Institution: University of Reading

Unit of Assessment: 16 Architecture, Built Environment & Planning

Title of case study: Making the built environment and public transport more user-friendly for visually-impaired people

1. Summary of the impact

There are about two million visually-impaired people (VIP) in the UK, over four times the number of wheelchair users. Research performed in Reading's School of Construction Management and Engineering has brought significant improvements to the quality of life and safety of VIP by developing a better measurement of their visual contrast sensitivity and putting this measurement into practice. For someone with a visual impairment, the ability to distinguish between different objects and surfaces is crucial for assessing the surrounding environment and navigating it accurately and safely. The research has defined a measurable contrast difference (30 points on a 1-to-100 light reflectance value (LRV) scale) between surfaces of any colour that can be confidently identified by 80% of VIP in the UK. This new contrast standard offers a significant breakthrough in understanding and simplifies the concept of LRV. It provides designers and product manufacturers with a useful yardstick by which urban environments and public transport systems can be made more accessible and safer for VIP to use. The new definition has effectively replaced the previously used concept of luminous reflectance in this arena and is now in widespread use, thanks to the establishment of an internationally recognised method of surface colour measurement (BS 8493) in 2009 that draws on the Reading work. The research has led to improved national and international standards and national regulations on building and accessability product design, among other things, and continues to enhance the quality of life and employment prospects of people who are visually impaired by providing clear guidance for designers and manufacturers.

2. Underpinning research

The Disability Discrimination Act (DDA) of 1995 prompted the need for new research and evidence-based guidance for designers on improving accessibility across a range of disabilities. This research arose against that background, and was also informed by the work of CIB (International Council for Research and Innovation in Building and Construction) Working Group 84 (on non-handicapping environments, established in 1994). The lead Reading researcher (Cook) and others in the School began discussions in 1994 with contacts in the charity sector, including at the Royal National Institute for the Blind (RNIB), the Royal National Institute for Deaf People (RNID) and the Guide Dogs for the Blind Association (GDBA), about the role of research in improving accessibility. Discussions focused around the potential to improve the built and transport environment for VIP, who number around two million in the UK (compared to around 450,000 wheelchair users). In addition to the RNIB and the GDBA, ICI Dulux agreed to engage in the research proposal to examine how colour and contrast could help VIP when they interact with the built environment. This highly successful collaboration resulted in the award of a two-year EPSRC Grant (GR/K51860/01) in March 1995.

The research project had three distinct but related stages. The first stage, completed in November 1995, involved obtaining information about how and why VIP interact with, and navigate through, the built environment and how they use public transport. This was achieved using a survey distributed by the RNIB to 1500 VIP. Follow-up group interviews with 66 VIP were performed to understand why VIP make certain choices when interacting with their environment. The second part of the project, completed in October 1996, measured the 'colour contrast perception' – the ability to identify contrasting coloured surfaces as different - of a representative sample of VIPs. Because of weaknesses in using conventional vision registration classification criteria, two new test methods were developed. One determined the field of vision of test subjects and the other measured colour contrast perception. Both tests have relevance beyond the built/transport environments. A special visual display chamber was constructed to display two standard samples to all 38 test subjects, who were asked to identify a contrast difference between them and to give their level of confidence in doing so. This generated a large data set (over 10,000 observations) covering a large part of the colour spectrum and enabled the researchers to identify a threshold for the confident identification of contrast across a range of sample colours. A key finding was that

colour contrast is more consistently evident when considering the value (light/dark) element of a coloured surface, than the hue or chroma (intensity) of the colour itself.

The third stage, completed in January 1997, examined the survey and test results in a 'real world' setting. A series of six rooms were decorated to show a wide range of colours and different contrasts between elements and components within them. Test subjects were a subset of those who had undertaken the colour contrast perception test. They were asked to identify the contrast differences between different surfaces and surface components (e.g. doors built into walls) in these rooms.

Overall, the key finding of this study is that if two coloured surfaces adjacent to one another have a contrast difference defined as a CIE (International Commission on Illumination) 'Y' difference of 30 points, they would be identified as different surfaces by 80% of the visually-impaired/blind population of the UK. In 2008, this finding led to the establishment of a new standard test (BS8493) for accurately measuring the contrast between two different-coloured surfaces. This contrast was formerly known as the CIE 'Y' difference but is now named by the Reading team as LRV. Today, the LRV contrast measurement is used by designers of built environments and manufacturers of paints, carpets, vinyl flooring, stair nosings, handrails, office furniture and a wide range of surface finishes with a view to making products as useful to the spectrum of VIP as possible.

3. References to the research

A total of 15 academic and policy-related publications have stemmed from this research. Key publications include:

1. Cook, G.K., Bright, K.T., "The colour, light and contrast manual - Designing and managing inclusive built environments", Wiley-Blackwell, Oxford ISBN 978 1 4051 9504 1 (2010). http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1405195045.html
2. Cook, G.K., "Colour Contrast and Lighting", in Disability: Making Buildings Accessible, Workplace Law Network Special Report, Chapter 6, 3rd edition, Ed. Bright K.T., ISBN 1 900 648 48 2 (2005). http://www.ribabookshops.com/item/disability-making-buildings-accessible-special-report-third-edition/36286/
3. Cook, G.K., Bright, K.T., "Research into Practice - The Innovative use of colour and contrast to produce an inclusive environment", CIOB Innovation Award Archive, CIOB, Ascot Berkshire (2004). [Runner-up in the CIOB Innovation Award 2004.] Available upon request.
4. Cook, G.K., Bright, K.T., Harris, J., "Building Design: The importance of flooring pattern and finish for people with a visual impairment", The British Journal of Visual Impairment, 17, 3, 121-126 (1999). http://jvi.sagepub.com/content/17/3/121.abstract
5. Cook, G.K., Bright, K.T., "Project Rainbow: A Research Project to Provide Colour and Contrast. Design Guidance for Internal Built Environments", Occasional Paper No. 57, The Chartered Institute of Building, Ascot, Berkshire. ISBN 1 85380 084 8 (1999) [Winner of the CIOB Innovation Award, Research Papers Competition 1997.] Available upon request.
6. Cook, G.K., "Lighting Quality aspects - Essential Requirements for Visually Impaired People", in Proceedings of the 1st CIE Symposium on Lighting Quality, National Research Council, Ottawa, Canada, pp48-59 ISBN 3 900 734 91 7 (1998). http://www.techstreet.com/cie/products/1210099

The work has been incorporated into two national and two international standards. In addition to the CIOB awards noted above for Cook and Bright (1999, 2004), Cook (1998) was presented at the inaugural CIE Symposium in 1998 dealing with lighting for the visually impaired. Cook (2004) was published by CIBSE (Chartered Institution of Building Services Engineers) and was peer-reviewed by the CIBSE Technical Committee. The British Journal of Visual Impairment (Cook, Bright and Harris, 1999) is a leading peer-reviewed journal in the field.

Grant Funding

Principal Investigator: Mr. K. Bright.
Title: Colour in Refurbishment: A Design Guide for the Visually Impaired.
Sponsor: EPSRC-LINK
Value: £380,000

Year: 1995

4. Details of the impact

The research has redefined best practice in visual contrast standards for the regulation and design of urban environments and public transport systems, thereby improving the way in which VIP interact with their environment and making environments easier for VIP to navigate. It has helped guide those responsible for the design and management of these environments in creating environments that are accessible, safe and inclusive, and that adhere to the scope of the DDA 1995 and 2005 (as embedded within the more recent Equality Act 2010). The work described here has led directly to new formal standards and design/test methods and, crucially, to changes in national regulations. While these standards and regulations previously emphasised the need to maximise colour and luminance contrast - and to ensure 'adequate' colour contrast, between surfaces with different functions (eg walls and doors) so that VIPs could confidently identify them - it did not, prior to the Reading work, provide any clear definition of what 'adequacy' of contrast meant. Nor did it demonstrate how designers and others might achieve this (in terms, for example, of what contrasting colours to use). The Reading work developed a measurable contrast difference between colours that can confidently be identified by 80% of VIPs in the UK, and defined a new standard for how this may be achieved.

These research findings are being used by a number of organisations, including large manufacturing companies such as ICI Dulux, a variety of charities, government departments, such as the Department for Transport, and national and international bodies that set standards for buildings and products. This informs the design of products such as floor and wall finishes (carpets, floor tiling, paints, etc), edgings (stair nosings, carpet edge strips, etc), handrails, door and window 'furniture' (handles, locks, etc) and signage.

The Business Area R&D Director at ICI Dulux, commented on the "Colour and Contrast" guide published by ICI Dulux as a result of the Reading work (correspondence, March 2013): ".. *this guide forms the basis of various offerings to specifiers and healthcare organisations… It is regularly presented around the country, and showing how the colour palette notation makes it easy to specify in accordance with the Equality Act guidelines is also good for sales volumes*." Manufacturer Gradus, which produces flooring and flooring accessories, references the Reading findings in their product literature at: http://www.gradusworld.com/geoff-cook-expert-view-part-1.

The Thomas Pocklington Trust charity has used the findings of the Reading work to produce a housing design guide for people with sight loss: http://bit.ly/I2Y9pC . The Director of Services and Public Affairs at Royal London Society for the Blind, has noted (correspondence, March 2013) how the research continues to be used to advise on the provision for vision-impaired people, and concludes: "*Project Rainbow* [the Reading work] *has, in my view, had a significant impact on the regulation and design of public transport and public infrastructure for the benefit of vision-impaired people*."

In the area of standards development, the Reading work is referenced in the British code of practice for designing buildings to meet the needs of disabled people (BS8300:2009 (Annex B)). An associated Standard, BS 8493:2008, describes the method used to determine the LRV of different material surfaces, which again draws on the Reading work. The Building Regulations 2010 Approved Document M, available at http://www.planningportal.gov.uk/uploads/br/BR_PDF_AD_M_2010.pdf , and a previous 2004 version, reference the Reading work in the context of the need for adequate visual contrast to be provided in new buildings (as appeared in the 2004 version). The international standard ISO 23599 (related to assistive products for blind and vision-impaired persons, and concerned with tactile surfaces) has adopted the Reading LRV approach. At the European level, standard CEN/BT/WG 207 on accessibility in built-up environments is also drawing on the Reading work (Sections 33 and 35 and more detailed comments in Annex B 9.2 of ISO21542).

The work continues to have an important impact on the transport sector. Commenting on a new emerging pan-European access standard for mainline trains and stations (PRM TSI, 2008) a spokesman for the UK Department for Transport (DfT) has noted (correspondence, March 2013) that it initially used a different measure from the Reading work for adequate contrast but: *"… This has proved to be unworkable so British representatives [on the EN drafting committee] have used*

Reading's work to develop a Euro-Norm that combines both techniques… Once in force, it will guide the interpretation of the PRM TSI across the European Union." All new regulated rail vehicles must now comply with the contrast requirements defined at Reading. The Reading researchers were consulted in the drafting of the Rail Vehicle Accessibility Regulations (RVAR). In 2008 the UK government amended and updated the RVAR (S.I.1998/2456) so that it draws directly on the Reading work. A statement from DfT has commented that: "*The Department [for Transport] has used the findings of Project Rainbow to set out for transport providers how their vehicles and facilities can achieve the contrast requirements required by law*," and that "*Latest statistics (November 2012) show that 71 per cent of buses in England now fully meet accessibility requirements, including for contrast. Meanwhile, 45 per cent of rail vehicles in Great Britain (over 7,600 carriages) meet their relevant standards*". The work has also been used by DfT to craft requirements for train stations; see "DfT Accessible Train Station Design for Disabled People" (2011), available at: http://bit.ly/18nnOmZ. This is in addition to existing DfT documents that include the Reading work, such as "Inclusive Mobility" (www.dft.gov.uk/transportforyou/access/peti/inclusivemobility).

The reach of this project is very wide, covering urban planning as well as major elements of the transport sector, in particular relating to public transport provision. Its impact is in the areas of quality of life (including health and safety), as well as employment and manufacturing. Whilst quality of life is difficult to measure, the Government's Disability Equality Indicators cite ability to obtain employment as important. The RNIB estimates that the indirect costs of not realising employment opportunities for VIP is around £1.6 billion. In addition, employers are required to deal with current and potential employees (including VIP) in a non-discriminatory way, and this Reading visual contrast work is highly relevant for improving the employability of VIPs as well as their safety in the workplace by providing the standards by which this may be assessed. Manufacturers such as ICI Dulux and Gradus have used the Reading work to develop a unique market position, enhance their activities and tailor their products to meet clear LRV criteria. Further evidence of impact can also be found in many new buildings completed since 2004, including Heathrow Terminal 5 and the London Olympics 2012 facilities. The Olympic Delivery Authority/London Organising Committee of the Olympic and Paralympic Games Inclusive Design Standard (http://www.london2012.com/documents/oda-publications/inclusive-design-standards.pdf) goes further than BS8300:2001/9 and makes specific reference to the concept of LRV developed by Reading.

5. Sources to corroborate the impact

http://www.icipaints.co.uk/news/news_colour_contrast.jsp ICI Dulux's CD release, taking Project Rainbow research into account.

Key users/stakeholders who may be contacted to provide corroboration of research impact include (contact details provided separately):

1. Business Area R&D Director, Decorative Paints, ICI Dulux and member of the drafting committee on BS8394:2009. To corroborate the application of the research findings on colour contrast measurement into a guide published by ICI Paints 'Colour and Contrast'
2. Department for Transport (Rolling Stock – Technical & Accessibility) to corroborate impact on transport providers and overall impact in transport environments.
3. Director of Services and Public Affairs, Royal London Society for Blind People to corroborate the influence the research has on guidance and standards and on the development of practical tools.
4. Technical Director, Gradus Ltd; also a member of the drafting committee of BS8393:2008 to corroborate impact in defining practical and measureable means of achieving compliance with Building Regulations Part M (Accessibility) using colour and contracts.
5. Senior Manager, Accessibility and Inclusive Design, London Legacy Development Corporation to corroborate incorporation of Reading research into London 2012 Olympic facilities to improve accessibility for vision impaired people.