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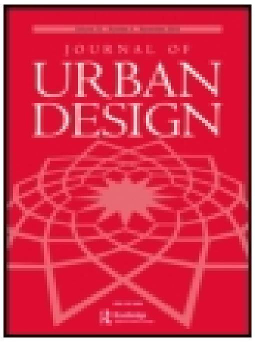

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Mapping the importance of specific physical elements in urban space for blind and visually impaired people

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ABSTRACT
This paper is based on a questionnaire of all Danish Orientation & Mobility instructors, assessing the importance of 34 physical elements as clues in the pedestrian environment to support blind and visually impaired people (BVIP)'s orientation. The aim is to contribute to a body of knowledge about why the design of physical elements is so crucial for (BVIP)'s orientation, accounting for the perceptual sight function and using other senses to compensate for the impaired vision. The study shows that all elements were generally assessed as being very important. Furthermore, the paper discusses how to plan urban space in the future.

KEYWORDS
Blind; mobility; orientation; pedestrian; visually impaired; urban space

Introduction

Good walkability concerns and benefits all people, thus contributing to good health and urban sustainability. The accessibility of the urban space is crucial to the user's ability to move around and use the space with a feeling of safety. Visual impairment and blindness impede peoples' ability to live independently and participate in society (WHO 2014). Being visually impaired or blind makes it difficult to move around, which may lead to reduced self-dependence (Norgate 2012; Jacobsen 1998).

A Danish study (Amilon et al. 2017) shows that 63.1% of the blind and visually impaired people (BVIP) in the 16–64 age range decide where to go in the neighbourhood based on ease of access. By comparison, good access is a decisive factor for only 23.7% of people without disabilities (Amilon et al. 2017). Based on the social model, where people's possibilities depend on the environment, the mismatch between the ability of the individual and the environment can be described as a gap (Lie 1996). The design of an accessible urban space reduces the gap (Lid 2013a, 2013b). To put it simply, urban planners, landscape architects and engineers can plan and design an urban realm that supports and contributes to an independent life for BVIP.

However, it requires knowledge and an understanding of how BVIP navigate in urban spaces and the techniques they use (Parkin and Smithies 2012).

Few possess this understanding and people with disabilities are primarily thought of as wheelchair users (Bates 2008). Furthermore, the requirements of wheelchair users and blind people are often conflicting (Lid and Solvang 2016). It involves a more complex and

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time consuming design process that calls for know-how that is hard to get, e.g., through user expertise (Heylighen, Van der Linden, and Van Steenwinkel 2017). In addition, the professionals are not used to think about users with a disability. Danish landscape architects have e.g., limited expertise and knowledge concerning working with accessible design solutions. (Gramkow, Merit, and Stigsdotter 2022).

Over the years, challenges faced by BVIP in relation to the space have been mapped, and different solutions have been tested and studied in relation to details or thematic situations. One theme is kerbs (Childs et al. 2009) and crossing a street (Bentzen, Barlow, and Franck 2000; Scott et al. 2011; Bentzen et al. 2017; Ginnerup and Bredmose 2013). Others include accessible pedestrian signals (Williams et al. 2005; Barlow, Bentzen, and Bond 2005; Scott et al. 2008), tactile walking surface indicators (Gallon 1992; Ginnerup and Bredmose 2013; Tekeda et al. 2006; Stahl et al. 2010), the luminance and contrast of these, (Mitani et al. 2007, 2009) and shared space (Parkin and Smithies 2012; Hammond and Musselwhite 2013; Havik et al. 2015; Brown and Norgate 2019).

Many countries have developed guidelines and standards for ensuring an accessible built and urban environment (Grangaard and Ginnerup 2013). From 2000 to 2017, a Danish workgroup worked on handbooks. In 2017, the third version:

'Circulation area for all – Universal Design and Accessibility' (CAfALL) (The Danish Road Directorate 2017) was published alongside a booklet of examples. The handbook is not a part of the legal framework but has guideline status.

The municipalities in Denmark are in charge of the urban space. Few of them address accessibility in their architectural policies, indicating that the municipalities do not regard accessibility as an aspect of the architectural ambitions (Grangaard 2018). Despite the focus on accessibility in the urban space, the administration of the appropriation varies from municipality to municipality, as do the results (Feldthaus 2019). Feldthaus (2019) describes two examples: 1) A very ambitious but ultimately bad example, where comprehensive mapping of accessibility problems ended up in extensive action plans that were never implemented. 2) A much smaller and cheaper but ultimately successful project where sketches of how to solve accessibility problems were shown on photos, the project was completed, and the level of accessibility was raised. Feldthaus (2019) argues that it is crucial for clients to consider how accessibility can be increased as much as possible for a certain amount of money. At the end of the day, blind and visually impaired pedestrians cannot benefit from reports or audits that have not been effectuated.

In situations where it is not possible for municipalities to comply 100% with the CAfALL handbook, e.g., due to financial resources or physical constraints, it would be desirable to prepare the municipalities and the different professionals involved for a qualified prioritization to select a design that includes the elements having the greatest impact on mobility.

In this paper, the aim is to contribute to the body of knowledge and understanding about the importance of specific physical elements in the urban space in terms of BVIP's navigation, and thereby provide a prioritization tool for municipalities.

The paper is based on a survey of all Danish Orientation and Mobility instructors (O&M instructors) (Bredmose and Hansen 2020). They are employed at the Danish municipal communication centres, care homes for BVIPs, and Institute for the Blind and Partially Sighted, all training BVIPs in mobility.

Most previous studies about physical design elements and their functionality in urban spaces have involved a group of blind or visually impaired people testing the elements, with around 10 to 50 participants (e.g., Barlow, Bentzen, and Bond 2005; Williams et al. 2005; Tekeda et al. 2006; Scott et al. 2008; Childs et al. 2009; Stahl et al. 2010; Scott et al. 2011; Parkin and Smithies 2012; Ginnerup and Bredmose 2013; Hammond and Musselwhite 2013; Havik et al. 2015; Bentzen et al. 2017; Brown and Norgate 2019). Adding to these studies, this present study takes a different and quantitative approach involving the perspectives of BVIPs. These people are not involved by themselves. However, in order to build this study on as many experiences of BVIPs as possible, O&M instructors were chosen to represent the BVIPs because they, if any, have extensive professional expertise based on experiences from training and interacting with thousands of BVIPs.

A survey of 1,123 O&M instructors and members of The Association for Education and Rehabilitation of the BVIP was completed by Bentzen, Barlow, and Franck (2000). However, it was based on yes/no questions concerning four categories of difficulty for BVIPs at signalized intersections. The survey in this study is different from and adds to previous studies by inviting all Danish O&M instructors to rank the 34 physical elements (e.g., tactile attention patterns and audible beacons) from CAfALL as clues to encounter in the pedestrian environment to support BVIP's orientation in a vision-oriented urban space.

The paper is organized with an introduction about the BVIP and the way the urban space is perceived by the blind or visually impaired. This is followed by a description of the method and data. Finally, the paper discusses what kind of knowledge can support the municipalities, landscape architects and planners designing urban spaces when it comes to meeting the functional requirements of BVIPs.

Blindness and visual impairment

In Denmark, there is no register of people with disabilities, and the number of blind or visually impaired citizens is therefore unknown (Danish Association of the Blind 2020). However, a recent study estimated the number to be approx. 50,000 people, of whom 25,000 are moderately visually impaired and 25,000 are severely visually impaired or blind (Bredmose and Hansen 2020). The classification of vision categories varies slightly (WHO 2016; Danish Association of the Blind 2020; Institute for the Blind and Partially Sighted (IBOS) 2020; Amilon et al. 2017), and this study uses the following definitions to classify sight loss:

- Complete blindness (no light perception or light perception without projection).
- Practical blindness (better than light perception with projection up to and including visus 1/60[1] or vision field of max. 10 degrees).[2]
- Severe visual impairment (better than visus 1/60 up to and including visus 6/60, or vision field of 10–20 degrees).
- Moderate visual impairment (better than visus 6/60 up to and including visus 6/18, or vision field defects).

Perceptual sight function

For a better understanding of the challenges faced by BVIP and to substantiate why it is so difficult for BVIPs to orient themselves and walk around the streets, this section describes perceptual sight function and how BVIP compensate using other senses and learning mobility.

Sight function can be divided in two parts:

(1) The physical and sensory aspect where the eye perceives light and sends signals via the optic nerve to the brain.
(2) The perceptual sight function where the brain forms pictures from the sensory perception.

The first part is not relevant to this paper, but the second is important for understanding how – and especially how fast or slow – other senses such as hearing and touch can take over in informing about the surroundings when visual information is lacking, or there is very little residual vision left.

Sight is an analogue sense, meaning that it is possible to observe much information at a time, for example surface, size, shape and orientation in space (Mortensen 2007). In contrast, tactile and auditory senses are sequential senses, meaning that it is only possible to detect one bit of information at a time and therefore information received from these senses is perceived more slowly than the visual information (Mortensen 2007). As a consequence, these perceptions are less efficient (Swobodzinski and Martin 2009; Jacobsen 1998).

In contrast to visual perception, tactile perception is a very complicated process that involves considerable elements of the sensory system and a large number of different areas of the brain (Mortensen 2007). Sighted people are therefore able to change their direction to avoid e.g., danger much faster than blind people as sight very quickly shows changes in the expected surroundings.

The brain saves all sensory perceptions as memories, and interpretations therefore largely depend on our expectations of the surroundings, gleaned from both visual and tactile information. When we walk around the streets, we save route information by forming a cognitive map in the brain, then when we next walk that route, we have expectations about what we will encounter based on the saved information (Stadheim and Nersveen 2016; Jacobsen 1998).

Furthermore, the notion of time is related to our movements. Memorizing the amount of time that passes between encountering clues on a route is important in estimating distances and orienting oneself when visual information is missing. BVIPs seem to concentrate on this ability more intensively than sighted people (Dischinger 2000).

How do visually impaired people orient themselves?

Studies have showed the embodied experiences of BVIPs (e.g., Worth 2013) or other disabilities (e.g., Butler and Bowlby 1997) in urban space. However, this study focuses on the effect of, and BVIPs need for, specific physical elements that enable orientation in urban space. People will always orient themselves as easily as possible. If a sense is missing, the person will compensate using the other senses more actively. Sighted adults will orient themselves from an overview that forms a picture of their surroundings and then they will focus on details to plan a route (Golledge 1993; Nesse and Rystad 2015). BVIP must use the opposite strategy (Nesse and Rystad 2015), searching for expected details like clues or landmarks saved in their mental map and bit by bit, they can form a picture of the surroundings (Chandler and Worsfold 2013; Mortensen 2007). Blind people will save tactile clues, e.g., a kerb or an attention pattern as well as audible clues such as echoes. Visually impaired people with some residual vision will save clear visible landmarks, e.g., a very bright wall or a brightly illuminated shop window. People with practical blindness and severe visual impairment will save a combination of tactile and clear visible elements in their cognitive map.

Mobility

Training blind and visually impaired people in mobility is done by O&M instructors with the basic techniques of using the long white cane and special routes. When training for a route, the O&M instructor will first walk the route alone, mapping clues such as physical elements that can be used for orientation depending on the ability of the BVIP (Deichmann 2016), e.g., audible beacons, attention and guidance patterns, scents or sounds. Together with the O&M instructor, the BVIP learns the route step by step, walking a longer distance together each time until the whole route is memorized (Deichmann 2016; Jeffries, Gilroy, and Townshend 2018). It appears that orientation and walking around streets when blind or visually impaired requires increased cognitive power as it demands a high level of concentration (Norgate 2012; Lid and Solvang 2016; Jacobsen 1998; Dischinger 2000).

As described above, BVIPs memorize not only the sequence of clues along a route but also a notion of the time between the clues. The memory of the rhythm and duration in time while walking a familiar route can help to estimate when you will encounter the next clue. For this reason, obstacles along the route disturb the BVIP's orientation due to a diversion from the intended direction as well as an interruption to the rhythm of movement (Dischinger 2000).

Therefore, it is of great importance that the environment is designed with predictability and order in mind (Danish Association of the Blind 2015; Stadheim and Nersveen 2016; Royal National Institute of blind people 2015). Elements such as signs, cycles and scaffolding placed on the pavement can easily obstruct the rhythm of walking and orientation for people who are blind or visually impaired (Danish Association of the Blind 2015; Chandler and Worsfold 2013; Dischinger 2000).

Method

The investigation is based on a questionnaire of all Danish O&M instructors training BVIPs (over 16 years old) in mobility. During training, the O&M instructors observe the BVIP daily and therefore have extensive experience and knowledge of which difficulties the BVIP encounter in the pedestrian environment.

It therefore serves as a method to obtain professional and well-founded evaluations based on a high number of BVIPs.

Another advantage is that the O&M instructors in Denmark form a full population and it was therefore not necessary to draw a sample. Instead, the whole population is treated as the sample.

Names of 86 O&M instructors were collected by contacting all the Danish centres of communication and/or vision.

However, 19 of the names were not in the target group, resulting in a total of 67 O&M instructors, 59 of whom replied to the questionnaire. This resulted in a response rate of 88.1%.

Five experienced O&M instructors were selected to test a draft of the questionnaire and participate in a focus group meeting. Furthermore, The Danish Association of the Blind contributed to the questionnaire with their comments.

Using CAfALL, 34 physical elements were mapped, e.g., tactile walking surface indicators (TWSIs), audible beacons and colour contrast lines on the front edge of steps, which support an accessible and safe pedestrian environment for BVIPs. The survey was organized by nine different themes that each contained several element questions.

The O&M instructors were asked to estimate the importance of these elements on a scale of 1 to 5, where 1 reflected 'Somewhat important' and 5 reflected 'Very important' as no elements were expected to be thought of as 'not important'. It was also possible to answer 'No experience'. The importance of the elements were estimated for each of the following four categories:

(1) complete blindness,
(2) practical blindness,
(3) severe visual impairment,
(4) moderate visual impairment (see Table 1)

The specific physical elements were illustrated in order to increase comprehensibility. For an example, see Figure 1.

Table 1. Example of an element question.

	1 Somewhat important	2	3	4	5 Very important	No experience
Complete blindness						
Practical blindness						
Severe visual impairment						
Moderate visual impairment						

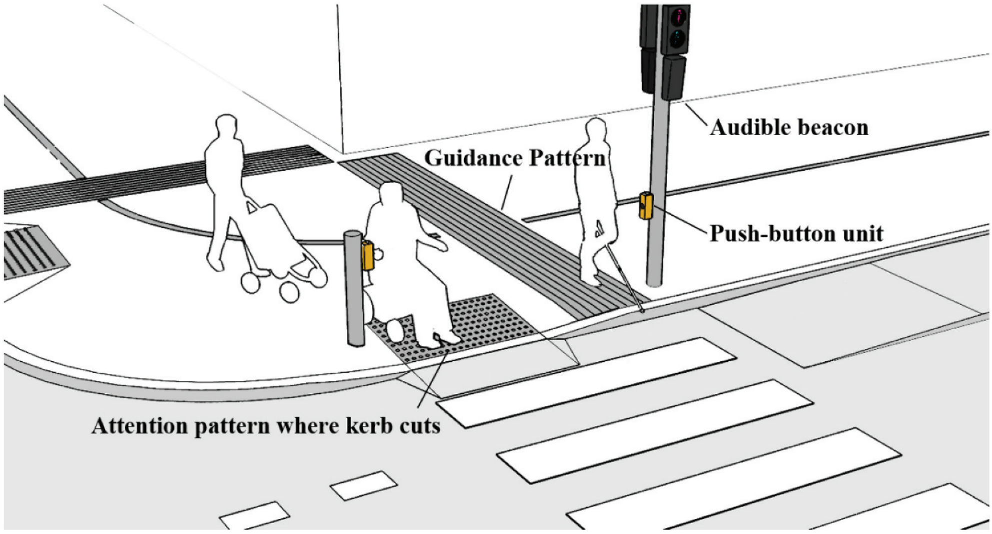

Figure 1. Sketch of a signal controlled crossing (Ginnerup 2021).

Example of an element question

In general, how important do you find audible beacons in signal-controlled crossings, in terms of your trainees in the following vision categories being able to orient themselves?

Questions covered an estimation of the average number of trainees each year, distribution of the trainees in terms of vision category and further disabilities in addition to blindness or vision impairment. It was possible to write several comments in the questionnaire. The questionnaire survey was sent out using the SurveyXact tool in August 2019 and the replies were received throughout September and October 2019.

Statistical methods for analysing the results

A scale based on a mean (1–5) was preferred over a summative scale, thereby enabling comparison across groups and elements and facilitating interpretations. The scale was therefore calculated by summing the assessments and dividing by the number of assessments for each question, which varied from question to question.

The questionnaire response variables were in principle ordinal scales, which means that they followed an order but without an equal difference between the categories. However, in this study, they were treated as a continuous scale for three reasons: 1) the questionnaire clearly stated that the respondents should consider the distance between the response options as equal, 2) it was assessed that five outcomes were sufficient to calculate average values and 3) only the highest and lowest response options were given a description, whereas the options in between followed a (continuous) numeric order.

Comparing means

To investigate the data further, correlation analysis (based on Pearson's r) was used to help identify interesting differences across groups and elements. The groups reflected differences in O&M instructors' teaching experience of citizens with and without further disabilities.

The correlation analysis was only used for guidance. An actual correlation analysis would have been challenging as such an analysis assumes a normal distribution, a criterion that could only just have been met. For these reasons, the initial analysis has not been reported. Instead, means of assessed importance were compared across groups, and the comparison was tested using a two-sided unpaired t-test. The limit for rejecting two means as similar was calculated with at least 90% certainty (in most cases, the significance level was 95% or higher). Only cases with significant differences identified using a t-test were included in the analysis.

Results

This part of the paper presents the main results pertaining to the O&M instructors' assessment of the importance of the 34 physical elements in urban spaces (see Table 2). The initial aim of ranking the importance of the elements as a tool for municipalities could not be fulfilled because:

- On average, the importance of all 34 physical elements was assessed as being very high (4.0) across the four categories of visual impairment.
- 15 elements were assigned an average importance of between 4.8 and 5.0 (as shown in the light grey boxes in Table 2).
- No element was assigned a score lower than 4.3 for the vision category, where the element was needed most as an aid for orientating in the pedestrian environment (as shown in the dark grey box in Table 2).

Blindness and tactility versus visual impairment and visibility

The estimated importance of tactile elements was highest for the categories of blindness e.g., tactile delineation of walkways, while the importance of visual elements was highest for the categories of visual impairment. For example, 'Scaffolding marked with a contrasting colour' had a very high difference between the score for complete blindness (1.0) and moderate visual impairment (4.8). Thus, calculating the average assessment score across the four categories (4.0) is therefore meaningless and is only used to indicate the very high score of the physical elements.

All nine themes included one or more of the most important physical elements (4.8 to 5.0 as shown in the light grey boxes in Table 2). It is noteworthy that 13 of the elements were assessed to be most important for the categories of complete blindness and practical blindness. These were characterized by being tactile or detectable using a cane.

Table 2. Average assessed importance of elements using a scale of 1–5, where 1 reflects 'somewhat important' and 5 reflects 'very important'.

Physical Element	Complete blindness	Practical blindness	Severe visual impairment	Moderate visual impairment	*N (median)*	*N (interval)*
Pedestrian Areas						
Tactile delineation of walkways	*5.0*	*4.8*	*3.9*	*2.7*	*54*	*53–56*
Visual delineation of walkways	*1.4*	*2.1*	*4.4*	*4.5*	*56*	*54–56*
Clear walkway without obstacles	*4.3*	*4.4*	*4.1*	*3.5*	*55*	*54–55*
Smooth pavement in the pedestrian area.	*4.5*	*4.5*	*4.4*	*3.8*	*55*	*53–56*
Clearance under signage and trees	*4.7*	*4.7*	*4.4*	*4.0*	*54*	*53–55*
Paths						
Tactile delineation between walkway and cycle lane	*4.9*	*4.9*	*4.3*	*3.4*	*51*	*50–52*
Visual delineation between walkway and cycle lane	*1.7*	*2.6*	*4.5*	*4.7*	*53*	*52–54*
Shared Spaces						
Tactile delineation between safe space (only for pedestrians) and shared space	**4.8**	**4.9**	4.3	3.5	*46*	*45–46*
Visual delineation between safe space and shared space	1.8	2.6	4.4	4.5	*44*	*44–45*
Tactile walking surface indicators (TWSI)						
Guidance patterns through open pedestrian areas	**4.9**	**4.8**	4.3	3.3	*52*	*50–53*
Tactility of TWSIs	**4.9**	**4.9**	4.2	2.9	*54*	*52–56*
Visibility of TWSIs	1.1	2.3	4.7	4.5	*55*	*53–56*
Attention patterns at bus stops	**4.8**	**4.8**	4.1	3.2	*49*	*49–50*
Guidance patterns across the pavement at bus stops	4.6	4.5	3.6	2.7	*43*	*42–45*
Signal controlled intersections						
Attention patterns where the kerb cuts	4.6	4.6	4.1	3.1	*47*	*46–48*
Guidance patterns across the pavement leading to crossings	4.7	4.6	3.8	2.7	*47*	*45–47*
Kerbs at refuge islands	**4.7**	**4.8**	4.1	3.2	*50*	*48–51*
Attention patterns on refuge islands where kerb cuts	4.5	4.5	3.8	3.0	*47*	*45–49*
Guidance patterns on refuge islands	4.4	4.4	3.5	2.6	*40*	*39–41*
Audible beacons in signal controlled crossings	**5.0**	**5.0**	4.7	4.1	*52*	*52–54*
Uncontrolled pedestrian crossings						
Attention patterns where the kerb cuts at the crossing	**4.3**	4.3	3.7	2.4	*46*	*46–47*
Roundabouts						
Attention patterns where the kerb cuts at roundabouts	**4.8**	**4.8**	4.1	3.0	*23*	*21–26*
Guidance patterns across the pavement at roundabouts	**4.8**	**4.8**	4.1	2.9	*22*	*19–25*
Kerbs at refuge islands at roundabouts	**4.8**	**4.8**	4.2	3.0	*24*	*23–25*
Attention patterns where the kerb cuts on refuge islands at roundabouts	4.4	4.3	4.0	2.8	*22*	*20–23*
Guidance patterns on refuge islands at roundabouts	4.7	4.5	3.9	2.7	*20*	*18–22*
Stairs and Lighting						
Attention patterns at the top of stairs	4.6	4.6	4.3	3.6	*52*	*50–53*
Visually contrasting line on the front edge of each step	1.3	2.7	**4.8**	**4.7**	*55*	*53–56*
Handrails on stairs	4.5	4.5	4.5	4.3	*52*	*50–53*
Directional lighting on the pavement	1.2	3.4	4.7	4.4	*52*	*50–53*
Guards and Roadblocks						
Guarding detectable with a cane at the underside of stairs	**4.8**	**4.8**	4.2	3.7	*45*	*44–46*

(*Continued*)

Table 2. (Continued).

Physical Element	Complete blindness	Practical blindness	Severe visual impairment	Moderate visual impairment	*N (median)*	*N (interval)*
Guarding detectable with a cane at path barriers	4.7	4.7	4.1	3.1	*43*	*42–45*
Guarding detectable with a cane at roadblocks	**5.0**	**5.0**	4.7	3.9	*49*	*47–51*
Scaffolding marked with a contrasting colour	1.0	2.7	**4.9**	**4.8**	*45*	*42–47*

The order and themes follow the road rules in CAfALL. The number of observations (N, max. 59) varies across the individual elements for each visual category as the O&M instructors had the opportunity to answer 'No experience'.
N (median): The middle value of number of observations
N (interval): The highest and lowest number of observations.

A comment from the O&M instructors was e.g., that guidance pattern through a square is very important. If the tactility is missing, it is often necessary to train another and longer route. Only 2 ('Visually contrasting line on the front edge of each step' and 'Scaffolding marked with a contrasting colour') of the 15 elements with such a high score were visible elements with colour contrast to support the categories of severe visual impairment and moderate visual impairment. However, as described earlier, these two categories form the majority, and elements with a score lower than 4.8 are therefore also very important. As the O&M instructor commented, good colour contrast (e.g., visual delineation of walkways, walkway and cycle lane and between safe space and shared space) is of great importance for the severe and moderate visually impaired people.

Audible beacons and guarding detectable with a cane, positioned 10–20 cm above the terrain on roadblocks and with the purpose of 'catching' the long white cane and thereby forewarning of the hazard were assigned the highest importance (read safety) of 5.0 for the two categories completely blind and practically blind. Another theme the O&M instructors commented on was the design and the pacing, e.g., guiding patterns ending blind or too many of them confusing the wayfinding. Moreover, a problem addressed was the work of the pacer turning some tiles in wrong direction maybe due to lack of knowledge.

Increased importance for people with further disabilities

A further data analysis identified that some tactile elements were assessed as being even more important for people with further disabilities such as reduced hearing and physical or cognitive disabilities.

This is not without consequences, as this group form approximately 50–60% of the people being trained in mobility in this study. There was a significant difference with a score higher than 4.7 with regards to pedestrian areas, e.g., tactile delineation of walkways and shared space vs safe space, attention and guidance patterns on refuge islands, as well as guidance patterns across the pavement at bus stops and roundabouts.

Discussion

The analysis showed that the physical elements were generally assessed as being very important, but with wide variation among the vision groups. It suggests that the research, the preliminary work, and the revisions for CAfALL has been of high quality. The tactile elements were assessed as being very important for the two groups of blind people. This finding is substantiated by other studies involving BVIPs in test of different elements (e.g., Barlow, Bentzen, and Bond 2005; Williams et al. 2005; Tekeda et al. 2006; Scott et al. 2008; Childs et al. 2009; Stahl et al. 2010; Scott et al. 2011; Parkin and Smithies 2012; Ginnerup and Bredmose 2013; Hammond and Musselwhite 2013; Havik et al. 2015; Bentzen et al. 2017; Brown and Norgate 2019). Conversely, the visible contrast elements were assessed rather high with regard to orientation in the urban environment for the two groups of visually impaired people, who form the majority of the BVIPs.

The results indicate that the details in the description of how BVIPs orient themselves and search for expected details like clues or landmarks (physical elements) are very important in guiding the BVIPs around the urban space.

Even though other senses such as hearing and touch can take over in terms of informing about the surroundings when visual information is missing, perception from these senses is much slower and requires increased cognitive power as it demands a high level of concentration (Norgate 2012; Lid and Solvang 2016; Jacobsen 1998; Mortensen 2007). Therefore, it is also understandable that some physical elements were assigned even higher importance for people with another disability in addition to the blindness or visual impairment. BVIPs not hearing the traffic, are more dependent on tactile delineation between shared space and safe space, whereas BVIPs with walking impairement do not have time to cross all lanes of the intersection and are therefore dependent on the attention pattern of the refuge island. Furthermore, BVIPs with cognitive disabilities have an even greater need for tactile elements as both their sensory and cognitive abilities are reduced. All this variation in human ability suggests a design approach that acknowledge diversity and meet the different user needs. The intention of universal design is precisely to design for human diversity (Steinfeld and Maisel 2012). Looking at the eight goals of universal design especially goal three 'awareness' and four 'understanding' address issues related to reduced sensory and cognitive abilities.

How to plan urban spaces

Planning and designing walkable urban spaces for BVIPs is a great challenge. Regulations and standards play a constitutive role in the design of urban spaces (Imrie and Street 2009). One way forward is to comply with guidelines and standards prescribing how things ought to be designed. Danish Association of the Blind (2015) recommends the ISO Standard 23,599 'Assistive products for blind and vision-impaired persons – Tactile walking surface indicators' (Danish Standards/ISO 2019). Alternatives include the design developed by (The Danish National Railway Company 2018) called Intactila. Although designing to comply with standards may seem straightforward, there are several pitfalls. In the present study, the O&M instructors commented that some tactile guidance and attention patterns were unfortunately not laid out according to CAfALL, and therefore they risk confusing the BVIPs who expect something else. This problem is also highlighted in previous studies (Feldthaus 2019; Surico 2020). There can be an expectation among designers that the standards will automatically lead to accessible streets. However, following the standards without further thought can create problems that designers are not even aware exist (Surico 2020). Designing spaces with an unusual context and geometry can be a particular challenge. Unfortunately, the standards give only one solution and no option to adjust to deviating situations (Surico 2020). The main issue is that the standards themselves do not give an understanding of the user requirements with which they should comply – an understanding that is needed as background knowledge in order to make the standard a good and functional solution. Therefore, it is important to inform all involved parties (from architects to builders) about the background of the functional requirements of BVIPs to help them understand the function of the design. For example, if the paver is not informed, there is a risk they will continue working as usual (Feldthaus 2019).

Furthermore, (Jeffries, Gilroy, and Townshend 2018) argue that designing using checklists does not help in the understanding of a particular place or people, and that this way of designing can fail to capture what is important to consider in urban design and placemaking. There is a similar line of thought among Danish architects (Grangaard, Frandsen, and Ryhl 2016). Thus, the involvement of BVIPs in the design process of shared spaces has been proposed (Hammond and Musselwhite 2013). A good result would require exhaustive knowledge to understand the background of the functional requirements of BVIPs (Grangaard, Frandsen, and Ryhl 2016). However, professionals are keen to understand how BVIPs perceive space, but they do not know where to find this information (Grangaard 2021).

Therefore, to support good solutions, the prescriptive approach could be supplemented by an understanding of users and human diversity, together with a focus on compliance with user needs. Understanding how BVIPs orient themselves and how they use physical elements as clues for orientation within the urban space is paramount when designing using standards and working with innovative solutions (Dischinger 2000). Having universal design as a mindset is a good starting point. Goal six 'social integration' emphasizes that all groups should be treated with respect and dignity (Steinfeld and Maisel 2012). In relation to urban space, this means that everybody should be able to move around in urban space independently and thereby participate in society. However, there is a lack of knowledge, methods, and tools to support designers in identifying and including user needs in an inclusive design process (Mosca et al. 2019).

Future research

Architects and designers have an understanding of space that focuses on the visual qualities without being aware of the bodily experience in relation to all the senses. In contrast, blind people experience the space in a multisensory way (Heylighen and Herssens 2014; Dischinger 2000). Transforming a professional discipline is an extensive undertaking. However, it would be interesting to study how greater consciousness about the bodily experience of space can be ensured in a way that encompasses all the senses and different degrees of ability among professionals and in the curricula of education and training. This could be combined with communication about user needs.

It would then be possible to reduce the gap between the ability of the individual and the physical environment and to ensure that the universal values of the UN Sustainability Goal 'Leave no one behind' are upheld (The United Nations System Shared Framework for Action 2017).

Notes

1. The numerator refers to the distance at which a visually impaired person can see an object and the denominator refers to the distance a person with normal sight can see the same object.
2. Individuals with normal sight have a vision field of 180 degrees to the sides.

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