Applied Ergonomics 43 (2012) 713–726

Contents lists available at SciVerse ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Towards a capabilities database to inform inclusive design: Experimental investigation of effective survey-based predictors of human-product interaction

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A R T I C L E I N F O

Article history:
Received 22 March 2011
Accepted 2 November 2011

Keywords:
Inclusive design
Design practice
Design tools
User-centred design
Human factors

A B S T R A C T

A key issue in the field of inclusive design is the ability to provide designers with an understanding of people's range of capabilities. Since it is not feasible to assess product interactions with a large sample, this paper assesses a range of proxy measures of design-relevant capabilities. It describes a study that was conducted to identify which measures provide the best prediction of people's abilities to use a range of products. A detailed investigation with 100 respondents aged 50–80 years was undertaken to examine how they manage typical household products. Predictor variables included self-report and performance measures across a variety of capabilities (vision, hearing, dexterity and cognitive function), component activities used in product interactions (e.g. using a remote control, touch screen) and psychological characteristics (e.g. self-efficacy, confidence with using electronic devices). Results showed, as expected, a higher prevalence of visual, hearing, dexterity, cognitive and product interaction difficulties in the 65–80 age group. Regression analyses showed that, in addition to age, performance measures of vision (acuity, contrast sensitivity) and hearing (hearing threshold) and self-report and performance measures of component activities are strong predictors of successful product interactions. These findings will guide the choice of measures to be used in a subsequent national survey of design-relevant capabilities, which will lead to the creation of a capability database. This will be converted into a tool for designers to understand the implications of their design decisions, so that they can design products in a more inclusive way.

1. Introduction

Capabilities are fundamental attributes that a person needs to use everyday products. When interacting with a product, demands will typically be made on sensory (such as vision, hearing), motor (such as dexterity, locomotion, reach and stretch) and cognitive (such as memory, learning, comprehension) capabilities. In the context of design, capability refers to an individual's level of functioning, from very high ability to extreme impairment, which has implications for the extent to which they can interact with products (Johnson et al., 2009). As the human body ages, especially beyond the age of 65 years, there is a substantial reduction in functional capability (motor, sensory and cognitive capabilities) (Huppert, 2003). Age-related decline has implications for design. Failure to take account of this reduced functional capability in the design process results in older people, who constitute a growing proportion of the adult population, becoming excluded from product use (Elton and Nicolle, 2010). Inclusive design is a design philosophy that aims to consider this reduced functional capability during the design process, with the aim of making products functionally accessible to and usable by as many people as reasonably possible. By meeting the needs of those who are often excluded from product use, inclusive design improves product experience across a broad range of users (Coleman, 2001).

One way of promoting a better understanding of user needs is through the provision of end-user data, such as anthropometrics (e.g. physical characteristics) and capabilities databases for design of environments and products (McGinley et al., 2010). It should be noted that an end-user database in itself is unlikely to be of use to designers and that tools need to be developed that present the relevant data in an accessible and useful way for predicting difficulty and exclusion from product use. Examples of such tools include ADAPS (Molenbroek, 1987), a computer-aided design

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doi:10.1016/j.apergo.2011.11.005

model which uses twenty-five functional body dimensions of 822 elderly Dutch people, HADRIAN (Porter et al., 2004), a computer-aided design tool which allows evaluation of products and services against a database which uses 3D anthropometry and functional abilities and the Exclusion Calculator (Clarkson et al., 2007), a tool designed to estimate the number of people who would be excluded from using a particular product, based on assessing the demands on each individual capability domain.

Tools for predicting difficulty and exclusion 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 (Johnson et al., 2009). For example, it may be important to know not only how many people will have difficulty with the vision or hearing demands of a product, but also how many people will have difficulty with neither or with both. To obtain such information requires extensive measurement of people's capability across a range of domains (e.g. vision, hearing, dexterity, reach and stretch, locomotion, communication, thinking). The best way to measure these capabilities for the prediction of difficulty with products is not yet known. The breadth and multi-dimensional nature of capabilities can be best captured and represented through a database that covers multiple capability domains for a representative sample of the population.

1.1. Limitations with existing databases

A number of problems exist with the currently available end-user capability databases that have implications for their value in estimating the capabilities of the population. Consideration of these issues is instrumental in identifying the key features of future surveys designed to create a reliable capability database to inform the measurement of inclusion in product designs. Some of the problems associated with these databases, identified by Johnson et al. (2009) include:

- Lack of data on multiple capabilities. Existing databases such as Adultdata (Peebles and Norris, 1998), Older Adultdata (Smith et al., 2000) and Childata (Norris and Wilson, 1995), which cover multiple domains in a single publication, draw their data for each capability domain from different samples and thus assessment of multiple capabilities is not possible.
- Absence of surveys with an appropriate level of specificity in the questions. Where existing health and disability surveys are used, they ask only general questions and disease-specific questions, which are not very useful to Inclusive Design, since knowing that someone suffers from a particular disease (e.g. diabetes) does not reliably provide an indication of their capabilities. Surveys that fall into this category include the General Household Survey, the Family and Children Study, the Family Resources Survey, the Labour Force Survey, the Omnibus Survey and the Census (Bajekal et al., 2004; European Commission, 2008).
- Data derived from a non-representative sample of the population. For example, Geron 1998 Dutch Elderly study was biased to high educational level of the sample (Steenbekkers and van Beijsterveldt, 1998) and the ONS (Office for National Statistics) Great Britain Disability Follow-up Survey 1996/97 (Grundy et al., 1999) is limited by problems with the sift criteria used to sample the population (e.g. certain age brackets are known to be under-represented). In addition, the Disability Follow-up Survey was designed to provide a measure of severity of disability and not intended for use in providing a full range of capability estimates across the normal population.

1.2. Design-relevant survey of capabilities

In light of the above-mentioned limitations with the existing surveys, it is evident that a design-relevant survey of capabilities is needed in order to build a capability database. The key question is what measures can be devised that provide the most accurate and generalisable predictors of difficulty or exclusion when interacting with products. Johnson et al. (2009) reviewed the potential influences on the measures of capability and concluded that a number of issues need to be considered for the construction of a survey to reliably assess capabilities. Specific issues include: self-report versus performance measures; granularity of measurement; psychological characteristics; and naturalistic versus experimental settings for performance. These are discussed below. For more information on these issues, please see (Johnson et al., 2009).

1.2.1. Self-report versus performance measures

A person's capability can be assessed through either their own reports of capabilities or product interactions or objective measures of their performance. While self-report measures rely on the accuracy of the respondent's judgements and are easier to administer and less expensive, objective performance measures of capabilities require specialised equipment and can be time consuming (Kivinen et al., 1998; Hupkens et al., 1999). The two types of measures potentially assess different aspects of capability, so it is informative to know how well each of them predicts people's experienced difficulty or exclusion when interacting with products.

1.2.2. Granularity of measurement

Whether self-report or performance measures are used, the granularity of the measurement needs to be considered. For example at the lowest level of granularity, measures could be taken of a component function (such as vision measured by an eyesight test); at a medium level of granularity, measures could be taken of a specific activity (such as reading the LCD on a mobile phone); or at a higher level of granularity, measures could be taken of a task which integrates number of functions and activities. In line with Johnson et al. (2009), we use the term component function to refer to the basic sensory, motor and cognitive capabilities, which provide data on an individual's capabilities independently of how these capabilities are used to interact with products. Component activities are defined as smaller tasks within the larger product interaction. All these types of measures are arguably relevant to designers. Therefore, it is important to know the extent to which each of these provide a good prediction of how well people interact with products.

1.2.3. Psychological characteristics

Certain psychological states and traits of a person are likely to directly influence their capability when using a product. There is extensive evidence that mood or emotional state can change a person's perception, thoughts and behaviour (see Forgas, 2008 for a review). Similarly it can be expected that greater self-confidence and motivation will increase a person's capability. The success of product interactions can be influenced by the beliefs and attitudes that a person holds. These include: self-efficacy, self-esteem, optimism and perceived mastery. However, there is a distinction between general self-efficacy and product-related self-efficacy. A question exploring general self-efficacy would be, 'I can solve most problems if I invest the necessary effort', whereas a question exploring product-related self-efficacy would be, 'I am confident in my current skills and ability to learn how to use a new piece of equipment in my home'. In other words, an individual may have high general self-efficacy but poor self-efficacy regarding