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Differences in vision performance in different scenarios and implications for design

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ABSTRACT

To design accessibly, designers need good, relevant population data on visual abilities. However, currently available data often focuses on clinical vision measures that are not entirely relevant to everyday product use. This paper presents data from a pilot survey of 362 participants in the UK, covering a range of vision measures of particular relevance to product design. The results from the different measures are compared, and recommendations are given for relative text sizes to use in different situations. The results indicate that text needs to be 17–18% larger for comfortable rather than perceived threshold viewing, and a further 20% larger when users are expected to wear their everyday vision setup rather than specific reading aids.

1. Introduction

Visual ability is often critical in product and service use, affecting many aspects such as the capability to read text, see warning signs and recognise icons. It is thus important to consider the visual ability of the target population when designing products and services. Otherwise, users may struggle or may even be excluded from using the product. This is particularly important in the context of accessibility and inclusive design, which aim to meet the needs of a wide range of users, and reduce the numbers of those who would be excluded (Keates and Clarkson, 2003).

To design appropriately, designers need good population data on visual abilities and how they relate to product use. However, the currently available data often focuses on just a few vision measures, which are appropriate for some but not all design situations.

Population-based surveys commonly use distance visual acuity to reflect visual function. This is important information for designing signage and advertising viewed at a distance, but products are often viewed close-up. Near vision ability is distinct from (not correlated well with) that at a distance (Lovie-Kitchin and Brown, 2000), and in older patients requires different refractive correction (Pointer, 1995).

Furthermore, surveys of visual ability typically measure best corrected vision. However, there are many product use situations where users may not want to or be able to change their glasses, such as in the middle of cooking or on a date. It is also important that people should be able to discover and read warning labels and critical information without first putting on their reading glasses. Further, not everyone has spectacles that provide best correction, even in developed countries such as the UK (Evans and Rowlands, 2004).

Lack of best correction can often be compensated for to some extent by changing the working distance of the task, i.e. the distance at which the items used are viewed at during the task. For example, people with uncorrected age-related long sightedness may hold text at arm's length. The distance does not matter as long as the text can be read at that distance without difficulty. Therefore near vision tests that examine physical print size, allowing the user to choose the working distance, are most relevant to product design. However, in clinical assessment, reading ability is usually assessed at standardised working distances (Bailey and Lovie, 1980; Mansfield et al., 1996) to determine the angular size of print that can be read.

Vision studies typically measure threshold performance, often

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examining the smallest letters that can consistently be correctly identified (Bailey, 1998). This is often chosen as it is a standardised measure that can easily be compared across groups. However, from the perspective of product design, it is more important to understand what people can see comfortably (Porter et al., 2004; Legge and Bigelow, 2011). Comfort (or lack of comfort) can impact perceptions of and emotional response to a product, as well as the effective use of the product. For example, if users cannot read text on a product comfortably, they may not read it carefully, resulting in misreading of information. For example, Kenagy and Stein (2001) explain that problems with medicine labels and packaging can result in serious medical errors, citing as an example “two vials that appear to be virtually identical (except for the drug name, in 8-point type)”.

For reading, the smallest print size that supports the maximum reading speed is termed the critical print size, and is often taken to indicate the print size that can be comfortably read (Legge et al., 1985; Whittaker and Lovie Kitchin, 1993). However, the size of print perceived as comfortable by an individual is different to measured values of critical print size (Friedman et al., 1999; Szlyk et al., 2001; Tejeria et al., 2002; Latham and Usherwood, 2010).

A further issue of visual function studies is that vision measures are typically collected under clinical conditions with optimal lighting levels. However, products are commonly used in the varying and often poor lighting conditions of people's homes (Farrell, 1991; Percival, 2007). Since visual ability declines with reduced illumination (Hecht, 1927; Elton et al., 2013), a design that is usable in a clinical environment may not be usable in practice.

These issues indicate that clinical measures of visual function may not correspond to visual ability as it relates to product use in the real world. This paper aims to address some of these issues, by presenting and comparing data on vision measures that have been intentionally chosen to be relevant to real-life product use situations. Vision measures were collected using printed vision charts in participants' own homes, which is a typical setting for product use. They include near as well as distance visual ability; perceived comfort as well as perceived threshold vision ability; and near vision with the vision aids participants wear on an everyday basis, and with the setup they choose for reading. Recommendations are given for relative text sizes to use in different design situations.

2. Methods

2.1. Survey as a whole

A survey was conducted examining a wide range of human capabilities and characteristics related to product use, including, but not limited to, vision. Items were a mix of self-report questions and performance tests. The survey was conducted face-to-face in participants' homes so that the testing environment would be similar to that in which most products are typically used. For pragmatic reasons, the in-house testing environment was used for all tests, even though some of the measures (e.g. distance vision measures) could be more applicable to an outdoor environment.

The survey was a pilot in preparation for a full national survey. There were 362 participants, with the sample taken to represent the general adult population living in private households (see below). It can therefore provide useful data and enable preliminary conclusions. The survey is described in more detail by Tenneti et al. (2013). The resultant dataset is publicly available online (Clarkson et al., 2012).

2.2. Sample and weighting

The sampling strategy was designed to obtain a representative sample of the general population in England and Wales aged 16+ and living in private households. 990 postcode addresses were drawn from 30 primary sampling units across England and Wales. At responding households, interviewers selected one individual aged 16+ at random. The response rate was 37% of the issued sample or 40% of the eligible sample. 362 responses were obtained (53.6% female). The age distribution was: 16–39 (31%), 40–65 (47%) and over 65 (22%).

Weighting factors were applied to the results to account for just one person being interviewed per address, even though some addresses had multiple people at them. The weights also accounted for household non-response based on a logistic regression model with various demographic variables. They were further adjusted so that the weighted sample best matched the population in terms of age, sex and region. The results reported in this paper use these weights. More details can be found in Collingwood et al. (2010).

2.3. Vision module

2.3.1. Vision charts

The tests were conducted using logarithmic progression letter charts as used by Elton et al. (2013). The distance charts used LogMAR progression, while the near vision charts were based on a logarithmic progression with the letter sizes rounded to the nearest 0.1 mm. The charts were printed at 300 dpi, and matt laminated.

The tests took place under the variable lighting levels present in the participants' homes. Vision performance declines with reduced lighting, e.g., Elton et al. (2013) found that “VA decreased by 0.2 log units between … overcast and street lighting conditions”. The variable lighting levels therefore affected the results, with some participants measuring at a poorer visual acuity because of low lighting levels. Nevertheless, lighting levels were not controlled in the study because lighting is not controlled in users' homes in practice. Designers do not typically design for a particular lighting level but simply for use in the “real-world” (as described in Section 1).

The interviewers coded 97.5% of the tests as taking place in at least “adequate” lighting, based on their personal judgement. This method of coding matches the situation in real world product use, where the lighting levels are typically chosen by users based on personal judgement. A more objective measure of lighting, such as a light meter, may have been desirable but was not feasible within the constraints of the study. The vision tests were part of a larger battery of tests, and were carried out in multiple areas of the UK by a team of interviewers from an external agency. The amount of time available to train interviewers on the vision module was limited, and introducing additional new equipment that they had not seen before was not feasible.

This paper describes results from tests using two charts: (i) a distance vision chart with very high contrast (90%) letters, and (ii) a handheld near vision chart with 70% contrast letters. A 90% contrast level was used for the former because this closely matches the standard vision chart for distance vision. A 70% contrast level was chosen for the near vision chart because Elton et al. (2013) demonstrated no significant difference in near vision readability between 70% and 90% contrast, and 70% is more typical of text and graphics used in product design.

The distance chart had nine rows, and the near chart had twelve rows with eight letters per row, consistent with the Regan acuity chart (Hazel and Elliott, 2002). Stroke width was one fifth of letter height. The capital letters used were: D, E, F, H, K, N, P, U, V and Z, presented in 5×5 format (as used by Elton et al., 2013). The letter sizes on each row of the charts are given in Table 1.

The distance test was chosen to closely match a standard distance visual acuity test. The near vision tests used scaled versions of