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Perceptual Impact of Environmental Factors in Sighted and Visually Impaired Individuals

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Keywords: Navigation, navigation aid, perception, perceptual difficulty, mental landscape, mental maps, environment.

Abstract

To a visually impaired individual the physical world presents many challenges. For a person with impaired sight, wayfinding through a complex environment is fraught with dangers, both actual and imagined. The current generation of mobility aids have the possibility of addressing a broad range of physical issues through technological solutions. The perception of difficulty however, can mean that many visually impaired individuals are fearful or uncomfortable about independent mobility or travel. In this context it becomes necessary to discover exactly what environments, environmental factors or items constitute a 'perception of difficulty' in the individuals mental landscape and may trigger a negative response *before* they interact with the physical environment. This paper reports on research, which sought to ascertain what levels of perceptual difficulties specific environments and factors presented to individuals. The research was conducted with both visually impaired and sighted groups and compared differences and similarities in perceptual difficulty between these two groups.

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1:Introduction

The Brunel Navigation System for the Blind (BNSB) is currently being developed by the Electronic System and Information Technology Research Group, Department of Design and System Engineering, Brunel University. The project requires the testing of the design artefact within a pedestrian environment to determine how effectively it serves as a navigation aid for blind and visually impaired users [1,2,3,4,5,6]. This paper approaches the subject in relation to the users preconceived interpretation or impression of factors and environments, and centres on perceptual difficulty. This perceptual difficulty may not be based on experience and indeed may not be factual in terms of their actual ability to interact with these environments, groupings and items. However, an individuals attitude and approach may be influenced by their pre-existing concerns, which may affect the design and testing of such an aid.

Perceptual understanding of space has been investigated in relation to visual studies [7,8] and has been shown to have a significant effect on action. Similarly, visually impaired pedestrians may experience perceptual difficulty before they make any attempt to physically engage in the navigation or wayfinding process. The impact of this perceptual difficulty can mean that many visually impaired individuals do not make any attempt to be independently mobile. This research measures the perceptual levels of difficulty to various factors occurring within the environment and between familiar and unfamiliar environments. Although this research focuses on the visually impaired pedestrian, two groups (sighted and visually impaired) of pedestrians were compared to determine what, if any, differences or similarities existed between these groups, and to what degree. An understanding of the perception of difficulty in the mental landscape of these groups can be seen as an aid in the design of both the interface and the navigation aid.

In his long career in Ergonomics and Cognitive Science, David Woods repeatedly raises the need for greater understanding of users requirements *before* artefacts are designed and presented to the user. [9] The reason for this approach is that once an artefact is created it then becomes a question of design strategies and innovation to advance and improve *that* artefact. Even before the users actual requirements are considered it was felt that consideration should be given to the mental landscape of the user. Fear and uncertainty may play a significant role in how the user approaches certain artefacts, particularly technology based items, and this research is a pilot study in addressing this question.

A clear need exists for mobility aids for visually impaired users. Much of the research available to researchers and designers identifies many of the requirements for visually impaired pedestrians and is often in response to a created mobility artefact. The requirements identified by the creators of such artefacts may be due to the ‘belief of the designers of the presumed impact on human cognition, collaboration and performance.’[10] ‘New systems create new burdens for already beleaguered practitioners, often at the busiest or most critical times.’[9] Certain of the high-technology mobility aids do indeed create new burdens. Very few of the guidelines outlined by Steve Mann [11] for wearable computing have been utilised in the currently available devices. From the difficulty of transporting the aid, many are too large to be comfortably carried or worn (e.g. Pulse Data), to the difficulty and confusion created by the interface.

In his 1990 pilot study Danny Sommers [12] introduced guided imagery as an aid to mobility performance to the congenitally blind. The ability to pre-plan or pre-imagine a journey is an important aid to visually impaired individuals and is serviced by such web sites as describeonline.com, which guides users through train stations. In a controlled study Sommers introduced guided imagery as an aid to mobility performance for the congenitally blind. Guided imagery or pre-planning consists of a series of route performances and landmark clues. Pre-knowledge of the route and occurrences of these landmark items or factors is an advantage to navigation and it is a powerful means to access and aid mobility performance. The imaging can show items with positive impact and also items with negative impact. Previous studies have considered abstract concepts to navigation such as safety or getting lost, [13] whereas in this study we consider factors and environments and look at both how sighted and visually impaired individuals may construct mental maps relating to perception of difficulty. When guided imagery wayfinding is reduced to specific factors and events [14] it can also show how the individual may regard their ability to cope with these factors and the hesitation or lack of confidence with which the individual approaches occurrences of these items.

Consideration was given to the influence of the environment on the users mental landscape and whether or not the choice of locations would present any significant impact on the users approach to the trials. This may have a bearing on results obtained in the testing of a navigation aid. Further trials with individual users would be necessary to establish whether the users perceptual understanding of the environment is borne out in their actual responses to these occurrences. This paper also examines how the users perceptual interpretation or impression based on their understanding of the environment might influence the design of various interfaces between the user and the artefact.

In this study subjects were selected from both the visually impaired and sighted population and they are independently grouped. The research measured the differences and similarities in the way that these two groups rated their perceptual level of difficulty when imagining various factors within three separate environments, home, familiar and unknown. The subjects were asked to rate their perceptual level of difficulty in imagining their interaction with these items.

2:Method

2:1. Questionnaire

The research was conducted using a designed questionnaire which was developed following extensive consultation with visually impaired individuals and observation at a forum dedicated to navigation for disabled travellers at the Helen Hamlyn Research Centre. The questionnaire was pre-tested with a small group of people including one visually impaired volunteer. The questionnaire was extensive, containing 56 items with 224 response potentials. The research objectives were to ascertain respondents perceived level of difficulty to items occurring within three environments. The environments were categorised as, home, familiar and unknown. In each environment the respondents were asked to rate on an ordinal scale response measure, whether they thought the items listed created difficulties for them. The item was listed and the respondent was asked to mark one of four levels. For example: Furniture: 4 = often, 3 = occasionally, 2 = seldom, 1 = not at all. In each environment a maximum of twenty-three items were identified. Some items were not applicable through all environments and for the correlation of familiar and unknown environments twenty corresponding items were selected including ground surface, passageways/halls, doors, noise and stairs. Broad categories were included, for example, electrical items, because the research was seeking to discover trigger responses. It was felt that someone might describe themselves as ‘technophobic’ but in reality be very capable at operating their mobile phone. However an attitude of technophobia may create difficulty in that individuals approach to learning, for example, computer skills. In addition the data was interrogated to determine whether or not these particular items within the environment were related in the respondents mental landscape. Respondents were also encouraged to add comments to any particular listing or category. Within the visually impaired group this was extensive, however within the sighted group no additional comments were recorded.

2:2. Participants and Procedure

Two categories of visual ability were used to define the groups, visually impaired and sighted. Seven responses from the visually impaired group and twelve responses from the sighted group were received. From the sighted group responses, three questionnaires were not useable due to respondent errors. Within the visually impaired group all the respondents had significant visual impairment and four of the seven were blind. Within this group a variety of navigational aids were used, some used a long cane and some used a guide dog as their primary mobility aid. There were no other significant differences or similarities between the groups. The subjects’ ages ranged from 22 to 61 with a mean age of visually impaired at 44.1 years and sighted at 42.3 years. They resided in multiple home locations, from metropolitan to country.

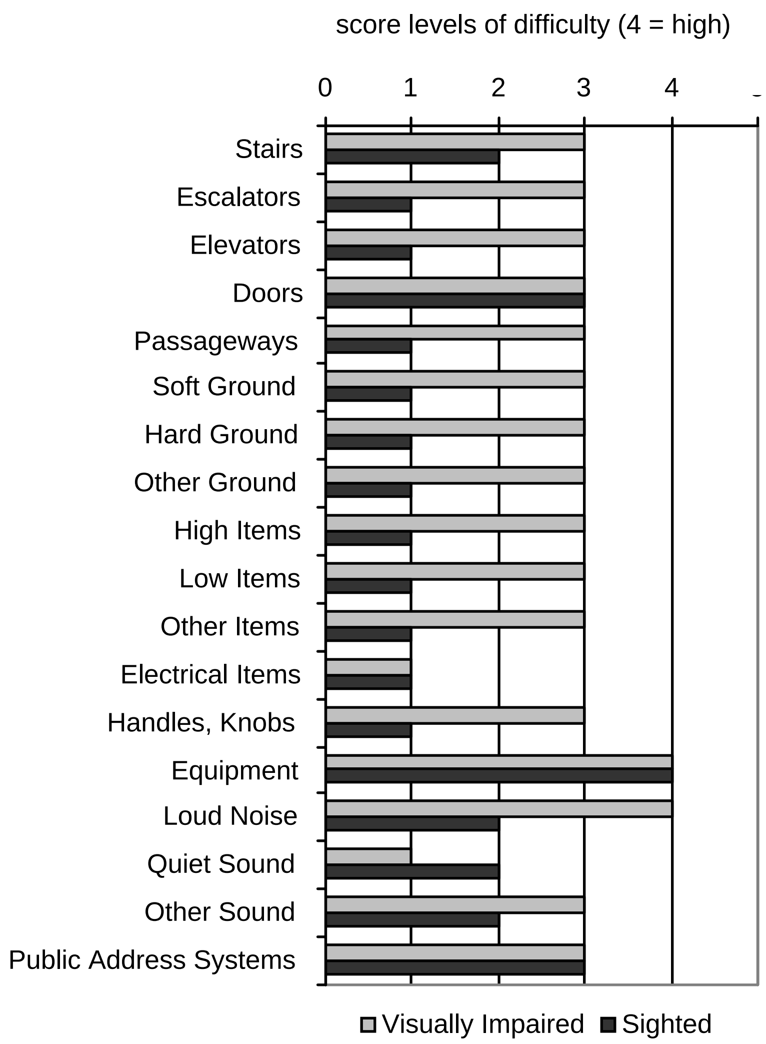
The visually impaired group respondents are all members of a list attached to the web site www.bcab.org.uk (British Computer Association of the Blind). A brief description of the research was posted and interested parties were asked to respond. The questionnaire was then sent on-line to the responders, which they completed and returned. The sighted group were individuals known to the researcher and were selected to reflect the general diversity of the visually impaired group although they were not an equivalent sample The sighted group were given printed questionnaires that were completed and returned.

3:Results and Discussions

3:1. Modal scores across environments

In the questionnaire, the participants were asked to rate their perceptual levels of difficulties to various factors that occur within three environments, home, familiar and unknown. The responses from participants were grouped into visually impaired and sighted. The scores were then analysed and the modal score across all environments was calculated. The modal score across the environments was considered to be the most appropriate measure to display, given that the scores were rated on an ordinal measure and were reasonably bunched around the central values. The results are shown in Table 1.

Table 1: Modal scores across environments



The results in Table 1 show that the overall levels of perceptual difficulty for visually impaired participants are significantly higher than that for sighted participants. However, in several areas such as doors, equipment and Public Address Systems, the score is equivalent. Other than quiet sound, the sound related scores also presented perceptual difficulties across groups and environments. If sound is combined with equipment the scores imply perceptual difficulties across all environments and all groups. This is of interest especially in regard to navigation or mobility aids which use an audio form to transmit navigational information to visually impaired users (Sonic Pathfinder, Brunel GPS amongst others) or indeed to sighted users (various in-car and other auditory navigational aids). The perception of difficulty of sound in relation to auditory transmission of information has been shown in the BNSB trials to be an actual physical difficulty. Ambient sound is vital to the visually impaired pedestrian and any interference, for example, a voice giving navigation instructions through a headset or other speaker system can interfere with other sounds (vehicles etc.) and compromise the safety of the user.

3:2. Environmental relationships

Section 3:2 of this analysis of the data is to determine the subjects' perceptual attitude to the environment and the understanding defined by them for a familiar compared with an unknown environment. The r_s test (Spearmans rank correlation coefficient) was applied to the data. Significance levels were then determined.

Correlation of Environments – familiar and unknown

Table 2: Visually Impaired (V.I.)

Subject Code	**r_s correlation**
1/001	**0.525**
1/002	**0.772**
1/003	**0.713**
1/004	**1**
1/005	**0.669**
1/006	**0.669**
1/007	**0.844**

Table 3: Sighted

Subject Code	**r_s correlation**
2/001	**1**
2/003	**0.832**
2/004	**0.668**
2/005	**0.884**
2/006	**0.83**
2/007	**0.879**
2/010	**0.662**
2/011	**0.781**
2/012	**0.943**

Both groups showed a high level of correlation between familiar and unknown environments. Within the visually impaired group, as shown in Table 2, the lowest score was 1/001 at 0.525, [r_s (20) = 0.525, p < .05] and the highest 1/004 at 1, [r_s (20) = 1, p < .01]. Within the sighted group, Table 3, the lowest score was 2/010 at 0.662, [r_s (20) = 0.662, p < .01] and the highest 2/001 at 1, [r_s (20) = 1, p < .01].

The perception of difficulty in the subject should not have an impact on the data obtained for the device. It would also imply that repeated testing of the device in the same environment would not show any change in the data gathered, which can be attributed to the subjects' perception of difficulty.

3:3.The relationship of items

Section 3:3 considers whether a perceptual relationship exists between items. The data shown in Table 4 was calculated across all environments. The r_s test (Spearmans rank correlation coefficient), $\underline{r_s}$ (V.I. 7) and $\underline{r_s}$ (sighted 9), was applied to the data.

Table 4: Correlation of relationship between specific occurrences of items

	V. I.	**Sighted**
Doors / Handles	**0.635**	**0.473**
Doors / Identifying Items	**0.749**	**0.487**
Handles / Identifying Items	**0.488**	**0.926**
Soft Ground / Hard Ground	**0.397**	**0.857**
Soft Ground / Other Ground	**0.48**	**0.71**
Hard Ground / Other Ground	**0.543**	**0.719**
Stairs / Escalators	**0.823**	**0.656**
Stairs / Elevators	**0.883**	**0.773**
Escalators / Elevators	**0.693**	**0.696**
High Items / Low Items	**0.85**	**0.703**
High Items /Other Items	**0.873**	**0.644**
Low Items / Other Items	**0.822**	**0.773**
Loud Noises / Quiet Noises	**0.806**	**0.477**
Loud Noise / Other Sound	**0.773**	**0.786**
Quiet Noise / Other Sound	**0.699**	**0.259**

All of the visually impaired participants scored very high perceptual level of difficulty in Identifying Items across all environments. Twenty-one possible responses. Eleven responses at 4 (high), seven responses at 3 (medium), two responses at 2 (low), one response at 1 (none), with the two and one response occurring in the home environment. When considering the correlation between ground surface the visually impaired group showed little relationship between ground surface. In this section several of the visually impaired participants referred to actual experience and noted that some ground surfaces were helpful in the navigation process in that it allowed them to discern their continued progress along a pavement or path. In the Stairs, Escalator section both groups showed a correlation and high to medium rate of difficulty. High Items, Low Items and Other Items were only considered in the familiar and unknown environments and overall received high scores of perceptual difficulty for both groups. Forty-two possible responses. Thirteen responses at 4 (high), twenty-five responses at 3 (medium), two responses at 2 (low), two responses at 1 (none). For the visually impaired participants, sound was an important factor and showed a high level of correlation.

It became apparent from the analysis of the data sets that a perceptual relationship existed between occurrences of specific items within the environment. This result indicates that a generic signal for specific groups of items may be sufficient to alert the user to their presence in the environment. This would help to alleviate the concern of visually impaired pedestrians, that the item, may 'appear without warning'[1]. For example, stairs, escalators and elevators may all elicit a signal reflecting 'large – up/down' and more specific information is only given if the visually impaired pedestrian wishes to use, or approaches, the item.

4:Conclusion

It was important in this study to ascertain what occurrences or factors in the physical world created perceptual difficulties in the minds of the respondents. In this way a view of the mental landscape of the participants was sought. The literature shows many examples where

[1] Synopsis of comments noted by visually impaired respondents on the questionnaire.

anxiety and stress are increased by fear of encountering factors or events over which the individual has insufficient knowledge or control. The Brunel navigational aid for the visually impaired pedestrian aims to lessen the impact of these factors as well as providing navigational information and it was important to establish exactly what perceptual difficulties could trigger a negative reaction in the user.

The data gathered in this paper from both groups of participants shows a correlation of perceptual difficulty between familiar and unfamiliar environments. For researchers and designers testing artefacts and aids, which interact with, or provide information about, the environment, these findings are relevant. They indicate that such devices may be tested in either of these environments, without showing significant difference in the data obtained which can be attributed to the users perceptual difficulty based on their understanding or mental landscape of these environments. Further research is indicated to establish whether or not a link exists between perception of difficulty and actual difficulty.

The data indicated significant perceptual difficulties with equipment and sound. These are both related to technological navigation aids, and both factors presented the highest scores from the visually impaired groups. These same occurrences also, however, received high scores, indicating significant levels of perceptual difficulty for the sighted group. These rankings based on perceptual difficulty indicate an advantage to classification and structure for the interface and suggests the order of importance to the user. Understanding of the levels of perceptual difficulty in the mental landscape of the user will enable the navigational aid to interface with the physical world in a synergistic manner that is complimentary to the needs of the user. This research seeks to identify and order some of the factors that trigger the responses of fear and uncertainty that blind and visually impaired pedestrians often experience in their contemplation of the physical environment. This pilot study, used in conjunction with literature defining actual difficulty, is intended to aid designers of navigational aids to address preconceived, and maybe unsubstantiated, notions of difficulty as well as actual difficulty.

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Web site

British Computer Association of the Blind at www.bcab.org.uk

Navigation Aids

The Sonic Pathfinder. www.users.bigpond.net.au/heyes/pa/pf_blerb.html

BrailleNote GPS. Pulse Data International Ltd. www.pulsedata.com

Audio descriptions of train stations at www.describeonline.com