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Accessibility of shared space for visually impaired persons: A comparative field study

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Abstract

Shared Space is a concept that comprises the design and planning process of a public space. There are concerns about the accessibility of Shared Spaces for people who are visually impaired. In a comparative field study, the wayfinding performance of 25 visually impaired persons (VIPs) was observed while they carried out standardized tasks in two Shared-Space locations and two conventionally designed settings. The tasks were followed by interviews regarding the participants' experiences. In Shared-Space locations, more time was needed to complete routes and the blind participants in particular were less independent compared to conventional locations. The Shared-Space locations were evaluated more negatively than the conventional locations. The most salient problems encountered in Shared Space were related to orientation. The results clearly confirm how complex navigating a Shared Space can be for VIPs, albeit not to the same extent for all individuals and for all locations.

Keywords

Accessibility, mobility, orientation, shared space, visually impaired

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Introduction

For visually impaired persons, that is, those who are blind or have low vision (hereafter abbreviated as VIPs), the nature of the environment can be an essential factor in determining whether they can travel safely and independently. A recent development that particularly affects the layout of streets and public places in a way that might affect the independent mobility of VIPs is 'Shared Space'. Shared Space refers to a concept related to the planning, designing, and managing of public spaces (CROW, 2011). Its intention is to combine multiple purposes of public areas (Hamilton-Baillie, 2008a, 2008b) and to create environments that are meant not only for passing through but, in the first place, for being there. The particular layout aims to emphasize the 'place' function of the environment, rather than the 'traffic' function, and to make motorized traffic feel like guests. Importantly, it should stimulate all users to act responsibly: that is, behave cautiously, display social behaviour, interact with fellow users, and reduce speed. There are no fixed rules for the design of Shared-Space areas, and, as shown in an inventory of 10 Shared-Space areas in the Netherlands, the diversity of the environmental characteristics of Shared Spaces does not allow for an overall definition of the general appearance of a Shared-Space location (Havik, Melis-Dankers, Steyvers, & Kooijman, 2012). However, the implementation of the concept generally leads to public spaces with a reduced, or a lack of, conventional infrastructure of kerbs, pedestrian crossings, and traffic signals, in which slow and faster traffic are mixed and do not have separate lanes. The popularity of Shared Space continues to increase and it is currently being implemented in countries both in Europe and beyond (e.g. Auckland Transport, 2012; Department for Transport, 2011; Gesamtverband der Deutschen Versicherungswirtschaft [GDV] e.V., 2011; Gillies, 2009).

There are serious concerns, however, regarding the accessibility of Shared Space for visually impaired individuals. For example, the expected social behaviour in a Shared-Space environment depends mainly on visual skills, that is, eye-contact and thus on (near) normal sight. Furthermore, the reduction in environmental features and landmarks can seriously affect the orientation and navigation abilities of VIPs. Finally, the less predictable environment and less-structured traffic flow may cause VIPs to feel unsafe in a Shared-Space environment. These and other issues have been raised by several organizations representing the visually impaired (e.g. Allen-King, 2009; The Guide Dogs for the Blind Association [GDBA], 2014; VISION2020, 2010).

The amount of (scientific) literature available on the experiences of VIPs in Shared-Space environments is scarce. To date, only a few structured studies, particularly in the United Kingdom, have investigated the problems experienced by VIPs in a Shared-Space environment. Two of these studies were set up by the GDBA. In their first study, the GDBA briefly reported the comments of 11 VIPs who navigated part of the New Road in Brighton before and after the road was converted to a Shared-Space area. All of the participants found the situation worse after the change in terms of both orientation and safety (Thomas & Wood, 2007). In the second study, the association commissioned a telephone survey among 500 VIPs across the United Kingdom (TNS-BMRB, 2010). Of the respondents, 91% indicated that they were concerned about Shared-Space-like environments. However, only 61% had (some) experience with them (albeit it all with different environments) and 39% had no such experience at all. The British Department for Transport conducted a qualitative study with 20 VIPs, collecting data by means of interviews during and after accompanied walks in both Shared-Space and control streets (MVA Consultancy Ltd, 2011). Most of the VIPs found it difficult to determine their position in the Shared-Space street relative to other users and preferred a clearly defined separation between pavement and street. However, the authors emphasized the qualitative nature of the study and noted that comparability between the different types of streets was low.

The only structured study on Shared Space in the Netherlands comprised an inventory of the characteristics of 10 typical Shared-Space locations and the possible problems associated with them

with regard to the accessibility for VIPs as judged by a panel of orientation and mobility (O&M) experts (Havik et al., 2012). Although not based on real-life experiences of VIPs, the results of this study clearly showed that none of the locations were free of potential problems for this user group. Some important potential accessibility problems that came forward in this study were the absence of kerb edges or any other clearly recognizable (tactile and/or by sufficient brightness contrast) demarcations between road parts and recognizable demarcations of a walking route, the possibility of cyclists riding on the section used by pedestrians, and the absence of designated parking places. The authors noted that to further assess the experiential value of the identified accessibility problems, more research with visually impaired individuals in real-life situations is needed.

In summary, the few studies that have been carried out on this topic reported the opinions and subjective experiences of various groups of VIPs regarding different Shared-Space environments and the (possible) consequences that Shared Space may have for them. The results mainly concern negative or disadvantageous aspects of a Shared-Space design. However, altogether they do not provide an objectified list of accessibility problems for VIPs related to Shared-Space design. The shortcomings of these studies are the subjective nature of the results, the lack of standardization and scientific quality, the lack of comparability of locations, or the lack of real-life experiences.

Regarding the great attention that the topic currently receives from the field and the lack of solid research, we conclude that there is an urgent need for more and structured research on the experiences of representative groups of VIPs in real-life environments. The ultimate objective of this type of study should be to contribute to evidence-based guidelines or recommendations for the accessibility of Shared Space for VIPs.

This study concerns a standardized field experiment with the aim to assess systematically the experiences and wayfinding issues that are encountered in real life by a representative group of VIPs in various Shared-Space situations in comparison with conventionally designed areas.

Methods

Participants

In all, 25 VIPs (14 males and 11 females) participated in this study. The mean age was 51 years (range: 19–69 years, median: 58 years, interquartile range [IQR]: 16.5 years). Available clinical data on visual functions were used, and this was checked by assessment at a Royal Dutch Visio location: confrontative measurement of the peripheral visual field (STYCAR ball method with arch perimeter) and binocular visual acuity measurement with current prescription (ETDRS 2000 chart for visual acuity at 500 lux at 4 m). A total of 14 participants were classified as blind (World Health Organization [WHO], 2010 definition: Snellen visual acuity $<.05$ [20/400, logMAR 1.3] or a visual field radius $<10^\circ$ [20]), including six without light perception. The remaining 11 participants were classified as low vision (moderate or severe visual impairment, various disorders, Snellen visual acuity $<.33$ [20/60, logMAR .5]).

A total of 13 participants had a visual impairment with early onset. Of the 14 blind individuals, 4 used a guide dog in combination with a white cane; the other 10 only used a white cane. In the low-vision group, one participant used a guide dog and a white cane, five used a white cane, and five did not use any mobility aid.

Individuals were included if they (1) had no additional impairments, (2) had sufficient independent mobility in daily life, and (3) were unfamiliar with the test locations. Compliance with the inclusion criteria was assessed during a telephone interview. All participants had received O&M instruction in the past. At inclusion, they had sufficient independent mobility in their familiar environments and they had no mobility-related needs for rehabilitation.

Figure 1. Haren (HA), Shared Space.

Participants were not informed of the intentions of the study, only that there was interest in their O&M abilities and their ability to access different places. The participants did not know that they were visiting Shared-Space locations. In fact, the term Shared Space was never mentioned before or during the study.

Written informed consent was obtained from all participants, and the Ethical Issues Board of the Department of Psychology (University of Groningen, Groningen, The Netherlands) approved the study protocol. The study was consistent with the principles outlined in the Declaration of Helsinki.

Locations

All participants visited two Shared-Space locations (Haren [HA] and Muntendam [MU]; Figures 1 and 2) and two more traditionally designed or ‘conventional’ locations (Helpman [HE] and Zuidbroek [ZU], Figures 3 and 4), all in the province of Groningen, the Netherlands. Although all four communities are small-scale villages or suburban areas, HA and HE can be considered more urban than MU and ZU because of their numerous shops, bars, terraces, and public activities and because there is more traffic (see Table 1 for details about traffic density). HA and HE are located near one another along the same road and thus deal with approximately the same traffic stream; the same applies to the ‘rural’ locations MU and ZU. Before HA was transformed into a Shared-Space location in 2001, it was quite similar to HE: there were traffic lights and separate cyclist lanes between the street and the traditional pavement. MU and ZU also had a rather comparable streetscape before MU was transformed into a Shared-Space location in 2009. For information about the design and character of the test locations, the reader is referred to the Google street view option (coordinates are given in Appendix 1).

Routes

At each location, the participants were asked to complete six mobility assignments, that is, six short routes had to be walked. These assignments comprised three different trajectories that were walked in both directions. The mean length of the routes was 144 m (ranging from 135 to 162 m;

Figure 2. Helpman (HE), Conventional street design.

Figure 3. Muntendam (MU), Shared Space.

standard deviation [*SD*]: 8.4 m). Each route contained one crossing, one or two turns, and a section where the participant had to walk along the road (see Figure 5). The crossing was at the start, in the middle, or at the end of the route. Existing zebra crossings (at all locations except MU) and

Figure 4. Zuidbroek (ZU), Conventional street design.

Table 1. Mean numbers of motor vehicles and cyclists passing per hour during the actual field experiment.

Location name	Location type	Location character	Motor vehicles		Cyclists	
			Mean	SD	Mean	SD
Haren (HA)	Shared Space	Urban	465.5	110.1	330.8	119.5
Helpman (HE)	Conventional	Urban	749.0	169.3	400.6	175.2
Muntendam (MU)	Shared Space	Rural	433.6	103.2	102.5	54.1
Zuidbroek (ZU)	Conventional	Rural	478.3	122.5	70.08	42.9

SD: standard deviation.

The mean number of vehicles passing per minute was counted during the experiment by the observer directly after each of the six routes that a participant walked per location (see further sections). The mean of all counts per location was multiplied by 60 to get the average per hour, approximately corresponding to the average number of vehicles and cars passing during a participant's stay at a location (which lasted for about an hour.)

a crossing with traffic lights with an audible pedestrian signal (in HE) were used as one of the crossings; however, each location also had at least one route that had a crossing without any cue. All routes were carefully designed with consultation of O&M specialists.

Mobility assignments

Each participant was accompanied by a test leader and an observer from a pool of four MSc students at the Department of Psychology or of Movement Sciences (University of Groningen). The students had received instruction and training with regard to orientation and mobility of VIPs at the

Figure 5. Simplified map of the experimental routes. Grey bars represent the two opposite sides of the street. Participants walked six routes per location. After the first three routes were completed as represented in this figure, the participants walked Routes 1, 2, and 3 in the reversed direction.

Royal Dutch Visio. Pilot studies were done with two visually impaired volunteers to check the feasibility of the mobility assignments and to train the test leaders and observers.

After arriving at the test location, a general introduction was given in which the participants were asked to walk the routes as they normally would, not to chat with the test leaders while walking, and, if they needed help, to ask a passer-by for assistance. They were told that ‘during the assignments, we will observe how you behave in a random traffic situation’. The participants were assured that they could not make any mistakes, that they were allowed to refuse an assignment, and that they could quit the experiment at any moment. They were also told that in the case of a dangerous situation, the test leader would intervene.

A specific assignment was given for each route. For example,

You are on your way to the florist. You can find the florist if you cross here. After crossing, turn right. Walk about 110 meters along the road until you reach the florist, which you will recognize by its display. That is the end-point of this route. Remember, there is no right or wrong in this assignment. You can start now.

In case the participant was not able to recognize the endpoint of a route or a crossing (when this occurred halfway during the route), he or she was assisted by the test leader.

During the routes, the test leader walked 1–2 m behind the participant in order to intervene if necessary. This could be in case of possible danger or when the participant drifted away from the designated route and was unable to return on his or her own. Interventions by the test leader, however, were restricted to a minimum: the main purpose was to let the participant walk as naturally as possible, approaching the situation as if he or she were alone. For example, if a participant was walking in the middle of the street, the test leader would not intervene unless there was approaching traffic nearby.

Observations

The observer followed at more of a distance on the opposite side of the road and filled in a separate observation form for each route. This form included a schematic map of the test location upon which the exact route walked by the participant was drawn, for the purpose of later analysis. The observer noted the time needed for each part of the route (separately for walking along the road and

for crossing). Interventions by the test leader were also noted on the observation form and marked at the corresponding spot on the map.

Wayfinding performance was characterized by the percentage of preferred walking speed (PPWS) and the percentage of routes without interventions per location. To correct for individual differences in walking speed, preferred walking speed (PWS) was measured for each participant prior to one of the sessions. This was measured twice on a path with a length of 25 m that was obstacle-free, straight, and supplied with tactile paving. The mean velocity over these two measurements was used as the individual's PWS (overall mean PWS was 1.29 m/s; *SD*: 0.27 m/s). Participants used their regular mobility aids during both the PWS measurement and the mobility assignments. PPWS was only calculated for those parts of the route where the participant walked alongside the road. The velocity resulting from the walking time divided by the length of the pre-planned route (minus the length of the crossing) was calculated and expressed as a percentage of the individual's preferred walking speed. Since some participants deviated from the pre-planned route (e.g. because they walked into a side street) and thus walked a longer distance, the PPWS was used as an indication of wayfinding efficiency.

Subjective experiences

After each route, the participant's experiences of the route were assessed using questions about experienced level of safety and fear, both during crossing and during walking along the road. These questions were scored on a 5-point Likert scale. After completing all routes at a location, they estimated their level of independency at this location on a 5-point Likert scale and indicated whether they thought they 'could learn to walk a route at this location, feeling comfortable and secure'.

Procedure

Each participant carried out the assignments at each of the four locations. This within-subject design guaranteed reliable comparisons between individual performances and experiences at the different locations. The study was divided into two sessions which were held on two separate days: during one session, the participants visited HA and HE (the 'urban' locations) and during the other MU and ZU (the 'rural' locations). The order in which the four locations were visited was balanced between participants. The six mobility assignments took approximately 1 hr to complete at each location. There was always a break between the two location visits at one day.

Data analysis

Data on wayfinding performance. PPWS and the percentage of routes without intervention were averaged per participant over the completed routes for each location and were subjected to repeated-measures analyses of variance (ANOVAs) with the within-subject factors Location Type (Shared Space versus conventional) and Location Character (urban versus rural) and the between-subject factor Visual Impairment (blind group vs low-vision group).

The reasons why the test leader had to intervene were grouped into five categories: (1) participant walked on the middle of the street when there was approaching traffic, (2) participant walked into a side street, (3) participant drifted away from the intended route, (4) participant walked in the wrong direction after having crossed the street, and (5) participant wanted to cross at an unsafe moment.

Interview data. The responses to the questions regarding the experienced levels of anxiety and safety showed substantial correlations at all locations (Pearson's r ranging from .62 to .86, $p \leq .001$). Therefore, they were averaged into a combined variable expressing the level of 'Safety comfort' (1 expressing a low level of Safety comfort [feeling very unsafe and very anxious] and 5 expressing a high level of Safety comfort [feeling very safe and not at all anxious]). These scores were averaged for each participant over the number of completed routes per location. Both the Safety Comfort scores and the scores for the estimated level of independency were subjected to a repeated-measures ANOVA with the within-subject factors Location Type and Location Character, and the between-subject factor Visual Impairment. Only the significant interactions and main effects are reported in the 'Results' section.

Results

Missing data

Of the 600 routes (25 participants $\times$ 4 locations $\times$ 6 routes per location), the data of 52 routes are missing. Data on 42 of these 52 routes are missing because 10 participants did not complete the last one, two, or three routes at a location. This was often due to fatigue or lack of time (which was related to their slow performance on the previous routes) or due to weather conditions. Data from 10 routes are missing because three participants refused to cross at the indicated spot, for example, because there was no zebra crossing. The missing routes are equally distributed over the four locations, and over the Shared-Space locations (26) and the conventional locations (26), but not over the participant groups (41 routes were missed by the blind participants and 11 by the participants with low vision). In the case of missing routes, the means were calculated over the remaining routes.

Measures of wayfinding performance

The PPWS was consistently lower at the Shared-Space locations than at the conventional locations ($F(1, 23) = 79.64$; $p < .001$; respective means: 69.8% and 80.55% of preferred walking speed) and was lower for the blind group than for the low-vision group ($F(1, 23) = 44.07$; $p < .001$; respective means: 62.6% and 87.7% of preferred walking speed). There was also a main effect for Location Character, indicating a higher PPWS in the more urban locations with a higher traffic density than in the more rural quieter locations ($F(1, 23) = 4.50$; $p < .05$; respective means: 76.5% and 73.9% of preferred walking speed) (see Figure 6).

For each individual participant, the PPWS was lower at Shared-Space locations than at conventional locations. Inspection of the sizes of the individual mean differences in PPWS between conventional and Shared-Space locations showed that the largest individual differences were clearly found in the blind group, although nearly half of the blind participants showed differences in the same range as the low-vision group.

The blind group showed proportionally (with respect to the total number of completed routes per participant) fewer routes without interventions than the low-vision group ($F(1, 23) = 25.63$; $p = .01$; respective means: 75.2% and 97.4% of routes without interventions). While for both groups the number of routes without interventions did not substantially differ between the two relatively more urban locations (HA and HE), a large difference was found between MU and ZU for the blind group (47.7% and 85% of routes without interventions, respectively; interaction between Location Type, Location Character, and Visual Impairment: $F(1, 23) = 13.56$; $p < .05$) (see Figure 7).

Figure 6. PPWS averaged over the number of completed routes per participant per location. Error bars represent standard errors of the means.

Figure 7. Routes without interventions as a percentage of completed routes per participant, averaged per location. Error bars represent standard errors of the means.

In the low-vision group, nearly all participants walked all routes without interventions. Only two of them occasionally needed assistance (e.g. an intervention by the test leader) at the Shared-Space locations, and only one of them also needed assistance at a conventional location. If assistance was needed, this occurred only at one or two routes per location. Hardly ever it concerned more than one intervention per route.

In the blind group, none of the 14 participants walked all of the routes without interventions. Nearly all of them walked fewer routes without interventions at the Shared-Space locations than at the conventional locations (for two it was the other way around and for one there was no difference). When the blind participants needed assistance, this concerned about one to three interventions per route. In MU, however, two of the blind participants needed six or seven interventions on one route.

Table 2. Total number of interventions per location, sorted by reason for intervention.

Location	Shared Space		Conventional		Total
Group	HA	MU	HE	ZU	B/LV
	B/LV	B/LV	B/LV	B/LV	
<i>Reason for intervention</i>					
Walking on street	4/1	22/1	2/0	5/1	33/3
Walking into side street	5/0	28/0	3/0	2/0	38/0
Drifting away from intended route	3/0	9/0	0/0	0/0	12/0
Wrong direction after crossing	4/2	5/0	0/0	3/0	12/2
Wanting to cross at unsafe moment	6/1	1/1	11/0	2/0	20/2
Total	22/4	65/2	16/0	12/1	115/7

Locations – HA: Haren; MU: Muntendam; HE: Helpman; ZU: Zuidbroek. Groups – B: Blind group; LV: Low-vision group.

To get an impression of the relative difficulty subjects had between Shared-Space and conventional locations, we looked at the individual differences between the proportion of routes without interventions in Shared-Space and conventional locations.

Among the 25% of participants with the largest differences between the proportion of routes without interventions in Shared-Space and conventional locations were only blind participants. The largest differences were found among the four blind participants with a guide dog.

Reasons for interventions

The reasons why the test leader had to intervene are presented in Table 2. More than half of all interventions (67 out of total 122 interventions over all participants and all locations) occurred in MU. This was mainly because participants were walking on the street (without being aware of this) when traffic was approaching, leading to a potentially dangerous situation (23 interventions) or because participants walked into a side street, became disoriented, and were not able to return to the intended route without assistance (28 interventions).

In HA, the other Shared-Space location, interventions in the blind group were made exclusively on the trajectory that included a crossing that was similar to crossing a square, that is, without any tactile guidance or marks in the paving, in contrast to the other four routes with crossings that were more marked. These were the only routes in HA where participants drifted onto the street or into a side street. In the conventional HE, the location with the highest traffic density, most interventions took place when a participant wanted to cross at an unsafe moment. No interventions were needed in the low-vision group at this location.

Subjective experiences

On the question whether they thought they ‘could learn to walk a route at this location, feeling comfortable and secure’, the majority (92%) of the participants with low vision answered ‘yes’ at all locations. Also, 92% of the blind participants answered ‘yes’ at the conventional locations. However, at the Shared-Space locations fewer blind participants did expect themselves to be able to navigate independently (77% ‘yes’ in HA and 46% ‘yes’ in MU).

Results for the other questions about the participants’ experiences are presented in Table 3. Significant main effects of Visual impairment showed that the blind group gave significantly lower ratings than the low-vision group for the level of safety comfort when walking along the street ($F(1, 23)=4.58$; $p<.05$) and for the estimated level of independence ($F(1, 23)=12.36$; $p<.01$).

Table 3. Results from interviews.

Location		Blind group				Low-vision group			
		HA	HE	MU	ZU	HA	HE	MU	ZU
		S	C	S	C	S	C	S	C
Level of safety comfort when crossing the street	M	3.8	4.0	3.7	4.2	4.3	4.3	4.1	4.2
	SD	0.9	0.9	1.1	0.8	0.6	0.5	0.9	0.7
Level of safety comfort when walking along the road	M	4.1	4.4	3.9	4.3	4.7	4.8	4.4	4.8
	SD	0.7	0.6	1.1	0.8	0.4	0.2	0.6	0.4
Independence: 'to what extent do you think you can manage at this location?'	M	2.9	3.6	2.6	3.8	4.2	4.6	3.8	4.3
	SD	0.7	0.8	1.5	0.7	0.8	0.5	1.2	0.8

M = mean; *SD* = standard deviation; n.s. = not significant. Locations – HA: Haren; MU: Muntendam; HE: Helpman; ZU: Zuidbroek. Location type – S: Shared Space; C: Conventional.

Safety comfort indicates the level of experienced safety and fearlessness. Scores are rated on a scale of 1–5, where 1 indicates a very low level and 5 indicates a very high level of safety comfort or independence. Safety comfort scores are averaged over the six routes; for independence, only one score was given per location.

Significant main effects of Location Type, favouring the conventional locations above the Shared-Space locations, were found both for the level of Safety comfort when crossing and when walking along the street ($F(1, 23)=10.28$; $p<.01$ and $F(1, 23)=12.10$; $p<.05$, respectively) and for the estimated level of independence ($F(1, 23)=27.06$; $p<.001$). For the level of Safety comfort when crossing the street, it was found that the blind participants in particular rated the Shared-Space locations lower than the conventional locations (interaction between Location Type and Visual Impairment: $F(1, 23)=6.18$; $p<.05$).

Discussion

The goal of this study was to investigate, in a real-life situation, if and how a Shared-Space design influences the mobility performance of VIPs. Based on the literature and international experiences, it was expected that VIPs encounter more difficulties and feel less safe in Shared-Space areas than in conventionally designed situations. Although the population in this study was rather small, our results show clear differences between mobility behaviour of VIPs in conventional and Shared-Space locations and that some VIPs indeed have difficulty moving independently through Shared-Space environments.

The most salient result is that each individual participant showed lower walking speeds (PPWS) when walking the test routes in Shared Space than in conventionally designed areas. These lower walking speeds go together with more time needed to complete a route and indicate that our VIPs reached a lower level of walking efficiency in Shared-Space areas, suggesting more difficulty to move around. Whether that should be seen as an accessibility problem depends on the travel goals of the individual and is therefore rather subjective. In fact, one could say that in Shared Space all things tend to go slower, for each visitor, since it is meant to be a place to stay rather than to pass through quickly. We did not measure the walking speed of other (normally sighted) pedestrians, since at none of the test locations the density of other pedestrians was high enough to influence the participants' walking speed.

Interestingly, PPWS was found to be significantly higher at the more urban locations with a higher traffic density (HA and HE). Possible explanations for this effect are that busier surroundings allow VIPs to follow the traffic flow and that the extra orientation information that is provided by, for instance, the traffic sounds can give VIPs more confidence about their heading.

While one can discuss about whether needing more time to reach a destination is really an accessibility problem, not being able to reach this destination independently undoubtedly has negative consequences for the accessibility of an area. The decreased ability of blind participants to complete a route without assistance in the Shared-Space locations is therefore a very meaningful finding, clearly pointing out that Shared Space can decrease a VIP's independency. However, these results cannot be generalized to all visually impaired people visiting a Shared Space, since the decreased independence was not found to the same extent for all participants and was only found in one of the two Shared-Space locations studied.

Independence was only affected for the blind participants and not for the participants with low vision. The results of this study therefore do not imply a serious accessibility threat for the latter group. Within the blind group, however, it appeared to be in particular those using a guide dog who encountered most difficulties in the Shared-Space design: these were the participants showing the largest differences in independence (percentage of routes without interventions) between Shared-Space locations and conventional locations. However, the number of guide-dog users in this study was too low ($n=5$) to conduct statistical analyses. From our observations in the Shared-Space locations (in particular in MU), we got the impression that, in the absence of the regular cues such as kerbs (which guide dogs are trained to use), both the dogs and their owners became confused. Dogs veered over the street and their owners were unable to correct them because they could not detect where exactly they were walking.

By far, most of the interventions took place in the Shared-Space area in MU, while the Shared-Space area in HA turned out to be less complicated to navigate independently. Interestingly, the only part of HA where the VIPs needed assistance was the most Shared-Space-like area: a square-like part of the road, without any differences in paving or other demarcation between the street and the pedestrian area. This part of HA is, in that sense, also more similar to the Shared Space in MU. In comparison, the more conventional part of HA appears to offer more structure to the pedestrians and did not reduce the independent mobility of our VIPs. We conclude that it is the implementation of the Shared-Space concept, with a lack of detectable structure and the open space of the area that caused problems with orientation and navigation.

The reasons why the test leaders had to intervene during the mobility assignments were mainly related to orientation problems (i.e. difficulties determining one's place on the road, to maintain heading, and detecting side streets). Since by far most of the interventions took place in Shared-Space locations, this confirms our hypothesis that the Shared-Space design can lead to orientation problems due to lack of conventional infrastructure as well as the findings of the GDBA (TNS-BMRB, 2010) that Shared Space affects the independence and mobility of VIPs.

Based on the subjective experiences of the VIPs, the Shared-Space locations were evaluated more negatively than the conventional sites. However, the subjective safety was higher than expected. Although the conventional locations were rated higher than the Shared-Space locations, the Safety comfort scores at both location types were at the high end of the scale, indicating that participants did not feel very anxious or unsafe at any of the locations. Our findings thus do not confirm the Shared-Space-related safety concerns found in the GDBA study (TNS-BMRB, 2010). However, the findings may have been influenced by the presence of the test leader who intervened in cases of potential danger, possibly causing an overrating of subjective safety.

Objective safety was not assessed in this study: in potentially dangerous situations where a participant was walking on the street when there was approaching traffic nearby, the test leader obviously had to intervene. Although theoretically in Shared Space it should be safe to walk in the middle of the street, we do not know what would have happened without intervening. It is important at this point to stress the fact that in these situations the blind participants were *not aware* that they were walking on the street. Although Shared-Space design does not necessarily require smooth pavement gradients, these are often implemented. Without detectable tactile demarcation between

the pavement and the street, blind pedestrians unlike normally sighted pedestrians cannot make a voluntary decision to leave the pavement and walk on the street. The absence of detectable demarcation in many Shared Spaces can therefore lead to the highly undesirable situation of blind pedestrians walking in the middle of the street without knowing it and possibly without being able to react adequately to approaching vehicles. These situations occurred 28 times in the Shared-Space locations (vs eight times in the conventional locations), representing nearly 25% of all interventions. This number of potentially dangerous situations is considerable and represents a major concern for the accessibility of Shared Spaces. There are not yet sufficient accident and incident data available from the communities in question to reach a conclusion about general objective safety.

We can conclude that there is a need for clear guidelines on how to prevent the identified issues from occurring in newly designed Shared Spaces (and how to improve existing Shared-Space schemes). In order to assist policy makers, designers and architects in developing accessible Shared-Space areas, we developed a Shared-Space Guide. This guide is freely accessible through the internet (www.visio.org or <http://www.eccolo.nl/shared-space>). It provides practical information with respect to designing Shared-Space areas that are also accessible by people with a visual impairment. Furthermore, it contains a checklist of important issues during the design process. In addition, O&M instructors and guide-dog trainers should be made aware of the problems associated with Shared Space and think about how they can adjust their training to the specific circumstances.

Conclusion

This study has shown that navigating in an unfamiliar Shared-Space area is more complicated for VIPs than navigating in an unfamiliar, conventionally designed area. This is especially true for those who are blind and for those using a guide dog. Following the results of this study, orientation seems to be the main problem for VIPs in Shared-Space areas. Although subjective safety in Shared-Space areas is an important issue that deserves attention, in this study it did not come forward as a major problem. However, potentially dangerous situations of people walking in the middle of the street without being aware of this frequently occurred. These situations are undesirable and should be avoided by implementing adequate street design tailored to the needs of VIPs.

Other important findings are that there were also participants who managed well at both location types and that not all Shared-Space locations are equally difficult to navigate independently. In other words, it seems possible to create Shared-Space areas that are accessible for people who are visually impaired. Since Shared-Space areas can be highly complicated to navigate and also potentially dangerous for some VIPs, we have developed a Shared-Space Guide to improve the Shared-Space design for a better accessibility for this group.

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Appendix I

GPS coordinates of test locations

Use Google Street View to see the test locations. The following coordinates can be entered into the search bar.

Haren: Rijksweg: 53.172399,6.604435 to 53.171177,6.60568.

Helpman: Verlengde Hereweg: 53.197999,6.580017 to 53.196804,6.580907.

Muntendam: Kerkstraat: 53.135003,6.871111 to 53.134372,6.872715.

Zuidbroek: Kerkstraat: 53.162542,6.86277 to 53.163745,6.862641.