BEST AND BAD PRACTICES IN PUBLIC TRANSPORT: APPROACHES TO A BARRIER-FREE DESIGN FOR THE VISUALLY AND HEARING IMPAIRED

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1. Introduction

An emancipated and equal approach to all areas of public life has long been a target of social and disability policy. (B-VG, 2012; BGG, 2007; BGStG, 2011; United Nations, 2007) In order to realize that, however, some groups of people require special customized aids and measures adjusted to their specific needs. This paper puts its key focus on the visually and hearing impaired and their access to public transport services.

Whereas numerous measures are implemented for people with physical and mobility disabilities in the area of public transport, often at considerable expenses (e.g. installation of lifts in stations, wheelchair lifting devices in trains), it is the visually and hearing impaired who have to make do with partly inadequate compromises or are simply ignored as a special-needs group with particular demands on a public transport system. (Wölfl, Leuprecht, 2004) Sure enough, this is not an argument for cutting the means for wheelchair users and people with impaired motor skills, rather, it has to be considered that many measures and improvements which could lead to a considerable increase in mobility for the visually and hearing impaired are related to little or even no costs. This is particularly true if the demands of these groups are already taken into account in the planning or purchasing phase.

Moreover, an increased awareness of the visually and hearing impaired entails a number of positive side effects. On the one hand, according to conservative estimates the two groups are by far the largest in Austria in relation to other disabled groups, amounting to approximately 320,000 and 202,000 people, respectively. (Leitner, 2008) In addition to that, this group is going to continue growing due to demographic change (ageing population, increasing life expectancy) and medical developments (improving rehabilitation processes for visual and hearing impairments to prevent blindness or deafness). On the other hand, measures which enable the visually and hearing impaired to use public transport also provide practically all other passengers with an additional gain in comfort and thus increase the rates of both acceptance and popularity. It is particularly passengers who do not use public transport services on a regular basis, who considerably benefit from improved availability of information. (Blümel, 2004)

Furthermore, it is evident that elderly people not only want to be increasingly mobile but also claim this. (Verband deutscher Verkehrsunternehmen, 2011) At the same time, increasing age also tends to increase the likelihood of deteriorating visual and

hearing performance. (Rudberg et al., 1993, Taylor et al., 1997, Seland et al., 2011) It thus seems imperative even at this point in time, where this development is to be anticipated yet has not fully struck, to implement measures which allow for full and equal participation of the visually and hearing impaired in public transport. On the one hand, the relevant legal regulations and norms need to be established and their infringement needs to be sanctioned. On the other hand, a barrier-free implementation has to be the top priority (principle of form-follows-function) for all measures, particularly for long-term infrastructure projects (constructions and modifications), ordering of vehicles, etc.

Yet, in order to enable public transport companies to introduce targeted and accurate offers for the visually and hearing impaired, a number of requirements has to be met. First, the responsible persons in the companies need to be aware of the fact that the visually impaired are not blind (Wölfl, Leuprecht, 2004) and the hearing impaired are not deaf, and that due to the size of these groups (approx. 4% and 3% of the population) (Leitner, 2008), they represent an as yet unexploited economic potential. Additionally, the parameters according to which visual and hearing impairments can be classified and defined need to be clear in order to be able to focus on individual groups in a targeted way. (Fürst, Vogelauer, Hauck, Hauck, forthcoming) Furthermore, the problem areas and barriers which currently prevent the two groups from an emancipated use public transport (Fürst and Kuhar, 2009, Fürst, 2010) need to be identified along with the existing legal framework and possibilities in the area of “barrier-free” design. Finally, it has to be aim and task of both research and interest groups to provide public transport companies with practical examples for successful and acceptable solutions. Therefore, this article deals with such “best and bad practices” and is to convey ideas as to which solutions provide real benefits for the visually and hearing impaired and which approaches, although well-intentioned, are ultimately not feasible.

2. Visual Impairment and Hearing Impairment

The eye is a highly complex organ which, by an interaction of muscles, lens and retina, enables the human being to see. Due to this unique structure, there is a great number of factors that can affect the eyesight. In general, six different parameters of sight can be differentiated. These are briefly presented in the following in order to facilitate the understanding of the evaluation of solutions in this paper.

Parameter	Description	Consequence
Acuity	Indicates the visual acuity of an individual. People with “normal” vision show acuity of 1.0, with values smaller than 0.3 counting as visual impairment. There is a distinction between distance visual acuity and	For individuals with reduced acuity, objects and letters are harder to identify.

	near visual acuity.	
Contrast sensitivity	Defines the contrast needed by an individual between two or more different surfaces in order to be able to distinguish them.	A heightened contrast demand leads to an aggravated perception of objects that are not clearly distinguishable in color (e.g. dark furniture on dark floor)
Field of vision	Refers to the angle that an individual can perceive. Non-impaired people can perceive an angle of approximately 180° horizontally and 60-70° vertically.	Impairment limits the angle of peripheral vision and thus heightens the danger of missing objects that come towards an individual from the side.
Color vision	Specifies, whether a person can see the entire color spectrum and distinguish between the individual colors, or if some colors are perceived as being the same (e.g. red-green color blindness)	An individual may incorrectly interpret visual information which is primarily based on color coding.
Motion perception	People with limited motion perception find it hard to perceive moving pictures as fluent movements. Rather, they are perceived as jerky or blurry.	Due to the jerky or blurry perception, an assessment of speed and direction of moving objects is made difficult.
Stereoscopic vision	Refers to an individual's ability to perceive depth of field and thus the ability to estimate the distance to objects.	Due to a defective evaluation of distance, objects may seem closer or further away that they really are. Thus, there is an increased risk of accidents, road accidents in particular.

Table 1: 6 Parameters of vision

The situation regarding the sense of hearing is somewhat simpler. Basically, there are two central parameters that are, however, always interconnected and thus have to be considered in connection with each other. At the same time, a distinction can be made according to the part of the ear which is impaired – conductive hearing loss (outer ear and middle ear) or sensorineural hearing loss (inner ear).

Parameter	Description	Consequences
Intensity of sound required (dB)	The intensity of a sound on a logarithmic scale which is required by an individual in order to be able to hear it.	Faint noises (e.g. electric cars) cannot be perceived by the person concerned and can thus appear unexpectedly (e.g. approaching from behind).
Frequency	Indicates the frequency of a sound which is played to the person concerned. Human voice ranges from 0.5 - 2 kHz, while machines and vehicles are mostly lower.	Depending on the relevant frequency range, the impairment can lead to considerable difficulties in the perception of acoustic signals (e.g. announcements, vehicles, alarm signals).

Table 2: 2 Parameters of hearing

3. Method

Based on a literature analysis as well as expert interviews with persons concerned as well as stakeholders and representatives of public transport companies (see table 3), problematic areas and barriers were identified which hinder the visually and hearing impaired from navigating capably despite their impaired sense.

Interview partner	People
Visually impaired	96
Hearing impaired	8
Societies and stakeholders of impaired people	11
Public transport companies	12
Authorities	4

Table 3: Interview partners for identifying barriers

The areas identified were “stations and stops”, “vehicles”, “general mobility-related problems” and “public awareness”. While it was relatively easy to identify “best and bad practices” for the first three areas, as can be seen below, they were less easily identifiable for the area of “public awareness”. In addition to these areas, particular elements (see table 4) were identified that particular attention was to be paid to. This was achieved by expert interviews on the one hand, and by literature analysis of law codes, regulations, norms and guidelines on the other hand. Yet, it has to be stated that de facto, hardly any binding requirements or standards have been defined so far, or the existing requirements are absolutely inadequate.

	Problematic areas		
Vehicles	Destination display	Notices	Displays
	Signposting	Ticket vending machines	Announcements
	Interior design (contrasts)	Exterior design (doors, painting)	
Stations and stops	Notices	Displays and monitors	Visual guidance system (also visual - tactile)
	Doors in stations	Ticket vending machines	Signposting
	Lifts	Announcements	Interior design (contrasts)
General mobility-related problems	Obstacles on the floor and construction site safety	Weather conditions	Unguarded railroad crossings
	Glass fronts		
Awareness	Trained personnel		

Table 4: Elements identified as potentially problematic

In the course of this research, the problematic areas identified and solutions to them were recorded and visually captured in various cities all over the world. Subsequently, the respective solutions were discussed with both persons concerned and an expert panel made up of representatives of the visually and hearing impaired and were compared to their requirements. As a result, the evaluations are to a high degree based on subjective perceptions and assessments. It has to be mentioned, however, that the experts interviewed have many years of experience in working for the visually or hearing impaired and are in many cases affected by impaired senses themselves.

4. Results

Based on the findings from numerous interviews and the resulting identification of specific barriers, we worked out minimum requirements for particular systems on the one hand, and on the other hand we recorded images which depict the (non-)compliance with these requirements. Following the tables above, the organization is as follows: destination displays, notices, announcements, displays and monitors, signposting, ticket vending machines, interior design, exterior design of vehicles, visual (tactile) guidance systems, doors in stations, lifts, floor markings and construction site safety, glass fronts, and trained personnel.

4.1 Destination Displays

Information and barrier-free access to it is probably the most important requirement in order to participate in public transport independently. One of the most discussed, and most important, information carriers of a public transport system are the destination displays on the individual vehicles. These can range from simple, monochrome printed signs to multi-colored, multi-line LED signs with scrolling text. In the literature, there is generally a number of demands regarding the design of destination displays. For one thing, the font size should be as large as possible, whereby abbreviations are to be avoided and a sans-serif font is to be used if possible. Moreover, a distinction in upper- and lower case letters as well as ascenders and descenders is considered to be helpful for readability. (Deutscher Blinden- und Sehbehindertenverband, 2010, PP.122ff) In general, it has to be taken into account that although the display may be illuminated or feature a particular luminance, it should not dazzle the visually impaired in darker conditions (in this case, dimming displays are recommended in the dark) and there should, if possible, not be any combination of red and green. (Buser, 2006, Buser et al., 2008, Forschungsgesellschaft Mobilität, 2009a, pp.34-45, Forschungsgesellschaft Mobilität, 2009d, pp.30-33, 35-37, Forschungsgesellschaft Mobilität, 2009e, pp.27-37, Deutscher Blinden- und Sehbehindertenverband, 2010, pp. 109ff)

Illustration 1: Low luminance and font too small

Illustration 2: Better luminance but small font in punctiform design

Illustration 3: Font of destination display too thin and punctiform

Illustration 4: Good destination display with high luminance in Vienna

Illustration 5: Good destination display with high luminance in Stuttgart

Illustration 6: Good solution without electronic display in Vienna

Illustrations 1 to 3 show how a destination display can be designed without taking into account the needs of the visually impaired. While the display in illustration 1 shows bad contrast and low luminance in addition to a very small font size, at least the contrast values in illustrations 2 and 3 are notably better. In these cases, however, the small font and the punctiform display considerably hamper perception. Illustrations 4 and 5 depict a significantly better solution. The displays feature

sufficient luminance and a broader font, which is even approachable in the case of a destination display on the side (illustration 5). A good solution without electronic display is shown in illustration 6, a scrolling display of the Wiener Linien, which is characterized by high contrast values (black on white) and large letters.

Illustration 7: Destination display with high luminance inside the vehicle in Vienna

Illustration 8: Another well contrasting display

Illustration 9: Over-fading of information due to the direct ceiling lighting which is too intense

Destination displays in the interior of vehicles - like outside displays - should feature high contrast as well as broad, continuous letters (illustrations 7 and 8), the more so as their accessibility is limited due to being mounted on the ceilings. Due to their positioning, it is important to make sure that there is no over-fading or reflection caused by the ceiling lighting (illustration 9).

Illustration 10: Badly readable destination display in a station due to its low luminance

Illustration 11: Well mounted destination display in a station

Also the destination displays mounted in stations have to meet the requirements of the visually impaired. This is not the case in illustration 10, as the luminance of the display is too low considering the bright background. A frame protecting the display against the dazzling effect would be a considerable improvement. Alternatively, the destination display could be integrated in the station structure, as shown in illustration 11.

4.2 Notices

Notices are another key element of access to information. They comprise all network plans, route plans and timetables as well as bulletins, information posters and other notices. (Deutscher Blinden- und Sehbehindertenverband, 2010, pp.105f) In contrast to displays, which shall be mentioned later, this category refers to purely offline media which present purely static information. Again, a preferably simple and clearly structured presentation with large letters (14+ pt) and strong contrasts (white on black, dark blue/black on white) is the best choice. (Forschungsgesellschaft Mobilität, 2009f, pp.30f, Deutscher Blinden- und Sehbehindertenverband, 2010, pp.112f) Contrary to destination displays, however, the design of the font is not of key importance due to the static presentation and mounting as long as the individuals

concerned have the possibility to approach the information. The possibility to approach the information may also help when mirroring covers are used or when the notices are pinned on glaring background. In the case of tables, the lines should alternate in background color in order to facilitate reading within the lines.

Illustration 12: Notice mounted on back wall of a deep display cabinet

Illustration 13: Very large distance between glass pane and information with bad lighting

Illustration 14: Network plan on opposite side of rail track

Illustration 15: Small fonts and a lot of information with advertisements

Illustration 16: Timetable with background lighting at info column

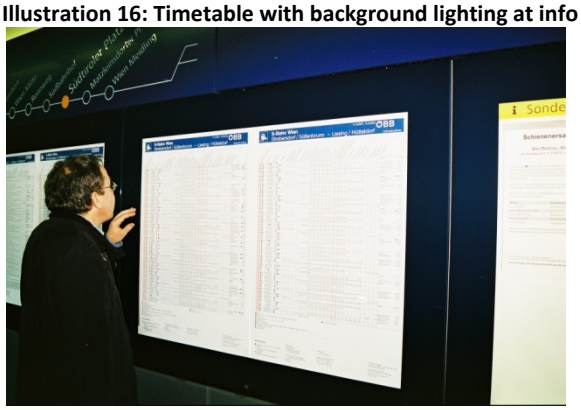

Illustration 17: Timetable at eye level and without gap to the front

The possibility to approach the information is among the options that are considerably helpful to the visually impaired. This basic assumption, however, is often rendered impossible by mounting the information in deep display cabinets (illustrations 12 and 13). Mounting plans on walls which are separated from the platform by the rail track is not a good solution either (illustration 14). Flooding the readers with non-relevant details is an additional obstacle to information access. Moreover, the space which could be used for enlarging the notices is often occupied by meaningless advertisements (illustration 15). Notices can be rated as very good if they are approachable (ideally, the individuals concerned can “have their noses pressed to the notice” to be able to use enlarging vision aids), at eye level and are not mounted on mirroring fronts (illustrations 16 and 17). Illustration 16 additionally features background lighting which enables reading the notice even in diffuse or dark situations.

4.3 Announcements

Apart from notices and signs, announcements are another important element of imparting information in public transport. Besides general notes relating to incoming and departing vehicles, current information such as trouble reports and bad weather conditions (development of black ice) can among others be communicated via this channel. In general, all announcements should ensure clear and articulate pronunciation and avoid terms that are used only locally. This is particularly true for live announcements, which require trained staff, yet it is also essential for designing and recording taped announcements. A key element of announcements is their proper introduction. The hearing impaired above all benefit enormously from being

able to pay attention in time and listen carefully. At the same time, adjusting the volume to the surroundings is considered a very helpful measure, specifically if there are many interfering noises (nearby thoroughfares, busy train lines, during thunderstorms / heavy rain). (Schmitz and Goertz, 2008, Neukomm, 2009, Deutscher Blinden- und Sehbehindertenverband, 2010, pp.37-39, pp.130-139, p.166, Schmitz et al., 2010)

Another possible approach to a barrier-free design is the simultaneous provision of spoken information and textual notices on displays or tickers (implementation of two-senses-principle).

Mounting the speakers in approachable positions also constitutes a useful support for the hearing impaired, as the sound can be assimilated more directly. In this case, induction loops are an ideal technical aid which helps the hearing impaired to listen to the announcements directly through their hearing aids via specific receivers without any medium loss (other pressure waves / sound waves in the air). However, there are high costs involved, particularly in retrofitting. Devices that feature such a unit should be marked with the icon for induction loops. (Illustration 18)

Illustration 18: Icon for induction loop

4.4 Displays and Monitors

The increasing modernization of train stations, stops and vehicles leads to the introduction of more and more electronic displays which are to provide passengers with manifold information. As they are generally mounted overhead and thus create a larger distance to the information shown, they usually pose a problem to the visually impaired. In this case at least one monitor should be at eye level to provide the possibility of approaching the information. (Deutscher Blinden- und Sehbehindertenverband, 2010, pp.109-113) At the same time, this can easily lead to a dazzling effect due to glaring backgrounds (sky). Even if the information provided should follow similar guidelines as notices, it has to be taken into consideration that the interactive presentation – on tickers in particular – constitutes an impediment to the use of information. (Forschungsgesellschaft Mobilität, 2009b, p.25, Forschungsgesellschaft Mobilität, 2009c, p.22) In this case, it is recommended to have a short break after one full ticker line. In dark rooms and during nighttime, a brightly lit display can lead to dazzling effects for the visually impaired. The brightness of displays should thus be adjusted to the surrounding brightness. (Buser, 2006, Buser et al., 2008, Deutscher Blinden- und Sehbehindertenverband, 2010, pp.25-29, Allgemeiner Blinden- und Sehbehindertenverein Berlin, 2009)

Illustration 19: Monitors mounted too high with font being too small

Illustration 20: Monitors at eye level with good contrasts

An example of monitors mounted too high with the font size being too small for the distance is depicted in illustration 19. Illustration 20 shows well-placed and contrasting monitors. These are at eye level and thus approachable for the person concerned.

4.5 Signposting

The primary intention of signs in stations and also in vehicles is to support to passengers' navigation. Therefore, clear transfer of information is of major importance. In contrast to notices, which often have to impart a great amount of information, signs aim at a simple and singular transfer of information. Again, rather large and sans-serif fonts should preferably be used, and the contrast between the sign's background, its color and its font should be as distinctive as possible. (Forschungsgesellschaft Mobilität, 2009c, pp.22, 29f, Forschungsgesellschaft Mobilität, 2009b, pp.37f) These two parameters are of central significance, as orientation signs are generally mounted overhead, and thus lack the possibility of being approached. In addition to that, signs often feature icons which should also be designed rich in contrast without containing too much information (as a rule, not more than 5 icons per sign). (Deutscher Blinden- und Sehbehindertenverband, 2010, pp. 114-121)

Illustration 21: Station signposting in sufficient size and rich in contrast

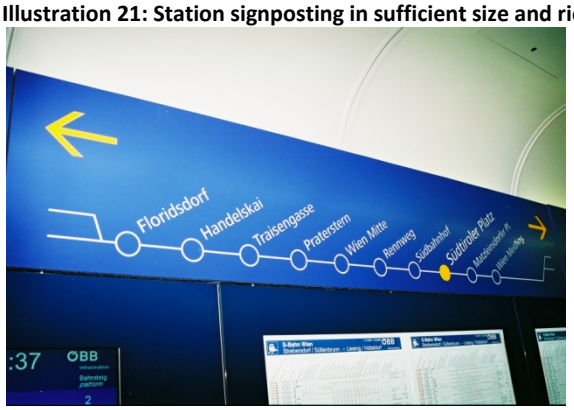

Illustration 22: Signposting with high contrast and sufficient size

Illustration 23: Approachable sign with large, sans-serif and backlit font

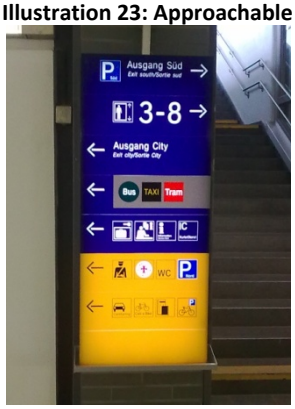

Illustration 24: Good readability due to backlighting as well as different colors for different functions

Illustrations 21 and 22 show signs of the Vienna S-Bahn (regional railway) which can easily be deciphered due to the high contrast between the white font and the blue background as well as the appropriately large and sans-serif font. Apart from the high contrasts, further positive aspects of illustrations 23 and 24 are the mounting at eye-level and the backlighting with dimmed light to avoid any dazzling effect.

Particularly with signs which are to be used within a visual guidance system, it is important to make sure that they are set apart from their normal surroundings and are clearly identifiable as such from a distance. This means that, on the one hand, the guidance system needs to be internally consistent (all signs in the same or respectively negative design) and, on the other hand, private companies' advertising boards have to be clearly distinguishable from the parts of the guidance system.

4.6 Ticket Vending Machines

Due to the continuing reduction of staff, station staff in particular, public transport passengers are increasingly dependent on ticket vending machines. At the same time, most transport systems offer various options of tickets and reductions which should enable impaired people to use public transport at lower prices. These manifold options, however, often lead to confusing user interfaces which have a discouraging effect not only on impaired people, but also on infrequent travellers. One approach to improve or solve this problematic situation is to display the most common tickets at the first level, or the question-based selection of tickets (whereby the process of buying a ticket is significantly prolonged). Along the lines of electronic displays, they have to have sufficient luminance and require dazzle-free mounting. The mounting of the machines is often unsatisfactory for the visually impaired in particular, as they have to bend down to approach the monitors. Another important aspect is the location of the machines. If they are not located directly at the entrance, clear signs should point to the closest machine. Apart from that, access to ticket vending machines should be barrier-free. (Forschungsgesellschaft Mobilität, 2009f, pp.20-26, Deutscher Blinden- und Sehbehindertenverband, 2010, pp.103f)

4.7 Interior Design

Generally designing interior spaces such as lounges or corridors in stations or the interior of a vehicle (passenger room, multi-purpose rooms, toilets, etc.) in contrasting colors and with dazzle-free materials (matt surfaces, no polished metal elements) significantly improves the orientation of the visually impaired. (Deutscher Blinden- und Sehbehindertenverband, 2010, pp.53-101) Another important aspect is the way the lights are mounted, as the dazzling effect can be considerably decreased by indirect light sources. (Deutscher Blinden- und Sehbehindertenverband, 2010, pp.25-29) The hearing impaired, however, mainly profit from avoiding echo-situations which increase the general noise level and thus render potential announcements unintelligible. (Deutscher Blinden- und Sehbehindertenverband, 2010, p.69) This also concerns the visually impaired who, by means of acoustic signals, try to grasp additional parts of their surroundings. At this point, it must be mentioned that the barrier-free design of interior spaces does not exclude a valuable and high-quality appearance. (Forschungsgesellschaft Mobilität, 2009d, pp.17-22, Forschungsgesellschaft Mobilität, 2009e, pp.15-22, Forschungsgesellschaft Mobilität, 2009a, pp.26-31)

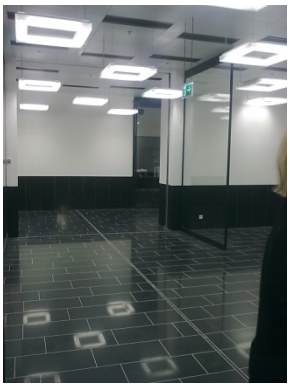

Illustration 25: Dazzling dark floor with direct lighting

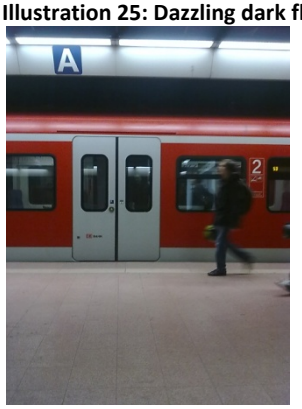

Illustration 26: Matt light floor, again with direct lighting

Illustrations 25 and 26, in particular, illustrate the different perceptions of dazzling and matt floors. While illustration 25 shows a dazzling effect from both ceiling and floor, the floor in illustration 26 absorbs the light and thus prevents disturbing reflections.

Illustration 27: Classic, easily recognizable yellow handrails

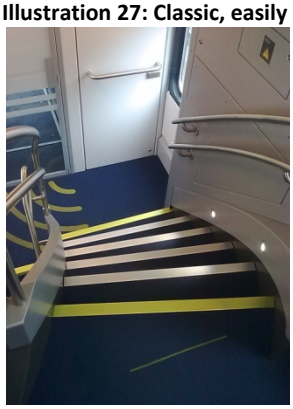

Illustration 28: Stair markings in wagon

In the interior of vehicles, high contrast design also supports the visually impaired to recognize potential dangers and to react in time. The yellow handrails in illustration 27 and the top and bottom steps in illustration 28 (as well as the metal ledges on the

middle steps) are good examples. The silver handrail in illustration 28, however, may arouse criticism, as it does not contrast well against the grey background. It is worth mentioning that yellow markings are not an absolute necessity but that they have so far led to satisfactory empirical values. Other color combinations should be tested in a mock-up in realistic conditions including persons concerned.

4.8 Exterior Design of Vehicles

In the case of vehicles, the design of the exterior is a particularly relevant factor concerning the accessibility of a means of transport. The possibility of finding the position of the entrance as well as the door openers on the outside is a fundamental requirement. (Deutscher Blinden- und Sehbehindertenverband, 2010, pp.32-34) Also, the general coloring in relation to the environment can assist the impaired in recognizing the transport vehicle, thus preventing hazardous situations. (Forschungsgesellschaft Mobilität, 2009d, pp.11-16, Forschungsgesellschaft Mobilität, 2009e, pp.11-15, Forschungsgesellschaft Mobilität, 2009a, pp.10-23)

Illustration 29: Doors are clearly set off from the rest of the wagon

Illustration 30: The advertisement partly covers the doors

Illustrations 29 and 30 show a very good and a rather bad example of exterior design of vehicles. While in the first picture, the entrance door is clearly set off from the rest of the vehicle and can easily be found, the advertisement in the second picture creates a restless and badly distinguishable pattern which makes it difficult for the impaired to find the entrance.

4.9 Visual (tactile) Guidance Systems

Even though purely tactile guidance systems (which are less used by the visually impaired compared to the blind) are quite common and are often part of the standard planning of stops, the potential visual component is often not considered or not used. Yet, implementing a contrasting design would facilitate the perception of the guidance system and thus, an additional benefit for the visually impaired could be generated at low cost. This category also comprises Braille and handrail information in raised letters on information signs and handrails. In general, it has to be stated that the visually impaired do not learn Braille, and people with “normal vision” cannot make use of this information either. At the same time, making the tactile letters stand out in color could improve the perception of the guidance system. If a guidance system with attention areas, e.g. for entrances, is in place, this has to be adhered to by the drivers. (Kuratorium für Verkehrssicherheit, 2003, pp.28f, Forschungsgesellschaft Mobilität, 2009b, pp.29-31, Forschungsgesellschaft Mobilität, 2009a, pp.39-47, Allgemeiner Blinden- und Sehbehindertenverein Berlin, 2009)

Illustration 31: Visual floor guidance system including information

In illustrations 21, 23 and 24, the elements of a visual guidance system are easily recognizable apart from the signposting. On the one hand, they are set off from their background due to their color; on the other hand, they are large and obvious enough to be easily identified. Illustration 31 depicts a visual floor guidance system which does not only give directions, but also conveys information.

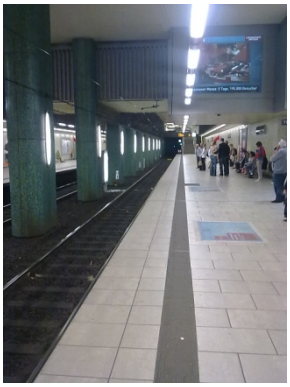

Illustration 32: Dark visual-tactile guidance system

Illustration 33: Light visual-tactile guidance system with attention area

Illustration 34: Guidance system designed in three colors with contrasting post

The contrasting design set off against the surroundings assumes a key role in the area of visual-tactile guidance systems. Illustrations 32 and 33 present well designed systems which clearly stand out. The design in illustration 34 is even better, as it features different colors of sidewalk, guidance system and street, which provides the visually impaired with an additional aid for orientation. In contrast to the guidance system in illustration 31, however, the latter three do not provide any destination-related information.

4.10 Doors in Stations

As with vehicles, doors in buildings are usually integrated into the design of the façade. There are frequent problems with glass sliding doors and swing doors. With glass sliding doors, this is mainly due to insufficient marking of the glass area and the opening direction or point of opening. With swing doors, thoughtless swinging, especially if there are no door stoppers, can pose an enormous risk for the visually impaired, who may not be able to see the approaching door before it is too late and who may suffer considerable injuries if a door swings shut with full impact. In all cases, it should be considered that the door, as well as the opening direction and the opening area are marked rich in contrast. (Forschungsgesellschaft Mobilität, 2009a, pp.20f)

Illustration 35: Badly marked door

Illustration 36: Well marked door including marking of opening

The difference between well marked doors and invisible doors is highlighted in illustrations 35 and 36. Whereas in the first one, the door (especially frame and edges) is hardly recognizable, the bicolored marking in the second one guarantees easy recognition of the entrance area, especially since the markings are applied on two levels.

4.11 Lifts

In the course of creating barrier-free access for the mobility impaired, most stations and stops are gradually equipped with lift units. Thus, it is incomprehensible that these lifts may constitute a barrier for the visually and hearing impaired. Finding the call button as well as selecting the correct destination often proves to be difficult. The inconsiderate location of lights (e.g. direct light source next to the selection bar) often complicates the selection of the correct level for the visually impaired. In the case of emergencies, it is the hearing impaired in particular who are confronted with considerable problems in lifts, as the emergency equipment is frequently designed for acoustic communication only. (Forschungsgesellschaft Mobilität, 2009b, pp.18f, Forschungsgesellschaft Mobilität, 2009a, pp.19f)

Illustration 37: Lift call-system with hidden call button.

The lift call-system in illustration 37 constitutes a particularly successful error-design. Even people with “normal vision” should find it hard to find the button to call the lift. For this visually impaired, this is almost impossible.

Illustration 38: Well-designed entrance to lift

Illustration 39: Level selection unit with good contrast

Illustration 40: Level selection unit set off in contrasting color, featuring lit buttons

Illustrations 38 and 39 present good examples of how to integrate a lift. The first one is equipped with a visual guidance system as feeder path. The low contrast design of

the door frames, however, could arouse criticism. The second illustration shows the level selection unit of a lift in the Wiener Linien, which use icons and contrasting lighting of the selected buttons. Illustration 40, too, depicts a very good solution which combines high contrasts and clear fonts with good lighting.

4.12 Obstacles on the Floor and Construction Site Safety

If marked badly, bollards, cordons, construction site grids and other sign boards and stand-up displays in public space constitute considerable obstacles for the visually impaired. Apart from the increase of hazards of stumbling and falling, by far more dangerous situations (e.g. falling into pit, sharp-edged signs) may arise at construction sites and signs mounted overhead. Keeping the design in colors contrasting with the background would be a helpful solution in this case. Simultaneously, barriers and signs should be designed in a way that sidetracking or shifting is not possible. (Kuratorium für Verkehrssicherheit, 2003, pp.32f, Wölfl and Leuprecht, 2004, p.104)

Illustration 41: Non-contrasting traffic sign post

Illustration 42: Non contrasting bollards at half-height

Illustration 43: Unsecured tree patch on sidewalk

Illustration 44: Pedestrian crossing leading directly into tree patch and unmarked post

Illustration 45: Unsecured and unmarked construction site grid

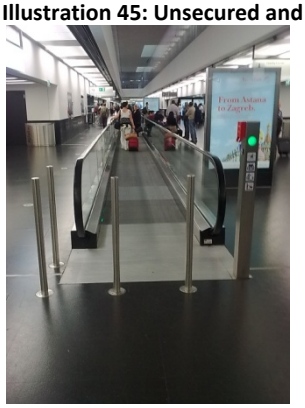

Illustration 46: Unmarked bollard in front of passenger conveyor

As can be seen in illustrations 41 to 46, many problems arise for the visually impaired, particularly in public space. These could easily be avoided with some considerations on the part of constructors and builders. The generally bad contrast situations in all illustrations are especially problematic. In illustrations 43 and 44, in particular, the hazard of falling due to unsecured edges in the middle of the sidewalk must not be underestimated.

Illustration 47: Bollards marked in reflective colors

Illustration 48: Traffic sign post with markings at two levels

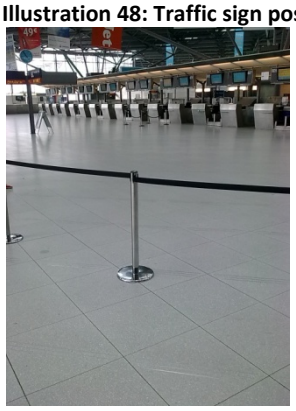

Illustration 49: Cordon with high contrast to floor

By contrast, illustrations 47 to 49 illustrate how the perceptibility of obstacles on the ground – both outside and in buildings – can be improved by simply applying contrasting or colorful markings.

4.13 Glass Fronts

Glass fronts often have a dazzling effect caused by incident sunlight (inside) or mirrored sunlight (outside), which leads to a loss of visual information in the direction of the glass front, not only for the visually impaired. In this case, matt or light-diffusing surface coatings present a useful solution. In entrance areas where doors are not clearly marked, however, larger glass fronts can pose an obstacle and a risk of injury as it is difficult to perceive how to enter and exit the building. Markings contrasting in color at eye level and below are helpful to avoid crashes. (Forschungsgesellschaft

Mobilität, 2009b, p.23, Forschungsgesellschaft Mobilität, 2009a, p.28, Allgemeiner Blinden- und Sehbehindertenverein Berlin, 2009)

The glass front in illustration 25 features markings at the edges, yet, they are so inconspicuous and low in contrast that they are easily overlooked, which significantly increases the visually impaired persons' risk of crashes.

Illustration 50: Well marked glass fronts and sliding doors with marked opening

Illustrations 36 and 50 depict a well-contrasting marking of glass front, not only twice horizontally, but also vertically at the door opening. Thus, the visually impaired know where to turn to and are aware of a glass front before them. In this respect, the precise intensity of color is less important than the fact that a dark and a light surface have to be combined and that they should stand out from their surroundings.

4.14 Trained Staff

In addition to structural measures, a transport company's staff plays an important role in creating barrier-free public transport. This does not only apply to drivers of trains, buses and trams or station staff, but also – at least to the same extent – to executives and the management. While the first are usually in contact with customers and thus have to be advised on special needs of the impaired for the respective means of transport, it is within the responsibilities of the management or the administrative and technical departments to design the long-term orientation of the transport company and implement measures to promote barrier-free accessibility. In this context, relatively simple measures such as entering an existing station under "difficult" conditions (with sight-obstructing glasses, earplugs, etc.) can lead to a fundamental awareness of problems and barriers faced by the impaired. Moreover, targeted instructions during training as well as during employment lead to a deeper and more sustainable understanding for the situation of impaired passengers. These instructions should be jointly developed and held with the respective Association for impaired people in order to make sure that on the one hand, the most current information is transmitted and on the other hand, the actual problems of the target groups are conveyed. (Kuratorium für Verkehrssicherheit, 2003, pp.104-109, Wölfl and Leuprecht, 2004, S.34f, Forschungsgesellschaft Mobilität, 2009, pp.12-15, Deutscher Blinden- und Sehbehindertenverband, 2010, pp.155-157)

5. Conclusion

As mentioned at the outset of this paper, the visually impaired constitute a relevant and growing target group not to be neglected by public transport operators. The key focus of considerations on how to improve existing systems should specifically be put on individuals who are not able to switch to individual traffic due to their respective impairments. At the same time, it can be demonstrated that measures which improve the mobility of the impaired also improve the comfort and quality of the public transport system for all passengers.
As could be shown, best and bad practices related to a barrier-free system can be identified in all areas of the system “public transport”, be it stations or vehicles.
However, many of the useful solutions presented here are not any harder to realize than their bad counterparts, but require planners’, architects’ and technicians’ knowledge and awareness that there are people who cannot use one (part of or entire) sense and can thus not use a certain component of the respective product.
Some basic findings could be generated for these groups which might be considered in future projects and which are to be presented as simple formulas.

1. Make it possible for the user to approach the information offered at eye level and at short distance.
2. Use the space available on signs, walls and notices and consider the reading distance.
3. Announce (spoken) information.
4. Be aware of the fact that by means of minor adaptions, a system can assist even more target groups (visual-tactile guidance systems instead of just tactile ones)
5. Speak to the different groups before making a final decision.

At the same time, it must be mentioned that there is further need for research and action in the area of the mobility of the impaired. On the one hand, the relevant laws and norms need to be harmonized and put into practice in order to give public transport operators the opportunity to develop appropriate barrier-free systems. On the other hand, the issue of barrier-free accessibility has to be anchored within the training of traffic planners, architects, technicians, construction workers, but also traffic scientists in order to achieve a sensitization of all relevant groups in good time.

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