DO INDIVIDUALS WITH INTELLECTUAL DISABILITY SELECT APPROPRIATE OBJECTS AS LANDMARKS WHEN LEARNING A NEW ROUTE?

Yannick Courbois [1]

Mark Blades [2]

Emily K. Farran [3]

Pascal Sockeel[1]

[1] Laboratoire PSITEC, EDL3, Université Lille Nord de France

[2] University of Sheffield, UK

[3] Department of Psychology and Human Development, Institute of Education, UK

Address correspondence to:

Yannick Courbois

Laboratoire PSITEC, EDL3,

Université Lille Nord de France

BP 60140

59653 Villeneuve d'Ascq Cedex

yannick.courbois@univ-lille3.fr

ACKNOWLEDGMENTS

This study was funded by the Conseil Régional du Nord Pas de Calais (Institut Régional de Recherche sur le Handicap). We are grateful to Jennifer Miche for her help in collecting the data. We also thank the participants who have kindly taken part in the study and the staff of IMPRO de Tourcoing for their co-operation.

KEYWORDS :

Wayfinding, Landmarks, Intellectual disability.

ABSTRACT

Background. The present study was aimed at investigating the selection of landmarks by individuals with intellectual disability. The hypothesis was that they would be less efficient than individuals without intellectual disabilities in the selection of landmarks when learning a new route.

Method. The experiment took place in a natural setting with a group of participants with intellectual disability and a group of control participants matched by chronological age. The participants were first guided along a route situated in an unfamiliar district. Then, they had to guide the experimenter along the route whilst pointing to all the objects and features they found useful for wayfinding.

Results. The designated objects were categorized as a function of their landmarks properties. There were significant differences between the two groups for non-permanent landmarks, distant landmarks and non-unique landmarks. The two groups selected landmarks near intersections in the same proportions. However, the individuals with intellectual disability selected more non-unique landmarks and less textual signage than the control group at these decision points.

Conclusion. Individuals with intellectual disability seem to be less efficient than individuals without disability in landmark selection. This may limit their wayfinding abilities in their day-to-day travelling. This may also account for their difficulties in obtaining the kind of spatial knowledge which relates to the configural structure of their environment.

INTRODUCTION

The ability to independently move about one's community is essential for social participation. It allows individuals to attain a wide range of educational, recreational, and vocational opportunities (Mechling & O'Brien, 2010, Neef *et al.* 1978). Individuals who travel independently have better access to friends or to a community. Their autonomy, their self-determination and their quality of life are enhanced (Slevin *et al.* 1998). However, travel skills in individuals with intellectual disabilities are often limited. Some of these individuals restrict their movements around their neighbourhood, and only few of them can travel independently (Mengue-Topio & Courbois, 2011, Slevin *et al*. 1998). There are many obstacles to independent travel in individuals with intellectual disabilities. Some of them are located in the environment. Such obstacles are both material and social. Indeed, urban settings and public transportations are poorly designed for people with intellectual disabilities and their accessibility is limited. Parents may be unwilling to allow their children to travel independently due to perceived risks. Moreover, social expectations towards individuals with intellectual disabilities are often low (Slevin *et al*. 1998). Other obstacles to independent travel are related to the individuals' cognitive deficiencies. Their wayfinding abilities are often limited.

According to Montello, wayfinding is a goal-directed and planned movement of one's self around an environment, the purpose of which is to reach a destination beyond the local surround (Montello, 2005). Wayfinding is equivalent to a spatial problem solving task, involving planning and decision-making. It relies heavily on a variety of types of spatial knowledge, all of which are acquired by individuals as a function of the experience of their environment (Golledge *et al.* 1985, Siegel & White, 1975). At the simplest level, individuals have knowledge of objects and places located in the environment. This is referred to as landmark knowledge. Then, landmarks are linked together through the establishment of route knowledge, including information of the sequential order of the turns and landmarks. Finally, configurational knowledge is a two-dimensional representation containing information about spatial relationships among landmarks and routes, and including metric properties such as distance and direction. Golledge, *et al.* (1983) found that individuals with intellectual disability can develop landmark and route knowledge of the environment in which they live. In their day-to-day navigation, they are often able to follow a small number of familiar routes from one point to another. However, Golledge *et al.* (1983) also found that individuals with intellectual disability cannot access configurational knowledge. This would explain their wayfinding limitations since a two dimensional representation of the environment makes flexible navigation possible (e.g. taking detours, using shortcuts).

Encoding landmarks is a fundamental strategy for wayfinding and for elaborating spatial representations of an environment. This strategy may be even more important for individuals who are not able to elaborate a two-dimensional representation of the topography of an environment. Antonakos (2004) reported case studies of three individuals with spatial disorientation acquired from brain injury. Her patients lacked configurational representations of the places they travelled. However, they relied heavily on compensatory strategies including the use of landmarks and the sequencing of landmarks. Other neuropsychological research also reported patients with spatial disorientation who navigated by reference to an extensive body of minute landmarks located along the route (see Aguirre & D'Esposito, 1999). Individuals with intellectual disability, who do not attain configurational knowledge, may also rely heavily on landmark based strategies. But, do they select environmental features that have good landmark properties?

Landmarks are distinctive objects or features in the environment that can be used as reference points. They are considered as spatial cues associated with locations or behavioural responses, or as spatial reference points that organize mental representations by defining the location of other elements (Presson & Montello, 1988). Any element in an environment can be used as a landmark, however all the landmarks do not have the same value for wayfinding. According to Stankiewicz and Kalia (2007), adults who are acquiring knowledge about an environment evaluate the landmarks on the basis of three important properties. First, landmarks need to be persistent; so that they are seen at the same location each time the individual follows a given route. Second, landmarks need to be perceptually salient so that they can be easily detectable each time the individuals return to a particular location. Objects or features with a distinctive colour, shape or size can make specific locations easier to remember (see Kitchin & Blades, 2002). Third, landmarks need to be informative so that they provide non-equivocal information about an individual's position within the environment. The same object located in different locations within an environment (phone boxes), or objects that lack distinctiveness (similar buildings see Fenner *et al.* 2000), may have low information value regarding one's location.

The identification of what objects are important landmarks within an environment is not easily achieved (Presson & Montello, 1988). Indeed, adults and children do not select the same objects as landmarks along a route, and the selection of reliable landmarks for wayfinding improves during childhood (Allen *et al.* 1979). Experiments conducted in real-world settings showed that 12-year-old children select more persistent landmarks and more unique landmarks than 8-year-old children (Cornell *et al.* 2001, Heth *et al.* 1997). Moreover, the older children also selected more distant landmarks and more landmarks located near decision points than the younger children. Distant landmarks are high objects in the skyline that can be seen from different places along the route (e.g. towers). Hence, they provide reference points within a large-scale environment, with respect to which an individual can directionally orient themselves (Presson & Montello, 1988). Landmarks located near decision points (e.g. intersections) can be considered as spatial cues associated with behavioural responses where changes of direction can potentially take place. Both these categories of landmarks are very useful for efficient wayfinding.

According to Cornell *et al.*, children's self-directed travels are very important for the development of the ability to select appropriate landmarks (Cornell *et al.* 2001, Cornell & Heth, 2006). During self-initiated exploration, children gradually extend the outdoor territory surrounding their house (home range). Due to this, they experience increasingly more difficult wayfinding problems and efficient strategies for attending to landmarks with good informational value are naturally selected "because children need to arrive at a destination with a reasonable time, minimize the efforts to travel, and avoid the danger of being lost" (Cornell *et al.* 2001, p. 220). Moreover, active exploration of an environment is thought to be important for the development of spatial knowledge (Foreman *et al.* 1990, Lehnung *et al.* 2003, Foreman *et al.* 1994). Rissotto and Tonucci (2002) found that children's mode of travel between home and school was important for acquiring, processing and structuring environmental knowledge. Indeed, 8-11 year old children who travelled unaccompanied to school had a better spatial knowledge of the environment in which they lived than children who travelled accompanied by an adult.

Foreman (2006) pointed out that children with disabilities often lack the opportunity to freely explore their environment. Compared with typically developing children, they experience a restricted region of space. They often travel accompanied by adults and have a passive experience of their environment. Consequently, they rarely have the possibility to correct errors or to decide alternative routes. Golledge (1993) also noticed that, for individuals with intellectual disabilities, opportunities to travel independently are limited, few in number, and are often controlled by supervisors. Indeed, it is obvious that many individuals with intellectual disability have very limited access to their environment. They do not have the opportunity to be involved in normal activities such as moving freely about their environment and this reduced autonomy probably has a negative influence on the development of their spatial knowledge.

The present experiment was designed to study the selection of landmarks during wayfinding in individuals with intellectual disability. We focused on landmarks since they are very important for wayfinding and for the organisation of spatial knowledge. Our hypothesis was that individuals with intellectual disabilities would be less efficient than individuals without intellectual disabilities in their selection of landmarks when learning a route. In other words, our predictions were that, when compared to individuals of the same age, they would select less distant landmarks, more non-unique landmarks, less landmarks near intersections, and more non-permanent landmarks. As in Cornell's studies, our experiment took place in a naturalistic setting (Heth *et al.* 1997, Cornell *et al.* 2001). The participants were first guided along a route situated in an unfamiliar environment. Then they had to walk the route a second time, this time guiding the experimenter. During the second walk, participants were instructed to point to all the objects and features they found useful for wayfinding.

METHOD

Participants

Fifteen teenagers with intellectual disability and fifteen teenagers without intellectual disability matched on chronological age participated in the study. The mean age of the group with intellectual disability (ID group) was 18.15 years (SD =1.07 years) and the mean IQ was 57.06 (WAIS III; SD = 7.14). The mean age of the control group (CT group) was 18.55 years (SD = 1.62 years). There were 6 males and 9 females in each group. All participants with intellectual disability were able to read. Their mean developmental age in reading was 9.63 years (SD = 0.51; assessment made with the French reading test *L'Alouette*; Lefavrais, 1967). The participants with intellectual disability attended a special school and followed a vocational training program. Moreover, they were about to leave the school and move to sheltered or competitive employment. They were interested in independent travel and were able to follow few familiar routes. The participants were informed regarding the nature of the study and gave their consent to take part in it. They were also informed that they were free to withdraw from the study at any time. All participants lived in the neighborhood of Lille, Northern France.

Procedure

The experiment took place in a district near the center of the city of Roubaix (population: 99,000). The participants were brought to this area by underground trains and the experiment began at the station entrance (the journey between the special school and the station lasted 20 minutes). The experimenter guided the participants along a 2.3 km route including 20 intersections (crossroads or T-junctions, see Figure 1). This circular route went though a diversified cityscape including shopping streets, residential areas and one industrial site (the route can be visualized using the Goggle software Street View, see Appendix for the itinerary description). Five participants in the ID group and 4 participants in the CT group knew the city of Roubaix. However, none of the participants had had any previous experience of this route.

Before leaving the underground station, the experimenter informed the participants they would walk along the route twice. He also instructed them to watch carefully during the first walk because they would be asked to guide the experimenter along the route when they walked it the second time. The time taken to walk the route was about 25 minutes. As soon as the first route walk had been completed, the second was started. During the second walk, the participants were asked to show the way to the experimenter. When participants made an incorrect turn at a crossroad or T-junction this was recorded as incorrect and the experimenter led them back to the junction and showed them the correct path. The experimenter also recorded when participants paused at a junction, hesitating over the way to take. The participants were asked to point to the objects or features that they found useful for finding their way along the route (the landmarks). It was not necessary to repeat the instructions during the walk. The experimenter recorded the name of each object designated by the participants and took a picture of the landmark.

Figure 1 about here

Landmarks were categorized in to five non-exclusive categories. Non-unique landmarks were objects that could be seen at several locations along the walk. For example, road markings, traffic signs, street furniture, access barriers, billboards or trees, were considered to be non-unique landmarks. Non-permanent landmarks were movable objects that could change their location at any moment (e.g. vehicles). Distant landmarks were high objects that were located off route but were visible from different locations of the walk (e.g. towers). Landmarks were judged to be near intersections if they were visible from at least two different roads leading to the intersection. Moreover, we subdivided the unique-landmark category into unique objects (example: a building with a distinctive feature) and textual signage (mainly provided by signposts that were also unique) subcategories.

RESULTS

Nonparametric comparisons were carried out because most of the variables were not normally distributed. Mann-Whitney U tests were used to examine differences between the ID group and the CT group. Considering our small sized samples ($N \leq 20$ per group), we applied the 2*(1-p) correction for the critical level calculation as recommended by Dinneen and Blakesley (1973) although this correction usually leads to underestimation of statistical significances. Frequency comparisons were also conducted using Fisher's exact test since some expected cell values were less than 5.

The individuals with intellectual disability made significantly more errors than the control participants during the test phase (see Table 1, $p < .045$). They also hesitated more during the test walk of the route ($p < .04$).

The participants chose 209 different objects as landmarks. Among these landmarks, 59 were only selected by participants with intellectual disability, 74 were only selected by control participants, and 76 were selected by participants in both groups (135 different landmarks were pointed by the ID group and 150 by the CT group). Many of these landmarks were idiosyncratic. Indeed, 68 objects in the ID group (50.35%) and 65 in the control group (43.33%) were selected by only one participant.

Participants in the CT group pointed to significantly more landmarks than participants in the ID group (see Table 1, $p<.045$). There were only two environmental features that could be categorized as *distant landmarks* along the route: A factory stack and a church tower. Among the 15 participants in each group, 4 in the control group and 0 in the ID group selected at least one distant landmark. This difference was significant ($p<.05$, one-tailed test). Only 6 different *non-permanent* objects were chosen as landmarks by the participants (for example: A car parked illegally, an unloading truck, a commercial vehicle, or a fork-lift truck). There were significantly more participants in the ID group who pointed to non-permanent landmarks than in the control group (6 and 1 respectively, $p<.05$, one-tailed test). The number of *non-unique landmarks* was significantly higher in the ID group compared to the control group (Table 1, $p<.006$). However, contrary to our prediction, the number of landmarks selected *near intersections* was not significantly different between the groups (see Table 1).

Table 1 and Table 2 about here

The participants of the ID group selected landmarks near intersections, but did they choose the same objects as participants of the CT group? We further explored this issue differentiating non-unique and unique landmarks. Moreover, in unique landmarks we made a distinction between unique objects and textual signage. The proportion of non-unique landmarks selected near intersections was significantly higher in the ID group compared to the CT group (see Table 2, $p<.006$). There was no significant difference between the two groups in the proportion of unique objects, however, the CT group selected significantly more textual signage than the ID group ($p<.003$).

DISCUSSION

Based on the theoretical statement that children's self-directed travelling is necessary for the development of the ability to select appropriate landmarks and on the observation that children and adults with intellectual disability often experience limited self-initiated travel in their environment, we assumed that the participants with intellectual disabilities would be less efficient than the control participants in landmark selection. The results were congruent with this hypothesis. Indeed, more participants with intellectual disability selected non-permanent landmarks and none of the participants with intellectual disability selected a distant landmark. Moreover, the proportion of non-unique landmarks selected was higher in the ID group than in the control group. Contrary to our prediction, participants with intellectual disabilities selected the same proportion of landmarks near the intersection as control participants. However, they selected less textual signage and more non-unique landmarks than controls at these decision points.

The selection of objects that have good landmark properties is fundamental for efficient wayfinding (Cornell *et al.* 2001, Heth *et al.* 1997). Landmarks need to be perceptually salient, persistent and informative (Stankiewicz & Kalia, 2007). Transient events, such as an unloading truck, are misleading landmarks. Moreover, non-unique landmarks are less informative regarding the individual's position in the environment than unique objects. According to Denis (1997) landmarks have three different key functions: They signal locations where specific actions need to be accomplished; they help determine the location of other landmarks; and they provide confirmation to individuals that they are still on the right route. Some of the landmarks selected by individuals with intellectual disability may not have been appropriate to carry out these functions efficiently. These individuals may run the risk of making an incorrect decision along the route that would lead to the possibility of becoming lost.

The participants with intellectual disability seemed to be less aware than the control participants of *what* is a good landmark. However they seemed to know *where* the important landmarks should be located. Indeed, they selected landmarks near intersections to the same extent as the control participants. This unexpected result may be the consequence of their difficulties in wayfinding. These individuals hesitated more than the control participants when they were at choice points and they probably looked for objects or features that would be useful for wayfinding. However, their landmark choice was not optimal. Textual signage has been shown to be very important for wayfinding, reducing wrong turns and backtracking (O'Neill, 1991). Despite the fact they were able to read easily, our participants with intellectual disability relied less on this useful information.

Landmarks are also thought to be the basis for the elaboration of spatial knowledge. For example Siegel and White (1975) described three stages in the development of spatial knowledge of a novel environment, with a progression from landmark to route to configurational knowledge. Given the hierarchical nature of this progression, Siegel and White stated that the most sophisticated stage could not be achieved without using landmark knowledge. Recent empirical evidence does not support this hierarchical model, suggesting that there is no stage at which only pure landmark or route knowledge exists without containing metric information (Montello, 1998; Ishikawa & Montello, 2006). However, the importance of landmarks in the organization and use of spatial knowledge has not been challenged (Montello, 1998, p. 148). Taking a slightly different approach, Couclelis *et al.* (1987) proposed that some salient cues in the environment can be used as anchor points that organize spatial knowledge and structure mental maps. Anchor points and their connecting paths are proposed to define the skeletal structure of a representation. Therefore, the individuals with intellectual disability who do not select objects with good landmarks properties during wayfinding may also have difficulties in elaborating their spatial knowledge. Their limitations in configurational knowledge might not be the consequence of a deficit preventing them from developing two-dimensional representations of the environment. Rather, it may be caused by the use of non-efficient strategies when learning the environment, including landmark selection.

Training studies will be necessary to solve this theoretical issue. According to the strategy limitation hypothesis, training experiments involving the selection and the memorization of objects with good landmark value would improve the individuals' spatial knowledge of a given environment. For example, distant landmarks, that are often visible from numerous locations, provide important spatial points of reference (Cornell *et al.* 2001). They may be useful to integrate separately learned routes into a global reference system. Thus, when trained to selectively attend to distant landmarks and to memorize them, individuals with intellectual disability could improve their spatial knowledge of the environment. Of course, training programs may also be valuable for improving day-to-day wayfinding in individuals with intellectual disability. Training these individuals to select persistent and informative landmarks may reduce the risk of wandering off route. Moreover, teaching them to attend to distant orientation cues may help them to find the correct direction to follow when they are off route.

In the present experiment, we deliberately opted for an undemanding response. The participants just had to point to objects or features they found useful for wayfinding. We are confident that the participant did not select objects along the route at random since they selected landmarks at choice points, as the control participants did. Moreover, this methodology was very informative because it allowed the participants to select their own landmarks. However, it may be interesting to further study landmark selection in individuals with intellectual disability, using other responses such as recognition of landmarks in pictures. Picture recognition tasks can be used to assess the ability to visually encode objects and features in the environment (Kirasic *et al.* 1980).

We conducted our experiment in a natural setting rather than using laboratory-based tasks, so that our methodology had strong ecological validity. By carrying out the experiment in a natural setting with an almost unlimited number of possible landmarks we found that both groups of participants used a very large number of different landmarks and that different individuals chose many different landmarks. This in itself is an important result, which could not have been established in a more limited or in artificial environments, but a natural setting has some limitations. The participants could only walk the route twice, due to time demands and physical demands. Moreover, the physical properties of the environment could not be modified. For example, there were only two distant landmarks visible from the route and it may be important to verify that individuals with intellectual disability do not select spontaneously distant landmarks in environments with a greater number of distant cues.

In future research the limitations of natural environments could be avoided by using virtual environments. Virtual environments can be manipulated in ways that are not possible in the real-world. For example, the number, the saliency and the location of the landmarks can be easily controled. Virtual environments do not entail the time and physical demands that limit real world studies. Furthermore, they allow the participants to explore new spaces actively and safely. Previous research has shown that is is possible to use virtual environments successfully with individuals with intellectual disability (Rose *et al.* 2002, Mengue-Topio *et al.* 2011). Virtual environment research may be used to test specific hypothesis coming from ecological real world studies. A recent study with virtual environments has shown that individuals with Williams syndrome recalled more landmarks near junctions than landmarks not located near a junction (Farran *et al.* in Press). This provided convergent evidence suggesting that individuals with intellectual disability rely on landmarks located near decision points when learning a route.

In their outstanding paper published in 1983, Golledge and his collaborators noted that the deinstitutionalization of people with intellectual disability raised the issue of how they understand the spatial structure of their urban environment and how they use such an environment on a day-to-day basis (Golledge *et al.* 1983). But several decades after Golledge *et al*'s contribution, the wayfinding abilities of individuals with intellectual disability have received very little research attention. The results of the current study suggest that independent travel is problematic for individuals with intellectual disability. Given the impact that this can have on daily living, further research in this area is vital if we are to be able to begin to suggest ways in which these difficulties can be supported and ameliorated.

REFERENCES

Aguirre, G. K. & D'Esposito, M. (1999) Topographical disorientation: a synthesis and taxonomy. *Brain,* **122,** 1613-1628.

Allen, G. L., Kirasic, K. C., Siegel, A. W. & Herman, J. F. (1979) Developmental issues in cognitive mapping: The selection and utilization of environmental landmarks. *Child Development,* **50,** 1062-1070.

Antonakos, C. L. (2004) Compensatory wayfinding behavior in topographic disorientation from brain injury. *Journal of Environmental Psychology,* **24,** 495-502.

Cornell, E. H., Hadley, D. C., Sterling, T. M., Chan, M. A. & Boechler, P. (2001) Adventure as a stimulus for cognitive development. *Journal of Environmental Psychology,* **21,** 219-231.

Cornell, E. H. & Heth, C. D. (2006) Home range and the development of children wayfinding. In: *Advances in Child Development and Behavior* (ed R. Kail). pp. 173-206. Elsevier.

Couclelis, H., Golledge, R. G., Gale, N. & Tobler, W. (1987) Exploring the anchor-point hypothesis of spatial cognition. *Journal of Environmental Psychology,* **7,** 99-122.

Denis, M. (1997) The description of routes: A cognitive approach to the production of spatial discourse. *Cahiers de Psychologie Cognitive,* **16,** 409-458.

Dinneen, L. C., & Blakesley, B. C. (1973). A generator for the sampling distribution of the Mann Whitney U statistic. *Applied Statistics*, **22**, 269-273.

Farran, E. K., Courbois, Y., Van Herwegen, J. & Blades, M. (in Press) Landmarks and route learning in Williams syndrome. *Journal of Experimental Child Psychology*.

Fenner, J., Heathcote, D. & Jerrams-Smith, J. (2000) The development of wayfinding competency: Asymmetrical effects of visuo-spatial and verbal ability. *Journal of Environmental Psychology,* **20,** 165-175.

Foreman, N. (2006) Spatial cognition and its facilitation in special populations. In: *Applied spatial cognition: From research to cognitive technology* (ed G. Allen). pp. 129-178. Lawrence Erlbaum Associates, Mahwah, NJ.

Foreman, N., Foreman, D., Cummings, A. & Owens, S. (1990) Locomotion, active choice, and spatial memory in children. *The Journal of General Psychology,* **117,** 215-33.

Foreman, N., Gillet, R. & Jones, S. (1994) Choice autonomy and memory for spatial location in six-year-old children. *British Journal of Psychology,* **85,** 17-27.

Golledge, R. G. (1993) Geography and the disabled: a survey with special reference to vision impairment and blind populations. *Transactions of the Insitute of British Geographers,* **18,** 63-85.

Golledge, R. G., Richardson, D., Rayner, J. N. & Parnicky, J. J. (1983) Procedures for defining and analysing cognitive maps of the mildly and moderately mentally retarded. In: *Spatial orientation: Theory, research and application* (eds H. L. Pick & A. P. Acredolo). Plenum Press, New York.

Golledge, R. G., Smith, T. R., Pellegrino, J. W., Doherty, S. & Marshal, S. P. (1985) A conceptual model and empirical analysis of children's acquisition of spatial knowledge. *Journal of Environmental Psychology*, **5,** 125-152.

Heth, C. D., Cornell, E. H. & Alberts, D. M. (1997) Differential use of landmarks by 8- and 12-year-old children during route reversal navigation. *Journal of Environmental Psychology*, **17,** 199-213.

Ishikawa, T., & Montello, D. R. (2006). Spatial Knowledge acquisition from direct experience in the environment : individual differences in the development of metric knowledge and the integration of separately learned places. *Cognitive Psychology,* **52**, 93-129.

Kirasic, K. C., Siegel, A. W. & Allen, G. L. (1980) Developmental changes in recognition-in-context memory. *Child Development,* **51,** 302-305.

Kitchin, R. & Blades, M. (2002) *The cognition of geographic space.* IB Tauris & Co Ltd, London.

Lehnung, M., Leplow, B., Ekroll, V., Herzog, A., Mehdorn, M. & Ferstl, R. (2003) The role of locomotion in the acquisition and transfer of spatial knowledge in children. *Scandinavian Journal of Psychology,* **44,** 79-86.

Lefavrais, P., (1967). *Test de l'Alouette,* Editions du Centre de Psychologie Appliquée, Paris.

Mechling, L. & O'Brien, E. (2010) Computer-based video instruction to teach students with intellectual disabilities to use public bus transportation. *Education and Training in Autism and Developmental Disabilities***,** **45**, 230-241.

Mengue-Topio, H. & Courbois, Y. (2011) L'autonomie des déplacements chez les personnes déficientes intellectuelles : une enquête réalisée auprès de travailleurs en établissement et service d'aide par le travail. *Revue Francophone de la Déficience Intellectuelle,* **22,** 5-13.

Mengue-Topio, H., Courbois, Y., Farran, E. K. & Sockeel, P. (2011) Route learning and shortcut performance in adults with intellectual disability: A study with virtual environments. *Research in Developmental Disabilities,* **32,** 345-352.

Montello, D. R. (1998). A new framework for understanding the acquisition of spatial knowledge in large-scale environments. In M. J. Egenhofer & R.G.Golledge (Eds.), *Spatial and temporal reasoning in geographic information systems*. pp 143-154. New York: Oxford University Press.

Montello, D. R. (2005) Navigation. In: *The Cambridge Handbook of visuospatial thinking* (eds P. Shah & A. Miyake). pp. 257-294. Cambridge University Press, Cambridge.

Neef, N. A., Iwata, B. A. & Page, T. J. (1978) Public transportation training: in vivo versus classroom instruction. *Journal of Applied Behavioral Analysis,* **11,** 331-344.

O'Neill, M. J. (1991) Effect of signage and floor plan configuration on wayfinding accuracy. *Environment and Behavior,* **23,** 553-574.

Presson, C. C. & Montello, D. R. (1988) Points of reference in spatial cognition: Stalking the elusive landmark. *British Journal of Developmental Psychology,* **6,** 378-381.

Rissotto, A. & Tonucci, F. (2002) Freedom of movement and environmental knowledge in elementary school children. *Journal of Environmental Psychology,* **22,** 65-77.

Rose, F. D., Brooks, B. M. & Attree, E. A. (2002) An exploratory investigation into the usability and usefulness of training people with learning disabilities in a virtual environment. *Disability and Rehabilitation,* **24,** 627-633.

Siegel, A. W. & White, S. H. (1975) The development of spatial representations of large-scale environments. In: *Advances in child development and behavior* (ed H. W. Reese). pp. 9-55. Academic Press, New York.

Slevin, E., Lavery, I., Sines, D. & Knox, J. (1998) Independant travel and people with leaning disabilities: the views of a sample of service providers on whether this need is being met. *Journal of Leaning Disabilities for Nursing, Health and Social Care,* **2,** 195-202.

Stankiewicz, B. J. & Kalia, A. A. (2007) Acquisition of structural versus object landmark knowledge. *Journal of Experimental Psychology: Human Perception and Performance,* **33,** 378-390.

Table 1. Summary of the results (summed totals across all participants in a group, with interquartile ranges in brackets) and comparisons between groups. (ID = participants with intellectual disability; CT = participants without intellectual disability

).

	Group		
	ID	Control	Mann-W U
Number of errors	25 *(4)*	1 *(0)*	64.5 *(p<.045)*
Number of hesitations	24 *(2)*	7 *(1)*	63 *(p<.04)*
Number of selected landmarks	329 *(6)*	452 *(12)*	64.5 *(p <.045)*
Number of non-unique landmarks	58 *(4)*	24 *(2)*	47,5 *(p <.006)*
Number of landmarks near intersections	133 *(6)*	175 *(3)*	*105* *(p <.149)*

Table 2. Number and proportion (in boldface) of objects selected near intersections as a function of landmark type (summed totals across all participants in a group with interquartile ranges in brackets) and comparisons between groups. (ID = participants with intellectual disability; CT = participants without intellectual disability).

	Group		
	ID	Control	Mann-W U
Non-unique landmarks	36 *(3)* **0.27**	11 *(1)* **0.06**	47 *(p <.006)*
Unique landmarks: Objects	11 *(1)* **0.11**	13 *(1)* **0.07**	105 *(p <.775)*
Unique landmarks: Textual signage	86 *(5)* **0.62**	151 *(4)* **0.88**	43.5 *(p <.003)*

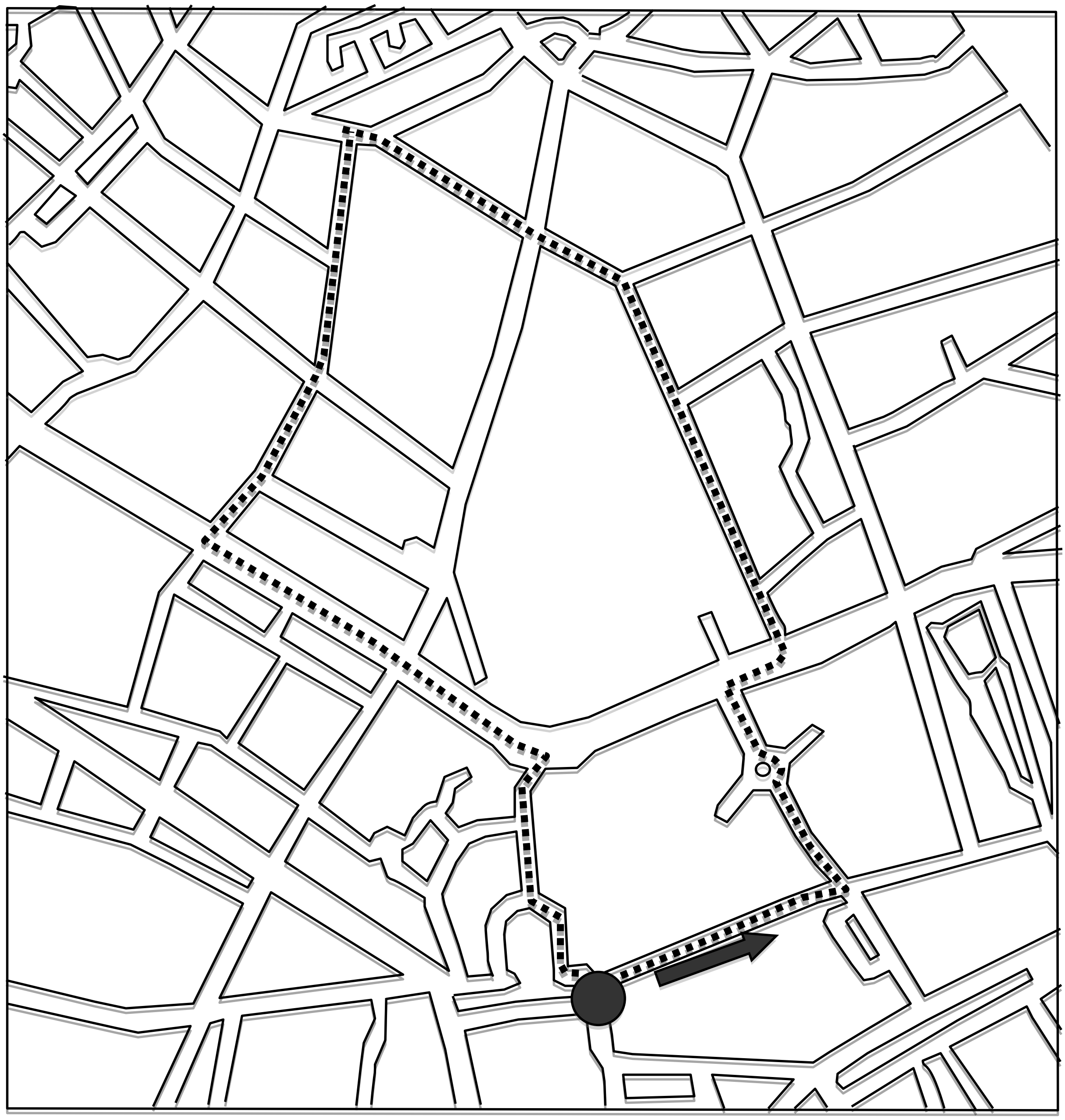

Figure 1. Map representing the route (dotted line). The circle indicates the start of the route, and the arrow shows the walking direction.

APPENDIX

ITINERARY

Departure: Roubaix, Grand Place, turn on right “Grand Rue”

Turn on left “Rue Jean Monet”

Turn on right “Avenue des Nations Unies”

Turn on left “Rue Saint-Antoine”

Continue on “Rue Cuvelle”

Continue on “Rue Henri Carette”

Turn on left “Rue Richard Lenoir”

Continue on “Rue Charlie Chaplin

Turn on left “Avenue des Nations Unies”

Turn on right “Rue du Cure”

Turn on left “Contour Saint-Martin”

Arrival: Roubaix Grand Place.

This itinerary can be visualized on the Internet using the Google software Street View