INCLUSIVE TRANSPORT ENVIRONMENTS FOR PEOPLE WHO ARE VISUALLY IMPAIRED

Cook, G.K.¹, Dalke, H.², Bright, K.T.¹, Yohannes, I.¹ and Camgoz, N.²

¹ The Research Group for Inclusive Environments, The University of Reading, UK.
² The Colour Design Research Unit, The University of the South Bank, UK.

ABSTRACT

This paper describes the scope and content of a research project concerned with producing design guidance for the colour and lighting of inter-modal transport environments. The research methodology includes literature reviews, questionnaires, semi-structured interviews, real-world tests and photometric and colour measurements. A selection of findings from a pilot questionnaire are summarised to outline the nature of the respondents and their views on using transport environments.

1. INTRODUCTION

As the Disability Discrimination Act 1995 (DDA) becomes applicable to service providers, future public transport environments will need to be designed to improve independent living and affect standards of social inclusion and accessibility (Prophet 1998). The report on travel and accessibility (COST 335 1999) has highlighted the need for colour, lighting and design to play a major role in creating socially inclusive environments. The widespread use of monochromatic colour schemes and highly reflective surfaces such as glass and metal are known to be problems for the visually impaired. The research reported here is part of a much larger project that will have important consequences for any recommendations concerning the provision of colour, lighting and design in future integrated transport environments for the assessment of adequate provision under the DDA. This work builds on earlier work by the research team (Bright, Cook & Harris, 1999) but addresses the accessibility issues of spaces within transport environments. The need to consider safety, wayfinding and interaction with external and internal environments is particularly important when using inter-modal transport environments. The identification of issues that influence the design and provision of such environments via expert audits, surveys, focus groups, testing, and consolidation of previous research and knowledge that affect the success or failure of the transport environments, is a summary of the overall project. Wayfinding issues in a transport environment escalate where inter-modal travel, choices and decisions have to be made. Therefore the research team aim to visit three inter-modal public transport sites including an airport, a bus station, and a railway station to make on-site assessments of lighting and colour design provision. This assessment is not intended to exclude the overall architectural design implications of these features. In addition to the academic partners the project is also supported by Transport for London, British Airports Authority and Railtrack.

A survey by the Royal National Institute for the Blind (Bruce, McKennell & Walker, 1991) established that about 1 million people in the UK have some form of visual impairment affecting central or peripheral vision, or the whole visual field. In the context of this work, the term 'visually impaired' meant those people who are either registered or eligible to be registered as blind or partially sighted. However, in addition to this number, there are currently 1.97million people who have some significant loss of vision, but not sufficient to be considered for registration. The
expanding ageing population faces difficulties in wayfinding and accessibility. Whilst visual impairment or blindness rarely leads to a total absence of light perception, often colour perception and the ability to see fine detail is impaired. Providing environments, in terms of colour and luminance contrast, which maximise residual vision, can assist visually impaired people when navigating and identifying features in buildings (Bright, Cook & Harris, 1997). Research has also identified that the strategy adopted by visually impaired people is of paramount importance in deciding where, and how, sources are used within a building to impart information. The COST 335 Report stated that 25% of all passengers across Europe are struggling to travel by train. All users would benefit from increasing the clarity of visual clues, clues that are substantially influenced by lighting and colour, as well as improvements in the nature and quality of information. Visually impaired people should be able to use transport environments with confidence.

There are particular characteristics of the design and management of transport premises that can have a major impact on the ease with which visually impaired people can use such buildings (Green, 1991). For example, the typical use of overhead information signs, frequent changes in the siting of objects amongst busy, environments all place added stress on visually impaired people when using spaces (Lopez, 1995) (Moore, 1994). Whilst some recommendations are available on size and letter style of signs (Green, 1991), no research has yet been carried out into the extent to which an information shortage, for example, caused by ill considered placing of signs contributes to a discriminating or unsafe environments. Significant problems are encountered by visually impaired users of modern buildings from level of glare and reflectance from shiny, glossy surfaces to safety, where large sections of glazing are used in architectural solutions. Comment on the management of space has called for improvements in signalling, graphics, typography and lighting, and challenges designers to think in interdisciplinary terms (Woudhuysen, 1997). Studies to date have not considered any additional difficulties brought about by restricted vision, while navigating around and identifying features that may be present in future transport environments. People generally require longer to understand visual information, as they grow older. Preliminary studies by the research team suggests that some stages in the design of transport environments, facilities, products and services assume that another department or agency has either resolved these issues already or are not aware of growing accessibility issues. Similarly designers and architects often do not see themselves accountable for these solutions or receive feedback on dissatisfaction. (Nayak 1999) Solutions, for the needs of visually impaired users, are not currently being delivered.

The overall research focuses on areas where colour, lighting and design are current factors of failure for visually impaired users. Audits, on-site observation, conceptual developments, testing and implementation will be examined. Discussions, for example with designers and architects, have shown gaps in ownership of responsibility in addressing these issues. This research will establish procedures, publish guidance and issue directives and should have an impact on functionality of environments for all users and the visually impaired. A consolidation of research undertaken already in discrete areas is required to develop tools for the assessment of existing and future transport environments where colour, lighting and contrast impact on wayfinding.

2. AIMS AND OBJECTIVES

The objectives of the overall research project are to:

- determine problems encountered by visually impaired and older users of current transportation systems through questionnaire surveys and other experimental work.
- define generic issues which can be researched and addressed with design solutions for inter-modal transfer points within future integrated large public transport environments
- audit the effects that colour design and lighting have on the ambience, efficiency and safety for the target groups.
establish the key functions at transfer points where good practice can be described in colour design and lighting to improve navigation by the elderly and visually impaired users

- review design guidance for architects and designers
- determine, experimentally, how spatial design, colour and luminance contrast and lighting can assist the achievement of inclusive and accessible environments
- gather and record subjective impressions concerning visually impaired users of 'real world' environments
- explore the potential of existing Computer Aided design (CAD) tools, eye-tracker, videophotometer and colour contrast analysis software in the assessment of lighting and colour design on typical transport environment sites.
- prepare relevant forms of guidance on colour design and luminance contrast for wayfinding in a modern future integrated transport environment defined by the research programme.

3. OVERALL METHODOLOGIES

3.1 Literature Review
A detailed review of international research publications relating to transport environment design issues, lighting regimes and the effects on visually impaired people has been undertaken. Specialists and experts involved in the design of inter-modal transport environments have been consulted as part of this process. The detailed literature review has included non-construction related research and publications on colour, lighting and design of transport environments. Supporting organisations and members of the advisory panel for the project have also been consulted.

3.2 Measurement Hardware
A range of hardware required for the measurement of tracking eye-movements, luminous intensity, luminance, reflectance, colour and luminance contrast, has been assessed and obtained for this project. These hardware items will be used in a later ‘real world’ phase of the work to gather information from the three inter-modal public transport sites mentioned earlier. The Applied Science Labs 4000 head mounted oculometer, which measures point of gaze to an accuracy of approximately 1 degree visual angle is to be used and whilst there are known to be problems when eye-tracking equipment is used by people who are visually impaired, the research team are interested to assess the application of this equipment (Horberry, et al, 1997). A Videophotometer will grab test frames from defined viewpoints within the interiors of the three sites. The test frames will be used to measure the absolute brightness of the scene and produce quantitative data of the intensity of surface reflectance light, and light from back light objects. The Videophotometer software, Eyeappearance, will be used to analyse these images and establish the photometric properties of the interiors. The output of this equipment is a plot of the reflectance and luminance of the interior. Images will be collected from still and video sources from all three sites and the Imagemaster software will process these results following site measurements for colour matching. These images will be used for colour image analysis of the colour contrast of surfaces, e.g., floors, walls and other objects. An examination of the colour contrast of two-dimensional images taken from the site under different illuminants will be undertaken with Imagemaster software on a calibrated monitor screen.

3.3 The Questionnaire
The research team has developed a questionnaire. This has been used to survey a representative sample of visually impaired people to establish the problems they experience when interacting with transport environments. The questionnaire will be used to determine how design, spatial, colour contrast, lighting and the use of materials generic to transport environments, e.g. monochrome palettes, stainless steel, glass and reflective surfaces, hinders or assists people who are visually impaired when using transport environments. The questionnaire has been developed using similar criteria as that developed for Project Rainbow (Bright, Cook and Harris, 1997). The questionnaire
has been distributed by post to a representative sample of more than 500 visually impaired people throughout the UK. An electronic version of the questionnaire is available at: www.extra.rdg.ac.uk/FIT Prior to distribution the questionnaire was piloted with a test panel of thirty visually impaired people. The results of the pilot test have not been considered in the overall analysis of responses although some of the results are reported here.

3.4 The Test Panel and Real-world Test Sites
In order to establish the influence of lighting and colour on the design of an inter-modal transport environment a representative panel of 24 visually impaired people and 8 fully sighted people will be used in 'real world' tests at the three inter-modal transport sites. The visually impaired test subjects will comprise of eight people with each of the visual field loss classifications identified in previous research namely, central field loss, peripheral field loss and general field loss. (Bright, Cook & Harris, 1997). Visually impaired participants will be given a field of vision and a visual acuity test to determine their residual vision. The test for assessing visual field will be identical to Project Rainbow (Bright & Cook 1999). Fully sighted participants will undertake the same vision tests to confirm they can be considered 'fully sighted'. The three inter-modal transport environments that will host the real world tests will present examples of generic spatial design problems that are likely to be met in future transport environments. They will be typical of spatial layout, lighting, colour and luminance contrast. The environments will contain features that are currently considered to represent good and bad practice in terms of assisting visually impaired people to navigate around a site.

3.5 Testing Performance
A method of testing the wayfinding performance of the test participants in the three inter-modal transport environments is to be devised. This will take into account a range of quantitative factors, including speed of movement, deviation from the shortest route and accuracy in arriving at the required destination. The data will be collected by carrying out a preferred walking speed test, timing the subject through a test route and videoing the test. Other quantitative factors which can influence performance of the wayfinding task will be assessed including; the type of visual impairment, the visual acuity; the field of vision and age. The subjective factors, which can influence wayfinding performance, will be based on the schematic differential test developed for an earlier research project (Cook, et al, 1999). This will allow the opinion of the participants to be analysed by the use of a post-test questionnaire. Pilot testing will precede full testing. A volunteer group will record journeys within the site wearing the head-mounted eye-tracking equipment. The Videophotometer will be used to collect key viewpoints within the spaces at pre-defined points for analysis. A medium format camera and Camcorder will be used to make the material for image analysis by Imagemaster software to compile data on colour contrast information at the pre-defined points within the sites.

4. PILOT QUESTIONNAIRE RESULTS
A pilot questionnaire survey has been undertaken. This was issued to 30 people in the UK and was used to assess the quality of the questions and give initial feedback concerning the overall content and coverage of the questions. This was seen as an essential precursor to the development of the final questionnaire. The pilot questionnaire contained a total of 54 questions and was printed in Arial 14 pt font on yellow paper following RNIB good print guidelines. All of the questionnaires were completed and returned. The only amendments to the pilot questionnaire were of a minor formatting nature and the need to include an additional question concerning light and dark and colour and contrast problems in transport environments. The questionnaire was coded into SPSS to allow pilot analysis to be undertaken. This operated successfully and has only received minor modification in order to analyse the final questionnaire. A selection of results from this pilot questionnaire is shown
here. The questionnaire contained 28 questions concerned with defining the respondent including an assessment of their visual abilities. This procedure has been used previously by the research team (Bright & Cook, 1999). In Figure 1 the age range of the respondents is shown. 72% of the respondents are over the age of 66, which, although not a perfect match with the national census profile, is not unusual since the incidence of visual problems is much greater in older people. In Figure 2, the nature of the visual loss is shown.

![Figure 1. Age range of questionnaire respondents.](image)

The Macular Society provided assistance with the distribution and completion of the pilot questionnaire to their members and this is shown by 75% of respondents having central vision loss. See (Marshall, J., 1991) for further information.

The respondent profile, as shown on Figure 3, was also unusual in that a very high proportion of people, 70%, had no other disability other than vision. The remaining 26 questions examined the travel habits of the respondent and their views concerning a range of issues associated with public transport environments. The results of responses to the question ‘How do you find the light levels in the following places?’ are shown in Figure 4.

![Figure 2. Nature of the visual loss of questionnaire respondents.](image)
Airports and Underground Stations were the only places that respondents considered bright, with 25% of respondents finding Airports bright. Apart from Airports all places were considered dim by at least 35% of respondents. In order to establish a pattern of transport use by respondents a series of questions were devised, including the frequency of using different transport types. The results shown in Figure 5 show that 5% of respondents never use the range of transport types shown. It is perhaps unsurprising that no respondents used air or coach travel on a daily basis. However, the significant numbers of respondents who never use train, air, or coach travel was concerning and is the subject of on-going further analysis. The questionnaire was also concerned to establish the nature and extent of independent travel. Taxi’s and buses were popular for independent travel, with 80% of respondents happy to use them. Indeed all forms of travel is used independently although the group including underground, train, coach and air were significantly less popular.
Whilst the results reported here are of summary nature, further analysis is proceeding and the results of this analysis will be presented at the IMC 11 Conference. In addition a series of semi-structured interviews are to be carried out with a representative group of 13 visually impaired people, comprising four from each visual impairment group and 1 monocular impaired person. The information gathered from the semi-structured interviews, and the qualitative data obtained from the open-ended questions included in the questionnaire, will also be examined.

5. OTHER RESULTS

The results of the literature review have been compiled into a cumulative index database. It is anticipated that this will be made available as a web based resource in the near future.

The results of the photometric measurements from the three inter-modal test sites are being collected at this time; therefore, it is not possible to make them available in this paper. This is also the case for the quantitative and qualitative data from the real world tests. It is the intention of the authors to present a summary of all of these results at the IMC 11 conference.
6. SUMMARY

Full results of the large-scale questionnaire are to be collated and evaluated. The key results will be developed into design guidance that will also include the results of the real world tests carried out in the inter-modal transport environments. The design guidance is intended for professionals involved in the development of transport environments. This will include architects, engineers, facilities managers and others and assist them in their design and specification role. Although at an early stage it is anticipated that the CAD generated data will be collated and verified to allow for the development of software 'plug-in' to provide designers with tools to evaluate contrast assessment within an environment. Indeed the design guidance will be disseminated to manufacturers and suppliers of materials and equipment for inter-modal transport environments. The research will also develop an information source, including a visual library, which may be CD-ROM based, to assist in the dissemination process. At [www.rdg.ac.uk/ie/Research/FIT/FIT.htm](http://www.rdg.ac.uk/ie/Research/FIT/FIT.htm) (an established web site), current information about the research outputs is provided. The design guidance is due to be launched in the summer of 2003.

ACKNOWLEDGEMENTS

This project was funded under the EPSRC – LINK Future Integrated Transport Initiative and was supported by the following industrial partners, The Joint Mobility Unit Access Partnership (JMUAP), The Royal National Institute for the Blind (RNIB), The Guide Dogs for the Blind Association (GDBA), Datacolor International, British Airports Authority (BAA), Transport for London, Nicholas Grimshaw and Partners, Designpoint and Railtrack. In addition the following organisations were represented on the advisory board for the project, The City of London, The Centre for Accessible Environments, Kings College London, The Macular Society, The National Physical Laboratory, The Office of The Deputy Prime Minister and The Disabled Passengers Transport Advisory Committee.

REFERENCES

[10] Nayak, L Dr., (1999), Telephone conversation, Department of Gerontology, Birmingham University, UK