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ADAPTATION OF A DISABILITY SEVERITY SCALE FOR PRODUCT ASSESSMENT

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Abstract

An inclusively-designed product should accommodate the widest possible range of user capabilities. Consequently, it is important for designers to know about the full range of potential user capabilities found across the general population when assessing product attributes prior to redesign or new concept development. A mapping between user capabilities and product assessment is thus required. This paper aims to find such a mapping through the application of a severity of impairment scale to product assessment.

Keywords: databases, evaluation of design, human factors

1 Introduction

Studies show that by 2021, half the adult population in the UK will be over 50 [1] and that similar trends are observable elsewhere (Figure 1). Such ageing populations are known to exhibit an increasing divergence in physical capabilities [2], in general more people become less capable.

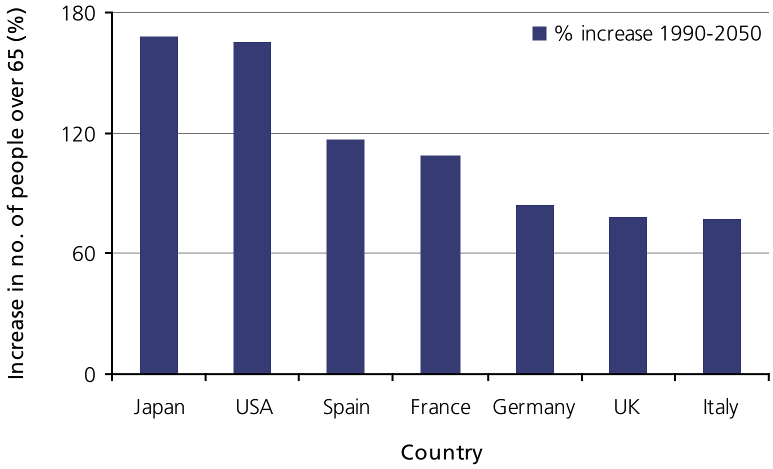

Figure 1. A sample of worldwide population trends

At the same time, the products that we use everyday seem to become ever more complex. Whether this trend is true or not, it is evident that products make demands of their users. For example, a mobile phone demands that its users can read the legends on its keys. If the size of the keys is reduced, with a corresponding reduction in legend size, to meet a marketing need for a smaller phone, then the demand made on the users' visual capabilities is increased.

When such demands exceed the capabilities of the user, then the user will find it difficult, or at worst impossible, to use the product, thus leading to exclusion. Hence, as populations age and capabilities fall, it becomes increasingly necessary for products to support a wider range of physical capabilities to avoid the risk of exclusion [3].

2 Design exclusion

One of the steps to ensuring that designs are as genuinely inclusive as possible is to provide metrics for defining the level of inclusivity attained for a given product. However, while it is useful to know who and how many can use the product, that information will not provide guidance on how to include more.

Conversely, knowing who and how many people cannot use the product and why they cannot do so immediately highlights the aspects of the product that need to be improved. For example, if a product excludes a significant proportion of the population because the users either cannot hear or see the output from the product, then designers know to re-design the features involved in providing the output to the users.

Many of the existing approaches to inclusive design and design for all are focused on making products and services more accessible by extending the initial concept of the user to include a wider range of users. While this is an excellent starting point, the success of the resultant design is highly dependent upon the choice of users at the outset. If the user selection is very specific, then the needs of those, and very similar, users should be well catered for. However, the overall capacity of the final product to meet the needs of different user groups may be compromised if the design is tailored too closely to a limited number of very particular users.

For example, consider the design of a computer input device that filters out tremor. Tremor can arise from a number of medical conditions, as a result of the aging process, or from external environmental factors such as movements from being on a train. Tailoring the input filters to assist users with just one condition, such as ataxic cerebral palsy, may inadvertently limit their usefulness for users with Parkinson's Disease, say. Therefore, it is best to consider the needs of all users with similar conditions during the design process. This can be achieved by careful consideration of all possible user groups at the outset of the design process. However, there is an alternative and complementary approach of identifying and countering design exclusion.

The underlying principle of exclusion is that by identifying the capability demands placed upon the user by the features of the product, it is possible to establish the users who cannot use the product irrespective of the cause of their functional impairment. Consequently, by re-designing the product to lessen the demand, users from a wider range of user groups can potentially be included and no-one is excluded unnecessarily by considering one cause to the detriment of others.

To support this concept of countering design exclusion, it is necessary to consider methods of assessing the features of a product and the user's interaction with them to establish the capability demands placed upon the user. Those demands can then be translated into numbers of people unable to use the product and as such provide a basis for measuring the success of the design with respect to levels of inclusion. The process of identifying the level of capability demanded by particular features and the consequent population exclusion also provides a basis for prioritising the re-design effort to modify the features that cause the most exclusion.

3 User data

In order to identify populations who can (or cannot) use products there is a need to identify relevant data describing prospective users. Fortunately, there are many sources of such data available, each tailored for different purposes, including, for example, descriptions of:

- coherence: a uniform measure of a wide range of capabilities;
- physical characteristics – the size (and strength) of the user;
- socio-economic characteristics – the educational and social background of the user;
- disability data – what the user cannot do;
- capability data – what the user can do (this may be an interpretation of the disability data);
- medical conditions – describes the health of the user (often in terms of a number of disabilities);
- longitudinal studies – how the user's health and abilities change with time;
- market surveys – what the user likes or dislikes.

Any or indeed all such data may be relevant to product design and much of it is certainly interrelated. However, in terms of understanding whether users are physically excluded from using a particular product, the disability/capability and physical data are more important. Indeed, anthropometric data provides the predominant source of physical data used in product design, allowing designers to knowingly accommodate users within extremes of physical size.

Such data is usually assembled from a variety of sources with no particular group of users providing all the data. The data can also be age related, as is the case with data available in the UK for children [4], adults [5] and older adults [6].

Specific standards also provide guidance on the interpretation of anthropometric data for the design of particular products. For example, there are international standards describing required practice for the design of machinery guards. In the absence of specific standards it can be difficult to relate user data to product design. This is particularly so with disability data.

3.1 A model of disability

Estimates of the prevalence of disability derived from any study depend on the purpose of the study and the methods used [7]. Since disability has no 'scientific' or commonly agreed upon definition [8], a major problem lies in the confusion over terminology. However, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) represents a rationalisation of the terminology frequently used.

The ICIDH identifies impairment, disability and handicap as consequences of diseases and presents a classification for each. This model can be extended to accommodate the effects of ageing and accident (Figure 2).

The ICIDH also defines disability as "any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being" [9]. This definition has been used widely for both disability research [7, 10] and design research [11]. However, such language is now generally considered too negative and it is preferable to describe users in terms of their capabilities rather than disabilities.

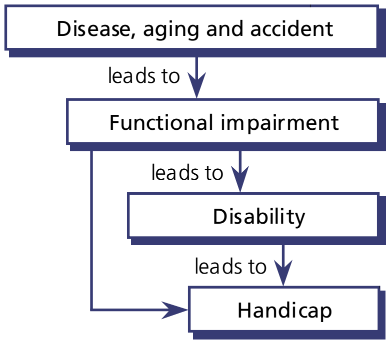

Figure 2. A model of disability (adapted from [9])

Thus ‘capability’ describes a continuum from high, i.e. ‘able-bodied’, to low representing those that are severely ‘disabled’. Data that describe such continua provide the means to define the populations that can use given products, thus leading to the possibility of evaluating metrics for inclusive design.

3.2 Multiple capability losses

Traditionally, design research tends to focus on accommodating single, primarily major, capability losses. The reasons for this are two-fold. First, single major impairments are often the most noticeable and therefore are the easiest to inspire the necessary motivation to address them. Second, such impairments are the easiest to understand and are comparatively easy to compensate for, as there are no complex interactions with other capabilities.

Unfortunately, many people do not just have single functional impairments, but several. This is especially true when considering older adults. Consequently, designers need to be aware of the prevalence of not only single, but also multiple capability losses.

Therein lies a problem, most user data focuses on single impairments. Even within single data sets, for example, Adultdata [5], individual tables may be derived from different user samples, making evaluation of user populations that take account of multiple capability losses difficult. The next section describes in more detail the only data set the authors have discovered to date that resolves this issue, providing from a single source data that describes a wide range of user capabilities.

4 The Great Britain disability surveys

Data assembled by the UK government as a means of assessing future care-provision requirements in Great Britain has the potential to be adapted for product evaluation. These data include the Survey of Disability in Great Britain and the Disability Follow-up (DFS) to the 1996/97 Family Resources Survey (FRS).

4.1 The Survey of Disability in Great Britain

The Survey of Disability in Great Britain [7] was carried out between 1985 and 1988. It aimed to provide up-to-date information about the number of disabled people in Britain with different levels of severity of functional impairment and their domestic circumstances. The purpose of the survey was to provide information to allow the planning of welfare benefits and services provision.

The survey used 13 different types of disabilities based on those identified in the ICIDH [9] and gave estimates of the prevalence of each type. It showed that musculo-skeletal complaints, most notably arthritis, were the most commonly cited causes of disability among adults living in private households. Ear complaints, eye complaints and diseases of the circulatory system were also common. For those living in communal establishments, mental complaints, particularly senile dementia, were mentioned most often.

An innovative feature of the survey was the construction of an overall measure of severity of disability, based on a consensus of assessments of people acting as 'judges', including doctors, physiotherapists, occupational therapists, psychologists, UK Department of Health staff and representatives of disabled people. In essence, the severity of all thirteen types of disability is established and the three highest scores combined to give an overall score, from which people are allocated to one of ten overall severity categories.

4.2 The Disability Follow-up Survey

The Disability Follow-up [10] to the 1996/97 Family Resources Survey [12] was designed primarily to update information collected by the earlier Survey of Disability in Great Britain [7] and to provide data on entitlement to state benefits. The results showed that an estimated 8 582 200 adults in Great Britain – 20% of the adult population – had a disability according to the definition used (Figure 3). Of these 34% had mild levels of impairment (categories 1-2 – i.e. high capability), 45% had moderate impairment (categories 3-6 – i.e. medium capability) and 21% had severe impairment (categories 7-10 – i.e. low capability). It was also found that 48% of the disabled population were aged 65 or older and 29% were aged 75 years or more.

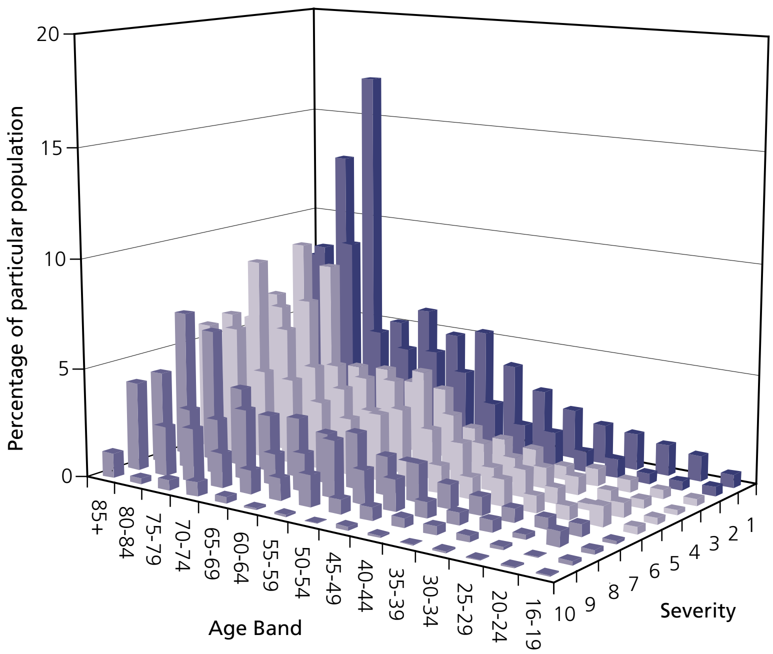

Figure 3. Distribution of disability for Great Britain

For the purposes of product assessment, 7 of the 13 separate capabilities used by the surveys are of particular relevance. These may be grouped into three overall categories:

- motion – locomotion, reaching and stretching and dexterity;
- sensory – seeing and hearing;
- cognitive – communication and intellectual functioning.

A typical capability scale is shown in Table 1. It should be noted that the scales were not defined with product assessment in mind. However, they can be adapted to this task.

Table 1. The dexterity capability scale [7]

Dexterity		Severity score
D1	Cannot pick up and hold a mug of coffee with either hand	10.5
D2	Cannot turn a tap or control knobs on a cooker with either hand	9.5
D3	Cannot pick up and carry a pint of milk or squeeze the water from a sponge with either hand	8.0
D4	Cannot pick up a small object such as a safety pin with either hand	7.0
D5	Has difficulty picking up and pouring from a full kettle or serving food from a pan using a spoon or ladle	6.5
D6	Has difficulty unscrewing the lid of a coffee jar or using a pen or pencil	5.5
D7	Cannot pick up and carry a 2.5kg bag of potatoes with either hand	4.0
D8	Has difficulty wringing out light washing or using a pair of scissors	3.0
D9	Can pick up and hold a mug of tea or coffee with one hand but not with the other	2.0
D10	Can turn a tap or control knob with one hand but not with the other/ Can squeeze the water from a sponge with one hand but not the other	1.5
D11	Can pick up a small object such as a safety pin with one hand but not with the other/Can pick up and carry a pint of milk with one hand but not the other/Has difficulty tying a bow in laces or strings	0.5

4.3 The prevalence of capability losses

A summary of the DFS data is presented in Figure 4 for the 16-49 years old and 75+ populations. Perhaps the most striking feature is the order of magnitude difference in the scales used for each figure. While the graphs have similar distributions, the percentage of those with a loss of capability in the 75+ age band is 10 times higher than for the 16-49 band.

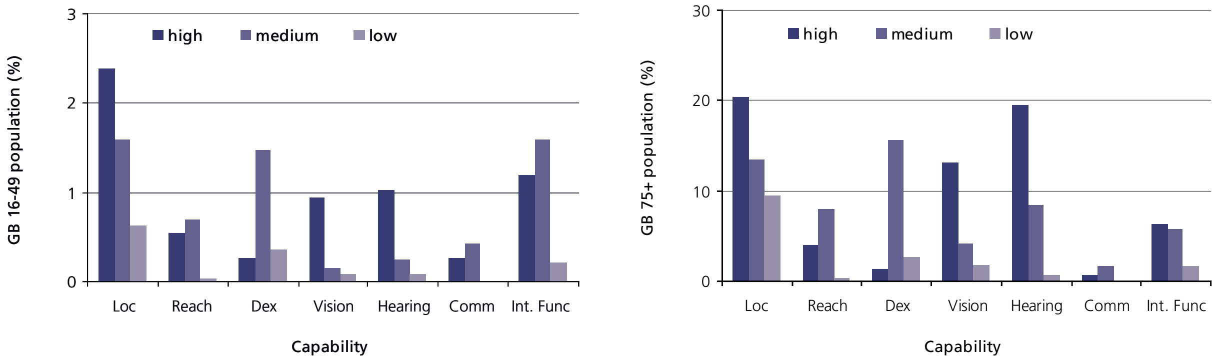

Figure 4. Capabilities for Great Britain 16-49 and 75+ populations

In terms of the prevalence of capability losses, the expected distribution for each capability would show the largest proportion of adults with little or no impairment of that capability. Fewer adults would exhibit moderate impairments and fewer still would be severely impaired.

Looking at Figure 4 again, it can be seen that the locomotion capability (the ability to walk), for example, follows the expected distribution. However, dexterity does not. The dexterity impairment distribution shows very few people with low impairment, then an increase for medium impairment, and finally a decrease for high impairment. The explanation for the discrepancy lies in the process of data collection.

The data for the DFS was gathered by interview, with the participants being asked to 'self-report' any impairments. As such, no consistent measures of performance were used, simply the opinions of the participants as to how difficult they found performing particular actions or activities to be. Therefore, the accuracy of the data collected is dependent upon the level of self-awareness required to detect and assess the magnitude of difficulties encountered with each action or activity.

Locomotion difficulties are more noticeable because they often have a defined end goal, such as reaching the top of the stairs, or keeping pace with someone else. As such, when someone's locomotion capability becomes reduced, it is more easy to recognise. The same applies for vision and hearing, which also follow the predicted distribution of severity.

Dexterity, however, typically degrades gradually over time, and there are no obvious measures of one's own dexterity performance. It is difficult to assess whether it is a little harder to pick up something than it used to be, or if glass jar lids seems a bit tighter than they were a few years ago.

The above example illustrates the importance of considering the process by which population capability data is collected. Only by knowing that the DFS was gathered by interview and self-reporting was it possible to understand the distribution of dexterity capability.

4.4 Multiple capability losses

Many people will, at some stage of their life, exhibit more than one capability loss. From a design perspective this is important since each loss has the potential to cause exclusion. Design improvement needs to address each capability loss if the full benefit of the improvements is to be realised.

The disability surveys provide valuable information for analysing multiple capability losses. For example, Table 2 summarises the data from the Disability Follow-up Survey. It is evident that at least half of those with some loss of capability have more than one loss of capability.

Table 2. Multiple capability losses for Great Britain

Loss of capability	Number of GB 16+ population	Percentage of GB 16+ population
Motion	6 710 000	14.3%
Sensory	3 979 000	8.5%
Cognitive	2 622 000	5.6%
Motion only	2 915 000	6.2%
Sensory only	771 000	1.6%
Cognitive only	431 000	0.9%
Motion and sensory only	1 819 000	3.9%
Sensory and cognitive only	213 000	0.5%
Cognitive and motion only	801 000	1.7%
Motion, sensory and cognitive	1 175 000	2.5%
Motion, sensory or cognitive	8 126 000	17.3%

Figure 5 provides more detail on multiple capability losses for the GB 16+ population. The darker circles correspond to the percentage of people who exhibit either of the capability losses, but not both. Conversely, the lighter circles represent people showing losses in both capabilities.

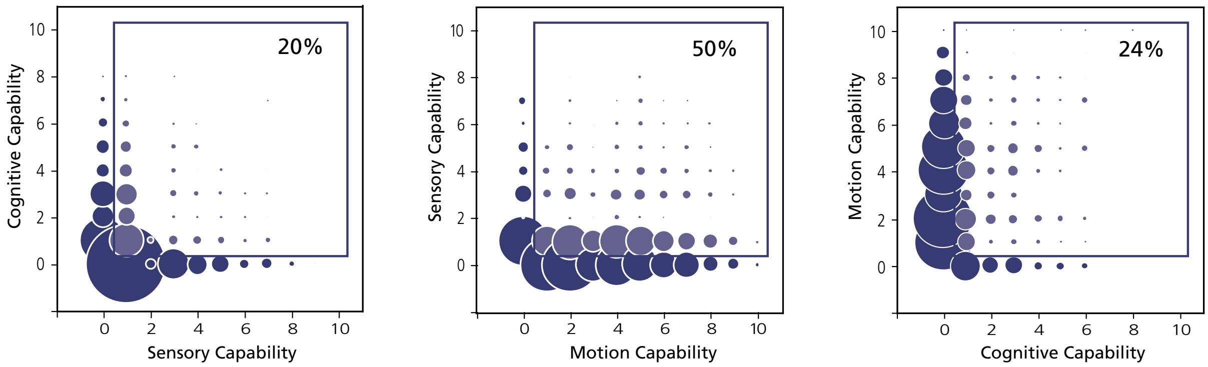

Figure 5. Motion, sensory and cognitive capability losses for GB 16+ population

The 'bubble' diagrams provide a direct summary of capability distribution. The area of each circle represents a percentage of 16+ age band. The percentages of couplings between each pair of capability losses are shown in the plot. For example, it is evident that there is a high level of coupling (50% - represented by the circles within the blue square) between motion and sensory capability losses.

Of particular note is the fact that many people with varying degrees of motion impairment also have some minor sensory or cognitive impairment.

4.5 Summary

The analysis of capability data generates useful information for designing for a wider range of user capabilities. However, different definitions of disability and data collection methods used for surveys often result in data that is not immediately comparable. Hence it is important to identify the purpose for which the data is required, the consequent nature of the data needed and thus the most appropriate data source. Even after this process, it may still be necessary to modify and adapt the data to meet the specific information need.

Multiple capability losses present particular challenges for designers and if their importance is to be fully appreciated, comparable capability data is essential. Hence, despite some reservations regarding the DFS data, it does at least provide some insights in this area.

5 Product assessment

The reduced scale, comprising the seven selected capability measures, was used for assessing a range of everyday products. It was found that the scale successfully provided a common platform for product assessment. It is particularly useful in identifying the most excluding features of the products in question, and different types of products were well differentiated by their overall exclusion. For example, telephones and kettles resulted in totally different exclusions in terms of their accommodation of people's capabilities.

The adaptation of the scale to product assessment also helped highlight important issues of designing inclusive products because it inspires designers to think of all possible barriers in terms of product/user interaction. However, since the scale was not originally designed for product assessment, there are a number of inherent shortcomings, for example, the lack of continuity between scale points and the lack of precise descriptions when applied to product assessment. It is difficult to differentiate features for similar products, such as a range of typical telephones. Also, the *cognitive* scale (including *communication* and *intellectual functioning*) lacks sophistication and has low verification [7].

It may be possible to refine the scale to overcome these difficulties by, for example:

1) *adding 'missing' points* – to create continuity interpolation could be used to even out the spread of scale points;
2) *subdividing scales* – a number of the scales are evidently constructed from a number of separate, but related, scales;
3) *reconstructing scales* – revised scales, based on the same survey questions, could be defined to better reflect cognitive requirements of the user/product interaction.

Interpolation on its own is difficult to use due to the often vague descriptions used by the capability scales. However, interpolation used in conjunction with a subdivision of the scales may be possible.

A number of the scales, including that shown in Table 1 include phrases such as "cannot", "has difficulty" and "can". Such descriptions could provide the basis for defining fixed points on a continuum scale. In addition, a number of the scales naturally decompose into sub-scales. Table 1, for example, is concerned with picking up, carrying, turning and fine control. Dividing product demands into these categories may also provide the means to interpolate between the existing data points.

It was thought that referring to other sources of disability/capability data could be helpful, but to date the investigation has shown that it is hard to compare data derived from different sources because the purpose of the survey and the underlying definitions of disability are frequently different and incompatible. Consequently the development of the assessment scale is concentrated on internal refinement.

The definition of new cognitive scales has been attempted and the results of this work are presented in a further paper [13].

6 Conclusions

In seeking for a mapping between user capability and product assessment, the Survey of Disability in Great Britain severity scale [7] and the up-dated data derived from the Disability Follow-up Survey [10] appear to provide a promising starting point. The unique feature of the data is that the descriptions of the component scales are applicable for both *performance measures* (user capability) and *product feature assessments* (capability demand). The adoption of the scale to product assessment has a number of advantages:

- coherence: a uniform measure of a wide range of capabilities;
- flexibility: predictable estimation of combined multiple capability losses;
- continuance: the same population base for all capabilities; and
- direct mapping: the scale descriptions are readily applicable for product assessment and can be mapped to the general population for quantified estimation.

However, as mentioned before, there are a number of shortcomings of the scale and it needs refinement to better adapt it to product assessment.

Acknowledgements

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