Capturing Older People's Cognitive Capability Data for Design

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Abstract. There is a lack of cognitive capability data in design. Existing capability databases lack consideration of older people who are suffering decline of cognitive capabilities. To explore older people's cognitive capability data for the design context, two pilot studies were conducted: a small-scale cognitive capability survey in China, and a study of a group of industrial designers' needs regarding user data. A Framework of user data were developed and key issues for cognitive capability data collection and application in design were identified and discussed.

Keywords: Cognitive capability · User data · Design for older people · Human factors and ergonomics

1 Introduction

In the context of design, capability refers to an individual's level of functioning, from very high ability to extreme impairments, which has implications for the extent to which they can interact with products [1]. However, the study on user cognitive capability data is relatively weak comparing to other functional capability data. For instance, the ongoing "Basic Chinese adults' ergonomics data collection" project by the China National Institute of Standardization (CNIS), has added the measurements on sensory capabilities, such as visual and hearing abilities [2]. But this project has not yet covered the measurement on cognitive capability. This is probably because it is more difficult in measuring cognitive capability [1]. A study named *Towards Better Design* [3] initiated by the University of Cambridge has incorporated cognitive capability measurement, but the tests were mainly adapted from cognitive psychology, thus having limited relevance to design.

Technology development pushes older people into the mobile-internet world, and there is a need to understand how they interact with information and communication technology. Cognitive capabilities play an important part in older people's interaction with these technologies.

1.1 User Capability Data

User capability data, derived from Human factors and ergonomics (HF&E), are widely recognized as a good resource that informs design in the early stages [4]; they are fundamental to the design of safe and usable products [5].

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Categories. There are two categories of user capability data: (1) physical capability data, (2) functional capability data [6] (Fig. 1). Physical capability data refer to traditional human factor data such as height, grip strength and the reach of limbs, which are associated with physical attributes. Functional capability data relate to senses, cognition and motion; and there are more and more studies focusing on these fields [7, 8].

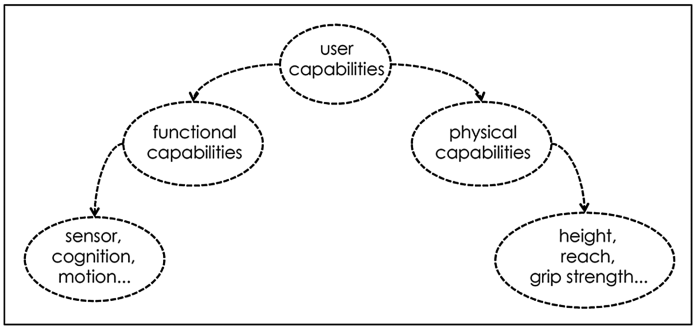

Fig. 1. Categories of user capability data (adapted from [6])

Functions. The benefits of involving user capability data in the design process are two folds. On one hand, it can serve as benchmarks that assist designers to make the design decisions and to estimate whether the design is accessible or not. And the metric that can serve as the benchmark is the significant element of design evaluation. By providing suitable metrics, designers should be able to measure the success of their designs and also identify accessibility shortcomings [6]. Apart from that, the range of capabilities is also an essential factor. Johnson et al. claims that tools for predicting difficulties need to be able to "give designers a picture of the full range of capabilities and also the ability to consider and understand the multi-dimensional nature of capability profiles" [1]. On the other hand, designers regard user capability data as resources that can inspire them. Design is a series of mental processes, manipulating intelligence to discover and solve problems, with moments of sudden illumination [9].

Capture Methods. Self-report and performance measure are methods commonly used to assess physical functions in health surveys of older people [10]. The method of self-report is based on a series of questions, which offers a fast, low-cost and easily executed path to users' information that can be gathered by questionnaires, face-to-face interviews or remote interviews (telephone or online interviews). Proxy response is a kind of self-report that can be conducted when an interviewee cannot answer by himself/herself. However, that should not be equivalent to self-report, because research has shown that a proxy report is not as accurate as self-report for the rating of ability to perform activities of daily living (ADLs) among older people [11]. Based on Fors and his colleagues' study [10], the limitation of self-report can be listed as follow:

- There is limited value in identifying clinically significant change.
- Lack of reliability: the subjective factor as individual expectations and aspirations may affect a person, especially an older one, to comparing to peers and level of functioning in earlier life.
- Be sensitive to the influence of cognitive impairments, culture, language and education.

Compared to self-report, performance measure appears to be safer, quicker and easier to administer when large samples are employed [11, 12]. Apart from that, performance measures are standardized tests designed either to mimic ADLs (e.g., reading message on cards to simulate using the message function of a mobile-phone) or to measure more specific dimensions of cognitive function (e.g., short-term memory, visual discrimination).

Both self-report and performance measure can be used in surveying cognitive capabilities [1]. Self-report involves questions about respondents' past experience, which can help access not only their physiological capability, but also attitudinal, environmental and cultural components. Performance measure can help collect some capability data more precisely.

1.2 Older People's Cognitive Capability

Cognition abilities are typically used in combination to perceive information, and the function of cognition can explain information processing [13]. But complex information processing contains much more than a cognition process. Figure 2 shows a model for the typical cycle of perceiving, thinking and acting that occurs in the interaction with a product [7], which suggests that the ability to successfully interact with computer terminals could be predicted according to the demands made on users' sensory, cognitive and motor abilities [14]. Information perceiving, memory and acting process compose a rounded cognitive process, and the cognitive capabilities involved in that process are considered in this study.

Individuals of all ages believe that memory undergoes a relatively precipitous decline after age 40 [15]. This cognitive retrogression makes it more challenging to design for older people. Older people's cognitive capabilities are mainly reflected in their visual perception, auditory perception, memory abilities and their sometimes attitudes. These factors are not isolated, but inter-related. Due to the decline of perception, older people's perception of time is intentionally longer than the other adults [16]. And due to their habitual thinking, acting and the decline of memory, their learning capacity falls sharply after age 45 [17], which often makes it more difficult for older people to learn to use products that they are not so familiar with (e.g. some mobile-internet products).

2 Pilot Studies

Many studies show that existing user capability databases are still lack of the consideration of older people [18]. Inclusive design as a design methodology emphasises on consciousness of the demands to design for a wider range of users, including the

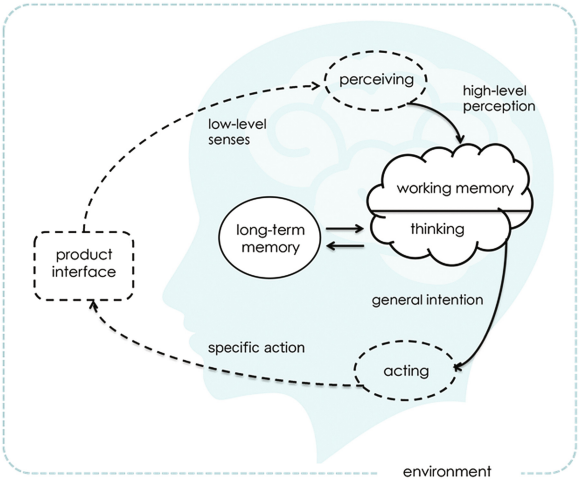

Fig. 2. A typical information-processing model for a product interaction (adapted from [14])

demands of older and disabled people. Studies also suggest that existing ergonomics database are lack of the consideration of designers [19].

An ideal user capability database need to be able to give designers a picture of the full range of capabilities and also the ability to consider and understand the multi-dimensional nature of capability profiles [1]. Therefore, two pilot studies were conducted to get insights into older people's cognitive capability data for design.

2.1 Pilot Study 1: A Small-Scale Cognitive Capability Survey in China

The first pilot study was a small-scale cognitive capability data collection, which was conducted by the Inclusive Design Research Group at Tongji University. It covered seven different cities and towns of China. The age range of respondents was from 50 to 80. Both self-report and performance measures were employed in the study. Self-assessed measures most likely draw on the participants' experiences from their everyday life whereas performance-based measures are more specific and standardized [10].

This pilot study was the cognition section of a multiple capability-related data survey conducted by the Tongji University. The survey questions were derived and adapted from *Towards Better Design* [3]. A variety of data were collected in this survey, including vision, hearing, dexterity, cognition, health condition, and contextual data collection. Table 1 summarises the methods employed in measuring different types of capabilities (i.e. component functions). As seen in Table 1, Cognitive function was measured through self-report.

A toolkit was designed for collecting multiple capability-related data. Figure 3 shows the tools included in the toolkit.

This paper focuses on the aspect of cognitive capability. The questions were directly derived and adapted from the field of psychology. For instance, to test short-term memory, the respondent was asked to recall the words that were prerecorded

Table 1. Summary of different measures used in the study

Component functions	Self-report	Performance test
Visual	√	√
Hearing	√	√
Dexterity	√	√
Cognitive function	√	–
Product interaction	√	√
…		

Fig. 3. The toolkit for the pilot multiple capability survey in China

in an audio file; to test their comprehension, a made-up medicine prescription was given to the respondent, followed by a few questions to test whether the respondent has fully understood the prescription; to test numerical abilities, the respondent was asked questions relating to his/her use of numbers in everyday life.

Main Findings. The cognitive data collected from the study seem to have little direct relevance to design, and it is difficult to predict product interaction based on the data collected. In addition, many respondents tended to overestimate their abilities in self-reporting.

Discussion. As the cognitive questions are mainly derived from the fields of psychology and healthcare surveys [20], the results have limited use for design. In the design process, user capability data are applied to predict a solution of a specific design problem, aiming at making the product more accessible to target users. Therefore it is important to develop new, design-relevant cognitive measures. In addition, because self-report is subjective [8], it is necessary to introduce objective measures in cognitive capability test.

2.2 Pilot Study 2: A Study of Industrial Designers' Needs for User Data

In order to develop design-related user capability survey, it is important to understand designers' needs regarding user data, including users' cognitive capability data. Existing ergonomics data are not designer-friendly; a study carried out in the UK [7] shows that 'all the interviewed designer considered the existing anthropometric data out of date, and seven out of ten believed the data was irrelevant or not applicable to their specific field of design practice.' So what are the useful and usable user data for design? A study was conducted with industrial designers to identify their needs.

There were two steps in this study. In the first step, 12 in-house designers, 12 consultant designers and 12 freelance designers were invited to answer a questionnaire. The questions covered the time designers use in understanding user capabilities, the means designers usually adopt when they need user data, the data designers prefer, and how they use user data in the design process. Table 2 shows the profiles of the participants. In the second step, designers from each category in the step 1 were invited for a focus group discussion, and three designers were able to participate in the focus group.

Table 2. The profiles of the designers participating in the study

Categories of designer	Design field	Number	Total
In-house designer	Digital device	4	12
	Household appliance	4	
	Engineering product	4	
Consultant designer	Digital device	4	12
	Household appliance	4	
	Engineering product	4	
Freelance designer	Student major in design	6	12
	Other	6	
			36

Main Findings. The results showed that different categories of designers spent quite different time in understanding user capabilities. In-house designers (27 %) spent more time than the other two categories of designers, while freelance designers (7 %) spent least time. Apart from that, the proportions of time designers spend on user data differed for different types of designs. There is a consistent trend that designers spent more time on understanding users for digital device design than for household appliances, and for engineering product design, designers seem to spent less time in understanding user capabilities.

The designers most often searched the Internet for information about their target users. The designers in the field of engineering product design preferred ergonomics data. Small-scale user research was a crucial method for designers to get first hand data of users. Almost all of the designers who did not prefer ergonomics data claimed that current ergonomics database was hard to use and had little relevance to their specific design problems.

There was not much difference on the preference of data formats among the three types of designers. The respondents all preferred visualized data (e.g. photos and informational graphics) than text information (e.g. numerical data). Designers needed both qualitative data and quantitative data. Moreover, some designers considered descriptive words as a kind of qualitative data that could help them to quickly get the information of target users.

It was also found that designers needed user data throughout the whole design process. Designers usually used qualitative data to get conceptual inspiration, and quantitative data could help designers to explore references to support a specific design decision.

Discussion. The study of designers' needs for user data suggest that a new type of user data (probably differ significantly from existing ergonomics data) is needed by designers, which should contain both qualitative and quantitative data. These data should be developed to support design activities at different design stages.

3 A Conceptual User Data Framework

Based on literature review and pilot studies, a conceptual user data framework was developed to illustrate the landscape of user data for design (Fig. 4). On one hand, quantitative data are obtained from larges (population), which can be regarded as benchmarks in the design process. On the other hand, qualitative data are obtained from relatively small samples (i.e. individual users), which can help designers to get conceptual inspiration. Most of existing capability databases focus on data collection. In contrast, designers tend to focus on data application. Therefore, establishing the connection between data collection and data application is the key issue for a designer-oriented user capability database.

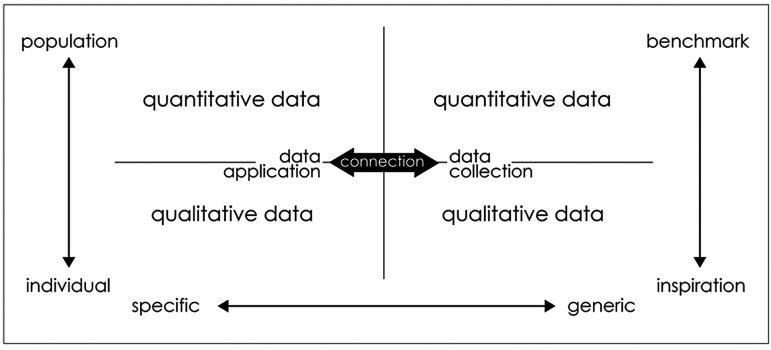

Fig. 4. The range of user capability data

In addition, it is also crucial to ingeniously combine quantitative data and qualitative data. Ergonomics data are often quantitative data, which cannot provide designers with contextual information of users. Particularly, in the concept generation phase, qualitative data are more helpful for gaining insights into target users.

4 Conclusions and Further Study

In a word, it is necessary to develop survey questions that can help collect older people's cognitive capability data for the purpose of improving design. Tests in the field of cognitive psychology can be used as a source of reference. Crucially, the test tasks (including self-report questions and performance measured tasks) should be related to product interaction.

The further study should aim to solve two critical questions:

(1) How to make cognitive capability data useful to designer?
(2) How to make the data easy to use?

In addition, more designers from different fields should be involved in the future study; this will help gain a deeper understanding of designers' needs and desires, so as to make the database useful and usable for the design community.

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