CAN SHARED SURFACES BE SAFELY NEGOTIATED BY BLIND AND PARTIALLY SIGHTED PEOPLE?

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SUMMARY

Some Shared Space Schemes incorporate level surfaces; with the removal of the traditional vertical kerb upstand between the footway (pedestrian space) and carriageway (vehicle space). Level surfaces make it more difficult for blind and partially sighted people to navigate safely, and they cannot use eye contact with drivers to navigate in a trafficked area, hence the suggestion of retaining a 'Safe Space' within the 'Shared Space'. Delineation of this 'Safe Space' from the space shared with vehicles requires a surface that is detectable by blind and partially sighted people, whilst not being an obstacle for other pedestrians. This work presents laboratory experiments that were designed to determine the detectability by blind and partially sighted participants of a number of potential surfaces and the ability of participants with mobility impairments to pass over these surfaces. The results show the difficulty of finding a surface that is suitable for both detection and ease of passing over, but indicate some possibilities worth further research.

Keywords: tactile; surface; detectability

PURPOSE OF THE STUDY

‘Shared Space’ schemes are designed to reduce the distinction between pedestrian space and traffic space in the street environment to encourage more pedestrians to use the area. Some shared space schemes have a level shared surface. Level surfaces may make it easier for people with wheelchairs, prams or similar to negotiate the space, (though these groups may not be comfortable sharing a space with vehicles). However, by removing the kerbs, blind and partially sighted people lose one of the key references that they normally use to know they are in a ‘safe space’ away from vehicles and to navigate around the area. The Guide Dogs for the Blind Association recommends that a clearly delineated ‘safe space’ equivalent to a footway [Nyvig et al. 2006] is required for vulnerable pedestrians in ‘shared space’ schemes. Without this clear delineation some pedestrians have described feeling more anxious in these level areas than they do in areas where the delineation is clear. So much so that some people, especially those who are blind or partially sighted, have reported avoiding such spaces altogether [TNS-BMRB 2010]. One question that arises from this is: what can be used to delineate between an area where vehicles are not expected and one where they are free to travel through: a delineator that is both clearly detectable, yet not a barrier to pedestrians? What is required of such a surface? Such a delineator could include a vertical step height, a sloped element, or have the same level of surface either side of the delineator.

MATERIALS AND METHODS

The experiments were all performed at the Pedestrian Accessibility and Mobility Environment Laboratory (PAMELA) [Childs et al. 2007]. This facility was arranged with an $80m^2$ test surface laid out as a simulated street environment including different surfaces. With an available area of $80m^2$ five layouts were required to include all the test surfaces. The basic action required in these experiments was to pass over a number of surfaces as if travelling through a normal street environment. This study was approved by UCL Ethics Committee (0410/005 – funded by Transport for London and 0410/006 – funded by Guide Dogs for the Blind Association). .

1.Layout

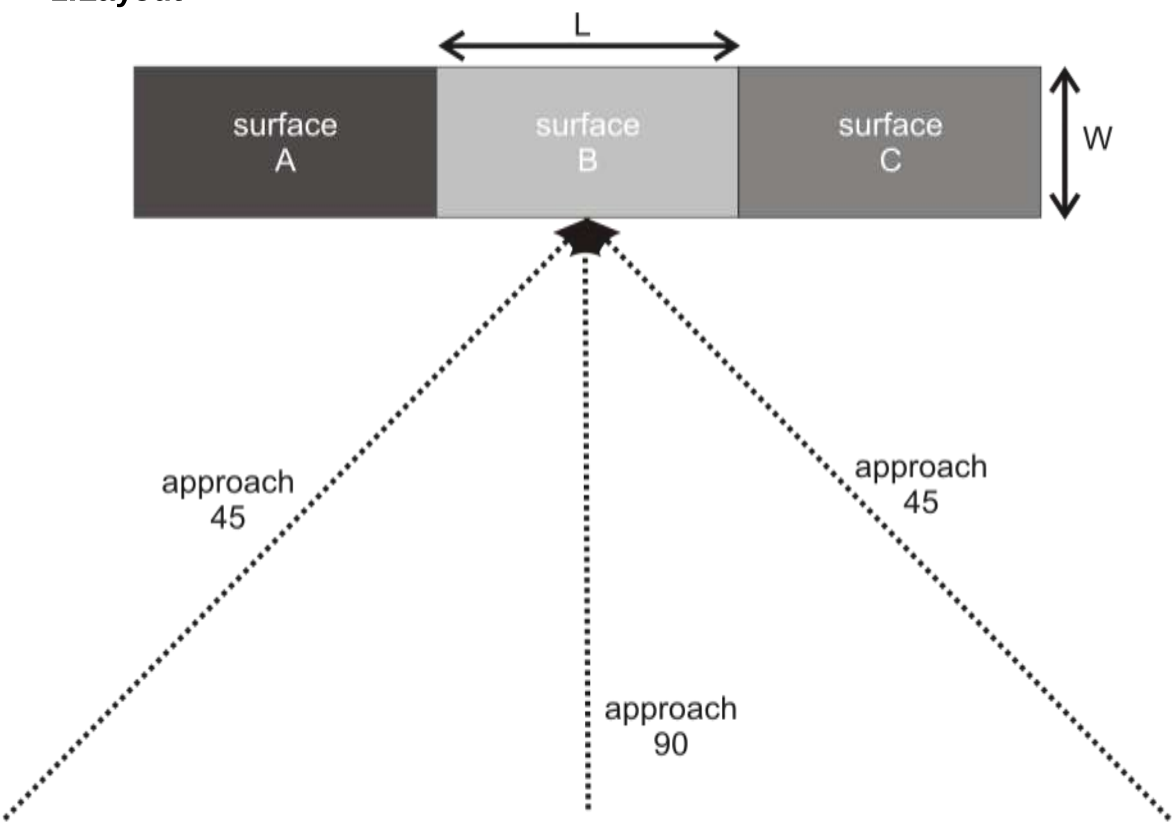

Figure 1 Task Diagram. Each surface was tested with a length (L) of 1.6m. The width (W) of each delineator is listed in Tables 5 and 6. The approach distance available for each surface was up to 4m, when approached from 90°. When approached from 45° greater than 4m was available. The approach distance was varied between trials. The surrounding surface was covered in chamfered concrete pavers.

2.Participants

Two groups of participants were recruited, one to test if the surfaces could be detected, and the other to test if the surfaces could be passed over. The first group included participants who were blind or partially sighted; people who used a long cane, had a guide dog, or did not use any aid to help them negotiate the street environment. For the purposes of this experiment, these are categorised as the 'Visually Impaired' group (VI group). The second group included participants who had mobility problems. There is a wide range of conditions where changes in surface could cause problems for mobility. For example, uneven surfaces can be a problem for both people with back pain sitting in wheelchairs and for creating ankle instabilities from awkward foot placement for those who have locomotor impairments, for example because they have had a stroke, or are wearing high heels. For the purposes of this experiment, these are categorised as the 'Mobility Impaired' group (MI group).

To cover the required range of abilities and sight/mobility limitations, participants were recruited from a database of people who had participated in previous experiments at the laboratory or heard from other participants and offered their details. For both groups it was intended to get as broad a range of abilities as possible to highlight the range of difficulties that could result from use of each of the surfaces as a delineator. All the participants except for those in attendant controlled wheelchairs regularly used the street environment independently.

Table 1 Number of Participants in each Age Group

	Step	Layout 1		Layout 2		Layout 3		Layout 4	
	VI	VI	MI	VI	MI	VI	MI	VI	MI
18-40	8	4	2	7	4	5	3	6	2
41-64	21	22	14	14	10	17	16	18	6
65+	7	3	3	4	4	3	3	3	6
Total	36	29	19	25	18	25	22	27	14

Table 2 Number of Participants of each Gender

	Step	Layout 1		Layout 2		Layout 3		Layout 4	
	VI	VI	MI	VI	MI	VI	MI	VI	MI
Male	23	16	10	18	10	16	10	16	5
Female	13	13	9	7	8	9	12	11	9
Total	36	29	19	25	18	25	22	27	14

Table 3 Number of VI Participants that used each type of Aid

	Step	Layout 1	Layout 2	Layout 3	Layout 4
Cane	17	21	16	14	17
Dog	11	1	6	3	6
None	8	7	3	8	4
Total	36	29	25	25	27

Table 4 Number of MI Participants that used each type of Aid

	L1	L2	L3	L4
Electric wheelchair or scooter	7	3	5	5
Self-propelled wheelchair	7	5	7	5
Attendant controlled wheelchair	2	1	2	0
One or two crutches, one or two sticks, or a wheeled walker	3	6	6	2
High heels, pushed a buggy with 10kg mass, or pulley trolley style luggage with 10kg mass	1	4	3	3
Total	20*	19*	23*	15*

* One participant participated in the tests using a manual wheelchair and two crutches

3.Delineator Surfaces

The vertical step heights were tested with concrete paving either side of the kerb : no additional tactile surface was used for these tests. The step heights tested were 20mm, 30mm, 40mm, 50mm, 60mm, 80mm, and the traditional 120mm. Only the VI group were tested over the step heights. The other surfaces can be categorised as either a Level Change or Level Surface, where the Level Change surfaces have one side of the surface higher than the other.

Table 5 Level Change Surface Delineator Characteristics

Layout	Delineator Surface Description	Profile Height (mm)	Height (mm)	Width (mm)
L1	Single Slope 1:5	0	80	400
L1	Double Slope 1:7 with 200mm valley in-between two 400mm slopes	0	57	1200
L2	level Corduroy Warning 400mm wide and 400mm wide Corduroy Warning at 1:8	6	50	800
L2	level Corduroy Warning 400mm wide, and 400mm non-chamfered paver at 1:8	6	50	800
L2	level Corduroy Warning 400mm wide at 1:8	6	50	400
L3	Non-chamfered pavers 800mm wide at 1:12	0	33	800
L3	Corduroy Warning 800mm wide at 1:12	6	33	800
L3	Blister Paving 800mm wide at 1:12	6	33	800
L3	level Corduroy Warning 400mm wide and 400mm wide Corduroy Warning at 1:12	6	33	800
L3	level Corduroy Warning 400mm wide, and 400mm non-chamfered paver at 1:12	6	33	800
L3	Corduroy Warning 400mm wide at 1:12	6	33	400

Table 6 Same Level Surface Delineator Characteristics

Layout	Delineator Surface Description	Profile Height (mm)	Width (mm)
L1	Rough Rumble paving with irregular surface	20 max	400
L1	Ridged Rumble paving with regular ‘^’ shaped ridges	15	400
L1	modified Central Delineator as used to separate bicycles from pedestrians in shared lanes	20	150
L1	Blister Paving 400mm wide	6	400
L2	Blister Paving 800mm wide	6	800
L2	Corduroy Warning	6	800
L2	Corduroy Warning raised 6mm above surrounding	6	800
L4	Guidance Paving	6	800
L4	Guidance Paving aligned perpendicular to kerb line	6	800
L4	Corduroy Warning aligned perpendicular to kerb line	6	800
L4	Blister Paving 800mm wide	6	800
L4	Dome set above surrounding surface	15	800
L4	Dome set below surrounding surface	10	800

The Department for Transport (DfT) has identified a number of tactile surfaces [DfT 2003]. Some of these have been incorporated into these tests; Blister Warning, Corduroy Hazard Warning paving, and Guidance Paving. The Corduroy Hazard Warning paving and Guidance Paving were laid with the ridges aligned parallel to the line of the kerb. In two cases (Table 6) these surfaces were aligned perpendicular to the line of the kerb. Four layouts were required to incorporate all the listed delineators.

4.Surface Choice

The results from the first layout indicated that the Ridged Rumble had potential if modified. When discussing these modifications the description fairly closely matched the design of the Corduroy Hazard Warning paving hence its inclusion for later layouts. There was also the indication that the Single Slope would be more acceptable if less steep and preceded (from above) by a warning surface; hence the modified slopes in later layouts. Although alignment of Guidance Paving and Hazard Warning paving is specified to indicate the direction of pedestrian travel/location of the potential hazard, by orientating these surface 90° to this alignment, car drivers would get a clear indication that they were driving onto a surface not suitable for vehicles; hence the inclusion of these alignments in Layout 4. An alternative surface was sought that provided a consistent profile presenting a different surface 'attitude' at every foot-fall and sought to minimise any ankle instability when passing over it. The recessed 10mm high dome prototype was manufactured in granite and 15mm high dome in concrete.

5.Task

The MI participants were asked to travel across each surface (approaching at 90°), turn around and return to their starting place. The experimenter marked each trial according to whether the participant failed to cross the surface, appeared to struggle but managed to cross the surface, or appeared to cross the surface easily. Immediately after the participant had finished each trial they were asked to rate the surface in terms of their perception of how easy it was to cross on a Numerical Rating Scale between '0' and '10' : a score of '0' being no problem, '10' being impossible to get over, and scores in-between relating to how much they felt they had to struggle.

The VI participants were positioned so that they were facing either perpendicular to the surface or approximately 45° to it. They were asked before starting each trial to stop if they encountered a change in surface, otherwise to walk towards the experimenter at their normal walking pace using the experimenter's voice to help with direction. The experimenter then went to the other side of the surface and asked the participant to walk towards them. The experimenter marked each trial according to whether the participant detected the surface or not. Once the participant had finished each trial they were asked to rate the surface in terms of their perception of how easy it was to detect on a Numerical Rating Scale between '0' and '10' :a score of '0' indicating that they had not detected any change in surface, '10' that they believed that there was definitely a delineator indicating a change of surface, and scores in-between indicating how much confidence they had that any difference in surface was intentionally there to indicate something. They were told to consider scoring 5 or more if they thought they would stop if they encountered the surface in the street situation, and less than 5 if they thought it was simply an irregular surface.

6.Layout Task Order

The surfaces were listed in an excel spreadsheet for each participant. Each task was given a random number (Microsoft Excel function RAND()) and the trials ordered according to the resulting ranked random numbers. Two of the surfaces (chamfered and non-chamfered pavers) represented level pavement with no delineator surface. These were included to give a baseline for the MI participants and to reduce any expectation on the part of the VI participants that they would always encounter a delineator surface.

RESULTS

The following tables list the summary results from all the trials, grouped according to the type of surface encountered : Vertical Step, Level Change, or Same Level Surface.

Each table includes the surface delineator description, the group of tests that included that surface (layout 1 to 4 or step) and the results. The pass, fail, total, and % fail columns show the relevant numbers for each delineator surface as evaluated by the experimenter. The % D<5 and % O>5 columns list the number of trials where the participants rated the surface on detection or ease of passing over.

For VI participants, a Detect score less than 5 indicated that they were not confident that they had encountered a delineator surface. On the other hand, for MI participants, difficulty in passing over the delineator surface resulted in an Overpass score greater than 5. The ideal delineator surface would have

0% fail to detect i.e. all the VI participants stopped at the delineator

0% D<5 i.e. all the VI participants were confident that what they had encountered was a delineator

0% fail to pass over i.e. all MI participants travelled over the surface

0% O>5 i.e. no MI participant found the surface difficult to pass over

1. Vertical Step Detection Results

Table 7 VI Vertical Step Detection Results					
	Experimenter evaluation				Participant evaluation
Step height (mm)	pass	fail	total	%fail	% D < 5
0					94%
20	166	53	219	24%	28%
30	212	11	223	5%	13%
40	213	7	220	3%	5%
50	220	2	222	1%	3%
60	221	0	221	0%	2%
80	222	0	222	0%	0%
120	217	0	217	0%	0%

2. Level Change (incorporating a slope) Detection and Overpass Results

Table 8 VI Level Change Detection Results						
		Evaluated by				
		Experimenter				Participant
Layout	Delineator	pass	fail	total	%fail	% D < 5
L3	Non-chamfered 800mm at 1:24	27	69	96	72%	76%
L2	Corduroy Warning 400mm at 1:8	92	4	96	4%	6%
L3	Corduroy Warning 800mm at 1:24	95	3	98	3%	4%
L3	Blister 800mm at 1:24	95	3	98	3%	3%
L1	Single Slope 400mm at1:5	81	1	82	1%	1%
L3	Corduroy Warning 400mm at 1:12	97	1	98	1%	7%
L3	Corduroy Warning level & flat paver 1:12	99	1	100	1%	7%
L1	Double Slope 1:7	52	0	52	0%	6%
L2	Corduroy Warning level & flat paver 1:8	100	0	100	0%	6%
L2	Corduroy Warning level & 1:8	97	0	97	0%	2%
L3	Corduroy Warning level & 1:12	99	0	99	0%	0%

Table 9 MI Level Change Overpass Results						
		Evaluated by				
		Experimenter				Participant
Layout	Delineator	pass	fail	total	%fail	% O > 5
L1	Double Slope 1:7	35	2	37	5%	22%
L1	Single Slope 400mm at1:5	74	3	77	4%	15%
L2	Corduroy Warning level & 1:8	56	0	56	0%	14%
L3	Corduroy Warning level & 1:12	57	0	57	0%	10%
L2	Corduroy Warning level & flat paver 1:8	55	0	55	0%	9%
L2	Corduroy Warning 400mm at 1:8	55	0	55	0%	9%
L3	Blister 800mm at 1:24	57	0	57	0%	8%
L3	Corduroy Warning 800mm at 1:24	57	0	57	0%	6%
L3	Corduroy Warning 400mm at 1:12	57	0	57	0%	6%
L3	Corduroy Warning level & flat paver 1:12	57	0	57	0%	3%
L3	Non-chamfered 800mm at 1:24	57	0	57	0%	2%

3. Same Level Surface Detection and Overpass Results

Table 10 VI Same Level Surface Detection Results						
		Evaluated by				
		Experimenter				Participant
Layout	Delineator	pass	fail	total	%fail	% D < 5
L4	Guidance Paving aligned perpendicular to kerb line	78	22	100	22%	26%
L1	Blister 0.4m wide	44	10	54	19%	19%
L1	Central Delineator	48	6	54	11%	11%
L1	Rough Rumble	47	5	52	10%	8%
L1	Corduroy Warning aligned perpendicular to kerb line	92	8	100	8%	15%
L4	Guidance Paving	96	4	100	4%	9%
L1	Ridged Rumble	51	2	53	4%	2%
L2	Corduroy Warning	96	1	97	1%	5%
L3	Blister 0.8m wide	97	1	98	1%	4%
L4	Blister 0.8m wide	98	1	99	1%	4%
L2	raised Corduroy Warning	95	0	95	0%	6%
L4	Dome above surrounding	100	0	100	0%	0%
L4	Dome below surrounding	100	0	100	0%	0%

Table 11 MI Same Level Surface Overpass Results						
		Evaluated by				
		Experimenter				Participant
Layout	Delineator	pass	fail	total	%fail	% O > 5
L1	Ridged Rumble	39	2	41	5%	36%
L4	Dome above surrounding	56	2	58	3%	14%
L1	Rough Rumble	41	1	42	2%	20%
L1	Central Delineator	39	0	39	0%	20%
L4	Dome below surrounding	56	0	56	0%	16%
L4	Guidance Paving	57	0	57	0%	12%
L2	Corduroy Warning	55	0	55	0%	7%
L4	Blister 0.8m wide	57	0	57	0%	7%
L2	raised Corduroy Warning	55	0	55	0%	5%
L1	Blister 0.4m wide	39	0	39	0%	5%
L3	Blister 0.8m wide	55	0	55	0%	4%
L4	Guidance Paving aligned perpendicular to kerb line	57	0	57	0%	4%
L1	Corduroy Warning aligned perpendicular to kerb line	57	0	57	0%	0%

DISCUSSION

This paper presents research that considers the suitability of some possible surface delineators for Shared Space Schemes. A delineator surface could be deemed suitable if it can be reliably detected. If the area is also to allow free movement for people with mobility impairments, a delineator surface would be unsuitable if it created a barrier to such movements.

Traditionally delineation has been achieved with the 120mm kerb upstand, with flush kerb crossing points. If the levels of detection (%fail and % D < 5) for the 120mm kerb are used as a benchmark for the optimal delineator surface, then four of the delineators tested achieved this level. These were an 80mm kerb, 10mm recessed domes, 15mm domes proud of the surrounding surface, and a 400mm wide section of level Corduroy Hazard Warning Paving next to a 400mm wide section of Corduroy Hazard Warning Paving at a 1:12 slope. However, all of these options presented a barrier to movement for people with mobility impairments (10% to 16% O > 5).

Blister paving in some form is found across the world. In these experiments, Blister Paving was tested at 0.4m and 0.8m wide. With almost a fifth of participants failing to detect the 0.4m wide Blister, this width is not suitable as a delineator. The 0.8m wide Blister achieved detection rates comparable to those reported in the literature [Bentzen et al. 1994; Sueda 1998; Ståhl et al. 2010]. If this surface is used as the benchmark for these tests, then in terms of detection of the surfaces tested, none of the following would be suitable : the 1:24 slope, Guidance Paving aligned perpendicular to the kerb line, Central Delineator, Corduroy Hazard Warning Paving aligned perpendicular to the kerb line, and Rough Rumble.

The problem remains that surfaces which are good for detection by blind and partially sighted people are not easy for people with mobility impairments to pass over. Options with level changes appear to be better in terms of being detected, but is there a level of difficulty for mobility impaired people that is acceptable?

The difference in detection of the Corduroy Hazard Warning Paving when it was aligned parallel or perpendicular to the kerb line raises the question of how these surfaces would be laid in streets that were not predominantly straight and how the delineator would be started at the beginning of the scheme. In addition, it raises the question of the detectability of the surface when the pedestrian takes a side step onto the surface for any reason. Detection of delineator surface options such as the Blister and Domes appears to be less affected by angle of approach than for the delineator surfaces with bar profiles.

CONCLUSION

The work presented here refers to experiments carried out in a safe laboratory setting. This enabled many environmental factors to be controlled, but it is acknowledged that people’s activities in real street environments will differ from that witnessed during these experiments. These experiments should be regarded as providing criteria for surfaces which could be tested further in a street environment and identifying those which would not be worth testing in such circumstances. With this in mind further tests are required before any of these surfaces can be recommended as delineators of pedestrian space within level surfaces. In particular, the delineator surfaces were all tested laid next to level concrete pavers in good condition and further tests are needed to determine the level of broken/uneven paving that can surround such a delineator before the level of detectability reduces beyond an acceptable level. The implications for other disabled people, including people with cognitive impairments, should also be tested. Early suggestions for detectable surfaces – proposed in UK schemes - have been either a barrier to people with mobility impairments, or difficult to detect for blind and partially sighted people, or both. The work presented in this paper shows the difficulty in finding a suitable dual purpose surface, yet clarifies the design requirements for shared space delineators for people with mobility impairments and blind or partially sighted people.

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