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Effect of Cane Technique on Obstacle Detection with the Long Cane

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Modern long cane (also known as the white cane) techniques have changed little since their development in the 1940s. The two-point touch and the constant-contact techniques are the two used most widely by travelers who are blind. Regardless of which technique is used, obstacle detection, a key component of preview offered by a long cane (Blasch, La Grow, & De l'Aune, 1996), is crucial for the safety of blind travelers. When obstacles such as construction cones or toys left on the sidewalk are missed, they may trip the cane user, resulting in falls and consequent fall-induced injuries.

Several recent studies have examined how different factors affect drop-off detection with the long cane. Cane users detected drop-offs more reliably when they used the constant-contact technique than when they used the two-point touch technique, particularly if they were inexperienced cane users respectively (Kim, Wall Emerson, & Curtis, 2009; Kim, Wall Emerson, & Curtis, 2010a). Younger cane users and those with earlier-onset visual impairments detected drop-offs better than older cane users and those with later-onset visual impairments (Kim, Wall Emerson, & Curtis, 2010b). However, drop-off detection performance with a standard marshmallow tip was similar to that with a marshmallow roller tip (Kim, Wall Emerson, & Curtis, 2010c). In addition, a cane length difference of 10 inches did not result in a significant difference in drop-off detection (Kim & Wall Emerson, 2012).

In respect to obstacle detection, La Grow, Blasch, and De l'Aune (1997a) reported that participants achieved the greatest detection distance for foot-level objects (those that are not higher than the ankle) when the hand holding the cane was held at the midline and positioned below the waist. In another study, La Grow, Blasch, and De l'Aune (1997b) also documented that the two-point touch technique did not provide consistent surface previewing for four of seven participants. Wall and Ashmead (2002) found that pivoting the wrist when swinging the cane resulted in better body coverage than did moving the whole arm.

The reliability of traditional cane techniques for detecting obstacles is of particular interest because some of the previous studies reported path coverage rates that were inadequately low (61–69%) when the participants used the two-point touch technique (Uslan, 1978; Wall & Ashmead, 2002). Although one orientation and mobility (O&M) textbook indicated that missing some obstacles is inevitable when using the two-point touch technique (Jacobson,

2013), the findings of Uslan (1978) and Wall and Ashmead (2002) are not consistent with the contention of other O&M textbooks, which indicate that the two-point touch (or the constant-contact) technique provides “full” or “sufficient” coverage from the obstacles on one’s walking path (Hill & Ponder, 1976; La Grow & Long, 2011).

What is of additional interest is whether the constant-contact technique indeed has an advantage over the two-point touch technique in detecting low obstacles. Such claims have been made by many cane users based on the fact that the cane tip stays in contact with the walking surface at all times when the constant-contact technique is used. However, these claims have been solely based on anecdotes and have not been examined empirically. The purpose of the present study was to examine how reliable the traditional cane techniques are for detecting obstacles and whether the type of cane technique affects obstacle detection as it interacts with the height of the obstacles.

Method

Study design and recruitment criteria

A repeated-measures design with block randomization was used for the study. We recruited 14 sighted students (7 female and 7 male) aged 22 to 62 (median age = 26) from Western Michigan University’s (WMU) O&M program. The participants were familiar with both the two-point touch and the constant-contact techniques and their cane use experience ranged from one month to four months (median experience = four months).

Apparatus

Circular objects of different sizes (2-inch, 6-inch, 10-inch, and 14-inch diameters) and heights (1-inch, 3-inch, 5-inch, and 7-inch) were created with Styrofoam and linoleum (see Figure 1). These objects were presented on a participant’s walking path either at the midline of the path or slightly off to the side following a randomized schedule. A 20-foot-long rail (3 feet high), built with PVC pipes, was placed beside the walking path for participants to trail with their free hand, allowing them to walk consistently along the midline of the intended walking path. This precaution is designed to ensure that participants encountered the obstacles at the intended relative position from the sagittal plane of the participant’s body (see Figure 2).

Research procedure

Upon arriving at the study site, each participant signed the informed consent form approved by WMU’s Human Subjects Institutional Review Board. Sleep shades and a full-size headphone set (RadioShack Full-Size Stereo Headphone 33–1225) connected to an MP3 player (Apple iPod 5th Generation) were worn by all participants during all trials. Each participant was positioned on the midline of the obstacle detection walking path and properly aligned with the path before the beginning of each trial. To prevent participants from anticipating the obstacle at a predictable distance, the distance between the participant and the obstacle was randomly varied from 10 feet to 20 feet. At a signal from the experimenter, the participant approached the obstacle on the indicated walking path using a rigid graphite long cane (Ambutech UltraLite Graphite Rigid Cane) with a marshmallow tip

(Ambutech MT4080 High Mileage Tip). Each participant was given a cane that was as long as the vertical distance from the ground to 2 inches above the participant's xiphoid process (La Grow & Weessies, 1994).

Upon detecting the obstacle, the participant stopped immediately and said "obstacle." Upon completion of each trial, the experimenter guided the participant to the next starting point. A research assistant changed the type (size and height) and location of the obstacle for the next trial following a randomized schedule. Each participant completed three trials for each of the 16 size-height combinations (4 sizes $\times$ 4 heights). A trial was recorded as a miss if the participant failed to detect the obstacle with the cane before contacting it with the foot or another part of the body; inter-rater reliability was 98%.

Variables and analysis

The obstacle-detection rate was calculated by dividing the total number of detections by the total number of trials. Type of cane technique and obstacle height were the independent variables.

Upon completion of descriptive statistical procedures, we used a two-way repeated-measures ANOVA and within-subject *t*-tests to answer our research question. We used a significance level of .05 for all statistical tests (two-tailed). The statistical power of the *F*-tests and *t*-tests were .79 or higher when a large effect size ($f = .4$ or $d = .8$) was assumed (Cohen, 1988; Erdfelder, Faul, & Buchner, 1996). All statistical analyses, except for power analyses (G*Power version 3.0.10), were conducted with SPSS version 20.

Results

Overall, participants were able to detect approximately half of the obstacles on their walking path ($M = 50.7\%$, $SD = 5.0\%$). The drop-off detection rate with the constant-contact technique ($M = 56.0\%$, $SD = 7.2\%$) was statistically significantly higher than that with the two-point touch technique ($M = 45.4\%$, $SD = 9.9\%$), $F(1, 13) = 7.687$, $p = .016$. Obstacle detection performance improved as the height of the obstacle increased, $F(3, 39) = 46.663$, $p < .001$ (see Figure 3). There was a statistically significant interaction between cane technique and obstacle height, $F(3, 39) = 4.076$, $p = .013$ (see Figure 3). The obstacle detection rate difference between the two cane techniques was statistically significant for 1-inch-high obstacles (TT mean = 16.1%, $SD = 15.5\%$; CC mean = 42.9%, $SD = 15.3\%$), $t = 4.464$, $p = .001$. However, the difference between the two techniques was not statistically significant for the 3-inch (TT mean = 45.2%, $SD = 12.1\%$; CC mean = 45.8%, $SD = 13.8\%$), $t = .099$, $p = .923$; 5-inch (TT mean = 54.8%, $SD = 21.6\%$; CC mean = 64.9%, $SD = 14.3\%$), $t = 1.294$, $p = .218$; or 7-inch obstacles (TT mean = 65.5%, $SD = 10.3\%$; CC mean = 70.2%, $SD = 14.5\%$), $t = 1.017$, $p = .328$.

Discussion

Interpretation and practical implications

In this study, we found that the constant-contact technique was better than the two-point touch technique for detecting shorter obstacles, but that there was no significant difference

between the two techniques for detecting taller obstacles. A possible explanation may be that, when the two-point touch technique is used, the cane tip is picked up from the walking surface each time the cane is swung from one side to the other (whereas the cane tip stays in contact with the walking surface at all times when the constant-contact technique is used); this picking up of the cane might have caused the cane user to miss short obstacles during the periods the cane tip was raised from the walking surface. This finding is consistent with anecdotal evidence. In practice, if it is crucial for a cane user's safety to detect short as well as tall obstacles—because of poor balance, for example—O&M specialists may need to consider suggesting the constant-contact technique (with a tip that can reduce the frequency of sticking) as the primary cane technique, particularly when anticipating such obstacles in the environment (for instance, a residential neighborhood where small children often play outside with toys).

It is worth noting that the presence of 1-inch-high obstacles, given their limited height in the vertical plane, can be viewed as a change in the surface plane. Using this assumption, detecting 1-inch-high obstacles can be considered to be part of surface preview rather than object preview. An alternative interpretation of the study results using this classification may be that the constant-contact technique has an advantage over the two-point touch technique for previewing the walking surface (for a change in elevation), but that there is no difference between the two techniques in respect to their ability to preview one's walking path for sizable obstacles.

What was rather surprising is that, overall, the participants missed about half of the obstacles that were placed on their walking path, which resulted in collisions with the encountered obstacles. Even for tall obstacles (5-inch and 7-inch obstacles), which pose a serious risk of tripping the cane user if missed, the participants still missed them one out of three times, regardless of the technique. This finding is contrary to the common notion shared by many O&M specialists and the argument in some O&M textbooks that suggest the two-point touch (or the constant-contact) technique has an inherent ability to provide adequate protection from the foot-to-waist-level obstacles the cane user may encounter. However, our finding is consistent with the findings of two previous studies (Uslan, 1978; Wall & Ashmead, 2002), which reported path coverage rates of 60–70% when the participants used the traditional two-point touch technique. Missing one in three obstacles that may trip the cane user even when the cane technique is used correctly (with minor deviations from the standard) raises serious safety concerns for the cane users, and thus indicates the need to modify the current two-point touch and constant-contact techniques in order to improve the techniques' inherent ability to detect the obstacles on the cane user's walking path more reliably.

Limitations and recommendations

One of the limitations of the study is related to the use of sighted O&M students rather than cane users who are blind, which may limit the generalizability of the study findings to blind travelers. Although the drop-off detection thresholds of novice blind and sighted cane users were very similar (Kim & Wall Emerson, 2012), no attempts have been made to determine whether that is the case for obstacle-detection performance as well. Another limitation of the study arises from the use of only inexperienced cane users. None of the participants had

more than four months of cane use experience, which may limit the generalizability of the study findings to experienced cane users.

Comparing the traditional constant-contact technique with a modified constant-contact technique—similar to what Uslan (1978) proposed or what Jacobson (2013) suggested, the “fingertip grasp” method—would be beneficial to determine whether a modified technique can indeed improve performance in obstacle detection. Generalizability of the findings may be enhanced by including experienced blind cane users. In addition, practical applicability of the study findings can be demonstrated by conducting a similar experiment in a “real-world” setting such as an actual sidewalk with the obstacles a cane user may encounter during everyday travel (for instance, construction cones, bricks, toy trucks, and the like).

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Figure 1.
Obstacles of different sizes (2-inch, 6-inch, 10-inch, and 14-inch diameters) and heights (1-inch, 3-inch, 5-inch, and 7-inch).

Figure 2.
Participant approaching the obstacle on the obstacle detection path along the 20-foot-long guide rail.

Figure 3.

Obstacle detection rates by cane technique. The p value for each obstacle height indicates the result of the corresponding pair-wise comparison between the two-point touch and constant-contact techniques.