Lighting Multi-Modal Transport Intersections for Visually Impaired Travellers

Cook G, Yohannes I, Dalke H, Camgoz N

Research Group for Inclusive Environments, The University of Reading, UK.
Colour Design Centre, South Bank University, London, UK.

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Abstract
A two-year EPSRC/Link funded project was undertaken to study the lighting and colour/contrast provisions in multi-modal transport interchanges in the UK. The Research Group for Inclusive Environments (RGIE), which is based at the University of Reading, and the Colour Design Centre based at South Bank University in London carried out the study. The project examined issues concerning future multi-modal public transport environments for visually impaired people (VIP) and elderly users. Results from this project, have advanced the understanding of the factors that affect the success or failure of transport environments for visually impaired travellers.

Aging brings a diminishing of functional vision; there will be an increase in the proportion of older people in the population within the next few years making this work timely. It was found that visual field and colour and contrast sensitivity are more important than visual acuity for mobility. Even low functional vision can be enabled through inclusive design, even if it is only by enhancing the opportunity of light perception. Design for the visually impaired community is important; with only 6% of registered visually impaired people being totally without sight it has been shown that colour, contrast and lighting can empower and make visible an otherwise incomprehensible environment.

Over 24 months the recording of subjective impressions on transport sites, observations of navigation behaviour and the conducting of performance measurement tasks led to a unique bank of information. Working with 40 volunteers, both visually impaired and a sighted control group provided a snapshot of how VIPs interact with large transport sites. The questionnaires returned from 362 respondents, gave the teams insight into how VIPs prepare for travel, appraise and experience travel and even more about how they actually ‘feel’ when travelling. The ‘Real World’ Tests at Paddington Station, Gatwick Airport, Hammersmith Bus Station and Birmingham Bus Station with VIPs led to a wide range of results and recommendations, which in turn is informing the final guidance document. The challenge for the design community, with the Disability Discrimination Act 1995 (DDA) in operation, is to address designing for inclusive environments with knowledge acquired from ‘Real World’ tests with the target users. Colour and design has been shown to be an important tool for empowering VIPs in their navigation and wayfinding modes.

1. Introduction
A report on travel and accessibility, 'COST 335' (Maynard Lepton, 1999), suggested that 25% of all passengers across Europe struggle when travelling by train. It highlighted the need for colour, lighting and design to play a major role in creating socially inclusive environments. However, prior to this research, little had been done to examine the relationships between vision impairment and...
design within actual public transport environments. A survey (Bruce, McKennell, & Walker, 1991) established that about 1 million people in the UK have some form of visual impairment. There are currently a further 1.97 million people who have some significant loss of vision, but not sufficient to be considered for registration. In the context of this work, the term 'visually impaired' means those people who are either registered, or eligible to be registered, as blind or partially sighted. As the DDA becomes applicable to service providers, future public transport environments must be designed to improve independent living and affect standards of social inclusion and accessibility (Prophet, 1998). There are major trends, within architectural design for particular materials; either for robustness of the materials chosen or because of their aesthetic appeal, this can have a fundamental effect on transport environments' accessibility. For example, the widespread use of monochromatic colour schemes and large highly reflective surfaces, such as glass and steel, are known to present problems to VIPs. Modern environments contain very little shadow detail as found in Victorian mouldings for example; shadow and tonal detail are very useful to VIPs for spatial orientation. Building on previous work (K. Bright, G. Cook, & J. Harris, 1997), which established how partially sighted people search and navigate within and around buildings, this project examined how the accessibility of spaces within transport environments differ with regard to safety and wayfinding. Wayfinding issues in a transport environment escalate, where inter-modal travel choices and decisions have to be made fast.

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 functional vision, can assist visually impaired people. (K. Bright et al., 1997). Previous research has identified that the strategy adopted by visually impaired people is of paramount importance in deciding where and how to impart essential information. All users, regardless of visual performance, would benefit from an increase in the clarity and positioning of visual clues, influenced and improved by lighting and colour.

There are particular characteristics in the design and management of transport premises that can have a major impact on the ease with which visually impaired people use such environments (Green, 1991). For example, the typical use of overhead information signs, as well as frequent changes in the siting of objects within busy environments, all place added stress on visually impaired people (Moore, 1994) when using spaces (Lopez, 1995). No evidence based research was available to identify the extent to which an information shortage exists; for example the ill considered placing or inconsistency of signs, contributes to a discriminating or unsafe
Large sections of glazing are used in architectural design and this can cause problems due to glare or reflectance from shiny surfaces, both of which have clear implications for safety. It must also be appreciated that people with poor vision and older people generally require longer to access and understand the visual information presented to them.

Some designers and architects do not see themselves accountable for the provision of these solutions or do not receive dissatisfied feedback from disabled travellers to enable them to implement improvements. The decisions makers assume that another agency has resolved communication and design issues. Discussions with interior designers, architects, engineers as well as designers of graphical communication have sadly shown gaps in ownership of responsibility exist. Inaccessible environments create social exclusion and isolation. Transport environments have been reported to be very threatening, especially at night. There is massive scope for designers, planners and operators to improve the independent living for a wider community (Prophet, 1998).

2. Methodology
2.1. Questionnaire
A questionnaire was used to survey a sample of visually impaired people to establish the problems they experienced when interacting with transport environments. This questionnaire was used to determine how design, spatial, colour contrast, lighting and the use of materials generic to transport environments (for example, monochrome palettes, stainless steel, glass and reflective surfaces) hinder or assist people who are visually impaired when using transport environments. The questionnaire, developed using similar criteria as that created for Project Rainbow (Bright, Cook & Harris, 1997), was distributed to more than 1100 visually impaired people throughout the UK. More than 360 participants sent back their filled questionnaires. The questionnaire consisted of 5 parts, which were: "About You", "Your Vision", "Your Travel Habits", "Public Transport Environments", and "General Questions". It contained a total of 55 questions and was printed in Arial 14 pt font, on yellow paper following the RNIB good print guidelines.
2.2. Site Test

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 were observed when undertaking 'real world' tasks at the three inter-modal transport sites – Paddington Station, Gatwick Airport and Birmingham Airport. The test subjects comprised 8 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). All the participants undertook a field of vision and a visual acuity test, as was used in Project Rainbow (Bright & Cook, 1999), to determine their functional vision.

The three inter-modal transport environments that hosted the real world tests presented examples of generic spatial design problems that would be likely to be found in future transport environments. They were typical of spatial layout, lighting, colour and luminance contrast. The environments contained features that are currently considered to represent both good and bad practice in terms of assisting visually impaired people in navigating around a site.

A method of testing the wayfinding performance of the test participants in the three inter-modal transport environments was devised which took into account a range of quantitative factors, including speed of movement, deviation from the shortest route and accuracy in arriving at a specified destination. Data was collected by carrying out a preferred walking speed test, timing

![Figure-1: Classification of VIPs based on Severity of Impairment](image-url)
the subject through a test route and videoing the test. Other quantitative factors that could have influenced the performance of the wayfinding tasks that were assessed included: the type of visual impairment, the visual acuity, the field of vision and age. The subjective factors that could have influenced wayfinding performance were examined based on the schematic differential test developed and tested in a previous research project (Cook, et al, 1999). This allowed the opinion of the participants to be analysed by the use of a post-test questionnaire.

3. Results and Discussion

3.1 Questionnaire

The results gathered from the main questionnaire show that those respondents with a mild or very severe visual impairment were less likely to be affected by variations in lighting level or glare coming from reflective surfaces than those with moderate visual impairments for whom these issues were a problem. Bright daylight, particularly that coming through windows, was shown to be a particularly problematic lighting type to those with moderate visual impairments, that is, those people who seemed to be most affected by lighting. While it was shown that respondents with severe, or near severe, impairments made little use of coloured lights in an environment, the majority of respondents, who fell into the moderate level of impairment category, found them useful. It was also discovered that this majority also have difficulty going between areas with different lighting levels, with going from a bright to a dim area seen as more problematic than going from a dim to bright area. It was also found that, while those with more severe impairments were less likely to be affected by variations in lighting level or glare, they were more likely to find the light level in an environment inadequate than a person with a less severe impairment. Regarding specific transport environments and areas within transport environments, the majority of respondents considered airports to be the travel environments that have the most variation in lighting levels. It was found that the lighting at ticket booths was too dim, and this was a problem for the majority of VIPs. Lighting being too dim, as well as the presence of shadows, was also found to be a problem in places like the cafes and shops within certain transport environments. A third of the respondents with a mild visual impairment said that they found illuminated signs less useful. Discomfort caused by glare seemed to be more of a problem when the VIP was trying to find their way. This is likely to be due to the increase in the VIP’s concentration, while they are looking out for information.

3.2 Navigation Tasks
Visually impaired participants were asked to perform various wayfinding tasks that would involve connecting between different modes of transport, for example from a railway station to a bus stop. Close observations of these navigational tasks showed that visually impaired participants constantly encounter difficulties, and these difficulties were manifested through hesitations, halting and at times completely deviating from their intended route. To counter these difficulties the participants were using their travel aids- white cane, guide dog etc.; and also asking for assistance from staff and passers by.

<table>
<thead>
<tr>
<th>Difficulties in wayfinding manifested by:</th>
<th>Asked for assistance from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hesitation</td>
<td>Staff</td>
</tr>
<tr>
<td>Halting</td>
<td>Others</td>
</tr>
<tr>
<td>Deviation</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Table-1:** Occurrences of difficulties and help sought per person per task

### 3.3. Adaptation Tasks
On average people took more time to adapt to darker than brighter lighting conditions. However, adaptation test results from all the three "Real World" site tests indicated that there were no significant differences between the light-to-dark and dark-to-light adaptation tasks: \( t = 0.093, \ df = 19, p = 0.927 \). This could be ascribed to 'visual noise' and other non-visual distractions, like opening doors and crowded station entrances.

### 3.3.2. Reading Tasks
In all three levels of reading from an information board or a sign: detection of an object, recognising what it is, and identifying the message, backlit signs were preferred than front lit display units. And the distances at which a sign could be read was significantly higher for backlit signs for both visually impaired and control group participants. However, it was observed that VIPs encountered difficulty when they get closer to identify information given on visual display units placed much higher above eye-level, due to acute angle of observation.

### 3.3.3. Visual Conditions

<table>
<thead>
<tr>
<th>GROUP</th>
<th>TYPE OF LIGHTING PROVISION</th>
<th>AVERAGE RATE OF LIGHTING CONDITIONS (on a scale of 1 - 10)</th>
<th>ACCEPTABLE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIP</td>
<td>General diffuse</td>
<td>Comfortable: 6.4  Bland: 7.1  Gloomy: 5.4  Dramatic: 3.3</td>
<td>80%</td>
</tr>
</tbody>
</table>
Table-2: Participants’ reaction to lighting quality in “Real World” environments

<table>
<thead>
<tr>
<th>Lighting Conditions</th>
<th>Down-light</th>
<th>6.8</th>
<th>5.9</th>
<th>4.3</th>
<th>4.9</th>
<th>80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Wall-washer</td>
<td>5.0</td>
<td>7.0</td>
<td>6.8</td>
<td>6.6</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>General diffuse</td>
<td>8.5</td>
<td>5.2</td>
<td>2.7</td>
<td>4.0</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Down-light</td>
<td>7.7</td>
<td>6.2</td>
<td>4.0</td>
<td>4.5</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Wall-washer</td>
<td>6.8</td>
<td>5.5</td>
<td>5.7</td>
<td>5.2</td>
<td>80%</td>
</tr>
</tbody>
</table>

Lighting recommendations should include the use of light to draw people to central areas on concourse information points. There is also a need to be aware of the effect of surround lighting, with issues of glare and shadowing.

These aspects of lighting can cause VIPs to have a disabling fear of darkness. Many people with lower vision just need bigger clues to have the confidence to use transport environments and were scanning for platform numbers (Fig 9). Seeing the signs in the first place, is the most important task of good lighting. Diffused lighting helps by softening shadows that can be mistaken for steps or changes in level. Compared to the fully sighted, a significantly greater number of visually impaired people encounter problems with all coloured light sources. Bright daylight can be commonly problematic. Lights, showing between the treads on the escalators are useful and adaptation to a different or extreme change in lighting conditions was found to be a significant problem for VIPs. Going from bright to dimly lit areas without good transition lighting was both painful and further disabling. A large number of VIPs have problems when getting travel information or tickets due to variations in lighting levels by machines or ticket booths.
4. *Recommendations*

Some of the major findings with regard to lighting conditions in transport environments were:

- Compared to the fully sighted, a significantly greater number of visually impaired people encounter problems with all coloured light sources.
- Bright daylight was the main offender among the different light sources.
- Adaptation to a different lighting condition was found to be a big problem for VIP.
- By far a greater number of VIP's have problems in getting travel information than normally sighted people due to variation of lighting.
- Generally, it was seen that the worse the visual impairment is the more problematic glare from shiny surface is for the person.
- Strong light coming through a window affects significantly bigger proportion of the VIP group. On the other hand, not even one fully sighted respondent was 'always' affected by strong light coming from the directions of the ceiling, wall, walls or windows.
- The test showed that significantly greater number of VIP and non-VIP felt that light levels in airports are brighter compared to other transport stations or stops.
- Compared to fully sighted people significantly more VIP experience problems because of inadequate lighting levels in ticket booths of public transport areas.
- More people with higher functional vision found illuminated signs frequently useful while travelling.
- There was no significant difference in their reaction, between the VIP and control groups, to the usefulness of coloured light while travelling. On the other hand, significantly higher proportion of 'mild' VIP found the coloured lights in transport environments useful more frequently than those with 'moderate' impairment.
- When travelling around in public transport environments people (VIP and fully sighted) rarely find bright light useful.
- There was a significant difference between VIP and fully sighted respondents to the effect of light level in wayfinding in public transport environments. Whereas fully sighted people rarely experience difficulties, VIP frequently face problems due to changes in light levels.
• Fully sighted people found lighting variation rarely problematic when they are seeking for information in transport environments. Whereas VIP found significantly frequent occurrences of difficulties on the issue.
• Similarly, VIP experience significantly higher frequencies of glare while seeking for information in public transport environments compared to fully sighted participants.

5. Summary
An expanding ageing population faces difficulties in wayfinding and accessibility. Use of colour design, lighting and contrast are ways of increasing the clarity of visual clues and information provided in transport environments, beneficial for all. Designers already know the importance of lighting and contrast, but the project has produced evidence of the role that colour and lighting play in making the environment highly cognisant to VI Ps. The breadth of issues faced by people with low vision travelling through public transport sites has been established. Colour design strategies for safer transport environments have evolved from site audit calculations and the use of CAD tools in environment evaluation. Lighting assessment and guidance from results on backlit signage and glare, has provided a clear economical and effective methodology to delivering an accessible intermodal transport environment for multi-modal transfer points. Furthermore, all of these initiatives can, and should be planned from the 'drawing board' to be effective. Key guidance can now be presented on colour, design and lighting for commissioners, specifiers, architects, designers, site management, education through the publication of design guidance, papers and a web site. Many points of failure were not for lack of technology but mainly human error.

Collaboration
The collaborators supporting the project over two years were JMU/RNIB, Datacolor International, Nicholas Grimshaw and Partners, Wave and BAA. The major research questions, which the project has addressed, were:
- What profile can be formed of the views and experiences of visually impaired users of public transport environments?
- How do 'Real World' intermodal transport sites perform for visually impaired people?
- What issues were found to be important from questionnaires and 'Real World' tests?
- What key guidance can be presented on colour, design and lighting to make transport environments more accessible for visually impaired users?
References


