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AER Journal: Research and Practice in Visual Impairment and Blindness

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AER Journal: Research and Practice in Visual Impairment and Blindness

A quarterly journal in the field of education and rehabilitation of persons of all ages with low vision or blindness

AER Journal Welcomes Dr. Richard Long as Associate Editor

Richard G. Long, PhD, COMS, is the Associate Dean for the College of Health and Human Services at Western Michigan University, focusing on research and program development. He also holds the rank of professor in the Department of Blindness and Low Vision Studies at WMU. A native of Knoxville, Tennessee, Richard received a Master's degree in Rehabilitation Counseling from the University of Tennessee (1977) and a PhD in Special Education from Vanderbilt University (1985).

Since 1976, Richard has worked as a teacher, orientation and mobility specialist, counselor, program administrator, federal government researcher, and college professor. His focus during the last half of his career has been on the orientation and mobility of visually impaired individuals. A faculty member at WMU since 1998, Richard has been principal investigator of a large, multisite, NIH-supported research project focused on intersection design and the orientation and mobility of persons with blindness since 2000.

He has published many book chapters and articles in transportation engineering, human factors psychology, and rehabilitation journals, and co-authored the chapter on orientation and wayfinding for the third edition of *Foundations of Orientation and Mobility*, to be published in 2011 by the American Foundation for the Blind. Association for Education and Rehabilitation of the Blind and Visually Impaired

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Deafblindness creates challenges in communication, education and rehabilitation, as well as significant rewards. Professionals find there is only limited information in the research literature that applies to the work they do with people of all ages who are deafblind or who are losing both hearing and vision simultaneously due to their age. This issue aims to fill that gap.

Guest Editors:

Dr. Deborah Chen, PhD California State University, Northridge

Ms. Nancy O'Donnell, MA Helen Keller National Center

Manuscript submission deadline: January 31, 2010. Publication date: August 2010.

Visit www.aerbvi.org for submission information.

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1st prize: Free Registration to the AER International Conference 2010

2nd prize: One-Year AER Student Membership

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Submit your research paper today don't delay!

Guest Editors Announced for Summer 2010 Special Theme Issue! Graduate Students Invited to Submit Their Papers!

I could use this space to describe the excellent contents of this issue of the Journal. I do indeed urge you to discover the connections amongst the articles. The time has come however, to make two very important announcements.

The first announcement involves our special theme issue on working with people who are deafblind. I would like to welcome Dr. Deborah Chen and Ms. Nancy O'Donnell as co-editors of this theme issue. They have already done a stupendous job with invitations for submissions, and it looks highly likely that we will have several strong issues on the subject in the coming year. Deborah Chen, PhD, is a Professor in the Department of Special Education at California State University in Northridge where she coordinates and teaches in the Early Childhood Special Education program. She has extensive experience working with families and their children with sensory impairments and multiple disabilities as an early interventionist, teacher, program administrator, teacher trainer, and researcher. Dr. Chen has directed federally funded professional development and research-to-practice projects in working with families and children of diverse cultural and linguistic backgrounds, home-based early intervention, interdisciplinary training, caregiver-child interactions, and tactile communication strategies with children who are deafblind. Her publications reflect these professional efforts and interests.

Nancy O'Donnell is the Coordinator of Special Projects for the Helen Keller National Center. Ms. O'Donnell has a BA from Hofstra University in Speech Pathology and an MA from San Francisco State University's Deaf-Blind Education Program. She has worked with adults who are deafblind, their families, and professionals who serve them for 30 years. Her current projects include: research on congenital rubella syndrome; chairperson of Deafblind International's Rubella Network; collaboration with the Centers for Disease Control and Prevention on a research project investigating the development of a blood test that could diagnose congenital rubella syndrome in adults; Information Specialist for DB-LINK, the National Information Clearinghouse on Deaf-Blindness; management of the HKNC National Registry of Persons Who are Deaf-Blind; member of the Literacy Focus Group for the National Consortium on Deaf-Blindness; editing newsletters and promotional materials for the HKNC; and Special Advisor to the National Family Association for Deaf-Blind.

I would like to extend a warm welcome to both Dr. Chen and Ms. O'Donnell and thank them for the work they have done already, and all of the work to come.

My second announcement is very exciting: I want to promote our Journal as an excellent jumping-off point for graduate students hoping to publish their research. What are the advantages of submitting student work to AER Journal?

- In the early years of academic life, it is often very difficult to get one's work published. An established academic supervisor will often permit the participation of graduate students on publications with which the student has assisted, but the publishing of one's own work as a graduate student can be challenging. It is rare for peer-reviewed journals to encourage the publication of student research.
- Because the AER Journal is a new journal, established in 2008, there is a prime opportunity for students to submit their research papers as potentially publishable articles. As the Journal becomes better known, we may indeed have longer turnaround times but currently it takes only about 7 months to bring an article to publication, from the time of original submission.
- 3) Because many graduate students are training to work in the field, and therefore are likely to be AER members, they have the potential to be able to write on subjects of great interest to our readers, and to make an early contribution to the scholarly body of

work that is so very much needed and appreciated by our field of study and our association membership.

Now over one year old, the Journal is beginning to sit, crawl, and pull itself to standing. Soon it will be walking on strong legs, and I am glad I could be involved in its development. Thanks to all AER members who have supported us during the production of the first 6 issues... and to all those who will do so for those to come.

Until next time,

Yold.

Deborah Gold, PhD Editor-in-Chief

Audible Beaconing with Accessible Pedestrian Signals

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Abstract

Although accessible pedestrian signals often are assumed to provide wayfinding information, the type of accessible pedestrian signals that has typically been installed in the United States has not had positive effects on finding crosswalks, locating pushbuttons, or providing directional guidance. This article reports the results of research on crossings at complex signalized intersections by pedestrians who are blind, before and after the installation of accessible pedestrian signals with innovative audible beaconing features designed to improve wayfinding. Objective data on measures of street-crossing performance by 56 participants were obtained at four intersections, two each in Charlotte, North Carolina, and Portland, Oregon. In the first round of testing, accessible pedestrian signals with beaconing features resulted in only slightly improved wayfinding. Revisions to the audible beaconing features resulted in improved performance on four measures of wayfinding as compared with the preinstallation condition: beginning crossings within the crosswalk, ending crossings within the crosswalk, independence in finding the starting location, and independence in aligning to cross. Use of accessible pedestrian signals that provide beaconing from the far end of the crosswalk show promise of improving wayfinding at street crossings.

Keywords: orientation and mobility, wayfinding, street crossings, accessible pedestrian signals, audible beaconing

Introduction

Accessible or audible pedestrian signals (APS) have been installed around the world for many years. In some countries, such as Japan and the United

States, the audible indication has been provided from an overhead speaker aimed across the street. The speaker is typically mounted on the pedestrian signal head or walk/don't walk signal (pedhead) and this type of APS is called pedhead-mounted APS. They are intended to provide directional or wayfinding information to pedestrians during the crossing. In Australia, Sweden, and other countries, a different type of APS has been used that provides sounds

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from speakers at the pushbutton location. These pushbutton-integrated APS have not generally been expected to provide directional information during street crossings, although they include a locator tone that may help people find the crosswalk and home in on the opposite end of the crosswalk as they near it; the housing includes a tactile arrow that indicates the direction of the crossing actuated by the pushbutton.

Pedhead-mounted APS, as typically installed in the United States, Japan, and Canada, have not been found to provide good directional guidance (Bentzen, Barlow, & Franck, 2000; Carroll & Bentzen, 1999; Szeto, Valerio, & Novak, 1991; Uslan, Peck, & Waddell, 1988; Wall, Ashmead, Bentzen, & Barlow, 2004). Several researchers have evaluated modified pedhead-mounted APS, comparing simultaneous sounds provided from both ends of the crosswalk at the same time (typical installation), sounds alternating between ends of the crosswalk, and/or sound from only the far end of the crosswalk (Larouche, Leroux, Giguere, & Poirier, 2000; Poulsen, 1982; Stevens, 1993; Tauchi, Sawai, Takato, Yoshiura, & Takeuchi, 1998; Wall et al., 2004). Far-end-only signals resulted in more accurate crossings (Poulsen, 1982; Wall et al., 2004), as measured by deviation from a straight line while crossing. Results on alternating signals were mixed (Larouche et al., 2000; Stevens, 1993; Wall et al., 2004). A pushbutton locator tone during the last half of the crossing improved crossing accuracy at simulated crosswalks (Wall et al., 2004). These findings provided the basis for development of APS for this project.

This research is part of a multiyear project to examine the effectiveness of optimized APS for providing street-crossing information to pedestrians who are blind. In a preinstallation phase, data were collected in three cities. Pedestrians who are blind crossed at two complex signalized intersections in each city without accessible pedestrian signals. The findings confirmed that without accessible pedestrian signals, pedestrians who are blind have considerable difficulty independently locating crosswalks, aligning to cross, determining the onset of the walk interval, ending their crossing within the crosswalk, and completing crossings before the onset of traffic perpendicular to their path of travel at complex, unfamiliar, signalized intersections (Bentzen, Barlow, & Bond, 2004; Barlow, Bentzen, & Bond, 2005).

This article presents research on wayfinding and orientation task performance before and after

installation of pushbutton-integrated APS with audible beaconing features in two of these cities, Portland, Oregon, and Charlotte, North Carolina. The third city is not included in this analysis, because a different type of APS was installed there. Innovative audible beaconing features, providing tones for wayfinding from directional speakers, were successively refined and evaluated. Results related to crossing timing decisions before and after installation of APS were reported in a previous article (Scott, Barlow, Bentzen, Bond, & Gubbe, 2008).

Methods

Overview

In each city, each participant traveled four short routes, each requiring two or three crossings, for a total of nine crossings at the two intersections. In preinstallation testing in Portland, visual pedestrian signals were present for all crossings, with pushbuttons for five of the nine crossings. Postinstallation, pushbutton-integrated APS were installed at seven crossings, with audible beaconing signals installed at four of those crossings. In preinstallation testing in Charlotte, visual pedestrian signals were present for eight of the nine crossings, with pushbuttons for four of those crossings. Postinstallation, pushbuttonintegrated APS were installed at eight of the nine crossings, with audible beaconing installed at four of those crossings. Data were collected for several variables associated with each crossing subtask.

This article reports only the wayfinding results associated with those crossings where audible beaconing features were installed. These were the crossings at which participants who are blind were observed to have the most difficulty with one or more of the wayfinding tasks measured during the preinstallation testing.

Materials

Intersections

Intersection geometry can be seen in Figure 1. The intersections were chosen in consultation with city staff as examples of intersections with complex signal phasing or geometry. This article focuses on crosswalks 1, 5, and 7 in Portland and crosswalks 6, 7, and 9 in Charlotte. On some crosswalks, participants crossed in two directions on the same



Figure 1. Intersection diagrams, Portland (A, B) and Charlotte (C, D). This article reports wayfinding results for crosswalks 1, 5, and 7 in Portland and 6, 7, and 9 in Charlotte.

crosswalk, depending on the intersection and route, and those are referred to in the results as different crossings. APS with beaconing features were added at these crossings without any change to intersection geometry or curb ramps, although new poles for the APS were added in some locations. If possible, the APS pushbutton was installed on the side of the crossing farthest from the center of the intersection; pole locations are shown on Figure 1. Beaconing speakers were installed on top of the visual pedestrian signals and aimed at the center of the crosswalk. Signal timing was the same both pre- and postinstallation and met the requirements of the *Manual on Uniform Traffic Control Devices* (2003).



Figure 2. APS installation: left, pushbutton unit with integrated speaker; right, beaconing speaker on top of pedestrian signal head.

APS Devices

All of the APS were pushbutton-integrated, having pushbutton locator tones that repeated once per second and tactile arrows that vibrated during the audible walk indications and were oriented in the direction of the crossing. Volume of the pushbutton speaker was adjusted carefully so the locator tone and walk signal were normally audible within 6 to 12 feet of the pushbutton. On this type of APS, volume adjusts continuously in response to ambient sound levels and usually fluctuated between 30 and 80 decibels. In Portland, the audible walk signal was a rapid tick (approximately 10 times per second). In Charlotte, the walk indication was a speech message, followed by the rapid tick (e.g., "Kings, Walk sign is on to cross Kings, tick, tick, tick, tick."). An additional speaker was attached to the pedestrian signal head to provide the audible beaconing (see Figure 2).

In round 1, postinstallation, the audible beaconing was provided simultaneously from pedhead-mounted speakers at both ends of the crosswalk and was actuated by a pedestrian request (i.e., holding the pushbutton in for more than 3 seconds [Portland] or more than 1 second [Charlotte]). In Portland, when audible beaconing was actuated, both the walk tone and the locator tone during the next pedestrian phase (during the walk and flashing don't walk signals) were elevated to a maximum volume (89 decibels) from speakers aimed toward the center of the crosswalk. The louder sounds came from the pedhead-mounted speakers only; the pushbutton speakers were silent during the pedestrian phase if audible beaconing was actuated.

In Charlotte, there were two postinstallation rounds of data collection with somewhat different beaconing features. In postinstallation round 1 (Post-1), the walk indication and locator tone at elevated volume came simultaneously from pedhead-mounted speakers at both ends of the crosswalk, with the sounds also provided at normal (relatively quiet) volume from the pushbutton speakers. In Charlotte postinstallation round 2 (Post-2), the software and wiring of APS were modified to add other features. When audible beaconing was called, volume at the pedestrian's starting location was not increased, but

the locator tone was provided at maximum volume (110 decibels) during the subsequent flashing don't walk from the pedhead-mounted speaker on the end of the crosswalk opposite the location where the pushbutton was held (far end). Far-end beaconing is technically more difficult, requiring additional wiring and controller modifications. Walk indications and locator tones were provided at normal volume (ambient-sound responsive) from the pushbutton speakers at both ends of the crosswalk. Immediately after the extended button press during the flashing walk or don't walk signal, a pushbutton information message provided street names. This was followed by an "orientation tone"-seven repetitions of the locator tone at maximum volume from the pedheadmounted speaker at the far end of the crosswalk.

Participants

Sixteen individuals who reported their visual acuity as either no light perception or light perception only participated in each test phase. During the postinstallation testing sessions, half of the participants in each city were new to the study, and the other half had participated in an earlier testing session. This allowed practice effects to be evaluated as the cause of observed improvements and provided an adequate sample size from a limited population. There were a total of 56 different participants in these two cities. All participants were accustomed to crossing independently at signalized intersections using a long cane or dog guide and were unfamiliar with the intersections used in the study. Participant demographics were similar for the various testing phases and were similar across the two cities. Overall, 30 men and 26 women participated; ages ranged from 20 to 78 years, and mean ages for each testing session ranged between 44 and 48 years. In each 16-person group, 11 to 14 participants used a long cane and others used dog guides.

Procedure

Participants were tested individually for approximately 1.5 hours and traveled two routes at each intersection within their city. Order of intersections and routes was varied systematically. Guided approaches to all routes avoided the experimental crossings, thus avoiding learning immediately prior to each trial. Participants were accompanied at all times by an orientation and mobility (O&M) specialist who communicated instructions and was responsible for participant safety. Another researcher recorded observations and measured response times using a digital stopwatch.

At the beginning of all routes, participants were asked to assume that they needed to get to the other side of the intersection for an appointment. They were instructed to "cross the street in front of you, the perpendicular street, then cross the street beside you, the parallel street," using their usual travel aid and techniques to accomplish the task. They could request assistance from the researcher with all or any part of the crossing task, except the use of the APS, if they would typically request assistance from another pedestrian. The researcher immediately provided requested assistance with any crossing subtask (locating the pushbutton, locating the crosswalk, aligning to cross, determining when to start crossing) or with the entire crossing.

While participants were locating the crosswalk and aligning, researchers only intervened when the starting location and alignment would result in participants crossing the wrong street or at a clearly hazardous location or direction. Intervention occurred when starting crossing or while crossing the street only when participants were in, or stepping into, the path of moving vehicles. No information about the intersections was provided to the participants. Prior to preinstallation testing, participants were told that some crossings would have pushbuttons. Prior to postinstallation trials. participants were told that APS had been installed at each intersection but might not be installed for each crossing. Participants were thus unaware of which crossings would have pushbuttons or APS available. They were shown a demonstration model of the APS pushbutton and were told that where APS were installed, pushbuttons would have pushbutton locator tones, tactile arrows, and audible and vibrotactile walk indications, and the features were described. Participants were told that if they held the pushbuttons in and heard a confirmation tone or message, audible beaconing would be provided, and the beaconing feature was described. Finally, participants heard a recording of the locator tone, confirmation tone or message, and walk indication and were invited to ask questions. For the Post-2 installation, pilot testing indicated the need for on-site familiarization, so participants were familiarized with the pushbutton information message, the orientation tone, and the

	Por	tland	Charlotte		
	Preinstall	Postinstall	Preinstall	Postinstall Round 1	
Started within crosswalk	79.2	100.0***	72.4	78.8	
Found starting location					
independently	93.8	100.0	82.8	96.2	
Started correctly aligned	68.8	81.0	51.0	48.5	
Aligned independently	94.3	100.0	68.2	75.6	
Ended within crosswalk	51.6	75.6	23.2	48.7	
Crossed independently	77.6	82.1	78.0	82.1	

 Table 1. Comparison of Average Wayfinding Results between Pre- and Post-APS Installation for Four

 Crossings in Each City^a

^a All numbers reported are percentages reflecting the average percentage of four crossings each individual performed in the stated manner. The number of participants included in each analysis fluctuated some as a result of using only trials in which beaconing was actuated and participant task completion was independent. The total sample size (N) for the various analyses ranged between 27 and 30.

*** p < .001.

walk indications and beaconing locator tones at a crossing that was not on the experimental routes.

Results

General

The results reported here are restricted to wayfinding measures (and the associated measures of independence) for only those crossings at which audible beaconing features were installed. Measures of wayfinding included starting within the crosswalk, starting from an aligned position, and ending within the crosswalk, as well as independence in each of these tasks. Independence was measured by requests for assistance or the need for intervention on each task (see Table 1). Additional results, including those related to timing measures, have been reported elsewhere (Scott et al., 2008).

Only data that were collected during independent travel were used in analysis, so appropriate pre- and postinstallation comparisons could be made. This results in a small to moderate amount of missing data for nearly all variables in the data set (e.g., where participants ended their crossings was not recorded if they required an intervention during the course of the crossing; alignment was not recorded if assistance was requested and provided in aligning to cross). To compute inferential statistics and evaluate changes in

performance, percentages were calculated as follows. For each variable (e.g., started within the crosswalk) a percentage was calculated for each participant (e.g., based on how many of the crossings were begun from within the crosswalk). Because percentages were calculated across multiple trials by each participant, despite rates of use around 50 percent, most participants were still included in each analysis as they may have had two or three usable trials and one that was not usable due to not using the beaconing or an intervention. An average of all participants' percentages was then calculated for each city by condition. For the postinstallation data, the average was calculated using only the trials in which the beaconing feature was activated by use of an extended button press. In Portland, the beaconing was activated on approximately 50 percent of the crossings. In the first round of postinstallation testing in Charlotte, the use rate was 48 percent, whereas the rate of use was 98 percent during the second round of postinstallation testing.

Study 1: Preinstallation versus Postinstallation-1 (Simultaneous Tones from Both Ends of the Crosswalk)

Independent *t* tests between new and returning participants were performed for each variable on

	Preinstall	Post-2	Post-1	Post-2
Started within crosswalk	72.4	91.7**	78.8	91.7
Independently found starting position	82.8	96.9*	96.2	96.9
Started correctly aligned	51.0	64.6	48.5	64.6
Independently aligned	68.2	98.4***	75.6	98.4*
Ended within crosswalk	23.2	76.7***	48.7	76.7
Independently crossed	78.0	73.4	82.1	73.4

Table 2. Charlotte—Comparison of Average Results between Preinstallation and Post-2 and between Post-1 and Post-2^a

^a All numbers reported are percentages reflecting the average percentage of the four crossings across all participants that each individual performed in the stated manner. The number of participants included in each analysis fluctuated some as a result of using only trials in which beaconing was actuated and participant task completion was independent. The total sample size (N) for the various analyses thus ranged between 27 and 32.

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

postinstallation data. These tests compared the average posttest percentage scores of participants who completed both pre- and posttest with those who completed only the posttest. Returning participants did not differ from new participants, thus there was no evidence of learning resulting from participation in preinstallation testing. Therefore, the data from the two groups were combined, and inferential statistics were computed with between-subjects analyses (N = 32).

Wayfinding Measures

In Portland, there was significant improvement in the rate of starting within the crosswalk (t[28] =4.093, p < .001), and a trend toward increased ending within the crosswalk (t[27]=1.824, p = .079). Other wayfinding measures in Portland, and all wayfinding measures in Charlotte (Post-1) revealed no significant change in pedestrian behavior after APS installation. Thus, APS installation resulted in only slightly improved wayfinding and no negative effect on performance.

Audible Beaconing—Round 1

On only half of the crossings, participants who used the beaconing-enabled pushbuttons chose to activate the beaconing. The simultaneous beaconing signal, even with the beaconing locator tone during the flashing don't walk, did not significantly assist participants in finding the correct destination, although there was an increase in mean percentages. In Portland, participants finished, on average, 76 percent of their beaconing-actuated crossings within the crosswalk, whereas the average of finished crossings was 70 percent when the pushbutton was used but beaconing was not activated. In Charlotte, 48 percent of crossings ended within the crosswalk when beaconing was called, as compared with 39 percent without the beaconing.

Study 2: The Effect of Additional Beaconing Features on Measures of Wayfinding in Charlotte

Additional beaconing features were implemented between the two postinstallation tests in Charlotte in an attempt to improve wayfinding. Half of the participants in postinstallation testing had participated in one or both of the previous testing sessions; however, statistical analysis again revealed no evidence of practice effects or learning. Thus, the groups were combined for all analyses (N = 32).

The APS used during Post-2 did result in significantly improved performance on four measures of wayfinding as compared with the preinstallation condition (see Table 2). Participants began and ended a greater percentage of crossings within the crosswalk (t[30] = 2.819, p < .01 and t[27] = 4.321, p < .001, respectively). There was also increased independence with respect to both finding the starting location and aligning to cross (t[30] = 2.236, p < .05 and t[30] = 4.698, p < .001, respectively). Despite the increased independence

aligning to cross, rates of accurate alignment remained low (65 percent). Successfully ending within the crosswalk was thus often due to course corrections during crossing, after having started misaligned.

Compared with Post-1 performance, the Post-2 feature changes installed in Charlotte led to one additional improvement in participant wayfinding performance (see Table 2). There was a significant increase in independence aligning to the crosswalk (t[27] = 2.391, p < .05), although accurate alignment remained poor. Note that the intersection where beaconing was installed in Charlotte was a skewed intersection with conflicting vehicular cues; stop lines and idling perpendicular traffic were not parallel to the crosswalk. Following the introduction of new beaconing features for Post-2, ending within the crosswalk increased considerably, from 49 to 77 percent, a trend toward significant improvement (t[26] = 1.890, p = .070). Although there was no significant change in independently finding the starting position or starting within the crosswalk, the independent task performance was already quite high during Post-1 and remained high during Post-2.

In Post-2, the beaconing feature was actuated on nearly every crossing (62 of 64), whereas it had been actuated on only half of the crossings in Post-1. This change in participant behavior may have been attributable to either, or both, the hands-on familiarization with device features in Post-2 versus just hearing a recording of device features in Post-1 or it may be that participants perceived the additional features in Post-2 as helpful and were highly motivated to actuate them.

Discussion and Conclusions

Across the two cities, and at all locations where APS were installed, data showed numerous improvements in safety and independence and no negative impacts of APS installation. The addition of APS resulted in a nearly 2-second overall reduction in starting delay across the two cities (Scott et al., 2008).

During postinstallation in Portland, APS resulted in significant improvement in crossings started within the crosswalk, which was probably related to the pushbutton locator tone. One crosswalk (no. 1) was offset from the corner, and participants were more

likely to find the pushbutton, and the correct starting location, postinstallation. Researcher observations and participant comments indicated that when the audible beaconing was called, it was quite difficult to hear the walk indication at the starting location, because the sounds only came from the overhead speakers on both ends of the crosswalk and were aimed at the center of the crossing. In addition, the audible beaconing, provided by the louder locator tone throughout the flashing don't walk, did not seem to improve "ending within the crosswalk," as researchers had expected.

Results of the Portland testing were used to refine the technology and its operation for the first round of posttests in Charlotte. In Charlotte Post-1, audible beaconing was modified to provide audible walk indications from both pushbutton speakers and overhead speakers, rather than from just overhead speakers as in Portland. In addition, the length of the button press required to call the beaconing signal was shortened, because some individuals were observed to attempt to call the audible beaconing but did not hold the button for 3 full seconds. Research had meanwhile determined that a 1-second button press is adequate to prevent unintended calling of the beaconing by the general public (Noyce & Bentzen, 2005). Despite these changes, results were similar to those in Portland, without any real improvement in "ending within the crosswalk"; less than 50 percent of crossings were completed within the crosswalk.

There was also no improvement in starting within the crosswalk in Charlotte. Pushbuttons were almost 10 feet from the edge of the street on three of the four crossings, and as participants moved to the curb line after pushing the button, it seemed they used stopped traffic and curb alignment to decide where to begin crossing, which put them outside the crosswalk area. Although the pushbutton locator tone may have helped participants find the pushbutton in Post-1, it did not lead to improved "starting within the crosswalk," as was seen in Portland.

Generally, Post-1 showed that providing louder walk indications and pushbutton locator tones simultaneously from both ends of the crosswalk did not improve wayfinding. This was corroborated by concurrent research that evaluated a combination pedhead-mounted and pushbutton-integrated APS unit and an APS with the option of increased volume of the locator tone from the pushbutton-integrated

speaker, among others (Bentzen, Scott, & Barlow, 2006; Harkey et al., 2007).

In Charlotte Post-2, beaconing features were modified further in response to previous results and participant suggestions. Audible beaconing was provided only from the far-end speaker, and an orientation tone was added. These modifications resulted in faster crossing initiations (preinstallation, 8.2-second average starting delay; Post-1, 3.7 seconds; Post-2, 2.3 seconds) and a considerable increase in the percentage of crossings ending within the crosswalk, from 23 to 77 percent. Although the orientation tone may have led to somewhat improved understanding of ending location and produced increased alignment independence, rates of accurate alignment remained relatively poor (64 percent).

Pushbutton information messages (street names) from the pushbutton speaker were followed by seven repetitions of the orientation tone from the far end of the crosswalk, during which participants could confirm the location of the opposite end of the crosswalk. Researchers observed that participants would sometimes align toward the orientation tone, then move up to the edge of the street. The improvement in starting within the crosswalk might be related to participants using the orientation tone as a clue to the correct direction to walk from the pushbutton toward the edge of the street.

Data on their alignment were recorded just before participants started to cross. Participants often realigned while waiting to cross, listening to perpendicular traffic, which seemed to result in poor alignment at the point when data were recorded. The effect of the beaconing locator tone from the far end of the crosswalk in Charlotte was obvious as participants initiated their crossings. Participants often were observed to correct misalignment upon hearing the loud locator tone from the other end of the crosswalk as they began their crossing. Subjective responses to the Post-2 audible beaconing were exciting. Several participants stated that they wanted the feature installed everywhere, because it would help them cross at complex or skewed intersections.

Because the beaconing was provided by the farend pushbutton locator tone, rather than louder walk indications, the potential for hearing walk indications from the wrong crosswalk was minimized or eliminated. Audible beaconing had not been recommended previously at locations with channelized right turn lanes, split phasing, and other similar situations due to the researchers' concerns that there might sometimes be ambiguity regarding which crosswalk was being signaled if pedestrians who are visually impaired heard a loud walk signal for a different crossing. More evaluation is needed at those types of locations, but researchers were encouraged by the lack of ambiguity of the beaconing in Post-2 testing.

These results are quite promising, although they are related to crossings at only one intersection, but it is an intersection with very difficult, long, skewed crossings with confusing traffic cues for travelers who are blind (see Figure 1). At this location, the walk signal was only 4 seconds long, so participants heard the far-end locator tone very soon after they began to cross. A longer walk indication would delay the onset of audible beaconing and might make it less successful, because pedestrians would have more time to have veered from the crosswalk area and might not be able to hear the audible beaconing. Alternatively, pedestrians might wait at the curb until they heard the loud locator tone, thus delaying their crossing.

Implications for Practice

The results of this research indicate that although APS provide information about the status of the pedestrian signal, APS generally do not provide good wayfinding information, particularly when sound is presented simultaneously from both ends of crosswalk. O&M specialists and individuals who are blind need to understand that there is little or no improvement gained by installing loud signals unless they provide effective audible beaconing. They also need to understand the issues involved in audible beaconing in order to effectively advocate for beaconing where needed.

It may be possible to provide effective directional information from far-end speakers, but more research is needed in various situations to confirm results found in this study. More evaluation is planned at smaller intersections, with different walk indication lengths and where the intersection is more confined by nearby structures.

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Original Research

Comparing Two Fonts for Signage Accessibility in a Train Station

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Abstract

Legibility of two fonts (Tiresias Signfont and FF Transit Front Neg Normal) was compared. Selected intercity transit commuters and station passersby were asked to read signs in the two fonts and font sizes. The visual acuities of participants were measured using Bailey-Lovie charts from a distance of 3 meters. Distances from which the signs were read correctly were recorded. The Tiresias messages were reduced proportionately to meet the standard 23-character line length requirement, taking up the same horizontal length as Transit but using less vertical space. As the result, the cap height of the letters in Tiresias was smaller as compared with the cap height in Transit. The signs in Transit in a larger font size had slightly farther, but significant, mean distances for reading as compared with the signs in adjusted Tiresias. If Tiresias had the same cap height as Transit, the viewing angle would have been the same, and the Tiresias signs would presumably have been readable from an even farther distance. Tiresias was recommended to the transit company for new signs.

Keywords: signage, typeface, legibility, accessibility, wayfinding

Introduction

In recent years, universal design has been accepted as an ideal in the planning and implementation of environmental modifications to increase accessibility for people with disabilities. Universal design has generally had a positive impact on accessibility and, at the very least, has provided a useful conceptual framework for envisioning environmental design that follows an inclusive philosophy (Arditi & Brabyn, 2000). Developments in orientation and wayfinding technology originally intended to benefit people with permanent vision loss also may benefit others who simply need more clear signage now than in the past. Moreover, it is recommended that signs in public environments have adequate size, contrast, and typography to be readable by the maximum possible number of travelers (Arditi & Brabyn).

With the aging of the baby boom generation, senior citizens and people with vision loss are both growing segments of the ridership for many transit systems. They are also among the riders who may be the most transit dependent. Therefore, all aspects of wayfinding design must serve to communicate the intended message clearly and effectively within the environment in which they are placed and to the

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intended viewer (McGorman, 2005). The form of the message is concerned not only with aesthetics but also with key information-processing aspects. According to Arthur and Passini (2002),

Architects and graphic designers have tended to see the users of their settings as a stereotyped, physically fit, attentive individual, with only one preoccupation—to explore and enjoy the setting they have created. The reality, however, is quite different. Many users have impairments in respect to perception, cognition, and mobility (physical behavior), which affect their wayfinding abilities. (p. 62)

According to these authors, because designers have not typically seen the intended viewers as having a variety of viewing needs, signage has been inaccessible until recently. Thus, barriers are created by designers who are not thinking about the numbers of people with vision impairments who need to be able to read their signs (Arthur & Passini, 2002). Difficulties caused by the inability to find one's way because signs have not been designed to be as accessible as possible may be of such magnitude that the person with vision loss decides not to use these settings at all. In other words, inaccessible environments may contribute to social exclusion and isolation, as well as increasing costs to society.

It seems that little research has been done on typefaces for signage for public spaces. The majority of published research on the legibility of typefaces appears to be in the area of the print accessibility of public documents (Russell-Minda et al., 2007). In addition, research has been conducted on highway signage font design (Garvey, Pietrucha, & Meeker, 1998), road guide signs (Garvey et al., 2004), and typefaces for airport signs (Waller, 2007). In general, the amount of research on signage in public places is still limited, and its focus is not on readability but on graphic design.

Existing research on print accessibility suggests that for the most part, increasing the accessibility of signs through visual means involves simply making the text more legible. This usually is accomplished by increasing the text size and improving lighting, but manipulating other typographical features also can affect legibility and accessibility (Arditi, 1996). If the size of the sign is limited by spatial or economic constraints, typography is especially important. Factors found to have a significant impact on legibility are letter spacing, proportionality of spacing, stroke width, letter aspect ratio, interior "ink" within strokes, and contrast (Arditi & Brabyn, 2000). Also, italics, slanted fonts, and decorative and ornate styles are all found to be less legible than are standard styles (Arditi & Brabyn).

Toronto's Union Station accommodates approximately 160,000 regional rail commuters and nearly 11,000 regional bus travelers who pass through the station each day (Wyatt & Hope, 2007). The original station was equipped with four sets of stairs between each passengers' platform and the Centre Concourse. Over the years, additional stairs have been added to further increase vertical access capacity (Wyatt & Hope). These additional routes linked rail service to the various distribution paths taking passengers to and from their downtown destinations, but created a new challenge for the design and use of static and wayfinding signs. Government of Ontario (GO) Transit (southern Ontario's intercity transit system) and VIA Rail (Canada's passenger rail system) created new sign standards for their respective user areas. These signs were based on brand awareness and stakeholder operational need. The problems were compounded further by inadequate lighting in many locations and the addition of retail and advertising signs, the numbers of which increased in uncontrolled fashion (Wyatt & Hope). As a result, the site has become dysfunctional and confusing. In order to address these issues, the new wayfinding program was developed to anticipate the needs of all users in all operational scenarios. The purpose of the program was to ensure that the new wayfinding solution becomes an integral part of the planned architectural functionality of the site and not a stand-alone solution to existing problems (Wyatt & Hope).

With the idea of increasing accessibility for all GO Transit passengers using Union Station, GO Transit and the project management company for the new station, HDI Joint Venture, approached the researchers to conduct a study on signage font legibility for use in Union Station, the central station of Toronto. Union Station is a historic building with many redesign challenges for the project management company. The research team conducted two consecutive studies. This article presents the results of the second study, conducted in October 2007. In the first study (March 2007), previously published as an international conference paper, the research team compared five preselected font types (FF Transit Front Neg Normal, Verdana, ClearviewHwy, Tiresias Signfont, and Swis721BT) with participants with low vision, most of whom were Canadian National Institute for the Blind (CNIB) clients (Zuvela, Gold, Ineson, Hope, & MacDonald, 2008). Tiresias Signfont was selected by 59 percent of participants as their preferred font. Only 1 percent of participants chose FF Transit Front Neg Normal as their preferred font (Zuvela et al.).

Study Objective

The primary objective of this study was to compare legibility of two different sets of test signs, in two different fonts and font sizes. The compared fonts were Transit and Tiresias. The selection of the fonts was based on the following criteria:

- Transit is currently in use by the GO Transit Signage Department. Even though it did not perform well in the first sign-font study by the authors, it was felt by GO signage managers that it could not be replaced easily by another typeface selection. As McGorman (2007) stated, the Transit typeface font was designed in 1997 for "use in signage systems with an emphasis on legibility and practicality from a sign design and fabrication perspective" (p. 10). It is the font used in most transit systems in Germany. Its major advantage includes narrower, well-defined letter shapes with ample spacing. Accordingly, this font occupies less horizontal space without loss of legibility, which is important for creating bilingual signage, often a requirement in Canada. Transit was the most legible typeface examined in the GO Transit Typeface Review of 2006 (McGorman, 2007). A known problem with Transit is that there are no cross bars on the uppercase "I," making it almost identical to the lowercase "I." In addition, this font is not as well supported by research data as Tiresias is (McGorman)
- Tiresias was designed explicitly to provide increased legibility for sign messages for people living with vision loss. Tiresias was created by the Royal National Institute for the Blind to provide maximum effectiveness for

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messaging for people living with low vision. According to McGorman (2007), "this typeface is already established to be superior in terms of readability by people with low vision and, by logical extension, by people with normal vision under adverse or less optimal conditions" (p. 9). Its major advantages include clear differentiation between capital "I" and lowercase "I," a minimum of easily confused characters, and wider letters and ample spacing (McGorman). At the same time, wide letters and open letter spacing mean that this font occupies a lot of horizontal space, which may require reducing letter height in order to fit messages into constrained spaces. Based on the results of the first study on signage conducted by the authors, Tiresias appeared to have distinct advantages for people with a variety of vision levels

Methods

In compliance with the objective of this study to compare legibility of two different sets of test signs, in two different fonts and font sizes, a simple experimental research design to test the most accessible sign typeface was developed. A walkway space (Bay St. East Teamway*) at the Union Station was set up as a series of four corridors of equal length (8 meters). The Bay St. East Teamway is an access point to GO trains and buses, located on the east side of Bay Street across from the main Union Station building, just south of Front Street, Toronto, Canada. Figure 1 presents one of the corridors.

Each corridor had two sign mock-ups (one each in English and French) with white lettering on a black background (to copy the intended look of the eventual real signs). To the left of the two sign mock-ups was an instruction sign with black lettering on a white background. Figure 2 shows the test signs in English.

This sign had one message with a combination of letters and numbers. HDI Joint Venture designed the content of the signs to simulate actual GO Transit signage. The text for the signs was selected by the staff of the project management company to be similar but not the same in both fonts, so participants would not memorize wording from one testing

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Figure 1. A testing corridor with a participant reading the signs.

corridor to the next. Signs were hung from pipe and draped at the end of each corridor so that the top of each sign was 2,300 millimeters off the floor surface. All test signs were in both English and French. All signs were constructed by the same shop at the same time, and there was no difference in ink thickness. The floor was marked in exact intervals of 250 millimeters, starting from 750 millimeters to 7 meters away from the sign. Although exact lighting measurements were not taken, the researchers noted lighting differences within the setting, because two corridors were closer to a windowed wall and two were closer to a cement wall (slightly darker or shaded area). In an attempt to ensure that both typefaces were read under similar conditions by at least half of the participants, the signs in one set of corridors were switched midway through the study with the signs in the other set of corridors.

Two additional corridors of shorter length were set up for assessing participants' binocular visual acuity. The visual acuity was noted (prior to the sign reading exercises) from a distance of 3 meters by using Bailey-Lovie charts (1976). The Bailey-Lovie chart was selected as the best option for a quick binocular assessment of people's visual acuity; it is a visual acuity chart with letter sizes ranging from 6/60 (20/ 200) to 6/3 (20/10) in 14 rows of five letters each. Each row has letters that are approximately fourfifths the size of the next larger letters, and the letters in each row have approximately the same legibility $(\pm 10 \text{ percent})$. Participants with spectacles were asked if they were willing to remove their eyeglasses in order to assess the legibility of the signs with the widest possible range of seeing abilities (acuities). Of the total sample, approximately half (52.6 percent) were wearing glasses when they checked in to participate. Of these, 51 percent agreed to take off their glasses for the duration of the study protocol.

Participants were paired with a trained volunteer data collector who guided them through the study. Volunteers were trained in small groups at the beginning of each day of signage testing. Volunteers

Tiresias

87.37 points 22.375

English Sample 1

Turn left at the next block

- The train will stop at:
- . Wilson
- . Bradford
- . Eglinton

Call Customer Service at: (647) 681 3057

It is your responsibility to have proof of payment (ticket or pass) in your possession while on trains, train platforms and buses.

Failure to provide proof of payment (ticket or pass) upon request may result in a fine.

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Transit 101points, 25mm

English Sample 2

Turn right at the next door

The train will stop at:

- . Islington
- . Weston
- . Brantford

Call Customer Service at: (647) 861 7350

It is your responsibility to have proof of payment (ticket or pass) in your possession while on trains, train platforms and buses.

Failure to provide proof of payment (ticket or pass) upon request may result in a fine.

Figure 2. Test signs with white letters on a black background.

had the responsibility of recording the responses on a data reporting form. Volunteers were not responsible for giving instructions, because all instructions were on the instruction signs. Upon entering each corridor, volunteers asked participants to stand on the line marking 7 meters (first line upon entering and farthest from the signs). Participants were asked to read signs in a random order (two font sizes for each typeface). If participants were able to read the entire test sign out loud correctly, then the volunteer would mark down 7 meters on the predesigned data collection form. If the participant could not read the sign in full but could read numbers only, this distance was noted, and they were asked to move forward line by line, until the entire sign could be read aloud correctly. Data collectors noted this distance.

The signs developed for the study had fonts sized to the recommended minimum sizes of 20 millimeters (smaller signs) and 25 millimeters (larger signs) (CNIB, 1998). During the development of these signs, GO Transit's Signage Department identified that the horizontal length of signs is a limiting factor at a number of locations. To compensate for the fact that Tiresias occupies more horizontal space for a set number of characters, a standard 23-character line of text was set in Transit and used to determine the length of the line for both fonts. The Tiresias messages were reduced proportionately to meet this length requirement, taking up the same horizontal length but using less vertical space due to the proportional reduction. For the "larger" 25-millimeter letter height sign, Tiresias was reduced approximately 11 percent. As a result,

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	Total Sample	English	French
Tiresias words/letters	6.08	6.10	5.91
Transit words/letters	6.12	6.13	6.03
Tiresias numbers	6.06	6.01	5.91
Transit numbers	6.11	6.12	6.02

Table 1. Mean Viewing Distance (in Meters)—Larger Font Size

- Tiresias's cap height was 22.37 millimeters, whereas Transit's was 25 millimeters
- Tiresias's lowercase ascender was 23.74 millimeters, whereas Transit's was 26.75 millimeters

For the "smaller" 20-millimeter letter height, Tiresias was reduced approximately 5 percent. Consequently,

- Tiresias's cap height was 19 millimeters, whereas Transit's was 20 millimeters
- Tiresias's lowercase ascender was 20.31 millimeters, whereas Transit's was 21.43 millimeters

Participants

A convenience sample of GO Transit commuters, passersby, and local office workers age 18 and over was asked to walk through the study over 3 days. In order to recruit study participants, researchers and research assistants who were volunteers or CNIB staff randomly approached individuals at or near the Union Station, the Bay St. East Teamway walkway space, and the local streets. These potential participants had the study described to them and were asked if they would be willing to take part in the study. They were informed that the testing would take about 20 minutes. A \$5 (CAN) coffee chain gift certificate was offered to each participant.

A total of 361 individuals participated in the study. In terms of demographics, 51.5 percent of participants were men and 48.5 percent were women. Of the participants, 326 read the signs in English and 35 read the signs in French. Almost 60 percent of participants were categorized as having "normal" vision (binocular visual acuity 20/20 or better); 31 percent were participants whose vision can not be categorized as normal, but it is better than low vision (binocular visual acuity 20/25 to 20/60); and 10 percent were participants with low vision (binocular visual acuity 20/60 and worse). The majority of the participants (92 percent) were in the 18 to 57 age group, whereas 8 percent were age 57 and older.

Data Analysis

The quantitative data from the questionnaire were analyzed using Statistical Package for the Social Sciences (SPSS version 12 for Windows; SPSS, Inc., Chicago, IL). Frequency and percentage analyses were conducted, and the mean viewing distances for the signs in both fonts and both font sizes were calculated. Furthermore, paired-sample t tests were performed in order to test whether the differences in mean viewing distances for the two fonts were statistically significant.

Results

Reading Signs from a Distance

The mean viewing distances for the 25-millimeter (larger) font size signs were determined. Table 1 shows the mean viewing distance for the larger font size signs in Transit and reduced Tiresias. The distance is presented in meters.

Differences in mean viewing distance for the two fonts were compared. The results revealed that participants were able to read the larger font size signs in Transit from a greater distance than signs in reduced Tiresias (for words: t = 2.059, $p \le .05$; for numbers, t = 2.709, $p \le .05$). The same pattern occurred both for participants who read the English signs and those who read the French signs. However, because Tiresias signs in the larger font size were reduced approximately 11 percent to meet the length requirements, the following has to be considered:

• The cap height of the letters in Tiresias was lower than the cap height in Transit (22.37 millimeters as compared with 25 millimeters)

	Total Sample	English	French
Tiresias words/letters	5.91	5.93	5.74
Transit words/letters	5.91	5.93	5.75
Tiresias numbers	5.89	5.91	5.74
Transit numbers	5.88	5.89	5.72

Table 2. Mean Viewing Distance (in Meters)—Smaller Font Size

- Because Tiresias cap height was lower, the actual sign surface area occupied by this signfont was smaller (printed matter took up less space on the sign than did Transit printed matter). Vertical surface area for the Transit in the larger font size was 3,724 centimeters squared (78.4 centimeters \times 47.5 centimeters), whereas for the Tiresias sign it was 3,344 centimeters squared (70.4 centimeters) \times 47.5 centimeters)
- Space between paragraphs in the larger font size was 5.9 centimeters for the Transit sign and 5.3 centimeters for the Tiresias sign
- Space between lines for the Transit sign in the larger font size was 1.7 centimeters, whereas for the Tiresias sign it was 1.5 centimeters
- Space between words for the Transit sign in the larger font size was 1.5 centimeters, whereas for the Tiresias sign it was 1.4 centimeters
- The lower cap height in Tiresias resulted in a smaller viewing angle

The results for the mean viewing distances for the 20-millimeter (smaller) font size signs indicated that words were visible from 5.91 meters both for the Transit and the reduced Tiresias. Numbers were visible from 5.88 meters for the Transit font and 5.89 meters for the reduced Tiresias font. Table 2 outlines the mean viewing distances for smaller font size signs. It demonstrates the mean viewing distance for the total sample, as well as the mean distances for participants who read the signs in English and French. The distance is presented in meters. Differences in the mean viewing distances for the two smaller font size signs were found not to be statistically significant.

The Viewing Distance and Vision Level

In terms of vision levels, a difference between the mean viewing distances for the two larger font size

signs within the group of participants whose visual acuity was in the 20/25 to 20/60 range (for words: t = 2.400, $p \le .05$; for numbers: t = 2.994, $p \le .05$) was found to be significant, whereas for those whose vision levels were within the normal range or those with low vision it was not. For those with vision in the 20/25 to 20/60 range, Transit was read from a longer distance. Significant differences in the mean viewing distances for the two smaller font size signs were not confirmed in any vision category.

Discussion and Conclusion

Based on the results of the study, both signfonts—Transit and reduced Tiresias—performed well. Signs in both typefaces and both font sizes were readable from the minimum recommended viewing distance (CNIB, 1998). According to this standard maximum viewing distance for a minimum character height of 25 millimeters and 20 millimeters is 750 millimeters.

In both cases the mean viewing distance for the larger font size signs was longer than 6 meters (out of 7). The mean viewing distance for the smaller font size signs was close to 6 meters (out of 7). A significant difference between the mean distances for reading the smaller font size signs in the two fonts was not confirmed. It is worth noting that 60 to 70 percent of all participants could read the signs (both smaller and larger font sizes) from a distance of 7 meters. This distance was the first marker available to them upon entering each corridor.

The signs in Transit in the larger font size had a slightly longer, but significant mean viewing distance as compared with the signs in reduced Tiresias. However, the following has to be considered:

 The Tiresias signs in the larger font size were reduced approximately 11 percent to meet the standard 23-character line length requirement, taking up the same horizontal length as the

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Transit signs, but using less vertical space due to the proportional reduction

 As a result of this reduction, the cap height of the letters in Tiresias was smaller than the cap height in Transit. Because the Tiresias cap height was smaller, the actual sign surface area occupied by this signfont was smaller too. Additionally, the space between paragraphs, lines, and words was greater for the Transit signs in the larger font. It appears this spacing consequently made them easier to read

Also, the lower cap height in Tiresias resulted in a smaller viewing angle. If Tiresias had the same cap height as Transit (25 instead of 22.37 millimeters), the viewing angle would be the same, and the signs in Tiresias would be readable from even farther away than either the signs in Transit or the signs in the reduced Tiresias. According to our calculations, if this were the case, the mean distance for reading Tiresias words on the larger font size signs would be 6.76 meters (compared with 6.12 meters for Transit words read at the same distance). Given these conclusions, and given the results of the previous study by the authors on sign legibility, where Tiresias was indicated as one of the top performers and as a preferred font for people with vision loss, the authors suggested to GO Transit that Tiresias would best meet their signage requirements and the needs of the majority of users of this provincially operated transit system. In so doing, GO Transit would be approaching the principles of universal design, because the results of the two studies point to Tiresias Signfont as the best choice for people with vision loss.

A few limitations of this study are noteworthy. Because adjustments were made to Tiresias, the spaces taken up by letters of the two sign fonts differed, as noted above. This means the report is on results from testing specific signs, not the typefaces themselves. In other words, generalizations cannot be made about Tiresias and Transit as sign fonts, but only about the specific signs used in this study. In addition, the longest distance in the trial from which the signs could be read was 7 meters, which influenced the value of the mean viewing distance. It also was noted that the lighting of the different areas was not measured formally. Future research on fonts for signage would make a contribution by examining the farthest distance from which fonts can be read.

Furthermore, convenience sampling means that study participants are chosen mainly because they are readily available and willing to be involved. Such samples might not be representative of the population and, consequently, it might be difficult to generalize the results from the study. Another limitation of convenience sampling is that it does not set out to completely identify the population being studied and, therefore, it is hard to know how the study participants differed from the total population of those who use the transit system. In addition, the available evidence indicates that participants age 57 and older were not adequately represented. Only 8 percent of the participants were in this age group. Finally, participants who read French language signs were not adequately represented in the sample. Therefore, a complete picture of GO riders may not be represented herein. More scientific studies on fonts for signage are much needed if universal accessibility is to be achieved in the transportation industry.

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Original Research

The Effects of Brain Gym[®] on the Learning of Students with Visual Impairments

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Abstract

Three studies were conducted to examine the effects of several movements of the Brain Gym[®] program on the learning of the students who participated. The first two studies examined spelling skills of 25 students with and without disabilities, including 12 students with visual impairments, after the Brain Gym program was implemented. The third study investigated the effects of Brain Gym on the solving of math story problems by three students with visual impairments. In addition to quantitative data collection of spelling test scores and math story problem scores, observation was used as part of the evaluation process. The findings of both quantitative and observation data collection, along with the movements used in the three studies and the rationale in relation to learning, will be presented.

Keywords: Brain Gym®, visual impairments, learning disabilities

Brain Gym[®], pioneered by Dr. Paul Dennison and his wife (Gail Dennison) in the 1970s, is a series of simple movements used to integrate all areas of the brain to enhance whole-brain learning (Dennison & Dennison, 1989). The human brain has millions of different neural networks. Each part of the brain not only focuses on its own assigned tasks, but also communicates with other parts by way of the nerve fibers. Effective learning results from efficient communication among various parts of the brain. When information cannot flow freely among those

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parts due to some form of damage or stress, learning blockages may occur (Dennison & Dennison, 1989). Brain Gym movements were used to facilitate the flow of information within the brain (Cohen & Goldsmith, 2003; Dennison & Dennison, 1989). For the purpose of applying Brain Gym movements, the Dennisons described brain functioning in terms of three dimensions of movements: (a) laterality dimension: the left and right hemisphere (side to side); (b) focus dimension: the receptive brainstem and expressive forebrain (i.e., frontal lobe) (back to front); and (c) centering dimension: limbic system and cerebral cortex (top to bottom) (Cohen & Goldsmith, 2003; Dennison & Dennison, 1989). Brain Gym movements were designed to facilitate the integration of any one or more of the dimensions.

Despite the fact that Brain Gym has been taught in more than 80 countries, in both private and public schools as well as in corporate and artistic settings (http://www.braingym.org), the findings of research on the effects of Brain Gym are inconclusive. A number of research findings reported very positive results in the use of Brain Gym (Hannaford, 2005; Koester, 2004; Maguire, 2002; Pederson, n.d.), whereas others showed slight or no improvement or even a decline in students' learning (D'Alesio, Scalia, & Zabel; 2007; Goldacre, 2006; Templeton & Jensen, 1996). Hannaford reported that a 10-yearold girl, who had suffered from child abuse from 6 weeks of age and could not read, write, or communicate in a self-contained special classroom, made remarkable progress in all three areas following a combination of daily Brain Gym movements, art and music activities, and play with other children for about a year. By the end of the school year, she was able to read close to grade level, wrote highly imaginative stories, and could communicate effectively. An 11-year-old boy, who had been diagnosed as having total blindness with cerebral palsy and had a low functioning level, was able to use his eyes to look around and greatly improved his alert/attention level after 2 months of Brain Gym movements (Koester, 2004).

Pederson (n.d.) presented a successful case study of a 1st-grader with attention deficit hyperactivity disorder (ADHD) after 8 weeks of daily Brain Gym at school and at home. He further elaborated on the rationale of why Brain Gym can help students with ADHD. For example, the hyperactive behaviors in the students with ADHD were likely due to an unintegrated symmetric tonic neck reflex (STNR) and not enough crawling, which led to fidgety and involuntary movements that further interfered with the child gaining control over the body. Brain Gym activities such as repatterning processes complete the crawling stage and integrate the STNR. The child subsequently can sit still, focus, attend, and complete school work in a more effective manner (Pederson, n.d.). Moreover, numerous research projects have documented improvements in reading, spelling, and behaviors for students with and without disabilities following Brain Gym activities for a period of time (McClelland, 2007). On the other hand, a number of studies postulated different or opposite viewpoints relative to the effects of Brain Gym movements.

Templeton and Jensen (1996) conducted an experiment with 28 fourth-grade students to determine the effects of Brain Gym on the students' performance. These 28 students, 19 boys and nine girls, attended an urban parochial school in the Midwest. Twenty of them were White and eight were minority students. As an indicator of socioeconomic status, 6 of the 28 students were qualified for free lunches. Although their grades remained the same or declined in most subjects, their grades in English and spelling improved.

D'Alesio, Scalia, and Zabel (2007) conducted a study in improving students' vocabulary acquisition by using multisensory instruction, including Brain Gym. The study involved 73 students in one 2nd-grade classroom and two 7th-grade classrooms. Despite the results—improvement was seen in the students' vocabulary acquisition following the 4-month multisensory intervention—the researchers concluded that Brain Gym movements did not stand out as a clear-cut factor contributing to the students' improvement. Goldacre (2006) severely criticized and challenged the rationale and effectiveness of Brain Gym.

With such mixed studies and comments, this topic definitely is worth more exploration to determine its effects on the learning of students with and without disabilities. To respond to the call for more research, this article presents the findings of three studies conducted to evaluate the impact of several Brain Gym movements on the performance of students with and without disabilities, including 15 students with visual impairments (VI).

Method

Study 1 Participants

The first study involved 25 fourth-graders in a suburban area (16 students without disabilities, three students with learning disabilities [LD], and six students with VI). The students without disabilities and the three with LD were in the same classroom, whereas two other students without disabilities were not included in the study because their parents chose not to participate; the six students with VI were placed in a resource room of a separate school building. There were nine boys and seven girls in the

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group that had no disabilities, and two girls and one boy with LD. Among the six students with VI, there were four girls and two boys. Two girls were braille readers and the rest were large-print readers, ranging in visual acuity from 20/100 to 20/200. The six students with VI were mainstreamed into regular classrooms most of the day, depending on the students' needs.

Design

For the class of 16 students without disabilities and three with LD, the scores of six weekly spelling test scores were collected as the baseline scores without Brain Gym. The VI group had baseline scores of four weekly spelling tests. Several Brain Gym exercises (see next section) were then taught to students. Each exercise was performed at least 10 times, and time was taken to ensure that each exercise was being performed correctly. All the exercises took 5 to 10 minutes. They were done every Friday before the spelling test as part of the weekly spelling test routine. Once the Brain Gym program was in place, 6 weeks of spelling test scores were recorded for the class of 16 students without disabilities and three with LD, whereas 4 weeks were recorded for the six students with VI who were in a separate class.

Brain Gym Exercises Used in This Study

Among the 26 exercises designed by the Dennisons, the following were chosen to ensure three dimensions of brain functioning: PACE, Lazy 8s, Double Doodle, Alphabet 8s, the Elephant, the Owl, Arm Activation, and the Thinking Caps. PACE (positive, active, clear, and energetic) is a readiness routine that starts a series of Brain Gym activities. It entails drinking water for energetic learning, followed by Brain Buttons for clear thinking, Cross Crawls for active learning, and Hook-ups for positive attitude and learning. The subjects were instructed to stand up to execute all the movements. A description of each movement and its rationale in relation to learning is as follows (Dennison & Dennison, 1989; Hannaford, 2005; Koester, 2004; Promislow, 2005):

• Drinking water: This needs to be done at the beginning of any series or combination of Brain Gym movements. Water, a universal solvent, is essential for electrical transmissions within the nervous systems in our bodies.

- · Brain Buttons: One hand rubs the indentations between the first and second ribs under the clavicle (to the left and right of the sternum) while the other hand is held over the navel. Rubbing the points under the clavicle to both sides of the sternum stimulates blood flow through the carotid arteries to the brain so that clearer thinking can take place. The carotid arteries are among the first arteries out of the heart and go directly to the brain, furnishing it with nutrients and freshly oxygenated blood. The hand over the navel brings attention to the gravitational center of the body where the core muscles lie. Every muscle of the body connects directly or indirectly to the vestibular system, which gives information about gravity, motion, and balance. This action alerts the vestibular system, which connects to and stimulates the reticular activating system (RAS) in the brainstem. The RAS is a nerve reticulum that carries impulses from the medulla oblongata and pons to the neocortex. The RAS "wakes up" the neocortex, increasing responsiveness to incoming sensory stimuli from the environment.
- Cross Crawl: The student touches the right elbow to the left knee and then the left elbow to the right knee. By doing so, large areas of both brain hemispheres are being activated simultaneously.
- Hook-ups: This is done by first crossing one ankle over the other and then crossing, clasping, and inverting both hands. This crossover action has a similar integrative effect in the brain as that of the Cross Crawl. It activates the sensory and motor cortices of each hemisphere of the cerebrum, especially the large area devoted to the hands. While in this position, the student rests his/her tongue on the roof of his/her mouth behind the teeth (hard palate). This action stimulates the tongue ligaments, which connect to the vestibular system, thus activating the RAS for focus and balance.
- Lazy 8s: Starting at the middle, the student draws an infinity symbol (a sideways 8) by going counterclockwise first: up, over, and around; then clockwise: up, over, around, and

back to the midpoint. Students were encouraged to do a large sideways 8 first so large muscles could be stimulated and both hands areas in the motor and sensory cortices of the brain could be activated. This action relaxes the muscles of the hands, arms, and shoulders as well as facilitates visual tracking. Furthermore, the Lazy 8s allows cross-lateral integration of the brain.

- Double Doodle: The student "scribbles" any shapes, figures, or designs with both hands together at the same time. As in the Lazy 8s, starting with large arm movements and relaxing the eyes, neck, and arms, the student first works on a large board or piece of paper. Double Doodle helps develop eye– hand coordination and allows for bilateral integration of the brain.
- Alphabet 8s: The student does Lazy 8s before beginning this exercise. Performing on a large scale first is highly recommended, drawing on a board or in the air with hands clasped together, to activate the large muscles in the arms, shoulders, and chest. The student starts writing letters in the left visual field, from the midline and moves up, around, and down. Letters a, c, d, e, f, g, o, g, and s start on the curve and move up to the left. In the right visual field, the student also starts on the midline or moves down, up, and around for the following letters: b, h, i, j, k, l, m, n, p, r, t, u, v, w, x, y, and z. This exercise helps students discover the structural similarities between letters (e.g., "see the *r* in the *m* and the *n*").
- The Elephant: The student places the left ear on the left shoulder, tight enough to hold a piece of paper between the two, extending the left arm like a trunk, and allows the knees to relax and bend with the flow while the arm draws a Lazy 8 pattern in the midfield three to five times. Once the left side is done, the student places the right ear against the right shoulder and follows the same sequence. Mainly from the core muscles, the Elephant activates the vestibular system, basal ganglion of the limbic system in conjunction with cerebellum and sensory motor cortices of the cerebrum. Eye–hand coordination is also involved. Visual input activates the occipital

lobe. When the elephant sounds are added, the hearing mechanisms within the temporal lobes are activated.

- The Owl: This is one of the lengthening activities to activate the focus dimension of brain functioning (the back brain to the front brain). The student grasps and squeezes one shoulder to release neck muscles tensed in reaction to reading or other near-point tasks and moves his/her head to look back over his/ her shoulder. Breathing deeply, the student exhales in each extended head position (to the left, then to the right) and makes the owl's "who-o-o" sound on exhalation. The head then tilts forward or drops the chin to the chest to release muscles in the back of the neck. This exercise releases neck and shoulder tension that develops under stress and restores range of motion and circulation of blood to the brain for improved focus, attention, and memory.
- Arm Activation: This is another lengthening exercise. The student holds one arm next to his/her ear, then exhales gently while activating the muscles by pushing the arm against the other hand in four directions (front, back, in, and away) to release the shoulder muscles.
- The Thinking Caps: This is done by unrolling the outer cartilage of the ear from top to bottom several times. This action activates the temporal lobe as well as the limbic system, through which part of the external stimuli and information is received by the four lobes of the cerebrum, including the temporal lobe. The memory centers of the limbic system (the hippocampus and amygdala) are also activated. The hippocampus of the limbic system forms and stores short-term memory, and the amygdala converts important short-term experiences (keyed by emotion) into long-term memory.

Study 2

Participants

The subjects involved in this study were six students with VI in a self-contained classroom for 2nd- and 3rd-graders. The school was located in an economically disadvantaged urban area. Among the six students, three of them were braille readers. The

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other three students' vision ranged from 20/200 to 20/800. Two students came from families where Spanish was the only language spoken. One of the students was diagnosed with LD. Another was born to an addicted mother and was suspected of having cortical VI. All of them were below grade level.

Design

Three weekly spelling test scores were recorded before Brain Gym exercises were taught to the students. A different exercise was introduced each day through explanation, modeling, and hand-overhand techniques. Students practiced Brain Gym exercises during morning circle time Mondays through Thursdays and performed all on Fridays before the spelling test. Five weeks of spelling test scores were collected after Brain Gym was implemented.

Brain Gym Exercises Used in This Study

- PACE (Drinking water, Brain Buttons, Cross Crawl, and Hook-ups, see *Study 1* section).
- The Baboon and Ankle Touch: These are variations of the Cross Crawl, where the opposite arm and leg are used in the movement. For example, the participant touches the left ankle with the right hand.
- The Caterpillar: This is also another variation of the Cross Crawl, where the student is lying on the floor, head slightly lifted with knees bent. The student slides backward, with opposite shoulder and hip movements, until the knees are straight.
- The Thinking Caps (see Study 1 section).

In addition to activating the laterality dimension of the brain (right and left hemispheres), the above exercises were chosen because they were easier to do than the others, and the names were more interesting and allowed students to relate to them more readily.

Study 3

Participants

Three students with VI were involved in this study. They were placed in a self-contained classroom for 6th- and 7th-graders. One of them was reading braille but could also read and write large print. The other two students' vision ranged from 20/200 to 20/ 800. They were all far below grade level. Before being enrolled in this class, one of them had never done multiplication and another spelled at the 1stgrade level. Since the new school year started in September, two of them had made tremendous progress, but the braille reader remained at a similar level. All three students came from families with low socioeconomic status. One of the students was diagnosed with LD.

Design

Instead of spelling tests as in the first two studies, math story problems were assessed to determine the effect of several Brain Gym exercises. Ten math story problems of four operations were given orally to students on a daily basis except on Fridays. Students wrote down the problems and solved them. Four weeks of math scores were recorded before the implementation of the Brain Gym project. Several Brain Gym exercises were then introduced to students. The researcher explained, modeled, demonstrated, and used hand-over-hand techniques to ensure the accuracy of each exercise done by the student. Students performed these exercises after lunch every day except Friday and began math story problems immediately after completing the exercises. Six weeks of story problem scores were collected after Brain Gym was introduced.

Brain Gym Exercises Used in This Study

The exercises chosen for Study 2 also were used in this study: PACE, the Baboon, the Ankle Touch, the Caterpillar, and the Thinking Caps. This is because the participants in this study were similar to those of Study 2 in many ways. The students came from similar socioeconomic backgrounds and performed far below their grade levels. The activities needed to be fun and easy to do, yet integrate two hemispheres.

Results

Study 1

The means of 6-week spelling test scores before and after Brain Gym for three groups of subjects were calculated. The standard deviation also was calculated for the group of 16 students without disabilities. This was the only group with more than 10 subjects, so a nonparametric test (Wilcoxon
 Table 1. Students without Disabilities: Spelling

 Scores

Student	Before Brain Gym (6 weeks) Mean (%)	After Brain Gym (6 weeks) Mean (%)
1	85.3	91.4
2	90.0	100.0
3	90.6	93.1
4	89.3	93.0
5	86.6	95.4
6	89.3	100.0
7	100.0	99.4
8	93.3	98.6
9	90.6	89.1
10	90.6	95.4
11	100.0	100.0
12	98.6	100.0
13	90.0	91.7
14	92.6	100.0
15	94.0	95.4
16	96.0	98.8
Total	92.3	96.3

signed-rank test) was used to gauge whether the students' spelling skills statistically increased after Brain Gym. All three groups showed an increase in their spelling scores after Brain Gym.

Nondisabled Group

Before Brain Gym, the mean score for the nondisabled group was 92.3 percent. Regardless of the slight decreases (1.5 percent and .06 percent, respectively) in two students, the mean rose 4 percentage points after Brain Gym. The standard deviation was 4.43 before Brain Gym and 3.74 after Brain Gym. By using Wilcoxon signed-rank test, the p value is .002, which is much lower than the significance level .05. Thus, there is a statistically

Table 2. The Means and Standard Deviations of

 Spelling Scores of Students without Disabilities^a

	Mean	SD
Before Brain Gym	92.3	4.43
After Brain Gym	96.3	3.74

^a Wilcoxon signed-rank test is used; p = .002.

Table 3. Students with Learning Disabilities:Spelling Scores

Student	Before Brain Gym (6 weeks) Mean (%)	After Brain Gym (6 weeks) Mean (%)
1	91.3	93.1
2	92.6	98.9
3	74.6	92.7

significant difference in the spelling scores after Brain Gym (see Tables 1 and 2). Furthermore, the researcher observed that students appeared to enjoy Brain Gym exercises. Many of them indicated that they enjoyed the exercises and were looking forward to Fridays.

LD Group

All three students with LD showed an increase in their spelling scores after Brain Gym. The first student had a slight increase of 1.8 percent; the second, 6.3 percent; and the last one had a nearly 20 percent increase (see Table 3 for individual scores).

VI Group

Except for one student who remained the same, five students showed, on average, a 4 percent increase after Brain Gym (see Table 4 for individual scores).

Study 2

The class average on spelling tests was 72 percent before beginning Brain Gym. The class average after Brain Gym was 82 percent. An increase of 10 percent was found after Brain Gym was implemented (see Table 5 for individual scores). Except for one participant, the students had one to three absences during the research period. Missing school has been a pattern for these students due to family-related issues and had no connection to the implementation of the research. Because Brain Gym movements were practiced every day, the project continued with the students who were present. To allow a student who had been absent to continue without difficulties, the teacher would spend extra time introducing any new movements as well as practicing old ones with them.

Table 4. Stud∈	ents with Visual	Impairments: S	spelling Scores	s (Study 1)						
		Before	∍ Brain Gy	μ			After Br	ain Gym (E	3G)	
Student	Week 1	Week 2	Week 3	Week 4	Mean	Week 5 (BG)	Week 6 (BG)	Week 7 (BG)	Week 8 (BG)	Mean (BG)
← c	74 70	72	02	74 70	72.5 72.5	82 76	80	76	72	79 E
7 0	0/	07	70	0/ 00	C.71	0/	0/	00 00	71 71	C.01
o 4	00 28	00 00	72	00	15	04 76	70 78	8 8	92 92	83.5
5	98	92	96	06	94	96	92	94	100	95.5
9	82	84	76	78	80	78	74	86	82	80
		Before Br	ain Gym				After Brain	Gym (BG)		
Student	Week	1 Week	2 Week	3 Mean	Week 4 (BG)	Week 5 (BG)	Week 6 (BG)	Week 7 (BG)	Week 8 (BG)	Mean (BG)
-	20	100	100	06	100	100	75	100	100	95
2	06	70	Absent	80	100	75	75	65	100	83
с	Absent	100	85	92.5	100	Absent	100	60	100	06
4	100	60	Absent	80	100	65	Absent	100	Absent	88.3
5	60	Absent	20	40	100	Absent	50	60	100	77.5
9	50	50	50	50	Absent	60	50	65	55	57.5

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Story Problems	5	
Student	Before Brain Gym (4 weeks) Mean (%)	After Brain Gym (6 weeks) Mean (%)
1	65	70
2	80	80
3 (LD) ^a	70	95

Table 6. Students with Visual Impairments: Math

 Story Problems

^a LD = learning disabilities.

In addition to quantitative data collection of spelling test scores, the following are additional changes observed in students:

- Student A appeared to be more energetic after the implementation of Brain Gym exercises.
- Student B's attention span increased slightly, by approximately 1 to 2 minutes. Student B also began taking the initiative more often and frequently had more energy.
- Student C's attention span increased moderately, by approximately 4 minutes. Student C also had better interactions with his peers.
- Student D had more energy after the implementation of Brain Gym.
- Student E's attention span increased slightly, by approximately 1 to 2 minutes. Student E also was better able to follow instructions, had more energy, and had better interactions with others.
- The attention span of student F (also diagnosed with LD) increased significantly, more than 6 minutes. Student F also began to take initiative more often, was able to better follow instructions, and had better interactions with teachers. Although his spelling test scores did not indicate a significant improvement after Brain Gym, the student became more eager to learn. Before Brain Gym, he did not want to read to teachers; he asked to read to teachers after Brain Gym.

Study 3

On average, student A received 65 percent (obtained 6.5 correct responses out of 10 story

problems) before beginning Brain Gym and 70 percent after. Only a slight increase of 5 percent was found in this student. Student B remained the same after Brain Gym (80 percent). On average, student C showed a 25 percent increase after participating in Brain Gym (70 to 95 percent) (see Table 6).

The following are the changes seen in students after the implementation of Brain Gym:

- Student A appeared to be more energetic. He was excited about his work, asked questions if he did not understand something, and was generally interested in learning math.
- Student B showed no noticeable difference. This student is an outstanding student with a wonderful personality and affect.
- Student C, who also was diagnosed with LD, increased his attention span significantly. He was able to hold attention for up to 6 or 7 minutes at a time. Student C worked faster and more accurately. He seemed genuinely excited about math and remained attentive throughout the story problems. Student C became very bored very quickly, but was very settled and attentive during story problems after doing the Brain Gym exercises. He seemed to really like the exercises and often asked to do them more often.

Discussion

All three studies presented in this article indicated slight to significant improvement on spelling tests or math story problems after Brain Gym was implemented. In addition to the increased testing scores. many subjects made attitudinal and behavioral changes, such as looking forward to each Friday's spelling routines, being more energetic, having longer attention spans, and taking more initiative. Although there were such positive findings, it remains difficult to make conclusions about the effects of Brain Gym with confidence due to the sample size and lengths of the studies. There was only one group of participants, the 16 students without disabilities, who tested statistically for the significance of difference made by the new addition to the Friday spelling routine-Brain Gym exercises. The small sample of students with VI has long been a problem for quantitative research. Qualitative data collection thus becomes critical. This is particularly true for

Effects of Brain Gym

studies where insufficient data collection was an issue, as in the second study. The researchers had planned to collect data for 7 weeks after Brain Gym had been implemented, but only 5 or fewer weeks of scores were recorded due to the participants' absences.

Qualitatively, although not a direct observation of skills pertaining to spelling and the solving of math story problems, it was enlightening to see the positive changes in the participants' attitudes, motivation, and behaviors. With the given variables (i.e., sample size, duration of data collection, types of Brain Gym exercises), positive findings were undoubtedly shown quantitatively.

Final Thoughts

The three studies presented in this article are the first efforts in exploring Brain Gym in students with VI. The popularity of Brain Gym and relevant research done in various areas (e.g., reading, math) and with different populations (e.g., students with LD or attention deficit disorders) have long been documented, but no research or literature was found in relation to students with VI. The professions involved in the education of students with VI have ceaselessly sought anything that would benefit the learning of those students. This article opens a door for Brain Gym to be considered when working with this student population. Learning is a complex process where a multitude of physical, emotional, and psychological factors are involved. Research is not likely to pinpoint a single program, such as Brain Gym, to solve problems in certain subject areas such as reading and math. However, a program is worth a try if a student's learning or the status of learning can be heightened in such ways as described in the qualitative results of these studies (e.g., showing an increased attention span, taking more initiative, and appearing to be more energetic). Further research

that involves a larger size sample and different exercises is warranted. More consistent evidence is needed to prove the effectiveness of Brain Gym and shed some light in how educators can incorporate it in assisting the overall development and learning of students with VI.

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Practice Report

Orientation and Mobility Instruction Utilizing Web-Based Maps

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Abstract

This article proposes the utilization of two Web-based mapping technologies, Google[™] Maps (http:// maps.google.com/) and Microsoft's Bing[™] Maps (http://www.bing.com/maps), for the purposes of orientation and mobility instruction and/or use by travelers with low vision. Due to projected increases in the number of individuals requiring orientation and mobility services, the projected decrease of professional availability, and widespread geographic locations for service, new technologies and more efficient service delivery models must be considered. As a result, systems of organization, efficient preparation, high-quality instruction, and methods of data collection will become more vital to a Certified Orientation and Mobility Specialist's (COMS) provision of services. Web-based maps are not dependent on geographic location, therefore enabling either the traveler with low vision or the COMS to be anywhere in the world preparing for anywhere in the world. This article identifies how the features of Web-based maps have proven successful in fostering independence, encouraging confidence, enhancing safety, stimulating problem solving, increasing efficiency, and promoting fun for students and travelers with low vision.

Keywords: orientation & mobility, Web-based maps, low vision, independent travel, route scouting

This article proposes the utilization of two Webbased mapping technologies, GoogleTM Maps (GM; http://maps.google.com/) and Microsoft's BingTM Maps (Bing; http://www.bing.com/maps), for the purposes of orientation and mobility (O&M) instruction and/or use by travelers with low vision. It is written based on the author's experiences working with secondary and postsecondary students with low vision; however, the essence of the instruction is transferable across ages, diagnoses, geographic locations, travel experiences, and places of residence.

Rationale

Efficiency, consistency, and safety are among the leading components that Certified Orientation and Mobility Specialists (COMS) must consider when preparing for and providing instruction or consultation (Blasch, Wiener, & Welsh, 1997; Corn & Rosenblum, 2000; Hill & Ponder, 1976; Jacobson, 1993; Knott, 2002; Long & Hill, 1997; Ponchilla & Ponchilla, 1996). Because Web-based maps are not dependent on geographic location, the COMS or traveler can be anywhere in the world preparing for anywhere in the world. Due to projected increases in the number of individuals requiring O&M services, the projected decrease of professional availability, and widespread geographic locations for service, new technologies and more efficient service delivery models must be considered. The utilization of Web-based maps

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allows for generalization of skills across environments, increases independent computer use, provides instant access to travel planning, facilitates family involvement, and decreases geographic barriers related to O&M instruction.

O&M Instructional Components

Assessment drives instruction. Prior to the introduction of any O&M instruction, assessment or ongoing evaluation must occur to ensure the traveler's safety, evaluate prerequisite skills, adhere to instructional sequencing, promote efficiency, maximize independence, and meet expressed goals (Blasch, Wiener, & Welsh, 1997; Hill & Ponder, 1976; Knott, 2002; Jacobson, 1993; LaGrow & Weessies, 1994; Long & Hill, 1997; Perla & O'Donnell, 2004). Ultimately, the goal of O&M instruction is "to be complemented with a planned, systematic approach for developing generalizable problem-solving skills that are applicable to a variety of travel situations" (Perla & O'Donnell, p. 50).

One advantage of using Web-based maps is the COMS' ability to gain vital information in regard to a traveler's skill development, knowledge of O&M-specific terminology, travel experiences, travel preferences, current travel environments, and the use of technology. Another advantage of using GM and Bing are the features of saving, modifying, printing, and/or sharing visited locations. Because the caseloads of COMS are increasing and are often geographically widespread, systems of organization, progress reporting, and data collection will become even more vital to COMS' provision of services. Additionally, GM and Bing offer advantages for planning, instruction, and previewing environments with the click of a mouse. These include, but are not limited to

- Terminology (landmarks, clues, shoreline, etc.)
- Direction taking/alignment
- Environments (residential, semibusiness, business, rural, etc.)
- Intersection types (three-way, four-way, oneway, etc.)
- Atypical intersections (offset, channelized turn lane, islands, roundabout, etc.)
- Regulation identification (stop sign, stop light, yield, etc.)

- Traffic patterns—light cycles
- Numbering/address systems
- Road signage (yield, pedestrian crossing, merging traffic, etc.)
- Directional perspectives/directional corners (north vs. south vs. east vs. west)
- Route planning/scouting
- Public transportation (routes, stop locations, etc.)
- Wayfinding—rerouting (problem solving, construction navigation, etc.)
- Map making

Practical Implications/ Applications for Students

The use of Web-based maps has tremendous implications for our students with low vision with regard to the other areas of the expanded core curriculum (ECC). In order to promote O&M instruction in the home, school, and community environments, it is vital to ensure the ECC is being addressed. The outcomes resulting from the use of Web-based maps would yield a lifetime skill set that continually promotes many facets of each component of the ECC.

Interactive whiteboard technology in the classroom is another area that can be utilized with Webbased maps to promote O&M. Demonstrations and lessons can be conducted on a full-color, largedisplay, interactive whiteboard. In addition, the ability to create, edit, modify, save, and/or print individualized lessons with outcome-based strategies maximizes efficiency and effectiveness of instruction. The student can create and maintain portfolios, electronic resources, and/or paper resource binders for on-site or off-site use.

Because many students with low vision are nondrivers, the Web-based maps can provide a cost-effective, accessible way to assist students who are making decisions about living environments, access to public transportation, proximity to employment/college, and recreational activities. Instruction for the use of Web-based maps would promote general knowledge of surrounding communities, nearby resources, and the integration of public transportation.

Finally, the use of Web-based maps can help a student planning to attend a nonlocal university or

college feel more comfortable about his or her new environment. The ability to scout the campus and the community before a college visit or admittance can be beneficial. Furthermore, route planning can occur for campus navigation, class schedules, and activities to ensure safe, efficient routes. The same concepts hold true for a person with low vision considering a change of residence or geographic location—Web-based maps would support his or her transition.

Common Features Benefiting Travelers with Low Vision

In consideration of the use of these maps, it is important to note some features that may enhance the experience for persons with low vision. In addition to the high-contrast red location finder in Bing and red bubble in GM, both GM and Bing provide embedded keyboard shortcuts that minimize mouse use and may help sustain visual attention to the targeted location. For example, GM allows the user to pan up in small increments using the "up arrow," whereas the "page up" key provides a larger increment. Another example is the use of Bing's "+" and "-" to either zoom in or out, respectively. In regard to panning with the mouse in both systems, the movements are identical to the use of a closedcircuit television. The panning must be conducted in reverse order-to "pan right" the mouse must be clicked and dragged and moved left or to "pan up," the mouse must be clicked and dragged and moved down. However, when using the arrow keys, reversing the direction is not required.

The features of some screen magnification software programs also may support efficiency and independence in regard to GM and Bing use. One example would be the ability to modify the pointer, cursor, and color enhancements in programs such as MAGic or ZoomText Magnifier. Another feature offered in screen magnification software is split-screen or dual monitor use to increase the size and separation of the Web-based maps.

The Process and Features of GM and Bing

It's quite simple! Open a compatible Internet browser (see Table 1) and enter the corresponding

Web site for GM or Bing. Both sites open with a large search box at the top of the page in which you type a query (e.g., address, intersection, place of interest, business name) to begin your search. Inherently, the more information provided about the desired location, the more accurate the search result. Upon identifying or acquiring the desired location, the COMS or traveler can access the features (see Table 1) to promote instruction and/or travel planning.

Google Maps

Google Maps generates a text listing of locations and pertinent information on the left of a split window with a corresponding locator and "callout" on the map on the right of the split window. Upon location confirmation, the left side can be collapsed to increase the size of the map and the callout can be used to access "Direction" features or exited to access the exploration features. The level of zoom is controlled by double-clicks of the mouse, use of the map zoom-slider on the left of the map window, or use of the scroll wheel on the mouse, each enabling the isolation of intersections or areas of interest for instruction or exploration.

Google Map's default search uses the "Satellite" view feature, a look down from space. The other view types are "Map," resembling a street map, and "Terrain," a topographical or geospatial view. The "More..." feature includes options to show "Photos," "Videos," and "Wikipedia." Another component of GM is the "Traffic" feature that enables the user to show "live traffic," where available, or to show "traffic at day and time," with preference boxes. The preference box allows the traveler to modify the date. time, and location of travel for planning purposes. The user also can control the presence of "Labels," in the Satellite view, which enables three levels of color-coding for roads, colored directional arrows for traffic patterns, numbering systems, and identification of places of interest (e.g., parks, malls, golf courses, universities).

GM also utilizes Pegman, its mascot, who enables you to navigate or take virtual walks on "Street View." Street View features are accessed either by zooming in to the highest magnification level and clicking Street View in the callout or by clicking and dragging Pegman to the map and dropping him on any blue highlighted region. Pausing briefly on a blue

Map Feature	Google Maps	Bing Maps
Views	Map, satellite, terrain, street, traffic	Road, aerial, bird's eye, traffic, 2D, 3D
Zooming	19 levels	19 levels
Query/search by:	Locations, businesses, user-created content, mapped Web pages, real estate	Business, people, collections, locations [address], Web
Supported Internet browsers	Internet Explorer, Firefox, Safari	Internet Explorer, Firefox, Safari
Mouse scroll zooming	Yes	Yes
Types of directions	By car, by public transit, or walking	Driving
Save, edit, print maps	Yes	Yes
Hyperlink to e-mail or GPS	Yes	Yes
Integrate public transportation	Yes	No
Sending directions	E-mail, phone, car, GPS	Email, copy to clipboard, blog it
Right-click options	Directions to/from here, zoom in/out, center map here	Add pushpin; directions to/from here, 1-click directions, center map here

Table 1. Quick Reference	of	Web-Based	Мар	Features ^a
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^a 2D = two dimensional; 3D = three dimensional; GPS = global positioning system.

highlighted region causes a "preview callout" to open; however, should Pegman be placed at an undesired location in Street View, the user can click the "hand" inside the compass to return to the last result. Google Map's Street View feature could be considered an invaluable resource for a COMS or traveler, because it enables exploration of a location from a street-level panoramic viewpoint. The control features within Street View are vertical panning (look up/down); horizontal panning (look right/left); rotate (360° panoramic pivot from Pegman's position); zooming (in/out); advancing/reversing travel (white arrow navigation); and/or split screen (Street View image on top of the Satellite or Map image beneath). Finally, GM offers the integration of public transportation route planning in the "Get Directions" feature, although not every public transit agency participates. The COMS or traveler has the options to view departure/arrival times; view routing information and transfer times in text format; view routing information

in map format; one-click reverse directions for return trip planning; and specify future dates and travel times for itineraries. Google Maps also provides a user's guide as well as numerous video demonstrations for exploring its features.

Microsoft's Bing Maps

Similar to GM, after typing your query a split window will open with results in the left window and the map on the right. Bing allows the user to collapse either side of the results window as well as to hide the viewing control menu. The levels of magnification are controlled by double-clicks of the mouse, clicking the magnifier buttons on the view control menu, or use of the scroll wheel on the mouse to isolate the queried result.

Bing's default search uses the "Road" view feature in two dimensions (2D), resembling a street map with labels present. The other view types are "Aerial," an overhead view, "Bird's Eye," a 45° angle

overhead view, and "3D," a modeled three-dimensional view. The Bird's Eye view uniquely presents the viewpoint from four directions (north, east, south, and west) that offer different perspectives of the same intersection. It should be noted that the images may be different based on the capture date/time, which may impact aspects such as the presence/ absence of traffic, traffic flow, season, weather conditions, or time of day. This result may positively or negatively affect the COMS or traveler, based on the instructional or functional needs of a particular location or environment.

The difference between Bing's 2D and 3D images is that the 2D is real-world imaging at distances from 3,500 meters to 15 meters (scale of zooming; see Table 1), whereas the "Virtual Earth 3D (Beta)" (VE3D) is computer generated photo-realistic models of the location. Virtual Earth 3D, requiring a free software download upon clicking the 3D icon, allows views from the viewing control menu as well as three more: top, angle, and horizontal. Additional control features within VE3D are panning (left, right, up, down); camera angle rotation (clockwise and counterclockwise); continuous zooming (in/out); increase/decrease altitude; tilting (up/down); and direction taking (compass directions). In order to navigate, or walk through, a VE3D-modeled environment, clicking and dragging of the mouse is required. A unique feature of VE3D is the ability to navigate the queried search location using an Xbox® controller. VE3D has a street view similar to that of GM; however, it is not currently integrated into VE3D and provides only previews available in some locations.

Real-time traffic flow and the ability to report incidents are also features within Bing. The traffic patterns are color coded with four indicated levels of traffic speed. Bing also provides the toggle feature of "Labels." Street types (road, highway, interstate) are distinguished with color coding, whereas directional arrows indicate traffic patterns and numbering system information. In addition, places of interest (e.g., parks, malls, golf courses, universities) are also provided with the Labels feature.

Both Web-based maps offer additional features, accessed through links on the queried search text results, in callouts, or on the map, that may benefit COMS and travelers with low vision. Google Maps allows the user (a) to get "Directions," (b) to "Send,"

and/or (c) to "Link." When clicking on Directions, the user may choose "To here," "From here," "Search nearby," "Save to My Maps," and/or "Edit." The Send feature allows the current map and corresponding information to be sent to "Email," "Phone (mobile maps)," "Car (BMW or Mercedes)," and/or "GPS (Clarion, Garmin, Insignia, Pioneer, and/or TomTom)." Using the Link feature allows the user to paste the link in an e-mail/instant message or paste the HTML to embed in a Web site. Bing provides "1click Directions" as an accessible feature in the form of a link located in the queried search window or as a link following a right-click on a map location. A Bing user can either "Print" the directions or "Share" them by selecting one of the following: "Send in e-mail," "Copy to clipboard," and/or "Blog it." The 1-click Directions yield either turn-by-turn directions (link: "A specific location) or direction of origin (e.g., "from the west," "from the east").

Student Example

Daniel was a high school senior graduating with honors from a rural school district in May. His visual diagnosis is congenital night blindness, and he has been a cane traveler in low light and at night since the 6th grade. Daniel is awaiting admittance to three universities, with two of them more than 1,000 miles away. As a result, Daniel's desire to master as many O&M concepts and reach a level of confident independence with regard to travel increased significantly. Daniel will not receive any O&M services after high school graduation, because he does not meet current gualification standards of his state's rehabilitation agency. Daniel agreed to participate in Web-based map instruction to maximize instructional sessions, increase independent travel skills, and improve skill generalization across environments.

The instruction was developed and implemented to enhance his ability to evaluate intersection types for salient features (e.g., type, regulation, pedestrian signals, road signage); evaluate atypical intersections (e.g., offset, roundabouts with pedestrian crossings, channelized turn lanes) for traffic patterns and safe navigation; efficiently use numbering systems; practice accessing public transportation along routes; and preview college campuses of interest. In addition, Daniel also was assigned multiple homework assignments. Two examples included: (a)

conduct a Web-based tutorial for his parents while discussing and demonstrating O&M concepts; and (b) develop and execute a multistop travel route utilizing numbering systems and public transportation in a nearby downtown environment.

As a result of the Web-based instruction, Daniel mastered his O&M and self-advocacy goals prior to graduation. Most important, Daniel was able to share and demonstrate his knowledge with his family to help instill confidence in his ability to be a safe, independent cane traveler.

Conclusion

Web-based map technology offers COMS and travelers with low vision the opportunity to expand their knowledge base for safe, efficient travel in familiar and unfamiliar environments. They also have proven successful in fostering independence, encouraging confidence, enhancing safety, and promoting fun for students with low vision. Off-site or classroom use of the technology enables all users to make mistakes and thereby avoid fearing the consequences of a poor decision. The Web-based maps also provide a means of promoting problemsolving and increasing efficiency, as well as affording users the ability to freely explore any environment that stimulates their curiosity or interest.

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Book Review

Accessibility Demonstrated: Assistive Technology: A Guide to Assessment

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Assistive Technology for Students Who Are Blind or Visually Impaired: A Guide to Assessment by Ike Presley and Frances Mary D'Andrea



The field of assistive technology is a complex one, requiring a great deal of expertise to sort out. It can be challenging for the student teacher or the novice rehabilitation professional to understand all the different kinds of technology and assessments required to match the correct approach to the particular student or trainee. After 30 years in the field myself, working directly with students and staff requiring assistive technology solutions within the context of a large school for students who are blind or have low vision, I find there is still a great deal to learn. The greater the number and quality of resources at my disposal, the easier my job will be. One such resource is Assistive Technology for Students Who Are Blind or Visually Impaired: A Guide to Assessment by Ike Presley and Frances Mary D'Andrea, two established experts in the field.

This book is divided into two parts. Part One, "Overview of Assistive Technology for People Who Are Blind or Visually Impaired," describes why technology is important for learning and literacy, the issue of print access, accessing electronic information, producing written communication (including math), and producing materials in alternative formats (including tactile graphics). Because the field of assistive technology is expansive, so is the book's coverage of the topic.

Technology for each of these areas ranges from low-tech/nonelectronic (e.g., slate and stylus, abacus, tracing wheel, and human reader) to high-tech/ electronic/digital (e.g., accessible PDA, calculator, and electronic tactile graphics tablet); and no-cost to high-cost (e.g., built-in computer accessibility tools and screen readers). Within these categories, the range of technology described includes basic technology (e.g., paper and pens) and optical and nonoptical devices, as well as student access to classroom presentation tools (e.g., whiteboards and LCD projectors).

Describing technology using generic (conceptual) names such as screen magnifier or screen reader, the authors take care to ensure the book will not be outdated due to changing technology. Specific brand names are mentioned when appropriate. An appendix of resources details contact information for each type of technology described in the book.

In Part Two, "The Assistive Technology Process," the authors detail how to conduct the assessment, write the report, and develop the individualized education program (IEP) to implement the recommendations. To illustrate the assessment process, the authors use the example of a middle school student named "Bill" who has low vision. By the end of the chapter, I felt as though I had participated in the assessment myself. Every step is detailed: assembling the team, gathering

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Book Review

materials, determining the educational needs and tasks, observing, and conducting the assessment itself. Through each task, the assessment procedure is carefully described: the materials needed and why they were selected, expected outcomes, Bill's functioning, and excerpts from the completed assessment forms. Finally, the chapter includes the entire completed assessment form, sample materials, and detailed instructions for adjusting/using Microsoft Windows built-in accessibility tools.

The next chapter walks the reader through the writing of the recommendations report. This includes the use of technology as a learning and production tool, integration with school and district policies on technology, future planning, training, and cost justifications. The chapter concludes with the full report for this particular student.

The reader of this review may be wondering whether the book would be useful when assessing a student who is blind. An appendix presents the full case study of Semana, an elementary student who is blind. It includes the entire completed assessment form and written report. All of the steps for assessing nonprint skills are detailed and discussed in the chapters covering Bill's assessment.

The final chapter of the book illustrates the assessment in practice. Writing the IEP, assistive technology instruction, troubleshooting problems, and getting training are covered. The only item lacking in this chapter is a discussion of how to encourage the student to troubleshoot and the need to instill independence/responsibility to contact technology support to solve problems.

Using student-based scenarios makes the assessment process real and practical, engaging the reader and putting a human face to a concept. Some scenarios illustrate how a student would use the technology and for which tasks. Scenarios combined with relevant parts of the assessment forms detail adjustments needed in the assessment process for each individual student.

Several unique embedded features enhance the content of this book. The book uses sidebars to expand on a concept, illustrate specific pieces of technology, or build on other information mentioned in the main text. Examples include "Features Commonly Found in Video Magnifiers," "Assistive Technology for FREE," and "Knowledge Requirements for Members of the Assistive Technology Team." The second gem is "Technology Tips." These expand or provide new information specific to teaching technology. Examples include "Using Imaging Software to Complete Worksheets," "Monitoring Students' Assistive Technology Skills," and "Keyboard Commands and Shortcuts Quick Reference."

The book concludes with appendices and an index. Besides the additional resources and the case study noted above, there is an appendix called "It's the Law: Q&A about Assistive Technology and Special Education" and one containing assessment forms. However, information about the availability of the forms in electronic format (disk or download) is not indicated in the book or on the American Foundation for the Blind Web site. Electronic forms would add an extra bit of sparkle to this wonderful resource. As always, a good index lists all instances of information for easy retrieval. It would also be useful if the sidebars and Technology Tips sections of the book were listed in the index or appendices.

It is rare to find a resource in the assistive technology field that is "accessible" in every meaning of the word. Using their practical knowledge as educators, assessors, and trainers of assistive technology, the authors speak to both novice and experienced professionals. For example, the use of accessible language makes the information in this publication obtainable by both ends of the professional spectrum. The writing is friendly and respectful of their readers' vast array of skills. When writing about assistive technology, it is easy to overuse technical jargon. Here, there is little jargon used. All terms are defined and explained. Besides the slightly larger font and extra leading between the lines (making the book visually easy to read), the book is very well organized and sections are outlined throughout so that the content is easy to search and follow.

Although I have been involved with assistive technology for the past three decades, I found this book both useful and informative. I will say it again—this book contains a wealth of easy to use information. It deserves a place in any library that is used by educators or assistive technology professionals in the field of vision rehabilitation.

La Grow, S.J., Ihrke, E., Ponchillia, P.E., Sullins, C.D., Owiti, S.A., Lewis, L. (2009). User perceptions of accessible GPS as a wayfinding tool. *AER Journal: Research and Practice in Visual Impairment and Blindness*, 2, 111–120.

The previously printed version of the list of author names is incorrect. The corrected list and citation, in order of author contribution, are below. The editors and publisher apologize to the authors for the error.

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