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DESCRIPTION OF ROUTES IN INDIVIDUALS WITH INTELLECTUAL DISABILITY

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Abstract:

The ability to describe routes was assessed in participants with intellectual disability (ID) and participants without ID matched on chronological age (CA) or on mental age (MA). In two experiments, participants learned a route through a virtual environment until they reached a learning criterion. Then, they were asked to externalise their spatial knowledge in a verbal description task, a landmark recognition task or a map completion task. Results revealed that participants with ID mainly described the route as a succession of actions (“turn left”) while participants in the CA group prescribed actions referring to a landmark (“turn left at the swing”). Yet, results from the other tasks showed that individuals with ID had good landmark knowledge of the environment.

Spatial abilities in individuals with intellectual disability (ID) have been mainly studied using small-scale spatial tasks. Research has relied on small-scale spatial configurations to test memory for spatial location (Ellis, Woodley-Zanthos, & Dulaney, 1989; Giuliani, Favrod, Grasset, & Schenk, 2011), visuo-spatial working memory (Henry & MacLean, 2002; Rosenquist, Conners, & Roskos-Ewoldsen, 2003; Schuchardt, Gebhardt, & Mäehler, 2010) or spatial visual imagery (Courbois, Oross, & Clerc, 2007; Roskos-Ewoldsen, Conners, Atwell, & Prestopnik, 2006).

Recently, there has been renewed interest in studying spatial cognition in large-scale navigable environments, following the seminal work of Golledge, Richardson, Rayner, and Parnicky (1983). These researchers tried to assess the level of knowledge that individuals with mild and moderate ID had of the city in which they lived. Among different tasks, participants were asked to name all of the places that they knew in their town, to put pictures of different scenes located along a familiar route in the correct sequential order, and to place the main city landmarks on a map. The results were interpreted with reference to the developmental model of Siegel and White (1975) which predicts that children's representation of large-scale environments follows a sequence of three distinct types of spatial knowledge. The first stage of acquisition of spatial knowledge includes landmark information (visual objects or scenes in the environment that are memorized and recognized when perceived). In the second stage, routes are established between landmarks. Route knowledge consists of sequence of landmarks and associated decisions. In the third stage, configurational knowledge is elaborated. This consists of a two-dimensional representation containing information about spatial relationships among landmarks and routes, and including metric properties such as distance and direction (see also

Golledge, Smith, Pellegrino, Doherty, & Marshal, 1985; Montello, 1998). Golledge et al. (1983) found that individuals with ID could develop landmark and route knowledge of the environment in which they live but they could not access configurational knowledge. They knew places along routes to their workplaces, shopping areas and entertainment areas but they did not seem to understand the two-dimensional spatial relations of their environment.

Research on the acquisition of spatial knowledge in new environments (microgenesis) in individuals with ID has led to the same conclusion. Farran, Blades, Boucher, and Tranter (2010) studied route learning in participants with Williams Syndrome (mean age = 15;4, mean IQ = 59.3), participants with moderate ID (mean age = 14;11, mean IQ = 60.8) and typically developing teenagers matched on chronological age (mean age = 15;3). The participants were guided along an unfamiliar 1-km route with 20 junctions and then retraced the route twice. Results showed that participants with William syndrome (WS) and participants with ID were able to learn a new route through an unfamiliar environment. Moreover, the use of verbal labelling (instructions that included directional information and information about features along the route) improved learning in these groups. However, the WS group and the ID group had poor relational knowledge compared to the typically developing group. They were not able to correctly identify the spatial relationships between landmarks in a pointing task (pointing to non-visible landmarks located along the route). In another experiment, Mengue-Topio, Courbois, Farran, and Sockeel (2011) assessed the ability to learn routes though a virtual environment (VE) and to make a shortcut between two locations in individuals with ID (mean age = 29;4, mean IQ = 55.4) and in adults without intellectual disability (mean age = 27;1). Participants learned routes (A⇔B) and (A⇔ C) until they reached a learning criterion. Then they were asked to find the shortest route between B and C. The ability to take a novel shortcut between these two visited places was considered as a behavioural evidence of the acquisition of configurational knowledge of the environment (Foo, Warren, Duchon, & Tarr, 2005). Results showed that participants in both groups could learn the routes, however most of the participants with ID could not find the shortcut. These experiments suggested that individuals with ID have limitations in configurational knowledge, but they are able to learn routes. Recent research on route learning in WS and Down syndrome (DS) has yielded similar results, even though individuals with DS often performed more poorly than did participants with WS or with ID (Courbois et al., 2013; Davis, Merrill, Conners, & Roskos, 2014; Farran, Courbois, Van Herwegen, & Blades, 2012; Farran et al., 2015a).

The aim of the current experiment was to study how individuals with intellectual disability express their route knowledge using verbal descriptions. From an ecological point of view, the situation which involves a person asking another for information about how to find the way though the environment is very common (Blades & Medlicott, 1992). From a psychological point of view, verbal descriptions of routes relies on the interaction between two cognitive systems with different properties: the system that codes spatial knowledge and the linguistic system by which this knowledge is expressed in communicative situations (Daniel & Denis, 2004; Denis, 1997). Theoretical models of route direction production generally postulate a three-step procedure (Denis, 1997; Lovelace, Hegarty, & Montello, 1999). The first step is the activation of a spatial representation of the environment in which the movement will take place. This representation is supposed to be stored in a non-linguistic format. The second step requires planning a specific route through that environment. The third step is the formulation of the procedure that the person will have to execute to move along the route. This verbal description has two essentials components: referring to landmarks and prescribing actions.

Denis (1997) designed a classification of verbal descriptions including fives classes of statements. Action prescription without referring to any landmark constituted the first class (“turn right”, “go straight ahead”) and action prescription referring to a landmark constituted the second class (“turn left at the traffic lights”; “take the first street on the left”). The third class was reference to landmarks without specifying an associated action (“there is a bakery”). The fourth class was descriptions of landmarks (“it is a small green house”) and the fifth class included commentaries that referred to the route without providing any relevant information (“it is a nice trip”). Denis (1997) found that the frequency of theses different classes depended on the length of the route and the density of landmarks, but the overall distribution of the classes was quite similar across routes (see also, Denis, Michon, & Tom, 2007; Denis, Mores, Gras, Gyselinck, & Daniel, 2014). Verbal descriptions by adults mainly included class 2 (henceforth referred to as Action+Landmark) and class 3 statements (henceforth referred to as Landmark-only). The class 1 statements were less frequent (henceforth referred to as Action-only). Denis et al. (1999) described two types of landmarks. Two-dimensional landmarks made reference to path entities that were walked on (e.g. streets, road intersections, squares). Three-dimensional landmarks made reference to buildings or objects along the route (eg. monuments, shops; for a discussion see Westerbeek & Maes, 2013). The results of these studies highlighted the importance of landmarks, which were used to describe the environment, but also to specify locations where changes of direction have to be made.

Individuals with ID are able to learn routes, even though they need more trials than typically developing individuals to navigate without any error (Mengue-Topio et al., 2011). We know that they are able to follow routes, with landmarks guiding their navigational behaviour, but we do not know exactly the nature of the spatial knowledge (procedural or declarative) they extract from their perceptual and motor experience of the environment. Moreover, we do not know how they externalize this spatial knowledge using the linguistic system. The quality of verbal descriptions will depend on an individual's level of language development because route descriptions require the use of relational terms such as "left", "right" or "ahead". Individuals with ID present weaknesses in the mastery of relational concepts (Facon, Magis, & Courbois, 2012; Farran, Atkinson, & Broadbent, 2016). In the present study we expected that verbal descriptions of a route by individuals with ID would be inaccurate. However, as well as the issue of the quality of spatial discourse, we wanted to investigate how individuals with ID would verbally express their knowledge of a route. Would they use statements that explicitly connect actions to specific landmarks? Or, would they mainly describe a route as a series of actions, or mainly as a series of landmarks?

In our study, participants learned a route through a virtual environment (VE) until they reached a learning criterion. Then, they were asked to describe the route to someone who was unfamiliar with the route but needed to walk it. The route descriptions were transcribed and coded following the method used by Denis (1997). The VE was sparse and there was only one distinctive landmark at each intersection, with no other landmarks along the route. Our main interest was to analyse the verbal descriptions of decision points, because efficient wayfinding requires making correct choices at these points. Moreover, we assessed the spatial knowledge of the route using a landmark recognition task (experiment 1) and a map completion task (experiment 2)

This research was the first to examine the issue of route descriptions in individuals with ID. Following a developmental approach, we expected that individuals with ID would demonstrate difficulties in prescribing actions referring to a landmark (Action+Landmark) in their verbal description of routes because this ability has a late development in childhood. Blades and Medlicott (1992) asked typically developing adults and children aged of 6, 8, 10 and 12 years to describe routes from maps. They found that 6-year-old and 8-year-old children were unable to give correct route descriptions, and that the ability to combine landmarks and directions improved dramatically between the ages of 10 and 12 years. We made no assumptions about the relative importance of Action-only and Landmark-only statements in route descriptions of individuals with ID because previous developmental research has provided mixed results about this. For example, Waller (1986) asked 5- and 8-year-old children to give directions between places in a familiar area (their school). Waller found that the use of directional indicators (instructions such as “turn this way”, “you go across”, etc.) decreased with age while landmarks information increased. Nys, Gyselinck, Orriols, and Hickmann (2014) asked adults and children aged 6, 8 and 10 years to watch a movie of a route in a virtual town and then to describe the route. In constrast, Nys et al. (2014) found that both the number of landmarks and the number of directions produced in route descriptions increased with age. These last two experiments relied on a scoring system that did not explicitly take into account Action+Landmark statements, and so they could not be used as the basis for predictions in our study.

Experiment 1

Method

Participants. Nineteen teenagers with intellectual disability (11 males and 8 females) with undifferentiated etiology and a control group of 19 teenagers without intellectual disability

(13 males and 6 females) matched as a group on chronological age (CA group) participated in the study. The mean age of the group with intellectual disability (ID group) was 16 years and 6 months (SD = 1 year and 4 months) and the mean IQ was 60.26 (WISC III, SD = 9.07). The mean age of the control group was 15 years and 10 months (SD = 1 year and 1 month). 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.

Materials. A virtual environment (VE) was designed using the 3DVIA VIRTOOLS software (Dassault systèmes). It was presented on a 15-inch laptop computer screen. Participants navigated using the keyboard and the mouse. Pressing the space bar created forward movement and moving the mouse to the right or to the left controlled rotational movements.

The VE was composed of a 5 x 4 regular grid of streets lined with high brick walls. The VE contained 21 landmarks located at different places within the grid of streets (Figure 1). The landmarks were familiar and easy to recognize objects (a house, an apple, a ball, a bench, a bicycle, a caravan, a hen, a chapel, a car, a swing, a plane, a bedside lamp, a rabbit, a pig, a scooter, an armchair, shoes, a trumpet, a billboard, a parasol and a candle).

The participants navigated from a first person viewpoint, at a constant speed. They could only follow one route in the VE. The route started from the house and contained 10 junctions, with one landmark located at each of them (respectively, the plane, the swing, the ball, the bench, the bicycle, the chapel, the scooter, the pig, the rabbit and the bedside lamp). There were six changes of direction (at the plane, the swing, the ball, the bicycle, the scooter, and the bedside lamp) and the last section of the route lead back to the starting point (the house, see Figure 2).

During the familiarization phase, the correct route in the VE was demonstrated by using barriers that blocked all but the correct path. During the learning phase, the VE was presented in the same manner as at the familiarization, except that the barriers were not visible. When participants attempted to walk down an incorrect path, the barrier appeared, preventing them from going further.

Procedure. The experiment began with four familiarization trials. The participants were first asked to practice moving along the route using the space bar and the mouse and to pay attention to their surroundings as they walked the route.

During the learning phase, participants faced the house and were told to follow the same route as in the familiarization phase without choosing a wrong path. When participants entered an incorrect path, a barrier appeared, blocking the way. The procedure was the same as the one used by Mengue-Topio et al. (2011). The trial was repeated until participants reached a criterion of walking the route twice without any error. All participants reached the criterion of two consecutive trials without error. The maximum number of learning trials to criterion was 10.

The participants were then asked to pretend that they were describing the route to someone who needed to walk the route but did not know it. It was emphasized that the route description should be as clear as possible so that the person would not make any errors.

After this first verbal description they participated in a landmark recognition task. Participants were shown 10 slides showing objects in random order. Five of the slides showed landmarks located along the route, and 5 showed objects that were not in the VE. For each of the slides, they were asked to say if they had seen the landmark along the route.

The participants were told to follow the route again. Then they were asked to give a second verbal description of the route. The verbal descriptions of the route were recorded on a digital audio recorder and then transcribed.

Dependant variables The dependant variables in the route learning phase were the number of trials to reach the criterion and the total number of errors across trials. The dependant variable of the landmark recognition task was the number of errors.

The first and the second route descriptions were transcribed and coded as a set of minimal units of information, following the method used by Denis (1997). In the original classification, Denis and his collaborators divided the unit of information into five classes of statements (Daniel, Dibo-Cohen, Carité, Boyer, & Denis, 2007; Michon & Denis, 2001): Action prescription without referring to any landmark; action prescription referring to a landmark; reference to a landmark without referring to any associated action; descriptions of landmarks; commentaries that referred to the route without providing any relevant information. A preliminary analysis of the route descriptions revealed that there was no description of landmarks (probably because the virtual environment was sparse) and very few commentaries (3 for the CA group and 6 for the ID group). Therefore, we only used three classes for the analyses: Action-only ("you turn"); Action+Landmark ("you turn at the bench" or "you take the first street on the left"); Landmark-only ("there is a bench" or "there is an intersection"). As a result, for each of the two route descriptions, the dependant variables were: (1) the number of Action-only statements, (2) the number of Action+Landmark statements, (3) the number of Landmark-only statements. We also computed the total number of units of information (total number of statements) for each route description: (1) + (2) + (3).

Results

As the data did not meet the assumption of normality, it was analysed using non-parametric tests. The statistical significance level was set at .05 (two-tailed). Mann-Whitney U-tests were used to examine differences between the ID group and the CA group. Within each group, we used the Friedman analysis of variance test to compare the number of statements between the three classes. Then, pairwise comparisons were conducted using the Wilcoxon signed rank tests (with Bonferroni correction for multiple comparisons).

Route learning phase. All participants in both groups reached the criterion of two consecutive trials without error. The ID group needed more trials than the CA group to reach the criterion, but the difference was not significant (median number of trials to reach the criterion: CA = 2; ID = 3; $p<.15$). There was also a statistical trend for the ID group to make more errors during learning (see Table 1, $p<.08$).

Landmark recognition task. There was a trend for the ID group to make fewer errors than the CA group (see Table 1, $p<.10$).

Route descriptions. All route descriptions were coded by two of the authors. Fifty percent of these descriptions were coded for reliability purpose by a third coder. The coders agreed on the classification of descriptions in 93% of the cases (Cohen's k = 0.89, 95% CI 0.82-0.96 indicating excellent agreement).

There was a trend for the total number of units of information to be lower in the ID than in the CA group for both descriptions (first description, $p<.07$; second description, $p<.09$, see Table 1). The total number of units of information was not significantly different between the first and the second route description in the CA group ($p<.25$) but there was a trend for an increase in the ID group ($p<.08$).

Comparisons between groups were performed for each class of statement. The number of Action-only statements was higher in the ID group than in the CA group for the two route descriptions (Example of description for a participant with ID: ‘Start at the house. Move forward. Turn left. Go straight ahead. Turn right. You have to go straight ahead. Turn left. Go straight ahead again. Turn left again. Go straight ahead again. Turn left again. Go straight ahead again and turn left’). Conversely, the number of Action+Landmark and the number of Landmark-only statements was higher in the CA group than in the ID group for the two route descriptions (Example of a description for a participant of the CA groups: ‘Go straight ahead. There is a plane. Turn left at the plane. Turn right when there is a swing. Then there is a ball. Turn left at the ball. Go past a chair. Then move towards a bicycle. Turn left. Go past a chapel and move towards a scooter. There, turn left. Go past a rabbit…no a pig. Go straight ahead. Then continue straight ahead when you see a rabbit. Turn left at the lamp.’). Given the similarity of the results, the data from the first and the second descriptions were pooled for further analyses.

The Friedman analyses of variance test was significant for the CA group (χ^2 [2] = 20.72, $p<.0001$). Post hoc statistics revealed that the number of Action+Landmark statements was higher than the number of Action-only statements and Landmark-only statements (respectively, $p<.01$ and $p<.001$). The difference between the number of Action-only and the number of Landmark-only statements was not significant ($p=.39$). The Friedman analysis of variance test was also significant for the ID group (χ^2 [2] = 15.03, $p<.001$). Post-hoc analyses revealed that the number of Action-only statements was significantly higher than the number of Action+Landmark and Landmark-only statements (respectively, $p<.01$ and $p<.05$). The number of Action+Landmark 2 statement was also higher than the number of Landmark-only statements ($p<.05$).

Analysis of verbal protocols for navigational value. The verbal protocols were also analysed to assess their value in terms of navigational assistance. A protocol was classified as correct if it would help a person to follow the route and reach the final destination without any error. Out of the 19 participants in the CA group, 10 provided at least one correct route description, whereas out of the 19 participants with ID, only 1 provided at least one correct description. This difference was significant (Fisher exact test, $p<.01$).

Discussion.

In the present study, participants with or without ID learned a route through a virtual environment (VE) until they reached a learning criterion. Then, they were asked to give a description of the route. Because routes were learnt to a fixed criterion, wayfinding performance was equal between the two groups before the verbal description was given.

The results of the CA group were slightly different from those of Denis and collaborators. In their experiments, they found that route descriptions of adults mainly included Action+Landmark and Landmark-only statements in similar proportions (respectively 33.5% and 36%). In the current experiment, route description of the CA group mainly comprised Action+Landmark statements (63.6% of the total number of statements) and few Landmarks-only statements (23%). Our participants were younger those of Denis et al., but one can assume that spatial language and spatial cognition have already reached their adult level before the age of 15-16 (Cornell, Heth, & Broda, 1989; Jansen-Osmann & Wiedenbauer, 2004). The main difference between the two experiments was that Denis and collaborators studied route descriptions of natural environments, which included numerous landmarks, but we used a sparse VE. Michon and Denis (2001) analysed the spatial distribution of landmarks mentioned in route descriptions. They found that landmarks were spread along the whole route, even though they were reported more frequently at reorientation points. In our VE, landmarks were only located at the intersections and the CA participants mainly used them to signal places where actions should take place. The small number of landmarks - and their location at decision points - may explain why route descriptions in our CA group comprised few Landmark-only statements.

There was a clear difference between the ID group and the CA group in the route description task. Participants with ID mainly used Action-only statements in their descriptions (61% of the total number of statements). In comparison to the CA group, they mentioned few landmarks in their statements (Landmark-only), and made few associations between landmarks and actions (Action+Landmark statements). Yet, these individuals memorized the landmarks in the VE, since they made very few errors in the landmark recognition task. Moreover they made marginally fewer errors than the CA group, suggesting that they relied heavily on landmarks during the navigation task.

According to Denis (1997), when describing a route from memory, the speaker first has to activate their spatial representation of the environment. This representation includes visuo-spatial information as well as procedural components derived from moving within this environment. He/she plans a route (a sequence of segments which connect the starting point to the destination), and then translates this spatial information into linear linguistic information. Individuals with intellectual disability have limitations in visuo-spatial working memory (Henry & MacLean, 2002), executive functions (Danielsson, Henry, Ronnberg, & Nilsson, 2010) and language (Abbeduto, Kover, & McDuffie, 2011). All these limitations can easily explain the poor navigational value of their route description.

However, why did individuals with ID predominantly use Action-only statements in their route description? Was it because they described routes from memory? Is it a general characteristic of route description (without memory load) in these individuals? In Experiment 2, we included a control condition in which the participants were asked to verbally describe the route while walking it. This condition was added to check whether individuals with ID would use Action-only statements in route descriptions even when the task did not involve memory processes. Following a developmental approach (Hodapp, Burack, & Zigler, 1990; Karmiloff-Smith, 1998), we added a group of typically developing children to see whether individuals with ID would show the same pattern of results as children with a similar mental age. In Experiment 2, we also replaced the landmark recognition task with a map completion task. Participants were asked to draw the route they had followed on a map representing the virtual environment and to place the landmarks they had seen along the path. This complex task allowed a comprehensive assessment of spatial knowledge, including memory for landmarks (i.e. what the landmarks were in the VE), memory for location (i.e. where the landmarks were located) and memory for routes.

Experiment 2

Method

Participants. Seventeen teenagers with intellectual disability (9 males and 8 females) with undifferentiated etiology, 17 teenagers without intellectual disability (10 males and 7 females) matched as a group on chronological age, and 17 seven-year-old children with similar mental age to the ID group (9 males and 8 females), participated in the study. None of the participants had participated in Experiment 1. The mean age for the CA group was 16 years and 7 months (SD = 9 month) and the mean age for the MA group was 6 years and 11 months (SD = 8 months). The mean age of the group with intellectual disability (ID group) was 16 years and 6 months (SD = 9 months) and the mean mental age (MA) was 6 years and 7 months (SD = 6 months). MA was assessed with the *Nouvelle Echelle Métrique de l'Intelligence*, NEMI-2 (Cognet, 2006). This is an intelligence test comprising of 4 core subtests. The NEMI-2 is a reliable tool that provides an IQ score (*Indice d'Efficience Cognitive*, IEC) and age equivalence information for performance on each subtest. The correlation between IEC and IQ score from the WISC-III is high (.80). The test-retest reliability for the 4 core subtests ranges between .82 and .86 (information: .86; similarities: .90; analogical matrix: .82; vocabulary: .88).

Material and procedure. The VE was the same as the one used in Experiment 1. Experiment 2 began with a familiarization and learning phase (same procedure as Experiment 1). Then, the participants were asked to:

- describe the route from memory (first description);
- walk the route again, and describe it as they moved forward through the VE (second-control description);
- describe the route from memory again (third description).

At the end of the experiment, participants were provided with a map of the VE on a 29.7x42 cm sheet of paper. The landmarks were not represented on this map. Participants were also given 16 4x4 cm cardboard coloured cards which displayed pictures of objects. Eleven of these objects were landmarks located along the path (the house, the plane, the hen, the ball, the bench, the bicycle, the bedside lamp, the apple, the car, the rabbit and the scooter). The other 5 objects were not in the VE (a key, a drum, a horse, a flower, a penguin). The experimenter placed the house – starting point – on the map and asked the participant to draw the route they had followed on the map and to place the landmarks they had seen along the path.

Dependant variables. We used the same dependant variables as in Experiment 1 for the learning phase and the route description. Results from the map completion task were analysed in terms of landmarks and drawn routes. For each landmark placed on the map we coded whether the landmark was in the VE (number of correct landmarks, maximum = 10) and if it was correctly located on the map (number of correctly located landmarks, maximum = 10). For the drawn route, we coded whether it was correct or not, and we also computed the number of correct path choices at intersection prior the first error on the map (maximum = 10).

Results

As in Experiment 1, non-parametric statistical tests were conducted to analyse the data and the statistical significance level was set at .05 (two-tailed). We used the Kruskall-Wallis test, followed by Wilcoxon rank sum test (with Bonferroni correction for multiples comparisons), to compare the three groups. Within each group, we used the Friedman analysis of variance test followed by Wilcoxon rank sum test (with Bonferroni correction for multiples comparisons), to compare the number of statements between the three descriptions (first description, second-control description, third description) and to compare the number of statements between the three classes (Action-only, Action+Landmark, Landmark-only).

Route learning phase. All participants reached the criterion of two consecutive trials without error but the number of trials was significantly different across the three groups (χ^2 =

15.4, df = 2, $p<0.001$). The CA group needed fewer trials to reach the criterion than the ID or MA groups (see Table 2; respectively, $p<.001$ and $p<.05$). The number of errors was also significantly different ($\chi^2 = 15.45$ df = 2, $p<0.0001$), it was lower in the CA groups than in the ID or MA groups (respectively, $p<.0001$ and $p<.01$). There was also a trend for the ID group to make more errors than the MA group ($p<.06$).

Route descriptions. The total number of units of information was not significantly different across the three groups during the first description and during the second-control description (see Table 2). However, there was a trend to significance for the third route description, with the total number of units of information being lower in the ID group than in the CA group ($p= .083$). The number of units of information varied significantly as a function of description (first description, second-control description, third description) for the CA group and the MA group (respectively, $\chi^2=6.52$, $p<.05$ and $\chi^2=11.29$, $p<.01$), but not for the ID group ($\chi^2=3.07$, $p=0.21$). In the CA group, there was a trend for the third route description to have more units of information than the first one ($p<.10$). In the MA group, the number of units of information was significantly higher in the second (control) descriptions than in the first and the third route descriptions ($p<.01$ in both cases).

The number of Action-only statements was significantly different across the three groups for each of the three descriptions (see Table 2, first description, $\chi^2=9.78$, $p<.01$; second-control description, $\chi^2=21.08$, $p<.0001$; third description, $\chi^2=13.19$, $p<.01$). The number of Action-only statements was significantly lower in the CA group than in the two other groups ($p<.01$ for each comparison, except for the CA-MA comparison in the first route description, $p=.07$). The number of Action+Landmark statements was also significantly different across the three groups for the three route descriptions (first description, $\chi^2=27.11$; second-control description, $\chi^2=23.83$;

third description, χ^2=28.78, $p<.0001$ in all cases). It was significantly higher in the CA group than in the ID or in the MA groups ($p<.001$ for all post-hoc comparisons). There was no significant effect of group for the Landmark-only statements (first description, p=.91; second-control description, p=.91; third description, p=.66).

Friedman analyses of variance were conducted to test for the difference in the number of statements across the three statement types within each group and for each route description. In the ID group, statement type was significant for the three route descriptions (first description, χ^2 =33.66; second-control description, χ^2=33.7; third description, χ^2=20.67, $p<.0001$). The number of Action-only statements was significantly higher than the number of Action+Landmark and the number of Landmark-only statements for each route description ($p<.0001$ in all cases). The effects of statement type were also significant for the CA group (first description, χ^2 =32.9; second-control description, χ^2=72.37; third description, χ^2=63.7, $p<.0001$). The number of Action+Landmark statements was significantly higher than the number of Action-only or Landmarks-only statements for each route description ($p<.0001$ in all cases). The number of Landmark-only statements was also significantly higher than the number Action+Landmark statements for the third route description ($p<.01$). Results from the MA group were not consistent across route descriptions. The effect of statement type was significant for the first route description (χ^2=19.26, $p<0.001$). There was a trend for significance in the second-control route description (χ^2=5.89, p=0.052), and the third route description was not significant (p=0.33). In the first description, the number of Action-only statements was significantly higher than the number of Action+Landmark or of Landmark-only statements ($p<.05$ in both cases). The same pattern of results was found in the second-control description, but the comparison between Action-only and Action+Landmark did not reach significance ($p<.10$).

Analysis of verbal protocols for navigational value. Out of the 17 participants of the CA group, 10 provided at least one correct route description, whereas none of the participants with ID and none of the participants of the MA group provided at least one correct description (Fisher exact tests, $p<.01$)

Map completion task. The number of correct landmarks (independent of their location on the map) was not significantly different across the three groups (median: CA = 8; ID = 9; MA =10; $p=.38$). However, the number of correctly located landmarks was significantly different across the three groups (median: CA = 3; ID = 1; MA =2; $p<.01$). The number of correctly located landmarks was significantly higher in the CA group than in the ID group ($p<.01$).

There was a significant difference between the three groups in the number of correct path choices at intersections prior to the first error on the route drawn on the map (median: CA = 10; ID = 1; MA =1; $p<.001$). The number of correct path choices was significantly higher in the CA group compared to the two other groups ($p<.05$ for each comparison). All the routes drawn by the participants correctly formed a closed loop from the starting point. Out of the 17 participants, 9 drew the correct route on the map in the CA group, 2 in the MA group and none in the ID group (the comparisons CA/MA and CA/ID were significant, Fisher exact test; $p<.05$ in both cases).

General discussion

In Experiment 2, the number of trials to reach the learning criterion was higher in the ID group than in the CA group, which was not the case in Experiment 1 (there was no significant difference in between the two groups). This was probably because the ID group in Experiment 1 had a higher intellectual level than the ID group in Experiment 2 (however, it was not possible to directly compare the two ID groups, since we used the WISC III to assess IQ in Experiment 1 and the NEMI-2 to assess MA in Experiment 2). Despite this difference, results from route description in Experiment 2 confirmed and extended the findings of the Experiment 1. As in Experiment 1, the directions given from memory by the CA group mainly comprised Action+Landmark statements (68.5% of the total number of statements), while those given by the ID group mainly comprised Action-only statements (62.5%). Furthermore, the results of the ID group were similar to those of the MA group in the first route description, with more Action-only statements than Action+Landmark and Landmark-only statements. However, the results from the MA group were not consistent across route descriptions, making further comparisons between these two groups difficult.

With regards to the statement types, describing a route from memory and describing a route while walking it in Experiment 2 were very similar for both the CA group and the ID group. Indeed, in the second (control) description, the descriptions of routes by participants with ID were mainly made up of prescriptions of action without referring to any landmark (Action-only statements). Therefore, the characteristic of their route descriptions in both experiments was not the consequence of difficulties in retrieving spatial information from memory, or in translating this information into sequential statements. Moreover, in the second (control) description, the participants did not have to take the listener’s (experimenter’s) perspective into account since they were asked to describe the route while walking it. So, one can assume that the lack of Action+Landmark statements in the descriptions of participants with ID was not due to the fact that they had difficulties in adapting their communication in a way that made their description helpful for the listener.

The basic function of giving directions is to prescribe actions, and this is what the participants with ID did. However, it is not sufficient to prescribe actions, it is also important to specify where they take place (Michon & Denis, 2001). The individuals with ID seemed to have overlooked this crucial aspect of giving directions. A possible explanation for this result would be that route knowledge in individuals with ID is mainly based on actions. Adopting a developmental approach of ID, this would be consistent with the Piagetian theory indicating that young children build their spatial knowledge through their own actions. Indeed, Piaget, Inhelder, and Szeminska (1960) suggested that children, up the age of 7, base their route descriptions on their memory of movement through the environment (for a discussion, see Blades & Medlicott, 1992). Children of the MA group also described the route as a succession of actions in their first verbal description. These participants had a limited experience of the unfamiliar VE before describing the route and one can assume that their environmental cognition would have improved with more experience of the VE. Our results suggest, therefore, that at the very beginning of the microgenesis of environmental cognition, young children and individuals with ID refer to their own action first when dealing with routes. It can be assumed that these young participants had not received specific teaching regarding how to give directions. Therefore, it would be useful to teach children and individuals with ID how to describe actions related to landmarks in their route descriptions to see if they can learn efficient strategies for direction-giving.

Individuals with ID and children in the MA group had difficulties externalising their spatial knowledge in the verbal description task and in the map completion task. They were not able to describe the route accurately. Most of them were not able to draw the route on a map, and the number of correctly located landmarks was very low in both groups. By contrast, more than half of the participants of the CA group were able to describe the route correctly in the two experiments, and 9 participants out of 17 were able to correctly draw the route on the map in Experiment 2. This proportion was not high but, as regards to route descriptions, it was comparable to those observed in experiments conducted in real environments (see Daniel et al., 2007; Denis et al., 2014). Research with adults has also shown that there are large individual differences in the microgenesis of environmental knowledge (Ishikawa & Montello, 2006).

Participants in the ID group and in the MA group were better at wayfinding than at externalizing their spatial knowledge. They were able to use landmarks for guiding their navigational behaviour. Moreover, individuals with ID had a very good level of performance at the landmark recognition task (Experiment 1) and they selected the correct landmarks for the map completion task (Experiment 2). These results suggested that participants with ID (and children in the MA group) correctly memorized the landmarks they saw while navigating the VE (for similar findings, see Broadbent, Farran, & Tolmie, 2015). This is surprising given the small number of landmarks mentioned in their verbal descriptions. During navigation, these landmarks may have been used as associative cues to prompt the appropriate actions at decision points, or simply as beacons for navigation (for a taxonomy of landmark functions, see Chan, Baumann, Bellgrove, & Mattingley, 2012). In beacon-based navigation, the route is composed of successive beacons, each of them serving as a goal. Individuals progress along the route by directing themselves toward a landmark. When they reach it, they direct themselves towards the next one that they can see. According to Waller and Lippa (2007), beacon based navigation is an efficient way to learn a new route, but it leads to a less elaborated representation of route than navigation based on using landmarks as associative cues. Indeed, beacon-based route learning is equivalent to a recognition task (Chan et al., 2012; Waller & Lippa, 2007). In this situation, individuals learn to recognize landmarks leading to the goal. When they reach a beacon, they scan for the next one and move toward it (Waller & Lippa, 2007). Individuals using this strategy do not need to memorize the associations between the landmarks and the relevant navigational behaviours. We can make the assumption that individuals with ID mainly rely on beacon-based navigation, which would explain their good landmark recognition. They may be little inclined to use landmarks as associative cues, which would - at least partly - account for their low level of spatial representation of the route (as expressed in the map completion and the verbal description tasks in our experiments). Moreover, they may show a dissociation between the procedural knowledge (spatial knowledge drawn from their direct experience of the environment) and explicit knowledge of routes, the former being based on landmark information (beacon-based navigation) and the later on movement (action-only statements in the route description). Teaching individuals with ID how to prescribe actions related to landmarks in route directions may help them to link these two types of knowledge, and hence to improve their wayfinding abilities. Indeed, cognitive and developmental research has shown that language and spatial cognition interact (Goldin-Meadow et al., 2014; Hermer-Vazquez, Moffet, & Munkholm, 2001; Li & Gleitman, 2002; Majid, Bowerman, Kita, Haun, & Levinson, 2004; Newcombe & Huttenlocher, 2007). We can assume that being able to verbally describe route would increase the accuracy of mental representation of space, which would in turn lead to more efficient spatial navigation.

A limitation of this research was that the two experiments were conducted using sparse VEs, with brick walls and only one distinctive landmark at each intersection. This may not be an important factor because recent research, with individuals with intellectual disability and typically developing children, has shown that navigation performance was broadly similar across sparse and rich VE (whether the rich VE featured buildings instead of brick walls, Farran et al., 2015b, or the rich VE featured comparatively more landmarks than the sparse VE, Farran et al., 2016). However, future research could study route descriptions in rich virtual environments, with many landmarks spread along the route, and route descriptions in natural settings, which are ecologically valid. In such environments, one could assume that the number of Landmark-only statements would increase in all groups (CA, MA and ID), but there is no reason to think that action+landmark statements would also increase in individuals with ID or in typically developing children.

REFERENCES

Abbeduto, L., Kover, S. T., & McDuffie, A. (2011). Studying the language development of children with intellectual disabilities Research Methods in Child Language (pp. 330-346): Wiley-Blackwell.

Blades, M., & Medlicott, L. (1992). Developmental differences in the ability to give route directions from a map. Journal of Environmental Psychology, 12(2), 175-185. doi:http://dx.doi.org/10.1016/S0272-4944(05)80069-6

Broadbent, H. J., Farran, E. K., & Tolmie, A. (2015). Sequential egocentric navigation and reliance on landmarks in Williams syndrome and typical development. Frontiers in Psychology, 6. doi:10.3389/fpsyg.2015.00216

Chan, E., Baumann, O., Bellgrove, M. A., & Mattingley, J. B. (2012). From objects to landmarks: the function of visual location information in spatial navigation. Frontiers in Psychology, 3, 304, 1-11, doi:https://doi.org/10.3389/fpsyg.2012.00304

Cognet, G. (2006). Manuel de la NEMI-2. Paris: ECPA.

Cornell, E. H., Heth, C. D., & Broda, L. S. (1989). Children's wayfinding: Response to instructions to use environmental landmarks. Developmental Psychology, 25(5), 755-764, doi:http://dx.doi.org/10.1037/0012-1649.25.5.755

Courbois, Y., Farran, E. K., Lemahieu, A., Blades, M., Mengue-Topio, H., & Sockeel, P. (2013). Wayfinding behaviour in Down syndrome: a study with virtual environments. Research in Developmental Disabilities, 34(5), 1825-1831. doi:https://doi.org/10.1016/j.ridd.2013.02.023

Courbois, Y., Oross, S., 3rd, & Clerc, J. (2007). Mental rotation of unfamiliar stimuli by teenagers with mental retardation: role of feature salience. American Journal on Mental Retardation, 112(5), 311-318.

Daniel, M.-P., Dibo-Cohen, C. M., Carité, L., Boyer, P., & Denis, M. (2007). Dysfunctions of spatial cognition in schizophrenic patients. Spatial Cognition and Computation, 7(3), 287-309. doi:doi:10.1007/s10339-006-0131-1

Daniel, M. P., & Denis, M. (2004). The production of route directions: Investigating conditions that favour conciseness in spatial discourse. Applied Cognitive Psychology, 18(1), 57-75. doi:http://dx.doi.org/10.1002/acp.941

Danielsson, H., Henry, L., Ronnberg, J., & Nilsson, L. G. (2010). Executive functions in individuals with intellectual disability. Research in Developmental Disabilities, 31(6), 1299-1304.

Davis, M., Merrill, E. C., Conners, F. A., & Roskos, B. (2014). Patterns of differences in wayfinding performance and correlations among abilities between persons with and without Down syndrome and typically developing children. Frontiers in Psychology, 5(1446). doi:10.3389/fpsyg.2014.01446

Denis, M. (1997). The description of routes: A cognitive approach to the production of spatial discourse. Cahiers de psychologie cognitive, 16(4), 409-458.

Denis, M., Michon, P.-E., & Tom, A. (2007). Assisting pedestrian wayfinding in urban settings: Why references to landmarks are crucial in direction-giving. Applied spatial cognition: From research to cognitive technology, 25-51.

Denis, M., Mores, C., Gras, D., Gyselinck, V., & Daniel, M.-P. (2014). Is Memory for Routes Enhanced by an Environment's Richness in Visual Landmarks? Spatial Cognition & Computation, 14(4), 284-305. doi:http://dx.doi.org/10.1080/13875868.2014.945586

Denis, M., Pazzaglia, F., Cornoldi, C., & Bertolo, L. (1999). Spatial discourse and navigation: An analysis of route directions in the city of Venice. Applied Cognitive Psychology, 13(2), 145-174.

Ellis, N. R., Woodley-Zanthos, P., & Dulaney, C. L. (1989). Memory for spatial location in children, adults, and mentally retarded persons. American Journal on Mental Retardation, 93(5), 521-527.

Facon, B., Magis, D., & Courbois, Y. (2012). On the difficulty of relational concepts among participants with Down syndrome. Resarch in Developmental Disabilities, 33(1), 60-68. doi:S0891-4222(11)00317-9 [pii]10.1016/j.ridd.2011.08.014

Farran, E. K., Atkinson, L., & Broadbent, H. (2016). Impaired spatial category representations in Williams Syndrome; an investigation of the mechanistic contributions of non-verbal cognition and spatial language performance. Frontiers in Psychology, 7. doi:http://doi.org/10.3389/fpsyg.2016.01868

Farran, E. K., Blades, M., Boucher, J., & Tranter, L. J. (2010). How do individuals with Williams syndrome learn a route in a real-world environment? Developmental Science, 13(3), 454-468. doi:10.1111/j.1467-7687.2009.00894.x

Farran, E. K., Courbois, Y., Van Herwegen, J., & Blades, M. (2012). How useful are landmarks when learning a route in a virtual environment? Evidence from typical development and Williams Syndrome. Journal of Experimental Child Psychology, 111(4), 571-586.

Farran, E.K., Formby, S., Daniyal. F., Holmes. T., Van Herwegen, J. (2016). Route-learning strategies in typical and atypical development; eye tracking reveals atypical landmark selection in Williams syndrome. Journal of Intellectual Disability, 60, 933-944. doi: 10.1111/jir.12331

Farran, E. K., Purser, H. R., Courbois, Y., Ballé, M., Sockeel, P., Mellier, D., & Blades, M. (2015a). Route knowledge and configural knowledge in typical and atypical development: a comparison of sparse and rich environments. Journal of Neurodevelopmental Disorders, 7(1), 1. 1-16, doi:DOI: 10.1186/s11689-015-9133-6

Foo, P., Warren, W. H., Duchon, A., & Tarr, M. J. (2005). Do humans integrate routes into a cognitive map? Map-versus landmark-based navigation of novel shortcuts. Journal of Experimental Psychology: Learning, Memory, and Cognition, 31(2), 195.

Giuliani, F., Favrod, J., Grasset, F., & Schenk, F. (2011). Accurate memory for object location by individuals with intellectual disability: Absolute spatial tagging instead of configural processing? Resarch in Developmental Disabilities, 32(3), 986-994. doi:http://dx.doi.org/10.1016/j.ridd.2011.01.055

Goldin-Meadow, S., Levine, S. C., Hedges, L. V., Huttenlocher, J., Raudenbush, S. W., & Small, S. L. (2014). New evidence about language and cognitive development based on a longitudinal study: Hypotheses for intervention. American Psychologist, 69(6), 588.

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 H. L. Pick & A. P. Acredolo (Eds.), Spatial orientation: Theory, research and application (pp. 79-104). Boston, MA: Springer US.

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. doi:https://doi.org/10.1016/S0272-4944(85)80014-1

Henry, L. A., & MacLean, M. (2002). Working memory performance in chilren with and without intellectual disabilities. American Journal on Mental Retardation, 107(6), 421-432.

Hermer-Vazquez, L., Moffet, A., & Munkholm, P. (2001). Language, space, and the development of cognitive flexibility in humans: the case of two spatial memory tasks. Cognition, 79, 263-299.

Hodapp, R. M., Burack, J. A., & Zigler, E. (Eds.). (1990). Issues in the developmental approach to mental retardation. Cambridge: Cambridge University Press.

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. doi:https://doi.org/10.1016/j.cogpsych.2005.08.003

Jansen-Osmann, P., & Wiedenbauer, G. (2004). The representation of landmarks and routes in children and adults: A study in virtual environment. Journal of Environmental Psychology, 24, 347-357. doi:https://doi.org/10.1016/j.jenvp.2004.08.003

Karmiloff-Smith, A. (1998). Development itsef is the key to understanding developmental disorders. Trends in Cognitive Science, 2(10), 389-398.

Li, P., & Gleitman, L. (2002). Turning the tables: Language and spatial reasoning. Cognition, 83(3), 265-294.

Lovelace K.L., Hegarty M., Montello D.R. (1999) Elements of Good Route Directions in Familiar and Unfamiliar Environments. In: Freksa C., Mark D.M. (eds) Spatial Information Theory. Cognitive and Computational Foundations of Geographic Information Science. COSIT 1999. Lecture Notes in Computer Science, vol 1661. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-48384-5_5

Majid, A., Bowerman, M., Kita, S., Haun, D. B. M., & Levinson, S. C. (2004). Can language restructure cognition? The case for space. Trends in Cognitive Sciences, 8(3), 108-114.

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. Resarch in Developmental Disabilities, 32, 345-352.

Michon, P.-E., & Denis, M. (2001). When and why are visual landmarks used in giving directions? Paper presented at the International Conference on Spatial Information Theory. Berlin, Heidelberg.

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 (143-154). New York: Oxford University Press.

Newcombe, N. S., & Huttenlocher, J. (2007). Development of Spatial Cognition, Handbook of child psychology (734-776): John Wiley & Sons, Inc.

Nys, M., Gyselinck, V., Orriols, E., & Hickmann, M. (2014). Landmark and route knowledge in children's spatial representation of a virtual environment. Frontiers in Psychology, 5. doi:http://doi.org/10.3389/fpsyg.2014.01522

Piaget, J., Inhelder, B., & Szeminska, A. (1960). *The child's conception of geometry* (EA Lunzer, Trans.). New York: Basic.

Rosenquist, C., Conners, F. A., & Roskos-Ewoldsen, B. (2003). Phonological and visuo-spatial working memory in individuals with intellectual disability. American Journal on Mental Retardation, 108(6), 403-413.

Roskos-Ewoldsen, B., Conners, F. A., Atwell, J. A., & Prestopnik, J. L. (2006). Visual imagery scanning in young adults with intellectual disability. American Journal on Mental Retardation, 111(1), 35-47.

Schuchardt, K., Gebhardt, M., & Mäehler, C. (2010). Working memory functions in children with different degrees of intellectual disability. Journal of Intellectual Disability Research, 54(4), 346-353.

Siegel, A. W., & White, S. H. (1975). The development of spatial representations of large-scale environments. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 10, pp. 9-55). New York: Academic Press.

Waller, D., & Lippa, Y. (2007). Landmarks as beacons and associative cues: their role in route learning. Memory & Cognition, 35(5), 910-924. doi:doi:10.3758/BF03193465

Waller, G. (1986). The development of route knowledge: Multiple dimensions? Journal of Environmental Psychology, 6(2), 109-119. doi:http://dx.doi.org/10.1016/S0272-4944(86)80012-3

Westerbeek, H., & Maes, A. (2013). Route-external and route-internal landmarks in route descriptions: Effects of route length and map design. Applied Cognitive Psychology, 27(3), 297-305.

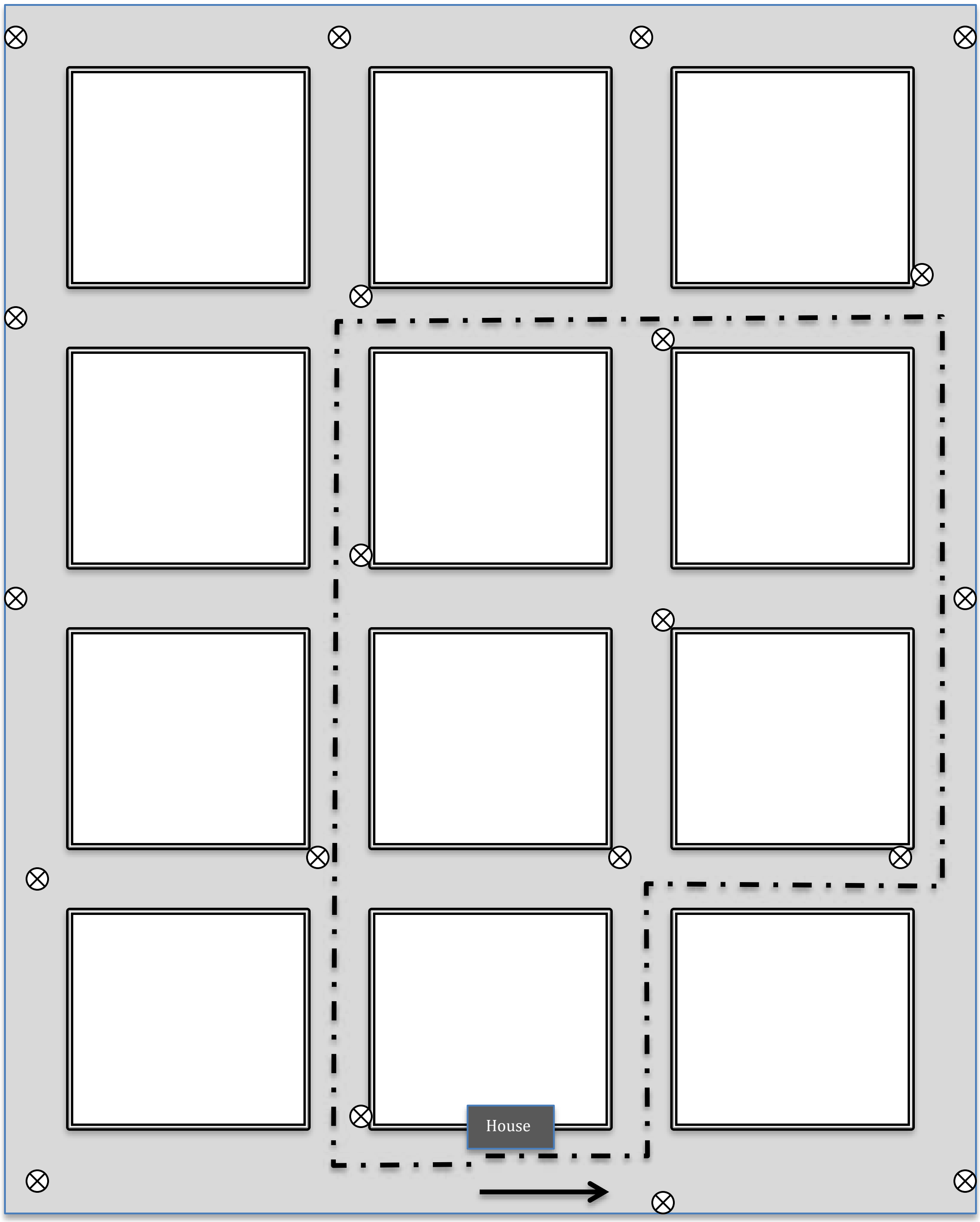

Figure 1. Map of the virtual environment (circles = landmarks ; dashed line = the route)

Figure 2. View of the virtual environment from the starting point (learning trial). Shows the house and two landmarks: the plane and the apple.

Table 1. Summary of the results (medians with interquartile ranges in brackets) and comparisons between groups (ID = participants with intellectual disability; CA = participants without intellectual disability).

		Group		
		ID	CA	Mann-W U
Route learning	Number of trials	3 (1.5)	2 (1)	NS
	Number of errors	1 (3.5)	0 (1)	p<.08
	Number of errors in landmark recognition	0 (0.5)	1(1)	p<.10
First description	Total number of units of information	10 (6)	12 (7)	P<.10
	Number of Actions-only	7 (7.5)	1 (1.5)	p <.001
	Number of Actions+Landmarks	1 (2)	8 (5.5)	p <.001
	Number of Landmarks-only	0 (2)	4 (6)	p <.01
Second description	Total number of units of information	10 (4.5)	13 (8)	P<.10
	Number of Actions-only	9 (7.5)	2 (3)	p <.001
	Number of Actions+Landmarks	2 (4)	8 (5)	p <.001
	Number of Landmarks-only	0 (1)	2 (5.5)	p <.05

Table 2. *Summary of the results (medians with interquartile ranges in brackets) and comparisons between groups (ID = participants with intellectual disability; MA = participants without intellectual disability matched on mental age, CA = participants without intellectual disability matched on chronological age, ** = p<.01, * = p<.05, (*) =p<.10)*.

		Group				
		ID	MA	CA	X^2 Kruskal-Wallis	Pairwise Comparisons
Route learning	Number of trials	5 *(2)*	4 *(3)*	2 *(2)*	15.46, p<0005	CA<ID ** CA<MA*
	Number of errors	5 *(7)*	3 *(3)*	0 *(2)*	22.03, p<0001	CA<ID * CA<MA * MA<ID (*)
First description	Number of units of information	6 *(5)*	9 *(7)*	9 *(5)*	2.07, NS	
	Number of actions	4 *(4)*	4 *(4)*	1 *(1)*	9.78, p<.01	CA<ID * CA<MA (*)
	Number of actions related to landmarks	0 *(1)*	2 *(4)*	6 *(3)*	27.11, p<.0001	ID<CA ** MA<CA **
	Number of landmarks	0 *(3)*	0 *(3)*	0 *(6)*	0.16, NS	
Second (control) description	Number of units of information	10 *(3)*	12 *(5)*	11 *(6)*	3.69, NS	
	Number of actions	7 (4)	5 (7)	1 (2)	21.80, p<.0001	CA<ID ** CA<MA *
	Number of actions related to landmarks	1 (3)	4 (5)	9 (4)	23.83, p<.0001	ID<CA ** MA<CA **
	Number of landmarks	1 (2)	1 (4)	1 (3)	0.18, NS	
Third description	Number of units of information	8 (4)	9 (4)	11 *(6)*	5.19, p<.10	ID<CA (*)
	Number of actions	5 (4)	4 (5)	1 (2)	13.16, p<.005	CA<ID ** CA<MA **

	Number of actions related to landmarks	2 (3)	1 (4)	8 (3)	28.78, p<.0001	ID<CA ** MA<CA **
	Number of landmarks	0 (4)	2 (3)	1 (5)	0.81, NS	