Involving persons with dementia in the evaluation of outdoor environments

Journal Item

How to cite:

Van Schaik, Paul; Martyr, Anthony; Blackman, Tim and Robinson, John (2008). Involving persons with dementia in the evaluation of outdoor environments. CyberPsychology & Behavior, 11(4) pp. 415–424.

Version: Version of Record

Link(s) to article on publisher's website:
http://dx.doi.org/doi:10.1089/cpb.2007.0105

CyberPsychology & Behavior
Volume 11, Number 4, 2008

DOI: 10.1089/cpb.2007.0105

Involving Persons with Dementia in the Evaluation of Outdoor Environments

PAUL VAN SCHAIK, Ph.D.,[1] ANTHONY MARTYR, M.Sc.,[2] TIM BLACKMAN, Ph.D.,[3]
and JOHN ROBINSON, M.Sc.[4]

ABSTRACT

Using virtual reality (VR), we examined the barriers to and facilitators of functioning outdoors in persons with dementia (PwD) and investigated the generalizability of findings in VR to the real world. An existing town center was modeled in VR. PwD took part in both real-world and VR walks. Based on the results, the model was redesigned and then tested again. Performance on the walks improved, and potentially beneficial adaptations to outdoor environments were identified, but limitations of VR as a representation of the real world were also identified. We conclude that VR models, together with a rigorous behavioral testing method, can be a useful tool for the evaluation of outdoor environments and for identifying improvements for PwD.

INTRODUCTION

A PROJECT RECENTLY UNDERTAKEN at Oxford Brookes University was the first in the world to investigate how older persons with dementia (PwD) perceive, experience, and use the outdoor environment and to identify design factors that influence their ability to successfully use and negotiate their local neighborhoods.[1] The project reported here takes this pioneering work a stage further by testing virtual outdoor design adaptations. Like the Oxford Brookes study, the present study involves older PwD at the mild to moderate stages of their dementia when outdoor activity is normally feasible and potentially beneficial, possibly delaying the progression of symptoms.[2,3] Virtual reality (VR) technology enables PwD to participate in the planning and design of public spaces and amenities, potentially improving the navigability and comfort of these environments for them. The feasibility of using VR technology with PwD was demonstrated in a pilot study using a semi-immersive VR model of a park.[4]

The project had two main aims: first, to examine the barriers and facilitators to functioning outdoors for older PwD by making innovative use of VR technology to undertake environmental adaptations and test them experimentally, and second, to investigate whether findings for VEs can be generalized to real environments. The overall design was to combine real-world walks outdoors with simulations of those walks indoors. A town-center environment was used, in which participants carried out typical tasks such as crossing a road and finding a post office or a bus station. The research was conducted in two phases. In Phase 1, real-world walks and VR walks through Middlesbrough town center as it exists were conducted, and these were compared with Phase-2 VR walks using an adapted town center. The main outcome measure was task performance in the walks.

---

[1] School of Social Sciences and Law, University of Teesside, Middlesbrough, United Kingdom.
[2] Department of Psychology, University of Wales, Bangor, United Kingdom.
[3] School of Applied Social Sciences, University of Durham, Durham, United Kingdom.
[4] School of Computing, University of Teesside, Middlesbrough, United Kingdom.

METHOD

Participants

There were 30 participants with symptoms of mild to moderate dementia, 19 in each of the two phases, with 2 not taking part in the outdoor walk due to mobility problems. Eight participants returned to Phase 2. There were 10 women and 9 men doing VR walks in Phase 1 (9 women and 8 men doing the outdoor walk) and 10 men and 9 women doing VR walks in VR2. The mean age of the PwD was 78.43: *SD* = 5.11; range = (71; 88). All were diagnosed by old-age psychiatrists as having dementia in the mild to moderate stages and were recruited through local hospitals where they were outpatients. The mean Mini-Mental State Examination (MMSE) score[5] was 23.47, *SD* = 4.43; range = (14; 30), and the mean Bristol Activities of Daily Living Scale[6] was 12.33, *SD* = 5.88; range = (4; 21). These scores confirmed that participants were in the early stages of dementia with relatively preserved independence from their caregivers.

Apparatus and materials

The outdoor environment. The outdoor environment tested in the research was that of the commercial center of the northern English town of Middlesbrough. The following three main areas of the town center were included: a route along a side street to a shopping street and then to a post office and a taxi rank, a pedestrianized shopping precinct, and a route across and along a busy road that concluded at some public toilets (see Figure 1).

The virtual environment. A previously developed VE formed the basis of the model of Middlesbrough town center that was then significantly elaborated with new sections and added detail (see Figure 2); for more details see van Schaik, Blackman, Martyr et al.[7] Based on results from participants' walks in the existing, unadapted town center, the VR model was adapted, including landscaping the side street, adding navigation aids and modifying road crossings (see Figure 3). For key differences between unadapted and adapted environments, see Table 1. The VR model was displayed on a 6m × 2m curved projection screen in the University of Teesside's VR auditorium.

Procedure

Virtual reality session (Phase 1). The VR session began with the PwD following a set route around the model according to a detailed protocol (see Appendix 1, available at http://sssl-staffweb.tees.ac.uk/U0011128/VRD/Appendix1.pdf). Both caregiver and researcher allowed the PwD to lead the walk. The researcher asked a series of conversational questions at key stages. These included setting off, en route to a destination, at junctions or nodes, on reaching a destination, and return journeys.

Real-world walk (Phase 1). The real-world walk followed the VR route and protocol (see Appendix 1): participants walked the same route and performed the same tasks with the same prompts in both sessions. The two matching environments were compared to establish if PwD acted the same in both environments. The VR and outdoor walks were counterbalanced, though due to the weather no pre-allocated ordering could be used; typically, if the weather was good for the first test session, the outdoor walk was done.

Virtual-reality session (Phase 2). The protocol for Phase 2 followed that of Phase 1, except the environment was adapted on the basis of the results from the Phase 1 walks and some revisions were made to the protocol (see Appendix 2, available at http://sssl-staffweb.tees.ac.uk/U0011128/VRD/Appendix2.pdf). The data recorded in the VR session in Phase 2 were compared with those from the VR session in Phase 1 to see if the adaptations had any effect on task performance.

Data and data analysis. Data analysis focused on the following aspects. Both video and audio data were recorded. Two raters viewed the recordings and independently assessed how well the PwD interacted with the environment, using the following criteria. *Navigability* was analyzed by how well PwD followed the route and managed at junctions and other decision points. *Legibility* was measured by how adeptly PwD identified, located, and used certain things in the environments. *Safety* was measured by comparing what PwD said in response to prompts along the route. Additionally, the safety of PwD's behavior and usage of different areas was subjectively assessed. *Environmental attractiveness*, including paving patterns, levels of noise, traffic, and density or design of street furniture, was assessed by specifically asking about certain objects in the environments. These criteria produced data for individual roads as well as measures for three different areas of the town (see Appendixes 1 and 2).

Strictly speaking, our method only allows one to establish if the results obtained from VR are generalizable to the real world in regard to identifying barriers for PwD, not in regard to the effectiveness

FIG. 1. Existing town centre (RW). (**A**) Quiet side street. (**B**) Post office seen from taxi stand. (**C**) Shopping precinct. (**D**) Road-crossing before public toilets. Some aspects of the environment used during the real-world walks had changed at the time the photographs of this environment were taken.

of any subsequent change to an environment. However, the comparison of VR1 with VR2 indicates potential design improvements that might be beneficial in the real world.

RESULTS

Reliability analysis

Two raters, the research assistant who led the walks and a research student, independently scored the walks using a standardized scoring system (see Appendixes 1 and 2). Reliability between raters was analyzed over all numerical (walk outcome) variables for each participant, using the intraclass correlation coefficient.[8] All reliability coefficients were significant ($p < 0.001$ for each of the walks) and on average reliability coefficients were greater than 0.70 for each type of walk (see Table 2). We conclude that the rating of walk outcomes was reliable. Therefore, and because the research assistant had direct experience of all the walks, subsequent data analysis used the ratings of the research assistant.

FIG. 2. VR model of existing town centre (VR1). (**A**) Quiet side street. (**B**) Post office seen from taxi stand. (**C**) Shopping precinct. (**D**) Road-crossing before public toilets.

FIG. 3. Adapted VR model (VR2). (**A**) Quiet side street. (**B**) Post office seen from taxi stand. (**C**) Shopping precinct. (**D**) Road-crossing before public toilets.

TABLE 1. KEY DIFFERENCES BETWEEN UNADAPTED AND ADAPTED ENVIRONMENTS

Unadapted (VR1/real world, outdoor)	*Adapted (VR2)*
Unattractive side street heavily congestive with parked cars	Attractive traffic-calmed side street, with trees and patterned paving
Traffic island/road crossing area. Grey paving stones, poorly marked crossing	Traffic island made clearer with red paving section to indicate crossing. Thick black lines added to edge of pavement as a visual barrier
Church as landmark to help find post office	Post box added as landmark to help find post office
Road and pavement merge with the same black herring bone design	Curbing added. Yellow paving stones added to be consistent with all other areas of walks. Road crossing added via dotted lines on curb.
"You Are Here" map to help locate bus station	Fish and ship sculptures pointing towards direction of bus station
Bus stops of old and modern design with poorly viewable timetable	Modern glass design bus stops with bus numbers in big black and white numbering on side
Modern public telephone recognition task and telephone as landmark to find toilets	Public telephone removed and three different signs added to find toilets: text only, text and picture and picture only.
Dangerous road-crossing (no pedestrian crossing) at exit of car park	Pedestrian crossing added with permanent red man to compare crossing behavior

Detailed analysis of the walks

Most tasks were rated using 4-point rating scales, where 1 is best (e.g., needed no prompts, acted safely) and 4 is worst (e.g., could not do task, did not act safely). Some other tasks used 3-point rating scales, where lower scores indicate a better outcome. Therefore, the median and semi-interquartile range were calculated for each individual task per walk. Effect sizes were calculated for significant test results (see Table 3). The results are presented under various themes that emerged.

Comparison between test environments

Potential design improvement. A potential design improvement was identified, where there was no difference between VR1 and RW, but where VR2 was better than VR1. The redesigned side street (VR2) was judged to be more aesthetic than the original one (both VR1 and RW). The red post box (VR2) was easier to find than the church (RW and VR1) as a landmark for the post office destination. Pedestrian and motor traffic surfaces were better discerned with clear demarcation (VR2) than without (RW and VR1). Therefore, when roads are not clearly demarcated from pavements, they are harder to see and could cause confusion for people with mild to moderate dementia. Participants had great difficulty with using the map (RW and VR1) and the fish sculpture (VR2). Neither seemed effective, perhaps because, unlike the post box, the sculpture had no association with the destination (bus station) and was not familiar to participants, whereas PwD use landmarks and other visual cues rather than maps to plan routes.[9] Overall performance at finding modern bus shelters was good. Therefore, it appears that these are easy to find, presumably because their function is easily recognizable.[3,9] When following directions to a public toilet, following the second in a sequence of three signs to the toilets (VR2) was better than using a landmark (telephone boxes in RW and VR1). Therefore, clear signage may be more useful for PwD than using a landmark to help find a destination. Overall performance at finding the toi-

TABLE 2. RELIABILITY OF RATING OF WALK OUTCOMES

Real-world		*VR1 (unadapted)*		*Adapted (VR2)*	
Participant	*Intraclass correlation coefficient*	*Participant*	*Intraclass correlation coefficient*	*Participant*	*Intraclass correlation coefficient*
5	0.79	5	0.73	24	0.73
6	0.76	6	0.81	25	0.71
7	0.78	7	0.77	26	0.78
8	0.74	8	0.72	27	0.88
10	0.76	9	0.75	28	0.97
11	0.76	10	0.73	29	0.77
12	0.78	11	0.83	30	0.79
13	0.77	12	0.81	31	0.69
15	0.84	13	0.80	32	0.69
16	0.78	14	0.73	33	0.66
17	0.81	15	0.73	34	0.74
18	0.85	16	0.77	35	0.74
19	0.80	17	0.75	36	0.78
20	0.73	18	0.82	37	0.75
21	0.79	19	0.77	38	0.77
22	0.86	20	0.76	39	0.82
		21	0.68	40	0.71
		22	0.85	41	0.70
		23	0.70	42	0.81
Mean	0.79	Mean	0.76	Mean	0.76
SD	0.04	SD	0.04	SD	0.07

Note: The four pilot participants were not included in the reliability analysis. The same participants were included in real-world walks and in VR walks with the unadapted model. Because not all participants in VR walks with the adapted model also took part in the real-world walks, participants for these VR walks have been numbered differently from those in the other two types of walk.

let was good. Consequently, it seems that clear signage is helpful and understood by people with mild to moderate dementia. Overall, the low median scores for navigation indicate there was not a general navigation problem; the results in favor of VR2 suggest that the adaptations made navigating the VR environment easier for PwD. Rather than major changes to the environment to assist PwD, our results suggest that outdoor environments may offer relatively few obstacles, with improvements needed only in respect of particular aspects, notably involving the use of signage.

Limitation of VR as a representation of the real world. A limitation of VR was identified, where RW was better than VR1, with no difference between VR1 and VR2 and, unexpectedly, no advantage of VR2 over VR1. When VR2 was better than VR1, this was seen as an indication that a limitation was overcome. Performance at road-crossing at a traffic island in VR1 was worse than in RW, showing the limitations of the VR model in replicating a wide field of vision despite the width of the projection. As a result, participants were inattentive to approaching traffic in the VE. The nonsignificant difference between VR2 and RW suggests that VR2 was as safe as RW and that the skill of crossing a road safely is preserved in mild to moderate dementia. Performance at finding the taxi rank sign on a silver post was worse in VR1 than in RW. This reflected a resolution problem given the small size of the sign in VR1. This was successfully compensated for in VR2 by making the sign larger. Legibility of bus stop numbers was worse in VR1 than in RW. Once more, the poorer resolution in VR is a likely cause. This explanation is consistent with the finding that performance did not differ between VR2 and RW.

Ability to carry out functional tasks preserved. The overall good performance at finding modern-design

TABLE 3. OUTCOMES OF WALK AS A FUNCTION OF TYPE OF ENVIRONMENT

	Medians (SIQR)			*Effect size (r)*		
Condition item	*Virtual reality 1*	*Real world*	*Virtual reality 2*	*VR1–RW*[b]	*VR1–VR2*[c]	*RW–VR2*[c]
21: Ambience of side street[d]	2 (1.0)	2 (1.0)	2 (1.0)	−0.51*	−0.57*	−0.86*
30: Finding somewhere to sit down	1 (0.5)	1 (0.0)	1 (0.5)	ns	ns	ns
32: Safety of crossing shopping street	3 (0.5)	1 (0.0)	1 (0.5)	−0.56**	−0.65***	ns
46: Attractiveness of shopping street	2 (0.5)	2 (0.5)	2 (0.0)	ns	ns	ns
56: Locating post box/church[e]	2 (0.5)	1 (0.3)	1 (0.0)	ns	−0.43**	ns
59: Finding the post office[f]	1 (0.5)	1 (0.0)	1 (0.5)	ns	ns	ns
81: Finding a taxi sign	2 (1.0)	1 (0.0)	1 (0.0)	−0.50**	−0.70***	ns
83: Distinguishing surface for pedestrians and that for traffic[f]	1 (0.5)	1 (1.0)	1 (0.0)	ns	−0.34*	−0.39*
99: Finding a seat in shopping center[g]	1 (0.0)	1 (0.0)	1 (0.0)	ns	ns	ns
100: Finding a litter bin in shopping center[g]	1 (0.0)	1 (0.0)	1 (0.0)	ns	ns	ns
115: Legibility of bus station	2 (0.5)	1 (0.5)	1 (0.0)	ns	ns	ns
118: Ambience of shopping center[g]	1 (0.1)	1 (0.5)	1 (0.5)	ns	ns	ns
119a/120: Locating the fish statue/"You Are Here" map[g]	2 (1.0)	2 (0.5)	1 (1.0)	ns	ns	ns
165: Finding new bus stops	1 (0.0)	1 (0.0)	1 (0.0)	ns	ns	ns
174: Legibility of bus stop numbers	2 (0.5)	1 (0.0)	1 (0.0)	−0.34*	−0.64***	ns
175: Ambience of busy road	2 (0.0)	2 (0.0)	2 (0.5)	ns	ns	ns
185a: Finding toilet sign 1	NA	NA	2 (0.5)	ns	ns	ns
190: Finding a modern telephone box	1 (0.5)	1 (0.5)	NA	ns	ns	ns
190a: Toilet sign 2	NA	NA	1 (0.5)	ns	ns	ns
203: Safety of crossing the goods entrance	2 (1.0)	1 (0.8)	2 (1.0)	ns	ns	ns
205: Toilet sign 3/ remembers destination[h]	4 (1.5)	2 (1.5)	1 (0.0)	ns	−0.51**	−0.50**
207: Crossing car park exit to toilets[h]	3 (0.5)	1 (0.5)	1 (0.0)	−0.53**	−0.71***	ns
208: Finding toilet	1 (0.0)	1 (0.0)	1 (0.0)	ns	ns	ns
223: Walk the route alone[i]	2 (1.0)	2 (1.0)	2 (1.0)	ns	ns	ns
224: Walk the route with someone else[i]	1 (1.0)	1 (0.8)	1 (0.0)	ns	ns	ns
225: Side effects[i]	1 (0.5)	1 (0.0)	1 (0.0)	ns	−0.34*	ns
226: Navigation[i]	1 (0.5)	1 (0.3)	1 (0.5)	−0.39*	ns	ns
227: Presence[i]	1 (0.5)	1 (0.0)	1 (0.5)	−0.41*	NS	0.42*

[a] Semi-interquartile range. [b] Wilcoxon matched-pairs signed-ranks test. [c] Mann-Whitney U test. [d] See Figures 1, 2, and 3(a). [e] Church in VR1 and real world, post box in VR2. [f] See figures 1, 2, and 3(b). [g] See Figures 1, 2, and 3(c). [h] See Figures 1, 2, and 3(d). [i] 3-point items.

ns, not statistically significant; na, not applicable.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 4. Correlations between Cognitive Ability (MMSE) and Task Performance

Condition	*Item*	*Spearman's rho*
Real world	Acting Safely in quiet side street	−0.697**
	Finding a taxi rank	−0.501*
	Legibility of modern phone boxes	−0.608**
Virtual Reality 1	Acting Safely in quiet side street	−0.414*
	Finding way around in quiet side street	−0.633**
	Finding modern seating in quite shopping street	−0.549*
	Recognizing modern seating	−0.631**
	Crossing to quiet shopping street on the way to modern seating	−0.599**
	Ability to read surroundings in quiet shopping street	−0.618**
	Know where to go in quiet shopping street	−0.706***
	Safety of crossing at goods entrance	−0.475*
	Legibility of crossing at goods entrance	−0.521*
	Acting safely at crossing at goods entrance	−0.498*
	Knowing where to go in busy road	−0.468**
	Getting about without experiencing failure in busy road	−0.445*
Virtual Reality 2	Finding house no. 17 in side street	−0.560*
	Remembering the goal of looking for the post office	−0.500*

*$p < .05$; **$p < .01$; ***$p < .001$.

metallic seating from across the road suggests that modern seats are distinguishable for people with mild to moderate dementia. Similarly, Mitchell and Burton[3] emphasize that PwD benefit from traditional or modern designs, provided that their function is obvious. The overall good performance at finding the post office reveals that a post office, with its longstanding and distinctive livery in the United Kingdom, is a destination people with mild to moderate dementia can reach successfully. The overall good performance at finding a seat and finding a litter bin in the shopping precinct shows that these abilities were preserved. Therefore, the overall good legibility of the bus station (through a very prominent Bus Station sign) in the shopping precinct suggests that clearly labeled destination points aid legibility for people with mild to moderate dementia. The overall good performance at finding a modern-style telephone booth, rather than a traditional red phone booth, suggests that people with mild to moderate levels of dementia have no problem with carrying out this task.

Comparison within test environments

Aesthetics. Differences on items 118 (shopping precinct), 46 (shopping street), and 175 (busy road) (see Table 3) indicate that the shopping precinct was the most liked area of the three walk environments ($p < 0.01$ for all Wilcoxon tests comparing the shopping precinct with the other environments for RW, VR1, and VR), possibly because this area was pedestrianized with an attractive paving pattern and plenty of seating. Although we found no evidence of adverse effects of patterned paving in the shopping precinct, it can cause dizziness in PwD and can give the impression of changes in level for those with impaired depth perception, which can cause people to trip or fall. Therefore, patterned paving cannot be universally recommended for PwD.

Road-crossings. All crossings were crossed safely in RW (see Table 3). The apparent failure of VR1 to simulate the dangers of oncoming motor traffic resulted in dangerous (virtual) road-crossing behavior. PwD appear to be very aware of the dangers of traffic, but this is also something that may discourage them from using certain parts of the town. The popularity of the shopping precinct had much to do with the absence of motor traffic, while the shopping street that was also popular elicited positive comments about the width of the pavements and road (something lacking in the widely disliked real-world side street).

Directional signs (toilet). Different types of sign were used for the stretch of the walk leading to the public toilets. The results from items 185a (picture only), 190a (text only), and 205 (text and picture) indicate that text is used more as a memory aid than a picture ($p < 0.05$ for picture only versus both text only and text and picture), using text is the most important aspect of signage usage ($p > 0.05$ for text versus text and picture), and directional signage is better than using a nonrelated landmark (phone booth in RW and VR1 walks; see item 205 in Table 3).

Assistance during walking. No difference was found in preference for unaided (item 223) and aided (item 224) walking of the route in RW and VR1 (both $p > 0.05$). However, in VR2 more PwD indicated they would walk it with someone else rather than alone ($p < 0.05$), perhaps reflecting the added difficulty of navigating the walk with a joystick.

Association of level of cognitive function and task performance

Level of cognitive function and task performance were negatively correlated for various aspects of the walk in each of the three environments (see Table 4). In particular, lower MMSE was associated with less safe behavior and a reduced ability to find and identify objects.

DISCUSSION

Regarding our first aim, we identified a number of barriers (e.g., lack of definition of pedestrian and motor traffic surfaces) and facilitators (e.g., directional signage) to functioning outdoors for older PwD, with effect sizes of medium and large size (medium: $r = 0.30$; large: $r = 0.50$)[10] and beyond for the difference between VR1 and VR2. Barriers included unattractive street layout, use of landmarks that were not associated with a destination, merging of road and pavement, and provision of a map for wayfinding.

The design improvements (facilitators) that we identified remain potential because we inferred them from findings where there was no difference between VR1 and RW, but where VR2 was better than VR1. A direct comparison of the unadapted real world with an adapted real world was not possible (because the latter was not available) but would have given more confidence regarding the improvements. Adding landmarks to help with navigation was not successful, except for the red post box on the way to the post office. This finding is consistent with Sheenan et al.'s[11] results, who found that landmarks are helpful for PwD provided their function is obvious and they are familiar, but in our study, environments and landmarks were unfamiliar. Directional signs worked well, but adding nonrelated landmarks (ship statue) was not effective. Therefore, possible adaptations include clearly displayed signs using numbers or words, as appropriate, both to give directions and to signify the purpose of buildings, such as a bus station or post office. These results are consistent with other studies showing that PwD are better at identifying written stimuli than photographs, particularly when the stimulus material is less familiar.[12] Although directional signs worked well, the overstimulation and clutter that the use of too many signs can produce should be avoided.[3,9] Adding curbing was effective in making the distinction between pedestrian and motor surfaces. Increasing the attractiveness of a street (traffic calming, trees, patterned paving) was successful. Furthermore, a (safe) pedestrianized environment (shopping precinct) was judged more favorably than environments with traffic. Indeed, out of the three town-center environments, the shopping precinct was the best liked and most easily navigable; this area was pedestrianized, and the lack of cars and other traffic was a frequent positive comment.

With respect to our second aim, we identified various aspects of the environment for which there was evidence that the virtual environment (VR1) can be generalized to the real world but also other aspects where this was not the case. Some limitations of current VR and projection technology for representing and evaluating outdoor environments were demonstrated by poorer performance of participants in the VEs compared to the real world, with medium and large effect sizes of the difference between RW and VR1. An example was less safe behavior when crossing a road because of a lack of peripheral vision and participants' apparent lack of concern for safety in a VE. Furthermore, small, but to scale, signs also presented resolution problems, although performance improved when participants used the adapted VR model with larger signs. Furthermore, there were various aspects of the environment (e.g., identifying street furniture) for which the results of VR and real world did not differ.

A positive finding was that PwD completed many tasks successfully. In particular, the ability to carry out various tasks, such as identifying street furniture and buildings, was preserved. However, there were various negative correlations with MMSE score. Consequently, we conclude that dementia pathology was important for the reported difficulties in task performance. Therefore, it can be expected that adapting the environment will be beneficial for people with mild to moderate dementia.

CONCLUSION

Overall, our results suggest that people with mild to moderate dementia are capable of walking through and enjoying a town center and carrying out functional tasks both in the real environment and in a VE. With careful and selective adaptations, it is likely that these activities can be supported as the disease progresses to at least the moderate stages of dementia and probably with more need to be accompanied. The findings demonstrate that our method of using conversational walks for evaluating PwD's use of outdoor environments and their VR representations produces reliable data between raters and is sensitive to individual differences (particularly level of cognitive function) and to some extent sensitive to differences in the fidelity of representations (VR1 versus RW) and changes made to an environment (VR1 versus VR2). We conclude that VR models, together with a rigorous behavioral testing method, can be a useful tool in the evaluation of (at least particular aspects of) outdoor environments and for identifying potential improvements.

Environmental adaptations should encourage cognitive activity and in doing so may help slow the progression of dementia and achieve a degree of "rementing" in response to a stimulus.[13,14] If signage is improved along the lines we recommend and more spaces are created free from traffic and with convenient seating, this is likely to encourage PwD to go outdoors.

ACKNOWLEDGMENTS

The project reported in this paper was supported by a grant from the Health Foundation (ref. 261/2353). We are also grateful to the following members of the project's advisory group: Dr. Pat Myint, Dr. Peter Howorth, William Kernohan, Jess Fergusson, Charlton Gibben, June Dickinson, and Sylvia Slaughter. Clive Fencott and Brian Hobbs assisted the project with advice on VR design and advice on technical design of the built environment respectively.

REFERENCES

1. Mitchell L, Burton E. Neighborhoods for life: designing dementia-friendly outdoor environments. Quality in Ageing 2006; 7:26–33.
2. Abbott RD, White LR, Ross GW, et al. Walking and dementia in physically capable elderly men. Journal of the American Medical Association 2004; 292:1447–53.
3. Weuve J, Kang JH, Manson JE, et al. Physical activity, including walking, and cognitive function in older women. Journal of the American Medical Association 2004; 292:1454–61.
4. Flynn D, van Schaik P, Blackman T, et al. Developing a virtual reality-based methodology for PwD: a feasibility study. CyberPsychology & Behavior 2003; 6:591–611.
5. Folstein M, Folstein S, McHugh P. Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. Journal of Psychological Research 1975; 12:189–98.
6. Bucks RS, Ashworth DL, Wilcock GK, et al. Assessment of activities of daily living in dementia: development of the Bristol Activities of Daily Living Scale. Age & Ageing 1996; 25:113–20.
7. van Schaik P, Blackman T, Martyr A, et al. (2006) A VR-based method for evaluating outdoor environments with PwD. In *Proceedings of CONVR 2006*. Orlando, FL.
8. Howell D. (1997) *Statistical methods in psychology*. Belmont, CA: Duxbury.
9. Mitchell L, Burton E, Raman S. (2004) *Neighborhoods for life: a checklist of recommendations for designing dementia-friendly outdoor environments*. Oxford, UK: OSCD and London Housing Corporation.
10. Cohen J. (1988) *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.
11. Sheenan B, Burton E, Mitchell L. Outdoor way finding in dementia. *Dementia* 2006; 5:271–81.
12. Gross J, Harmon M, Myers R, et al. Recognition of self among persons with dementia: pictures versus names as environmental supports. Environment & Behavior 2004; 36:424–54.
13. Kitwood T. (1997) *Dementia reconsidered*. Buckingham, UK: Open University Press.
14. Rizzo AA, Buckwalter G, van der Zaag C. (2002) Virtual environment applications in clinical neuropsychology. In Stanney KM, ed. *Handbook of virtual environments: design, implementation, and applications*. London: Erlbaum, pp. 1027–64.

Address reprint requests to:
Dr. Paul van Schaik
Psychology Section, School of Social Sciences and Law
University of Teesside
Borough Road
Middlesbrough, TS1 3BA
United Kingdom

E-mail: p.van-schaik@tees.ac.uk