occur above the head but can also be in front or out to the sides. Population statistics suggest that people have greater difficulty to reach above their heads [19], probably because the ability to exert forces is especially diminished when the arms are in this position. Tying a knot in a piece of string relates to the function of wrists and hands and is a measure of the ability to grip and perform manipulations. The Disability Follow-Up Survey of 1996/97 [19] assessed dexterity on an interval scale with scores ranging from one ("Cannot pick up and hold a mug of coffee with either hand") to 12 ("Full dexterity ability"), where an item similar to the one in the present study ("Has difficulty tying a bow in laces or strings") indicated a score of 11. Thus, the variables reflected high levels of functioning, making them suitable to investigate transitions from full capability to impairment. Estimates from longitudinal studies can be affected by attrition bias, *i.e.* the loss of subjects to follow-up. The characteristics of attrition in MRC CFAS have been studied in detail; poor cognition was associated with refusal and moving in both the short- and long-term [20, 21]. Individuals with missing data at follow-up were no different in terms of any other capability, and bias is therefore unlikely to be the cause of the results. Finally, it should be noted that the data provided were collected in the 1990s and the results might be different from what would be observed today.

Capability was assessed by asking the respondents to report on their abilities. Self-reports of function in older people have been found to be reliable independent of age and cognitive status [22] as well as being concordant with both objective measures and proxy reports [23, 24]. In addition, leading questions were asked ("Are you able to…?"), which has been shown to provide both better reliability (replication of measurement) and validity (intention of measurement) of the respondent's actual functional status than asking neutral questions [25].

The finding that women have higher prevalence and incidence of limited capability than men is in line with the literature [26]. Our study provided evidence for gender differences in terms of capability loss, with women losing their capabilities earlier than men except for hearing. Furthermore, the capabilities considered appeared to form a hierarchy. Locomotion was the first ability to be lost, followed by reaching, thinking, hearing, vision, and dexterity ability (although some were quite close). These results, from examining the age at loss of capability, produce a more definitive ordering than when looking at prevalence or incidence figures alone.

6 CONCLUSIONS

Capabilities required for product and service interaction are lost at different stages in later life, which has practical implications for design. A person's lack of locomotion ability may exclude them from using a product or service regardless of their vision, hearing, thinking, reaching, or dexterity ability. Reducing the locomotion demand (*i.e.* strength and balance) placed upon a user may help to include those with limited locomotion ability. This could, for example, be achieved by making extra allowance for the hands (*e.g.* handles), which are likely to be employed for compensation, to assist moving the body around. On the other hand, a product or service which places an excessive dexterity demand upon a user is unlikely to be counterbalanced by a low vision, hearing, thinking, locomotion, or reaching demand, resulting in exclusion.

Age at loss of capability was quite close for reaching and thinking as well as hearing and vision. Thus, designs that address only one of the abilities will still exclude people from using a product or service. Rather than reducing the demand associated with a single ability, it is more beneficial to reduce demand in preference to another. Thus, improvements to reduce design exclusion are likely to require changes that address more than one demand, although capabilities lost early in old age should take precedence over those lost later. Further work is now needed to confirm our findings and to establish how these can be used to inform design knowledge.

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