Structured Abstract

Primary Objective: Compare the effects of written landmark, cardinal, and left/right street directions on navigational success at the beginning of a walking route. *Research Design*: Matched control group comparison design

- Methods & Procedures: We compared navigational performance of 18 adults with acquired brain injury (ABI) to controls matched for gender, age, and education. Participants followed written directions with landmark, cardinal, or left/right directions at each of four locations. Dependent measures included accuracy, directness, stated confidence, and preference.
- *Main Results*: Participants with ABI demonstrated greater errors and hesitancy than controls when presented with cardinal and left/right directions. Both groups performed equally well with landmark directions. All participants stated preference for landmark directions. Participants with ABI were more likely to guess or become confused when following cardinal or left/right directions.
- *Conclusions*: Landmarks served as a performance equalizer between groups for navigational performance at the start of a walking route. Implications for the design of navigational assistive tools and future research are discussed.

Keywords: navigation, orientation, brain injury

Introduction

Survivors of acquired brain injury (ABI) who are unable to return to driving must rely on alternative forms of transportation (e.g. public transportation, taxi service, rides from family/friends). Survivors of traumatic brain injury identified availability of transportation as the most frequent barrier to successful community integration [1]. However, even in a city with a public transportation system that serves as a national model for disability access [2], mere location of a residential brain injury facility along a reliable major bus route was insufficient to integrate survivors of brain injury into the community [3]. Thus, availability and accessibility of public transportation appear insufficient to integrate individuals with ABI into the community. Travelers with a variety of impairments may need specific assistance to access and use public transportation effectively and confidently [4]. Assistive technology tools provide one possible form of navigational assistance.

There is a burgeoning literature investigating assistive technology tools to facilitate wayfinding abilities among individuals with cognitive impairments. For example, Kirsch and colleagues (2004) [5] demonstrated the benefits of picture and text prompts using a handheld computer to assist with indoor navigation within a rehabilitation hospital. Our research group has been investigating the functionality of assistive technology tools designed to prompt outdoor navigation to help individuals with ABI access public transportation. We found that individuals with ABI performed with fewer errors and hesitancy when presented with navigational directions in the auditory modality, compared to printed text, maps, or pictorial information [6]. However, to adequately control for orientation challenges, it was necessary to physically point participants in the correct directions that correctly orient individuals with ABI when starting a route (e.g. departing from the bus).

Characteristics of Route Directions

The quality of directions can affect the success or failure of navigation [7]. A rich literature has described the characteristics of route directions that affect navigational performance among adults without cognitive impairments.

Route directions provide step-by-step sequential instructions from the traveler's point of view and include descriptions of salient landmarks [7]. Route directions must include action statements that provide initial orientation at the route origin; they also include a description of the path and salient landmarks, and the approximate distance to travel [7,8]. Such directions are primarily used when navigating urban-type environments with clear, discrete paths (i.e. streets) as opposed to navigation in an open field, where compass type orientation would be required [9].

Ideal route directions should: prime the traveler for upcoming choice points, provide information to allow for error recovery, and limit the amount of redundant information [10]. In fact, Schneider and Taylor (1999) [11] found that providing too much information (e.g. elaborate descriptions of landmarks) led to increased confusion, increased wayfinding errors, and slower responses. Daniel and Denis (2004) [8] showed that concise directions that combined actions with landmarks (e.g. turn right at the blue mailbox) were treated 'in a very privileged way' (p. 70) to improve navigational accuracy and speed. Streeter, Vitello, and Wonsiewicz (1985) [12] further suggested that ideal

route directions should include error condition messages in case a person makes a wrong turn or other mistake (e.g. if you pass the deli, you went too far). Any navigational aid that provides route directions should allow for an overview of the route, provide stepby-step directions while remaining dynamic and adaptable to mistakes, allow for repetition of a step [7,12].

Three critical points along a route require special attention: the origin, choicepoints, and the destination [13]. These points represent locations at which the traveler requires specific information in order to successfully navigate along the route. In their series of studies, Denis and colleagues showed that participants: provided a greater frequency of descriptive statements at these critical points when giving directions to a stranger, indicated that these descriptions were essential to navigation when asked to follow the directions, rated directions with these descriptions as easier to follow, and completed navigational tasks with fewer errors and fewer hesitations when provided with directions including such descriptions at critical choice-points. However, no literature to date has specifically investigated how best to provide orientation instructions at the origin of a route in people with and without cognitive impairments.

Types of Orientation Directions

Landmarks may provide salient and clear navigational assistance along a route. Pedestrians perceived landmarks as useful, stated preference for route directions that included landmarks compared to street names, requested reference to landmarks when navigating in open spaces, and navigated with fewer errors and hesitancy when provided with landmarks [7,12,14]. Landmarks potentially provide at least five functions: orientation at the origin, confirmation of direction, signaling choice-points, assistance with locating other landmarks, and location of the destination [7,13]. In fact, LaDuke and LaGrow (1984) [15] demonstrated that provision of step-by-step pictures to assist a young adult with cognitive impairments due to developmental delay enabled the participant to successfully navigate a routine route. However, creation of such assistance for specific routes would require considerable time from a care provider. Alternatives to landmark orientation at the origin of a route include cardinal directions or left/right street directions.

Cardinal directions provide the traveler with instructions to face north, south, east, or west. Several Internet route planning tools provide cardinal directions for initial orientation for driving directions (e.g. Mapquest, Google Maps). Various researchers have demonstrated that age [16] and gender [17] play a role in navigational abilities within the population. However, no research to date has investigated the ability of individuals with ABI to orient with cardinal directions. If these individuals were able to successfully orient when provided with such directions, this would have important implications for utilizing off-the-shelf assistive technology devices, such as Global Positioning Systems (GPS) or software applications, such as Google Maps.

A third type of orientation direction employed is the use of left/right street directions. This type of direction assumes that a person is facing a certain direction and provides instructions to turn left or right at a given choice point. For example, if a care provider were offering directions to a person using the bus, s/he might indicate, 'When you get off the bus, go to your left'. However, it is unclear if this type of instruction will be of equal use at the origin of any given route, where the person's initial orientation may not be assumed. The person may disembark from the bus and face away from the street or may turn around to face the street; going 'left' would not be the same in both cases.

In summary, any assistive technology device designed to augment pedestrian navigational success must use an effective method to orient the traveler successfully at the beginning of a route. In our pilot studies, travelers with ABI who begin a route facing the wrong direction demonstrated greater navigational failure and increased frustration. Therefore, research must investigate the relative effectiveness of each of three types of orientation instructions to orient travelers with ABI at the beginning of a walking route.

Purpose

The purpose of this study was to compare the effects of three different types of orientation directions delivered at the beginning of a walking route on navigational ability in individuals with and without cognitive impairments. The three types of orientation directions included: landmark, cardinal, and left/right street directions. Study research questions were:

- 1. Do individuals with ABI demonstrate differences in navigation performance compared to matched control participants when following cardinal, left/right or landmark written route directions for initial route orientation as measured by accuracy, directness, and perceptions of confidence?
- 2. Do individuals with ABI report greater preference for landmark over left/right and cardinal directions than matched control participants for initial route orientation?
- 3. Do travelers with ABI use any strategies to orient themselves at the beginning of a route when presented with cardinal, left/right, or landmark written directions?

It was hypothesized that people with ABI would perform more poorly with all types of orientation instructions compared to non-impaired controls and that they would perform the most accurately and indicate the highest preference for landmark directions.

Methods

Participants

Two groups of participants completed this study: 18 adults with acquired brain injury (ABI) and 18 matched control participants. The university Institutional Review Board approved all procedures and the consent process was completed with each participant. Each participant received monetary compensation for completing this study. Characteristics of each participant are presented in table 1.

- - Insert table 1 about here - -

ABI group. Participants in the ABI group were at least eighteen years old (Range: 19-69 years) and had been diagnosed with an ABI (9 from trauma, 3 from cerebral vascular accident, 3 post intracranial surgery, 2 from anoxic event, and 1 with a seizure disorder). They were recruited from local supported living facilities and support groups serving adult survivors of ABI. Per care provider report, participants were medically stable (i.e. no seizures within the past three months and no recent medication changes), not currently driving (due to cognitive impairments), able to independently walk 12-15 city blocks, and demonstrated difficulty with walking a novel - - non-routine - - route.

Participants reported they were unfamiliar with the targeted downtown area, and a screening verified participants were able to hear adequately and to read and follow written instructions and street signs. We recruited 20 participants, but two of them were unable to complete the trial due to limited mobility. The sample consisted of 12 males and six females. Time post-onset of ABI ranged from four months to 40 years. Self-reported education levels also varied: two did not complete high-school; five completed high-school with no college; nine completed some college, but did not earn a degree; one completed college with a bachelor's degree; and one completed graduate school. A majority (16/18, 89%) described co-occurring psychiatric diagnoses (see table 1). One participant reported a diagnosis of schizophrenia, although she was stable on medications; care providers reported her primary cognitive challenges in memory were associated with her TBI. This sample was felt to represent the general ABI population (www.biausa.org).

Control group. Participants in the control group were matched to ABI participants, based on age (\pm 10 years), gender, and education level. Participants were recruited from an online public discussion board posting. Initial screening required that participants be: at least 18 years old, with no history of a developmental disability, ABI, or uncontrolled psychiatric diagnosis; medically stable; independently able to talk 12-15 city blocks; able to hear adequately; and able to see and read written instructions and street signs. Control participants self-reported unfamiliarity with the targeted downtown area.

Once recruited, participants in both groups completed a brief cognitive assessment. We administered the Cognitive-Linguistic Quick Test (CLQT) [18] as a rapid screening for general cognitive-linguistic impairments. The CLQT is a criterionreferenced evaluation designed to assess the relative strengths and weaknesses across five domains, and provides an overall severity score; eight participants with closed head injury were included among the 38 individuals in the clinical research sample during CLQT development. It was felt that the CLQT would provide a general measure of severity of cognitive-linguistic impairment. The composite severity ratings for each participant in the ABI group are reported in table 1. Significant differences were noted between the two groups (t(34) = 4.01, p = .000). All control participants scored within normal limits, while those with ABI demonstrated a range of impairment (M = 3.06, SD =0.99). It should be noted that the CLQT may not be a sensitive measure for cognitive dysfunction, especially dysexecutive syndrome. Although three participants with ABI tested within normal limits and seven in the mild range on this measure, the participants in this group nonetheless demonstrated cognitive impairments and dysexecutive symptoms that prevented community navigation. One of our inclusion criteria, as noted above, required that care providers report difficulty walking to non-routine destinations. The most common reasons reported for navigation challenges included forgetting the destination, becoming disoriented, and fear or anxiety visiting a novel destination alone.

In addition, each participant completed a 30-item cognitive questionnaire to elicit perceptions regarding performance in attention, memory and executive functions. This questionnaire was adapted from three standardized tools: the Attention Questionnaire from the Attention Process Training-II programme [19], the Everyday Memory Questionnaire [20], and the Dysexecutive Syndrome (DEX) Questionnaire [21].

Participants rated the frequency of cognitive challenges on a frequency scale, where 1 = never a problem and 5 = always a problem. Individuals with ABI reported greater cognitive challenges (M = 2.38, SD = 0.74) than control participants (M = 1.84, SD = 0.47). There was a significant difference between groups, t(34) = 2.66, p = .012. *Design*

We employed a matched case-control design to compare the effects of different written orientation directions on individuals with and without ABI. Each participant completed 12 orientation trials. They were asked to follow cardinal, landmark, and left/right directions at each of four different locations. The starting location was counterbalanced to minimize order effects. Each three-step written direction followed a consistent pattern of wording, length, and linguistic complexity; the only difference was the type of orientation instruction in the first step. Table 2 provides an example of each of the three types of direction. A series of pilot evaluations with uninjured adults ensured clear wording and use of perceptible landmarks.

- - Insert table 2 about here - -

Procedures

Each participant met the researcher at the target location in a nearby downtown area. Taxi transportation was provided for participants with ABI; control participants either commuted by bus or their own vehicle. The researcher followed a script to provide standardized instructions to each participant, including: 'follow each set of written directions to the best of your ability', 'you may carry the instructions; you do not need to memorize them', and 'do not take any short-cuts or deviate from the path'. The researcher asked questions to ensure comprehension. The researcher asked each participant to wear a pair of sunglasses, which contained an imbedded video camera and attached to a portable digital recorder (available from

http://www.theimportsworld.com/sunglspycawi.html). The captured audio and video were used for reliability assessment.

The researcher positioned the participant in a standardized location, facing the same direction, for the trial at each of four locations; this initial orientation direction did not match any of the orientation directions for that location. Written directions were provided individually. The researcher reminded participants to 'read the instructions and go ahead whenever you are ready'. If participants asked for assistance, the researcher reminded participants to 'just do your best'. The researcher observed each participant in the field and maintained field notes, while remaining about 6 feet behind the participant, and remaining vigilant to not provide any orienting cues. The researcher stopped each participants to rate their way-finding confidence and describe how they oriented.

After each trial, the researcher lead the participant back to the starting point, being careful not to use directional orientation (i.e. 'We'll go this way' rather than 'take a left on 6th Street here'). In addition, the researcher engaged the participant in casual conversation between trials in attempts to distract the participant from additional exposure to street signs. Participants followed three written instructions at each location.

After each set of three, the researcher provided the participant with the three instruction cards from that location and asked participants to rank them in order from the

easiest to the hardest to follow. The researcher then repeated the order back to the participant to ensure they understood the task. This sequence was repeated at the remaining three locations.

After completing this orientation trial, participants also completed a wayfinding navigational trial. Details and results of the wayfinding study are reported in the companion article.

Dependent Measures

Participant performance was captured with five different quantitative measures. The field researcher observed each participant and scored orientation response for Accuracy (0 = error; 1 = self-corrected; 2 = correct) and Directness (0 = hesitation; 1 = direct). Video recordings were captured for each participant; a second researcher watched the video recording for 18/36 (50%) participants across groups and time, and scored each for Accuracy and Directness. Percent Agreement was calculated for each score, and inter-rater agreement was found to be high, 90.63% agreement (Range: 67-100%). All disagreements were easily resolved by reviewing the video, and data were updated before running the analyses.

Participants self-reported their Confidence (scale of 1-3, where 1 = not at all confident; 2 = somewhat confident; 3 = completely confident) after following each written direction. They also described their Orientation Strategy after each trial. Responses were recorded verbatim in field notes and used later for qualitative analyses. Finally, participants were asked to rank order their Preference each set of three written directions at each of the four locations. These rank ordered responses (1 = easiest to follow to 3 = hardest to follow) were recorded with the field notes.

Data Analysis

Data were entered into SPSS 16.0 (2007). Mixed Model analyses were employed, due to repeated measures for each participant (i.e. 12 observational trials per participant). The Mixed Models analysis controls for repeated measures withinparticipant when investigating between-group differences [22]. To investigate the effects of ABI and type of direction on initial route orientation, we ran a Mixed Model analysis for Accuracy, Directness, and Confidence. Chi-Square analyses were used to investigate group differences on Preference ratings and Orientation Strategy use[23]. Significance tests explored relations between variables. Effect size measures estimated the practical significance of any statistically significant finding using Cohen's *d* [24].

Results

Assumptions

Descriptive statistics for the three dependent variables included in the Mixed Model analyses revealed non-normal distributions, especially for control group performance (e.g. kurtosis for accuracy scores = 21.04, SEM = 0.33). However, we conducted no transformations because these non-normal distributions represent hypothesized naturally occurring phenomena (i.e. the control group performed near ceiling levels with less variance on this task). The overall mixed model was significant, (Wald Z = 14.60, p = .00). *Orientation Accuracy*

There was a significant interaction effect of group and type of direction on accuracy, F(2,426) = 7.01, p = .001 (see table 3). The control group completed orientation trials with greater accuracy than the ABI group for cardinal directions, t(142) = 5.18, p = .000, a large effect, d = 0.86. The control group completed orientation trials with greater accuracy than the ABI group for left/right directions, t(142) = 3.00, p = .003, a large effect, d = 0.50. Both groups performed equally well with landmark directions, t(142) = 1.75, n.s.

The ABI group performed with the greatest proportion of errors when following cardinal directions (28/72, 39%), followed by left/right directions (18/72, 25%), and the fewest errors with landmark directions (6/72, 8%). A post-hoc Tukey test for accuracy revealed a significant difference between cardinal and landmark or left/right directions compared to cardinal directions, p < .05. As a group, participants performed worse on cardinal directions compared to both landmark and left/right directions

The control group performed with the greatest proportion of errors when following left/right directions (7/72, 10%), followed by cardinal directions (5/72, 7%), and the fewest errors with landmark directions (1/72, 1%). Within this group, there were no statistically significant differences between types of direction on the post-hoc Tukey test.

A series of follow-up significance tests was performed to examine relations between the first and last attempt at a cardinal, left/right, or landmark direction for both groups. Participants in the ABI performed the worst when presented with a cardinal direction on the first trial (Accuracy, M = 0.33) compared to a cardinal direction on the last trial (Accuracy, M = 1.60), although this difference was not statistically significant when a Bonferroni correction was applied (p = .037). The control group performed equally well with cardinal directions when presented on the first trial (M = 1.80) or the last trial (M = 2.00).

- - Insert table 3 about here - -

Orientation Directness

There was a significant interaction effect of group and type of direction on directness, F(2,426) = 4.92, p = .008 (see table 4). The control group completed orientation trials with less hesitancy than the ABI group for all three types of direction: cardinal directions, t(142) = 7.41, p = .000, a large effect, d = 1.23; left/right directions, t(142) = 3.16, p = .002, a large effect, d = 0.53; and landmark directions, t(142) = 3.28, p = .001, a large effect, d = 0.56.

The ABI group followed cardinal directions with greater hesitancy compared to both landmark and left/right directions, p < .05. The control group oriented with little hesitation for all three types of direction, n.s. Additional follow-up tests revealed no significant differences by group for order effects on directness.

- - Insert table 4 about here - -

Orientation Confidence

The interaction of group and type of direction was not significant. The main effect of type of direction was not significant. There was a significant effect of group on confidence, F(1,426) = 20.89, p = .000. The control group reported higher confidence

(M = 2.88, SD = 0.37) than the ABI group (M = 2.66, SD = 0.61) when completing orientation tasks, F(1,426) = 20.89, p = .000, a medium effect, d = 0.44. Additional follow-up tests revealed no significant differences by group for order effects on directness.

Orientation Preference

Chi-Square analyses revealed no significant differences between groups on preference ratings for cardinal directions ($\chi^2(2) = 1.83$, p = .401) left/right directions ($\chi^2(2) = 1.10$, p = .576), or landmark directions ($\chi^2(2) = 1.69$, p = .430). Participants in both groups ranked landmark directions as the easiest to follow (82/144, 57%), followed by left/right directions (45/144, 31%) and cardinal directions (19/144, 13%).

Orientation Strategy

Qualitative analysis of themes revealed three consistent patterns: error/guess; figured out directions based on street layout or memory from previous trial; or followed the direction as written. Two researchers reached consensus for these categorical themes. Individual responses were then coded as 0, 1, or 2, respectively. Chi-Square analyses revealed significant differences between groups for strategy use when following cardinal directions ($\chi^2(2) = 18.01$, p = .000) and left/right directions ($\chi^2(2) = 12.53$, p = .002 (see table 5). Participants with ABI were less likely to orient using knowledge of cardinal directions (16/72, 22%) compared to matched controls (35/72, 49%). Participants with ABI also were less likely to orient using left/right cues (48/72, 67%) compared to matched controls (64/72, 89%). There was no significant difference between groups for strategy used when following landmark directions ($\chi^2(2) = 2.21$, p = .331). Participants with ABI oriented to designated landmarks 79% (57/72) of the time; matched controls oriented to the same landmarks 86% (62/72) of the time. In addition, participants with ABI reported they were more likely to guess when unsure of which way to orient (29/216, 13%) compared to matched controls (4/216, 2%).

- - Insert table 5 about here - -

Impact of Severity of Cognitive Impairment

Additional follow-up tests examined the relations between severity of cognitive impairment—as measured by the *CLQT* composite score—and the five dependent measures for the ABI group. It should be noted that the ABI sample was skewed toward milder cognitive impairment on the *CLQT* (see table 1), thus limiting the power to detect relations between variables. There was a significant relation between severity of cognitive impairment and accuracy of orientation, Spearman rank correlation: r = .17, p = .014, a small effect, $r^2 = .03$. No other relations were significant.

Discussion

This study provides the first experimental evaluation comparing the relative effectiveness of landmark, cardinal, or left/right street directions on initial route orientation among individuals with ABI. Consistent with the study hypotheses, participants with ABI demonstrated greater difficulty orienting when using both cardinal and left/right written instructions, compared to control participants matched on age, gender, and education. Individuals with ABI performed with the greatest proportion of errors and hesitancy and least confidence when following cardinal directions; they were less likely than controls to report knowledge of cardinal directions. Contrary to our hypotheses, differences between groups were minimized when participants followed landmark directions; both groups performed equally well, with minimal hesitation, and greatest confidence with landmarks. Participants in both groups were also least likely to guess when following landmark directions, and all participants reported a preference for landmark directions. Landmark directions, therefore, served as a performance <u>equalizer</u> between groups.

The navigation literature supports the results of the current study and documents the potential advantages of landmark directions at three critical choice points along a route - - the origin, choice points, and destination [7,8,13]. The results of this study and findings from the literature provide direction for the design and dissemination of navigational assistance tools. Landmark directions are not the standard format delivered on navigational assistance programs (e.g. Web sites such as Mapquest) or on technology devices (e.g. GPS). Current tools commonly provide cardinal directions as the initial route orientation.

Despite the potential equalizing benefits of landmark directions for improving orientation at the origin of a route, a major barrier to wide-spread implementation of landmark orienting cues is that of scale. Although LaDuke and LaGrow (1984) [15] demonstrated the navigational benefits of providing step-by-step pictorial route directions based on salient landmarks at choice points along a routine route for individuals with cognitive impairments, this strategy is time-intensive. Most individual and agency care providers do not have time to preview each novel route for an individual with ABI, determine relevant and salient landmarks, and program these into an assistive navigational device, or incorporate them into a list of written instructions. An emerging technology application that may be able to scale and incorporate the landmark direction advantage is the use of Geographic Information Systems (GIS). GIS technology allows environmental features present at any given location (e.g. address or image of a business on a street corner) to be captured. When linked with GPS location information, it is possible to access these features on the spot. What is exciting in this area is the growing body of GIS information available in urban settings (e.g. Google Street View). We expect to see on-route navigation systems of the future access the body of GIS information available on the Web, and make it directly available to the traveler, without requiring a care provider to create it for each route.

A more difficult problem is to consider the effectiveness of different types of landmarks. The orienting landmarks in the current study differed at the four starting points. Although comparisons across each of the four landmarks did not reveal statistically significant differences, there was a trend that saliency or uniqueness of landmark choice made a difference. For example, a prompt to 'face the yellow house' was most salient (i.e. there was only one yellow house in view from this origin), while a prompt to 'face the parking lot' was least salient (i.e. choice of wording was considered more ambiguous since the lot was actually a car mechanic's lot). Therefore, when selecting landmark cues to orient a traveler along a route, the most salient and least ambiguous landmarks must be selected to maximize orientation success. There are some available models to categorize different types of landmarks that may guide future investigations [7]. Note that the images provided by GIS systems like Google Street View do <u>not</u> provide semantic information about the images captured, other than they are point of view shots taken at a specific location facing a specific direction. These images do not describe a landmark's potential uniqueness at an intersection. Hence, we see another promising avenue of research to be the image analysis of GIS images for their suitability as salient landmarks.

In summary, this study reveals the potential orientation advantage for people with ABI who experience navigational difficulties when orientation directions use landmarks. It also provides a model for measuring navigational performance that may enhance future studies. Evaluating performance by taking measures of accuracy, hesitation, confidence, and preference provided a valid, reliable, and comprehensive assessment of navigation. Use of a video camera mounted to sunglasses allowed a method to capture where the participant looked and moved that provided a permanent product record of performance and established reliability.

Study challenges included difficulty with participant recruitment. It was difficult to find people who were not familiar with the neighboring town and who matched the educational profiles of the experimental participants. Physical demands of the study also made it difficult to obtain participants with ABI. In general, the heterogeneous nature of the ABI pool did not allow prediction of navigational performance based on specific cognitive characteristics. Another limitation involves generalizability of findings. Our outdoor laboratory was designed to allow us to systematically investigate basic navigational questions. This laboratory is located in a neighborhood that uses a grid street layout, with street names corresponding to serial numbers or letters. It is possible that participants used the predictable nature of this street grid to assist with orientation. However, the data support the present claim that participants in the ABI group did not benefit from these potential prompts to the same extent as control participants; while a few participants with ABI reported using this strategy with cardinal directions, they did not always remember the layout accurately. Future research should also investigate the stability of these findings in other neighborhood designs.

The ability to navigate in one's community is central to independence [25,26]. Identifying the most efficacious format for providing directions to people with navigational challenges resulting from ABI is important for increasing community participation. It is hoped that the results of this study will spawn future investigations.

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Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Acquired Brain Injury (ABI) Group						Matched Control Group				
Age	Gender	Education Level*	ABI	ABI Onset (mos)	Psychiatric Diagnoses	Time in Eugene (mos)	<u>CLQT</u> Composite	Age	Gender	Education Level*
19	F	+ HS	seizure disorder	24	n/a	5	Mild	20	F	+ HS
22	М	- Coll	TBI, MVA	22	n/a	132	Mild	22	Μ	- Coll
23	М	+ HS	TBI, MVA	48	depression	228	Mild	22	М	+ HS
25	М	+ HS	TBI, MVA	90	depression	72	WNL	27	М	+ HS
28	F	- Coll	Surgery for brain CA	60	depression, ADD	12	WNL	31	F	- Coll
38	F	- Coll	TBI, MVA	200	depression	87	WNL	35	F	- Coll
44	F	+ Coll	anoxia	19	bipolar	16	WNL	45	F	+ Coll
45	М	- Coll	R CVA	4	depression	1	WNL	40	Μ	- Coll
48	М	- HS	TBI, MVA; epilepsy	408	depression	204	Mild	45	М	- HS
49	F	- Coll	TBI, MVA	120	depression	3	WNL	48	F	- Coll
51	М	- HS	aneurysm/ CVA	52	depression	180	WNL	44	М	- HS
53	М	+ HS	TBI, MVA	377	h/o EtOH	636	Moderate	50	Μ	+ HS
55	М	+ HS	syncope, ?anoxia	312	anger issues	84	Severe	52	М	+ HS
56	М	- Coll	TBI, assault	11	depression	492	Mild	53	Μ	- Coll
57	М	- Coll	L CVA	96	h/o drugs	336	Mild	65	Μ	- Coll
62	F	- Coll	TBI; surgery; seizures	480	schizophrenia	60	Moderate	58	F	- Coll
63	М	- Coll	Surgery for brain abcess	240	anger issues	120	Severe	63	М	- Coll
69	М	+ Grad	Surgery for brain CA	240	mild depression	360	Mild	65	М	+ Grad

Table 1. Description of participants in ABI and matched control groups.

*Education Levels: -HS (not completed high school), +HS (completed high school), -Coll (began college, but no degree), +Coll (completed bachelor's degree), +Grad (completed graduate school). Note. CLQT = Cognitive-Linguistic Quick Test

14

Type of Direction	Example			
Cardinal	Face south and walk down 6 th St			
	Turn right onto A St			
	End at the intersection of A St and 5 th St			
Landmark	Face the yellow house and walk towards it			
	Turn left onto C St			
	End at the intersection of C St and 5 th St			
Left/Right	Face B St and go left			
	Turn left onto 5 th St			
	End at the intersection of A St and 5 th St			

Table 2. Examples of the three types of written directions

Table 3. Orientation accuracy by group and type of direction

	Cardinal Directions	Left-Right Directions	Landmark Directions	
ABI group	1.29	1.60	1.86	
Mean (SD)	(0.93)	(0.74)	(0.48)	
Control group	1.90	1.89	1.97	
Mean (SD)	(0.38)	(0.36)	(0.24)	
Significance	t(142) = 5.18	t(142) = 3.00	<i>t</i> (142) = 1.75	
test	<i>ρ</i> = .000	p = .003	p = .082	
Effect size	<i>d</i> = 0.86	d = 0.50		

Note. n = 72 trials in each group

Table 4. Orientation directness by group and type of direction

	Cardinal Directions	Left-Right Directions	Landmark Directions	
ABI group	0.25	0.49	0.61	
Mean (SD)	(0.44)	(0.50)	(0.49)	
Control group	0.78	0.74	0.85	
Mean (SD)	(0.42)	(0.44)	(0.36)	
Significance	<i>t</i> (142) = 7.41	<i>t</i> (142) = 3.16	<i>t</i> (142) = 3.28	
test	<i>ρ</i> = .000	<i>ρ</i> = .002	<i>ρ</i> = .001	
Effect size	<i>d</i> = 1.23	<i>d</i> = 0.53	<i>d</i> = 0.56	

Note. n = 72 trials in each group

Stratogy	Cardinal Directions		Left/Right	Directions	Landmark Directions		
Strategy	ABI	Control	ABI	Control	ABI	Control	
	18	3	7	0	4	1	
Guess							
Use street grid or	38	34	17	8	11	9	
memory							
Follow type of	16	35	48	64	57	62	
direction							
χ^2 (signif)	$\chi^2(2) = 18.01, p = .000$		$\chi^2(2) = 12.53, p = .002$		$\chi^2(2) = 2.21, p = .331$		
η^2 (effect size)	$\eta^2 = 0.13$		$\eta^2 = 0.09$				

Table 5. Orientation strategy by group and type of direction

Note. n = 72 trials for each type of direction, per group