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Using visual contrast for effective, inclusive, environments

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Colour and lighting play important and unique roles in the way people enjoy environment or spaces.

There is a constant interaction between people and the colours that surround them which not only affects the way they move around within the space but also determines how safe, secure and confident they feel when doing so. In addition, colour can help people determine which route to take, and what potential hazards or obstacles they may encounter. Lighting plays an important role in how different colours and combinations of colours are seen and experienced.

Whilst this is true for all users, for people with sensory impairments, being able to navigate and to identify features is critical to their ability to use an environment or space without undue effort, in safely, with confidence and, wherever possible, independently.

For partially sighted people, maximising the effectiveness of their residual vision through the use of environmental factors such as visual contrast and lighting can also have a major impact on their sense of well-being and on their ability to make decisions about how to use the environments they encounter.

In considering the light reflected from a colour – known as its light reflectance value (LRV) – it is possible to specify levels of visual contrast that are appropriate to meet the needs of many partially sighted people. Linking this to an understanding of the search and navigation strategies they adopt when using buildings and spaces means it is also possible to create interesting and innovative designs and decoration schemes that assist partially sighted people without creating environments that are unacceptable to other users.

1.0 Inclusive design

The way places are designed affects our ability to move, see, hear and communicate effectively CABE 2006

The Commission for Architecture and the Built Environment (CABE), the UK government's advisors on the built environment in England, believe that good design is inclusive design, and design that does not achieve an inclusive environment is not good enough (CABE, 2006).

They further suggest that if incorporated as an integral part of a process that extends from inception through planning, detailed design, construction, and into the management practices adopted in use, that inclusive design will enhance rather than stifle creativity and design freedom.

Inclusive design is about much more than catering for the needs of disabled people. It is about designing and managing an environment in a way that removes the frustration and obstacles experienced by many users including disabled people, older people, children and families.

To understand this, it is necessary to appreciate the difference between an environment that is accessible to disabled people and one that is truly inclusive. This can be difficult to describe, but in simple terms, an approach to a building that offers a choice of either steps or a ramp addresses accessibility. However, a level approach to the building would be a truly inclusive design.

1.1 The principles of inclusive design

There are several published versions of the principles on which inclusive design should be founded. Whilst most versions are similar, there are differences in emphasis within each.

CABE (CABE 2006) suggest that the following five principles describe the overall aims for an appropriately designed inclusive environment:

Inclusive design:
- places people at the heart of the design process;
- acknowledges diversity and difference;
- offers choice where a single design solution cannot accommodate all users;
- provides for flexibility in use;
- provides buildings and environments that are convenient and enjoyable to use for everyone.

They further suggest that adopting and following the above five principles will lead to an environment that is:

Inclusive:	so everyone can use it safely, easily and with dignity;
Responsive:	taking into account what people say they need and want;
Flexible:	so different people can use it in different ways;
Convenient:	so everyone can use it without too much effort or separation;
Accommodating:	for all people, regardless of disability, age, mobility, ethnicity or circumstances;
Welcoming:	with no disabling barriers that might exclude some people;
Realistic:	offering more than one solution, to help balance everyone's needs and recognise that one solution may not work for all.

1.2 What are the benefits of adopting an inclusive design approach?

Adopting an inclusive approach to design offers designers and managers of environments the opportunity to:
- be creative;
- exceed minimum technical specifications;
- find, if needed, individual and innovative design solutions; and
- develop buildings, spaces and environments that are not only aesthetically pleasing or make bold statements but also ensure that usability, function and the needs of the end user play a fundamental role in that design and management process.

2.0 The role of colour in the environment

In everyday life, we use copious amounts of colour to create fashions, set trends or simply to externalise our inner thoughts and feelings. In the built environment, the use of colour enjoys a much more mixed reception, with lack of colour often being portrayed as some measure of creativity or architectural merit.

However, when using an environment or space, there is a constant interaction between the people and the colours that surround them, an interaction that not only affects how they feel emotionally about the space and how they move within it, but also how safe, secure and confident they feel when doing so.

In navigating around a space and identifying what features and facilities it contains, colour can help people determine which route to take, identify possible alternatives and make them aware of what potential hazards or obstacles they may encounter on the way.

Whilst almost everyone has or should have an interest in the experiences that the careful use of colour can create, most people know very little about it, what it is and how to use it.

Research has identified the extent to which colours can be selected and placed to increase the amount of visual information available to people using environments and spaces, and the impact that can have on the ability of all users to maximise their use of an environment. This paper now considers how that can be done.

3.0 Visual ability

In his book, Planet of the Blind, Stephen Kuusisto says that in his view:

> Blindness is often perceived by the sighted as an either/or condition: one sees or one does not. But often a blind person experiences a series of veils: I stare at the world through smeared and broken window panes. Ahead of me the shapes and colours suggest the sails of Tristan's ship or an elephants ear floating in air, though in reality it is a middle-aged man in a London Fog raincoat that billows behind him in the wind (Kuusisto, 1998).

The precise numbers of blind and partially sighted people in the world is not known. This is, in part, because what constitutes partial sight and blindness differs across the world. For example, people with cataracts can be classified in some countries as partially sighted, but as the condition can be corrected by an operation, in other countries they may be considered not to have a visual impairment at all.

It is suggested that there are around 30 million blind and partially sighted people in the 44 member countries of the European Blind Union (EBU). This figure is based on the premise that 1 in 30 people are blind or partially sighted and takes into account the varying definitions of visual impairment (EBU, 2004)

Worldwide, there are about 180 million blind and partially sighted people with 45 million being blind and 135 million experiencing less severe sight loss (EBU, 2004).

In arriving at these figures the EBU acknowledges variations in classifying blindness and partial sight and bases its figures on an agreed ophthalmic definition that a person can register as blind if they can read only the top letter of the optician's eye chart from three metres or less, and a person can register as partially sighted if they can read only the top letter of the chart from six metres or less.

A survey carried out in the UK in 1991 (Bruce et al., 1991) suggested that some 86% of people who are registered or registerable as blind or partially sighted in the UK have sufficient residual vision to perceive colour, with around 96% retaining the ability to detect light.

Clearly, a significant number of blind and partially sighted people worldwide experience some degree of residual vision – and designing an environment or a space that allows or encourages them to maximise that vision is critical in the design and management of a truly inclusive, accessible environment.

4.0 Project rainbow

4.1 Background

Identifying and interpreting colour and contrast is an established feature in the strategy that blind and partially sighted people use when moving around an environment and identifying the features and facilities it contains. But until the mid-1990s, most guidance available to designers was based on anecdotal information. This led to situations where providing visual contrast was addressed by the use of extreme combinations of adjacent colours such as black/white or black/yellow, which are unsuitable for use in decorating everyday environments.

In 1995, a research project was undertaken in the UK to establish how colour and contrast could play a role in assisting blind and partially sighted people using the built environment. A major objective of the project, Project Rainbow, was to establish how subtle (rather than how bold) contrast needed to be to suit the needs of most users and, importantly, where within an environment the use of colour and visual contrast would be most effective in conveying information about the space (Bright, Cook and Harris, 1997) and (Bright & Cook, 1999).

Project Rainbow studied the reactions and comments from a sample of fully sighted, blind and partially sighted people to combinations of colours frequently used in everyday environments. It also sought to establish the extent to which adjacent colours need to differ in terms of chromaticity, saturation and/or hue in order for participants to discern a difference between them.

Project Rainbow also included a questionnaire survey of a representative group of blind and partially sighted people (n=676) to establish how they used the built environment, how they gathered information, and what problems they experienced when doing so.

To support the 'what' and 'how often/how many' type of questions more suited to a large sample questionnaire, the findings of the questionnaire were examined and enhanced using group session interviews and 'real-world' tests to establish 'why' particular responses were being made (Bright, Cook and Harris, 1997).

Project Rainbow examined how and where colour and contrast could be used within an environment to maximise the information available to people using it, and how colour and contrast could enhance their independence. It did not consider how colour can be used to influence or affect emotional or behaviour patterns of individual people.

Project Rainbow also considered matt or low sheen surfaces. How surface finishes and textures, such as gloss, influence visual contrast was not considered in depth.

The following presents a résumé of the findings of Project Rainbow and the design guidance that emanated from it.

4.2 Visual contrast

4.2.1 *What is 'visual contrast'?*

Blind and partially sighted people are generally less confident than fully sighted people in differentiating colours. However, if the colour difference is above a certain threshold level, their confidence improves significantly (Bright & Cook, 1999).

For most people with good vision, contrast between colours will be provided by differences in the nature of the colours, the hue, or the intensity of the colours – the chroma. For blind and partially sighted people, the ability to detect a colour will depend less on the hue and more on the intensity of the colour and LRV, or a combination of the two. (BS 8300:2001).

4.2.2 *How can it be measured?*

LRV is described in terms of a scale that runs from 0 (zero), which is a perfectly absorbing surface (totally black), to 100, which is a perfectly reflecting surface (pure white). However, because of practical issues, both black and white are never absolute, so never equal exactly 0 or 100.

4.2.3 *How can 'adequate' visual contrast be determined?*

In using colour to gather information about a space, most blind and partially sighted people generally look for a contrast between the colours used on adjacent surfaces (Bright, Cook and Harris, 1997) and (Fleming & Bright, 2007). How adequate that contrast seems to them will depend on how obvious it is, and how confident they are in discerning it (Bright & Cook, 1999).

If contrast between larger surfaces such as walls, ceilings, floors and doors is used to gather information about a space or to assist when navigating around it, research evidence suggests that most blind and partially sighted people are confident in detecting a contrast between adjoining colours if the difference in LRV exceeds 30 points. However, there is also evidence to suggest that a difference of 20 points may be acceptable in certain situations where good illuminance is also provided (Cook, 2005).

For contrast between smaller areas, such as that found on signage between the words or symbols with the sign board, guidance suggests that this difference should be increased to 70 points (Barker & Fraser, 2004), (ADA, 2002).

4.2.4 *Where should contrast be used?*

To maximise the use of visual contrast as an information source, it is also necessary to know where within the environment or space it is best to use it (Bright, Cook & Harris, 1997). To know this it is necessary to consider the strategies people adopt when gathering information about an environment they have just entered or are moving within, and how they use their vision to maximise the information available to them.

When entering a space, fully sighted people require only a few seconds to obtain the visual clues needed to understand what surrounds them and how they will move through it. Project Rainbow established that entering and using an unfamiliar or re-arranged space is a very stressful experience for most blind and partially sighted people, and this was similar regardless of the visual impairment they experienced. To address this and to improve their confidence they use common strategies to identify features and negotiate their way around.

The following design guidance is drawn from responses to the questionnaire of blind and partially sighted people that formed part of Project Rainbow.

4.2.5 *Spatial awareness*

In gathering spatial information, most respondents (97%) indicated that they pause after entering the space and try to gather information about the space they have just entered. Visual contrast at the junction of the wall and the ceiling offers the best source of information because unlike the junction of the wall and the floor this area is, in most cases, not cluttered or obscured by furniture or other obstacles.

However, when moving around some 86% of respondents never concentrate their residual vision on the ceiling, preferring to look downwards, within 2 metres (72%) and continually scan the scene in front of them (74%) trying to discern visual contrast between features (see Figure 1).

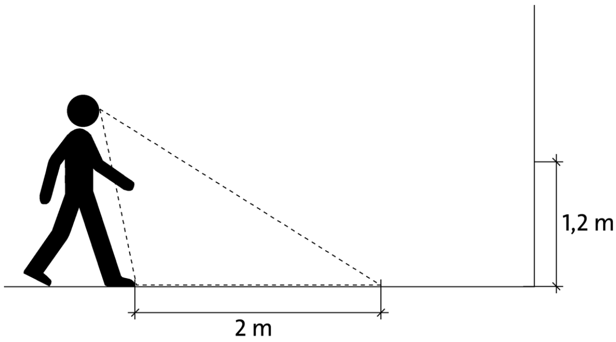

Figure 1. Blind and partially sighted people tend to look downwards, within 2 metres, continually scanning the scene in front of them. Important sources of information are the wall/floor junction and features on the wall up to about 1.2m above floor level.

These navigation strategies were adopted on a regular and frequent basis by most respondents to the questionnaire regardless of their type of visual loss (Bright, Cook & Harris, 1999).

Thus, for blind and partially sighted people, providing appropriate visual contrast at the ceiling/wall junction assists spatial awareness. However, for navigating around and identifying features, it is visual contrast at low level that is the most important.

4.2.6 *The floor as an information source*

Floor design and surface finish can also have a major impact on the ability of all users to gather information, but this is especially so for people with poor vision.

In Project Rainbow, 71% of respondents indicated that they use the floor to try to obtain visual clues. Respondents indicated a clear preference for plain rather than busy, highly patterned, highly contrasted or striped surfaces. Given the strategies adopted to gather information described above, this is to be expected.

In terms of surface finish, 74% of respondents indicated that reflective floor surfaces were detrimental or very detrimental to their use of a space, and only 5% considered them to be beneficial. For shiny surfaces, 68% indicated that they were detrimental or very detrimental, whereas only 7% found them to be of benefit. By contrast, matt surface floor finishes were found by almost 60% to beneficial or very beneficial, with only 5% finding them to be detrimental (Bright, Cook and Harris, 1999)

Such findings have clear implications for the selection and use of floor patterns and surface finishes in all buildings, but especially those to which the public have access or which may be unfamiliar to users of them.

4.2.7 *Identifying features*

Being able to discern the size, shape and characteristics of a feature is important for blind and partially sighted people when trying to identify what it is, and this is especially so if it needs to be identified quickly. Conversely, there will be situations where identifying the presence of a feature is not important, for example doors to staff areas in a public building.

In design, the benefits gained from the use of visual contrast come not only from understanding when it is essential, but also from recognising when it is not needed at all. However, if it is important to highlight the presence of a feature, what issues should be taken into account?

Most blind and partially sighted people have some residual vision and most are able to discern colour. In addition, many also have some understanding of the general shape, size or image that particular features display. Maximising the visibility of such clues will assist people to identify the presence of a feature and develop a strategy for using or avoiding it.

For example, using visual contrast to highlight the presence of a door within a wall can be done in several ways; the whole door could be contrasted with the wall, the door could have the same colour and LRV as the wall but with the architrave (door surround) contrasted, or the door and architrave could be the same colour and LRV as the wall, but the door furniture could be contrasted with the door.

There are very few features in the built environment that offer the same visual image in terms of size and shape as that of a door contrasted to its surrounding wall. Using contrast in this way will provide a strong clue as to the presence of the door. Importantly, once the door is identified, locating the handle of the door is relatively easy because its position above floor level is usually consistent and the only choice is whether it is located on the left or right of the door. Therefore, having identified the presence, or likely presence, of the door, locating the door handle should be relatively easy even if it does not contrast visually with the door itself.

If the door and the door furniture are of the same colour or LRV as the wall and only the architrave is contrasted, blind or partially sighted people may identify the presence of a feature – but it will take longer for them to establish what the feature actually is. This is because there are several likely alternatives including, for example a ducting for pipes or a decorative feature.

Providing a door and architrave have the same colour or LRV as the wall and contrasting only the door furniture with the door will also offer clues as to the presence of the door. This is again because there are few features in the built environment that offer the same visual image in terms of size, shape and pattern other than that displayed by the handle, kicking plate, escutcheon and hinge components on a door. However, identification is likely to take longer than if the door itself is contrasted with the wall (ICI Dulux, 2007) Fleming & Bright (2007).

There are many situations in which decisions about features and facilities will follow a similar process of identification and elimination. The appropriate use of visual contrast can make that process much easier for many people using an environment.

5.0 The importance of lighting in the built environment

Light is a fundamental feature of the design of the built environment (Cook, 2005).

The three-dimensional flow of light in a space is influenced by the reflective properties of the surfaces within it. Surfaces with lighter colours will encourage light flow, whereas darker surfaces will not. In addition, the colour rendering and colour temperature of the light source can have a major influence on the colour appearance of the space (SLL, 2004).

In larger open spaces, the reflectance of the floor, furniture and ceiling makes a greater contribution to light flow than the reflectance of the walls. However, light on the walls can add considerable interest to any space and, importantly, can also assist blind and partially sighted people assess the size and layout of the area. (Cook, 2005)

Adequate lighting is essential for people when moving around a space and identifying safe routes, obstacles or hazards. Light, in turn, enhances the visual contrast between adjacent surfaces and, hence, the information available.

Blind and partially sighted people are generally more sensitive to glare than fully sighted people and, in general, their adaptation time to changes between areas of high and low illuminance is longer.

For example, when walking out of a building on a sunny day, most fully sighted people may experience some initial short term slight discomfort as their eyes adapt. For blind and partially sighted people, this adaptation time will be greatly extended and discomfort, sometimes accompanied by pain, can be experienced.

5.1 Natural light or daylight

Natural light, or daylight, is a variable source but is considered by many to be the ideal light source (Cook, 2004).

The design and orientation of features such as windows and roof-lights can be critical in optimising the use of light and its positive or negative impact on those using the space.

Direct sunlight may need to be controlled by shading devices to prevent glare and as natural light is dynamic, changing light patterns can lead to the creation of sharp shadows that can be disorientating for users. However, providing it is properly controlled, there is no doubt that the nature and unique colour rendering qualities of natural light can give a special quality to the experience gained from using an interior space.

5.2 Artificial lighting in information gathering process

Artificial lighting offers an almost constant illuminance and flow of light which can be utilised to assist all users of a space to move around and identify features.

Increasing illuminance and avoiding glare will benefit many blind and partially sighted people. However for some people with cataracts, simply increasing illuminance may be detrimental and it is essential to match the lighting conditions to a person's visual impairment (CIBSE, 2002).

5.2.1 *Luminaires*

Most luminaires (commonly called lighting fittings) are sited on the ceiling, and this can assist blind or partially sighted people to orientate themselves within a space.

For example, luminaires positioned above the centre line of a circulation route can act as a useful wayfinding tool. In contrast, recessing the luminaires can provide dark ceilings which may not be helpful to blind and partially sighted people using the space.

Luminaires are commonly the brightest source of light in the visual field and it is important that they are designed and maintained to appropriately light a space without causing glare.

5.2.2 *Shadows*

Strong shadows and abrupt changes in lighting within a space can cause problems with visual adaptation and can offer misleading information. For example, strong shadows across a circulation route can give the impression of steps and affect the comfort and confidence of blind and partially sighted people using the space.

Similarly, pools of darker and lighter areas, perhaps caused by inappropriate spacing of luminaires, can make gathering and interpreting information difficult. A good lighting design will ensure an even distribution of light along and across circulation routes and spaces (SLL, 2006).

Subtle shadows can add form to the visual image experienced by blind and partially sighted people, which can aid them when locating and identifying features within a building. For example, shadows around the decorative panels on doors, or around notice boards that project slightly from a wall, can sometimes assist people in identifying their presence, even if there is little visual contrast between the feature and its surround. However the use of shadows to aid identification of a feature should always be treated with caution (Bright, Cook & Harris, 1997).

5.2.3 *Task lighting*

Blind and partially sighted people require a wide range of illuminance when undertaking tasks and they tend to work very close to both the light source and the task. Therefore, using task lights with cooler lamps, such as compact fluorescents, is preferable to using light sources that generate heat. It is essential that people with visual impairments are allowed to control the lighting for their tasks and at their workstations (Wright et al., 1999).

5.2.4 *How much light should be provided?*

The lighting provided should ensure that all areas are lit to an acceptable standard. Table 1 gives the recommended illuminance for a variety of common locations (BS8300, 2001).

Table 1. Recommended illuminance

Location	Illuminance	Comment and Location
Ramps	100	min at top and bottom of ramp
External steps	100	min at tread level
Entrance	200*	SMI at floor level.
Corridor	100*	SMI at floor level
Internal stairs	100	min at tread level
Internal ramps	100	min at top and bottom of ramp
Lavatory	100	SMI at floor level
Bathroom	100 to 300	SMI at sink level
Shower area	100 to 300	SMI at sink level
Bedroom	100	min at floor level
Kitchen	150 to 300	SMI at worktop level

Notes
* Illuminance recommendation taken from CIBSE (2006) and Cook (2004)
min = minimum illuminance (lux)
SMI = Standard Maintained Illuminance (lux).

6.0 Lighting and visual contrast

There is a clear link between visual contrast and the lighting within a space. Light is essential for the perception of colour and there must also be a coloured surface from which light is reflected into the eye. Different wavelengths of light contained within the reflected light and their relative power will influence the perceived colour.

Not everybody will be able to perceive all colours. However, most blind and partially sighted people can perceive light and dark and, since this is a feature of coloured surfaces, their appearance can be influenced by the nature of the lighting condition (Bright, Cook & Harris, 1997).

For all users of a space, identifying visual contrast constitutes an important part of the strategy they adopt when moving around and identifying features and facilities. If the adequacy of that contrast is assessed using differences in LRV, the amount of light available within the space to reflect from a surface, together with the colour rendering and colour temperature of the light source, will be critically important in determining the quality of visual contrast provided (Cook, 2004) (See Figure 2).

7.0 Colour, lighting and safety

Functional colour and lighting were first employed in the mid 1920s, driven by increased industrial automation and the need to support visual tasks under artificial lighting conditions. The first colour safety standard for industrial spaces was developed by Faber Birren in association with DuPont in 1943, with the intention to reduce the risk of accidents. It later became a worldwide code recommended by ISO as Safety Colour Standards. Some of the colour codes have entered public consciousness, for example red for fire protection, orange for electrical hazards or yellow for platform edges (Birren, 1978, Birren, 1988).

The use of functional colour in industry has resulted in a marked reduction of industrial accidents. However, the use of functional colour needs to be addressed and

Figure 2. On the left with illuminance of around 100 lux, visual contrast between the floor and the wall is evident. However, as the deep skirting is a similar colour to the floor the corridor will appear wider than it actually is. On the right, reduced lighting eliminates the visual contrast available. Designing to differences in LRV without also considering the lighting to the space is not appropriate.

emphasised in a much wider context than just the working environment.

Indeed this is essential if users of environments are to enjoy easy, convenient and independent use of environments and spaces, and be safe when doing so.

This point can be illustrated by considering data on accident figures for older people in Austria, where it has been found that 67% of accidents involving people over the age of 60 occur in the home or in close proximity to the home, for example travelling to shops or other local amenities.

Of these accidents, over 70% were falls and of these 80% have an external cause which could involve, for example, built environment factors such as a staircase, kerb or steps that were badly lit and/or poorly maintained (Furian & Rehberg, 2000). Of particular concern is a marked increase in the number of accidents resulting in death; figures suggest this rose by some 33% from 2001 to 2006 for people aged 60 and over (KfV, 2006).

Accidents clearly have implications, not only for the person concerned and their families, but also for the community as a whole in terms of the high economic impact on the provision of medical services, rehabilitation and short or long-term care.

Enhancing opportunities to gather information from signage and other wayfinding techniques by careful use of visual contrast and lighting within the general environment or space can dramatically improve the safety and quality of life of the people who will use it.

8.0 Information design and the role of the information designer

Access to information is as important as physical access when using the built environment. Unfortunately, many designs are conceived and developed without early input from an experienced information designer, and for some projects information design is seen as something that simply relates to identifying where the direction and location signs should be placed.

To maximise the decision making process an information strategy will, for example, encapsulate how information provided by the harder physical features of an environment, such as tactile indicators incorporated into handrail or step design or surface finish, can work in conjunction with softer information providers such as visual contrast, lighting and signage.

Designing around such issues should be one of the core competences that an information designer can bring to a project. Good, well-managed projects will encourage such expertise early in the strategic and planning stages, and ensure it continues through the project as information systems and orientation strategies are developed. If this is done, providing good information design is often an issue of selection rather than cost.

9.0 Conclusions

Information design that includes appropriate consideration of visual contrast and lighting provides subtle, sometimes subconscious but nonetheless vital clues which people use every day to understand the space that surrounds them. They use them to develop orientation and navigation strategies to move around and to identify facilities and features. Conscious use of these clues by the designer makes them part of an information strategy.

Providing adequate visual contrast and lighting within a space is not an exact science, nor need it be. There are many variations in the visual ability of fully sighted, partially sighted, and blind people, rendering precise specifications impossible. Lighting can change considerably with time, even within the hour and within the same space or environment.

However, it is possible to design and manage environments and spaces along relatively simple guidelines that can improve the independence, safety and quality of life for a considerable number of people, whilst also reducing the personal and economic costs associated with poor provision.

The question is, if we know this is the case, why aren't we doing it more often?

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Keith is a past winner of the Chartered Institute of Building Gold Medal for Innovation in Research for the work undertaken in developing design guidance on the use of colour and luminance contrast to assist visually impaired people when using buildings.

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Veronika Egger is a graphic designer by training, she has focused on understandability and usability of information throughout her professional life, for example at Philips Design in Vienna, where she established and led an interdisciplinary "User Interface Group" that developed and tested usability concepts for consumer electronics products.

Since 1997 Veronika has been running her own design consultancy – is design GmbH – focusing on Information Design. Her particular interest in inclusive design led her back to "school" for an MSc "Design and Management of Inclusive Environments" at the University of Reading. She consults for local clients who wish to create more usable environments, for example the Austrian Federal Railways for the inclusive design of the new Vienna Central Station.

She is also consultant to the Austrian pharmaceutical industry organisations PHARMIG and IGEPHA on issues surrounding the design and readability of patient information leaflets.

Veronika Egger is a board member of IIID and a founding member of "design for all", the first Austrian agency for the design of inclusive environments.

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