Masthead Logo

Western Michigan University
ScholarWorks at WMU

Transportation Research Center Reports

Transportation Research Center for Livable Communities

8-31-2015

# 14-11 Travel in Adverse Winter Weather Conditions by Blind Pedestrians

Dae Shik Kim
*Western Michigan University*, dae.kim@wmich.edu

Robert Wall Emerson
*Western Michigan University*, robert.wall@wmich.edu

Dave Guth
*Western Michigan University*, david.guth@wmich.edu

Richard Long
*Western Michigan University*, richard.long@wmich.edu

**TRCLC 14-11**
**August 31, 2015**

# Travel in Adverse Winter Weather Conditions by Blind Pedestrians

## FINAL REPORT

**Dae Shik Kim, Robert Wall Emerson, Dave Guth, Richard Long**

**Transportation Research Center for Livable Communities**
**Western Michigan University**

Western Michigan University | University of Texas at Arlington | Utah State University | Wayne State University | Tennessee State University

**Technical Report**
**Documentation Page**

| | | |
|---|---|---|
| **1. Report No.**<br>TRCLC 14-11 | **2. Government Accession No.**<br>N/A | **3. Recipient's Catalog No.**<br>N/A |
| **4. Title and Subtitle**<br>Travel in Adverse Winter Weather Conditions by Blind Pedestrians | | **5. Report Date**<br>August 31, 2015 |
| | | **6. Performing Organization Code**<br>N/A |
| **7. Author(s)**<br>Dae Shik Kim, Robert Wall Emerson, Dave Guth, Richard Long | | **8. Performing Org. Report No.**<br>N/A |
| **9. Performing Organization Name and Address**<br>Western Michigan University<br>1903 West Michigan Avenue<br>Kalamazoo, MI 49008 | | **10. Work Unit No. (TRAIS)**<br>N/A |
| | | **11. Contract No.**<br>TRCLC 14-11 |
| **12. Sponsoring Agency Name and Address**<br>Transportation Research Center for Livable Communities (TRCLC)<br>1903 W. Michigan Ave., Kalamazoo, MI 49008-5316 | | **13. Type of Report & Period Covered**<br>Final Report<br>7/1/2014 - 7/31/2015 |
| | | **14. Sponsoring Agency Code**<br>N/A |
| **15. Supplementary Notes** | | |

**16. Abstract**

Winter weather creates many orientation and mobility (O&M) challenges for people who are visually impaired. Getting the cane tip stuck is one of the noticeable challenges when traveling in snow, particularly when the walking surface is covered in deep snow. We compared four different cane tips: 1) metal glide, 2) marshmallow roller, 3) roller ball, and 4) bundu bahser. There was a statistically significant difference in frequency of sticking among the different cane tips. Post hoc analyses revealed that the sticking frequency for the metal glide tip was significantly higher than that for the roller ball tip, for the bundu basher tip, and for the marshmallow roller tip. In addition, there was a statistically significant difference in sticking frequency between the marshmallow roller tip and the roller ball tip. Cane tip shape appears to have contributed to differences in sticking frequency. For example, the metal glide tip, being the smallest and more sharply angled among the four cane tips, tended to get stuck on snow more often than more rounded and larger cane tips. Differences in sticking frequency among the cane tips observed in this study appear to be large enough to be practically significant for cane users and practitioners.

| | | | |
|---|---|---|---|
| **17. Key Words**<br>Long cane, blind pedestrian, winter weather, sticking, veering | | **18. Distribution Statement**<br>No restrictions. This document is available to the public through the Michigan Department of Transportation. | |
| **19. Security Classification - report**<br>Unclassified | **20. Security Classification - page**<br>Unclassified | **21. No. of Pages**<br>19 | **22. Price**<br>N/A |

## Disclaimer

The contents of this report reflect the views of the authors, who are solely responsible for the facts and the accuracy of the information presented herein. This publication is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of information exchange. This report does not necessarily reflect the official views or policies of the U.S. government, or the Transportation Research Center for Livable Communities, who assume no liability for the contents or use thereof. This report does not represent standards, specifications, or regulations.

## Acknowledgments

This research was funded by the US Department of Transportation through the Transportation Research Center for Livable Communities (TRCLC), a Tier 1 University Transportation Center.

# TABLE OF CONTENTS

**TABLE OF FIGURES**

## EXECUTIVE SUMMARY

Winter weather creates many orientation and mobility (O&M) challenges for people who are visually impaired. Getting the cane tip stuck is one of the noticeable challenges when traveling in snow, particularly when the walking surface is covered in deep snow. We compared four different cane tips: 1) metal glide, 2) marshmallow roller, 3) roller ball, and 4) bundu bahser. There was a statistically significant difference in frequency of sticking among the different cane tips. Post hoc analyses revealed that the sticking frequency for the metal glide tip was significantly higher than that for the roller ball tip, for the bundu basher tip, and for the marshmallow roller tip. In addition, there was a statistically significant difference in sticking frequency between the marshmallow roller tip and the roller ball tip. Cane tip shape appears to have contributed to differences in sticking frequency. For example, the metal glide tip, being the smallest and more sharply angled among the four cane tips, tended to get stuck on snow more often than more rounded and larger cane tips. Differences in sticking frequency among the cane tips observed in this study appear to be large enough to be practically significant for cane users and practitioners.

## 1. Introduction

Winter weather creates many orientation and mobility (O&M) challenges for people who are visually impaired (Couturier & Ratelle, 2010; Welsh & Wiener, 1976). Snow cover obscures familiar landmarks, makes it more difficult to manipulate the long cane, and alters one's cane-based perception of the surroundings (Wall, 2001). Getting the cane tip stuck is one of the noticeable challenges when traveling in snow, particularly when the walking surface is covered in deep snow (Welsh & Wiener, 1976; Couturier & Ratelle, 2010).

Having one's long cane get stuck may cause more frequent stops and starts, thereby increasing the time required to complete a given route. Such frequent stops and starts may also result in more steps being taken to cover a given distance which, in turn, may contribute to increased veering (Kallie, Schrater, & Legge, 2007). In addition, it appears that sticking can cause a traveler to veer from an intended line of travel by forcing the traveler's body to unintentionally turn from the intended line of travel (R. Savage, personal communication, April 2, 2015; M. Weessies, personal communication, April 2, 2015; S. Williams-Riseng, personal communication, December 10, 2014). Furthermore, cane sticking may cause frustration to the traveler by frequently disrupting a rhythmic cane swing (M. Ainsworth, personal communication, February 1, 2015; M. Jimenez, personal communication, February 1, 2015; N. Stanford, personal communication, January 31, 2015).

Only a handful of studies have examined the effect of cane tip design on the frequency of sticking. LaGrow, Kjeldstad, and Lewandowski (1988) found no significant difference in the frequency of sticking among the pencil, marshmallow, and curved tips when participants traveled on a sidewalk in a residential neighborhood. However, Pietrowicz (1987) and Robertson (1987) reported significantly fewer instances of sticking when using the marshmallow tip than when using the pencil tip on a rural road and residential sidewalk, respectively. In addition, Wang (1991) found the ball tip to be more effective than the marshmallow or metal glide tip in reducing the incident of sticking in a rural area. However, we found no published studies that experimentally examined the effect of cane tip design on cane sticking when traveling on a snow-covered surface. The purpose of the present study is to examine how different cane tip designs affect travel performance of blind pedestrians on a snow-covered surface.

## 2. Method

*Study design and recruitment criteria*

A repeated-measures design with Latin Square counter-balancing was used for the study. Recruitment criteria included legal blindness with no other disabilities, familiarity with basic cane techniques, regular travel in winter (even when the ground is covered with snow), and enough stamina to walk a few blocks without resting.

*Apparatus*

Participants used identical canes of different lengths (Ambutech UltraLite Graphite Rigid Cane) with four different cane tips: 1) metal glide tip (Ambutech MT 4070), 2) marshmallow roller tip (Ambutech MT 4090), 3) roller ball tip (Ambutech MT 4061), and 4) bundu basher tip (Bevria ES 4274) (see Figure 1). A participant's cane length was assigned based on height: vertical distance from the ground to 2 inches above the participant's xiphoid process as described in LaGrow and Long (2011).

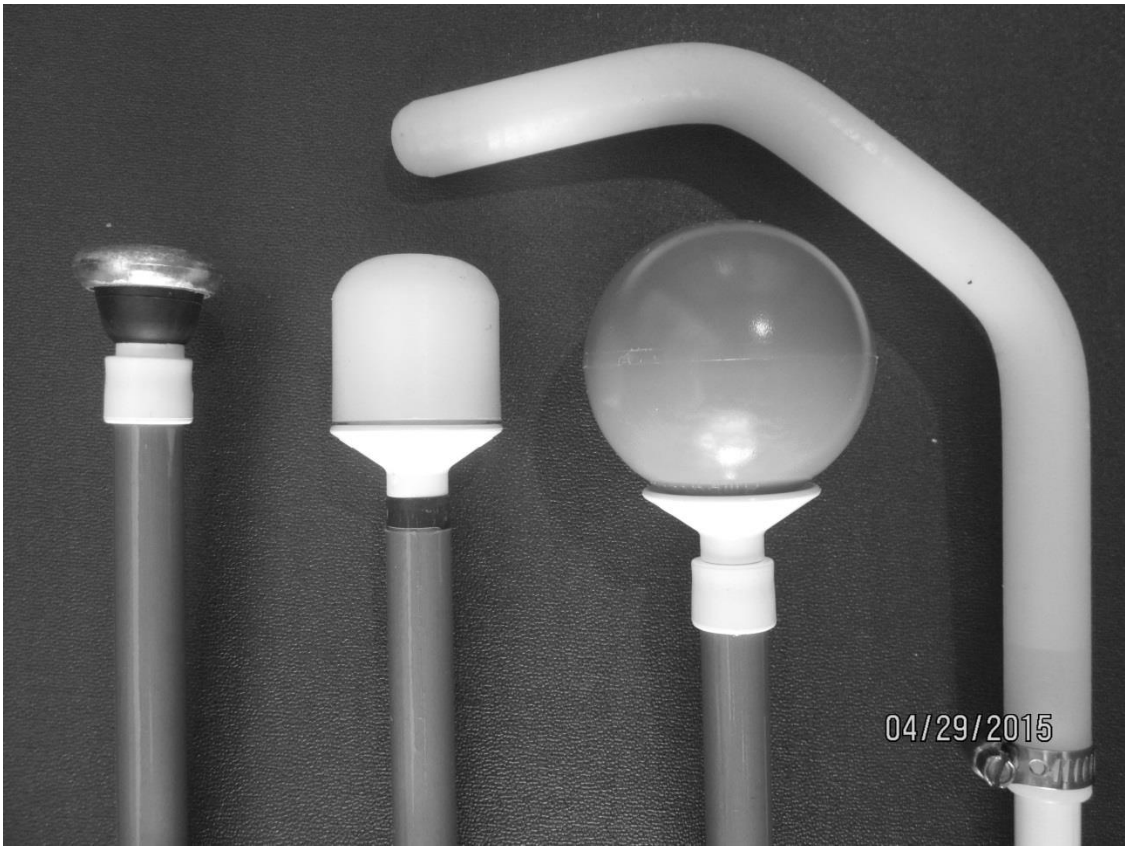


Figure 1

Starting from the left: 1) metal glide tip, 2) marshmallow roller tip, 3) roller ball tip, and 4) bundu basher tip

*Research procedure*

Each participant signed the informed consent form approved by WMU’s Human Subjects Institutional Review Board before participating in the study. Sleep shades (Mindfold Relaxation Mask) were worn by all participants during all trials (except for those with no light perception). A rectangular block in a residential neighborhood in Kalamazoo, was selected for the study (see Figure 2). Upon receiving a signal from the experimenter, a participant walked from one end of the block to the other end (a straight path approximately 600 feet long) using the constant contact technique (or a modified constant contact technique as long as the same technique was used for all conditions). Two independent raters tallied the frequency of cane sticking. For each sticking incident, they noted whether the cane got stuck on the snowy surface, snow bank, dry pavement, or grass. A cane tip was recorded to have stuck if the tip's forward movement was momentarily stopped by the irregularities of the walking surface, forcing the cane user to reposition the cane to resume his cane swing, regardless of whether he stopped his forward movement or not.

Figure 2

Participant walking on the snow-covered sidewalk

Experimenters also recorded the time it took the participant to walk the length of the block each time. An experimenter also recorded how many times a participant veered off the sidewalk and how long it took the participant to recover from veering back to the sidewalk. If the participant failed to independently recover from veering within 30 seconds, one of the experimenters guided the participant back to the sidewalk so that he could resume his trial. Upon arriving at the end of the block, the participant was instructed to make a 180 degree turn and walk back to the starting point. Frequencies of sticking and veering, travel time, and the time required to recover from veering were recorded for both the initial trip to the end of the block and the return trip to the starting point. Upon completion of all trials, participants were asked to rank the cane tips in the order of their preference for use on snow-covered surfaces.

*Variables*

Type of cane tip was the independent variable of the study. The dependent variables were 1) frequency of sticking, 2) frequency of veering, 3) time elapsed before arriving at a destination, 4) time required to recover from veering, and 5) preference rank.

*Analyses*

Upon completion of descriptive statistical procedures, a repeated-measures analysis of variance (ANOVA) was used to examine the effect of cane tip type on travel performance. In case of the violation of the sphericity assumption, adjustments were made to the ANOVA results by using Greenhouse-Geisser degree of freedom correction. Repeated-measures t-tests were used for pairwise post hoc comparisons. Friedman's ANOVA was used to compare preference rankings among the cane tips. A significance level of .05 was used for all statistical tests (two-tailed); Bonferroni correction was used for all pairwise post hoc tests. Statistical powers of the ANOVA tests were .94 when a large effect size ($f = .4$) was assumed, while the powers of post hoc t-tests were .48 with the assumption of a large effect size (*d* = .8) (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.

## 3. Results

*Demographic characteristics of the participants*

Ten male and 3 female adults participated. Visual acuities ranged from no light perception to 20/400. Etiologies of participants' visual impairment included retinitis pigmentosa (*n* = 2), glaucoma (*n* = 2), diabetic retinopathy (*n* = 2), optic nerve atrophy (*n* = 2), Stargardt's (*n* = 1), and others (*n* = 4). Participants' ages ranged from 21 to 62 (median age = 40). All participants either currently used or had used the long cane as their primary mobility aid; 12 participants were current cane users and 1 was a dog guide user. The participants' cane use experience ranged from 5 years to 39 years (median = 12 years).

*Sticking Frequency*

During all trials, snow banks—ranging from 6 inches to 14 inches high—were present on both sides of the sidewalk. Depth of snow on the sidewalk ranged from a 1/2 inch to 6 inches. Seventy-five percent of the sticking incidents were caused by snow banks, 17% of them resulted from snow-covered surface, and the remainder were from dry pavement and grass.

There was a statistically significant difference in frequency of sticking among the different cane tips, $F(3, 36) = 21.28$, $p < .001$ (see Figure 3). Post hoc analyses revealed that the sticking frequency for the metal glide tip ($M = 28.3$, $SD = 16.6$) was statistically significantly higher than that for the roller ball tip ($M = 8.2$, $SD = 13.2$), $p < .001$, $d = 1.34$, for the bundu basher tip ($M = 10.7$, $SD = 8.8$), $p < .001$, $d = 1.33$, and for the marshmallow roller tip ($M = 17.4$, *SD* = 14.1), *p* = .001, *d* = .71. In addition, there was a statistically significant difference in sticking frequency between the marshmallow roller tip and the roller ball tip, *p* = .003, *d* = .67.

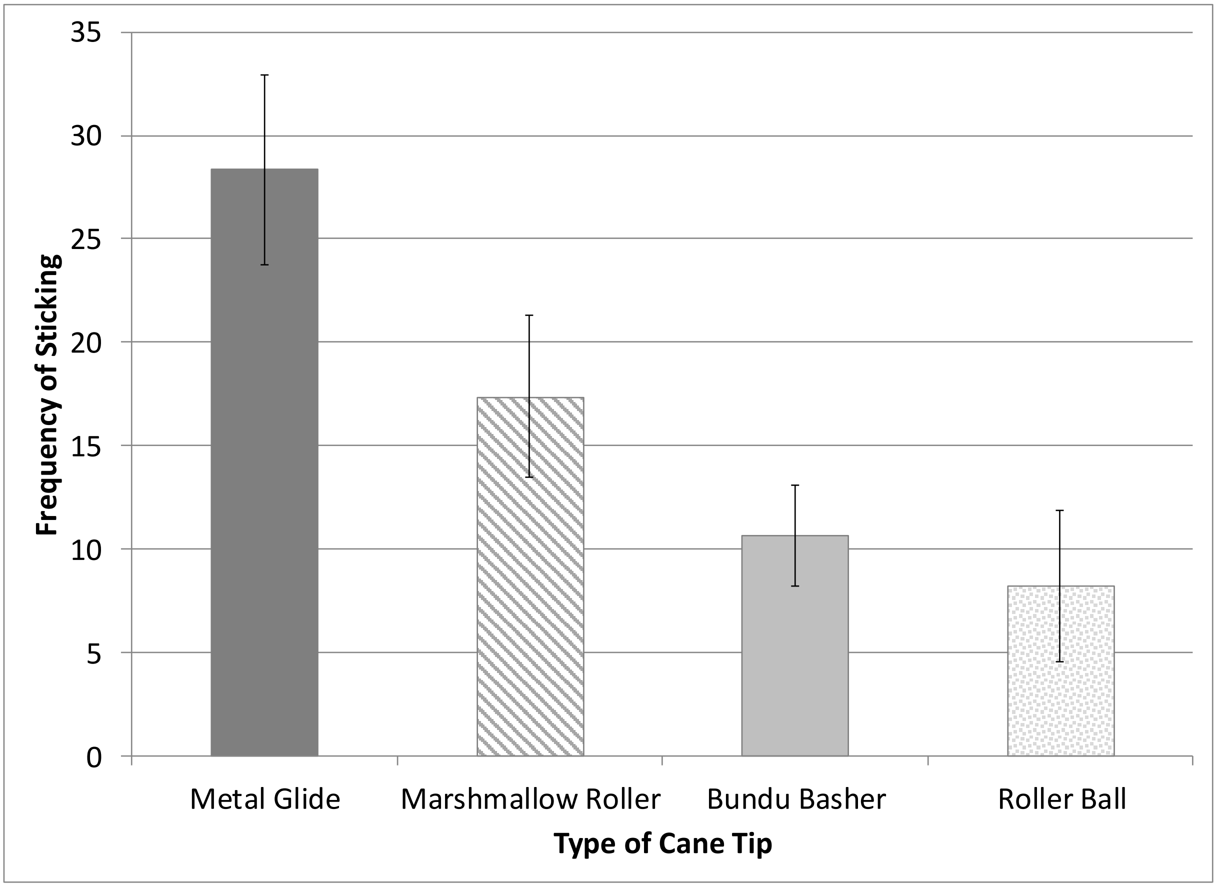


Figure 3

Frequency of sticking for different cane tips. Error bars indicate standard errors.

*Elapsed Travel Time and Veering*

There was no statistically significant difference in travel time (time elapsed before arriving at a destination) among the different cane tips, $F(3, 36) = 2.03$, $p = .127$ (see Figure 4). Similarly, there was no statistically significant difference among the cane tips in veering frequency, $F(3, 36) = .25$, $p = .864$, or in time required to recover from veering, $F(3, 36) = (1.9, 22.7) = .29$, $p = .737$.

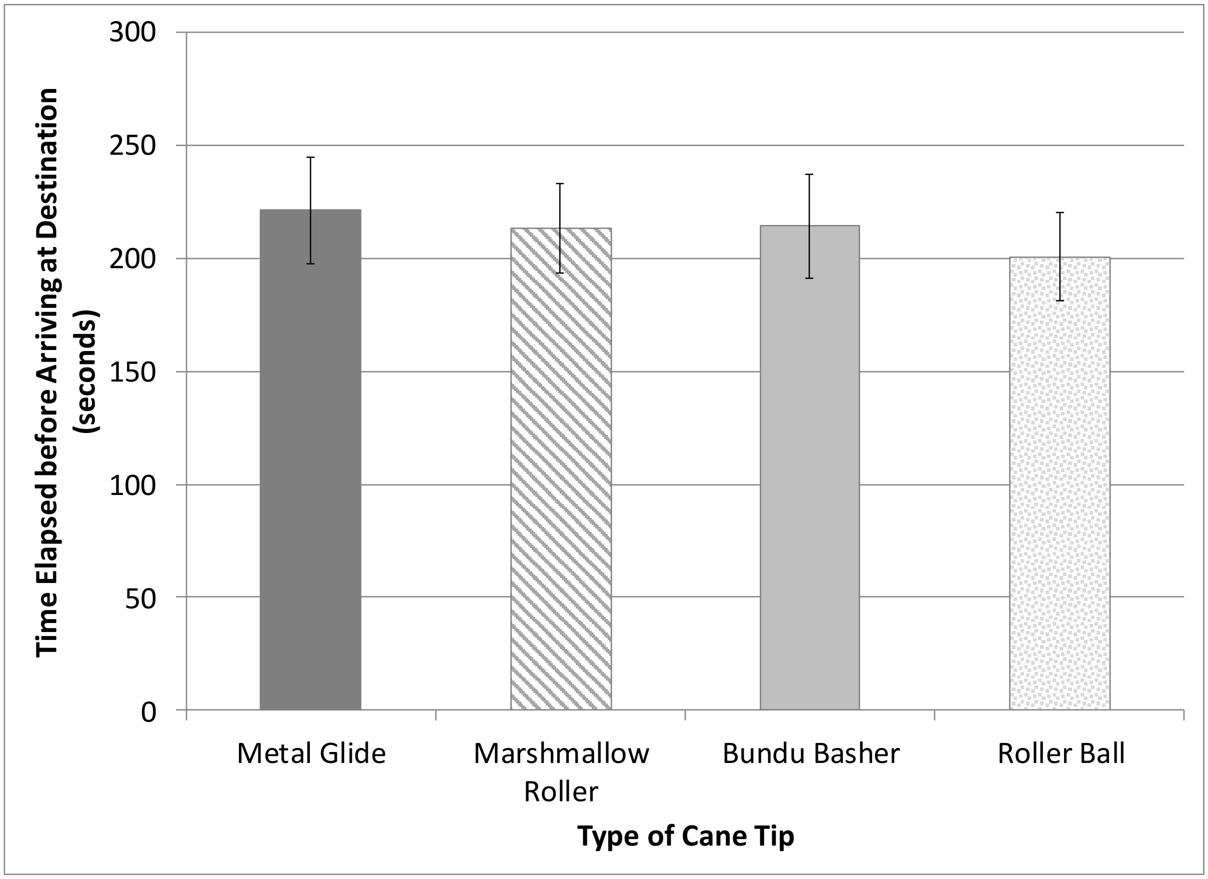


Figure 4

Time elapsed before arriving at a destination with different cane tips. Error bars indicate standard errors.

*Preference Ranking*

There was a statistically significant difference in preference ranking (1 being the highest and 4 being the lowest) among the cane tips, $\chi^2 = 9.65$, $p = .022$. Participants ranked the roller ball tip as the most preferred cane tip for use on snow-covered surface ($M = 1.9$, $SD = 1.0$), which was followed by the marshmallow roller tip ($M$ = 2.2, $SD$ = .8), the bundu basher tip ($M$ = 2.5, $SD$ = 1.0), and the metal glide tip ($M$ = 3.4, $SD$ = 1.2).

## 4. Discussion

*Interpretation and Practical Implications*

In this study, we found that cane users experienced significantly more sticking on a snow-covered surface when using the metal glide tip than when they used the roller ball, bundu basher, or marshmallow roller tip. The roller ball tip was ranked as the most preferred cane tip for travel on snow, while the metal glide tip was the least preferred.

Our findings on frequency of sticking with different cane tips are generally consistent with the findings of similar previous studies conducted on a dry walking surface (Lillie, 1987; Robertson, 1987; Wang, 1991). Cane tip shape appears to have contributed to differences in sticking frequency. For example, the metal glide tip, being the smallest and more sharply angled among the four cane tips, tended to get stuck on snow more often than more rounded and larger cane tips.

It was somewhat surprising to find that, despite the significant difference in sticking frequency, there was little difference in travel time among different cane tips. This appears to have resulted from the fact that most of the participants did not stop their forward movement even when their cane tip was stuck on the surface, partly because they knew it was a safe environment, and therefore didn't think it was necessary to break their stride even when their cane was momentarily stuck. In addition, similar veering frequency among the different cane tips might have resulted from the fact that there were grass lines (snow banks) on both sides of the sidewalk and the driveways the participants had to cross were rather narrow (9-12 feet wide), which limited the chances for veering.

Differences in sticking frequency among the cane tips observed in this study appear to be large enough to be practically significant. For example, a difference of 20 incidents of sticking between the metal glide tip and the roller ball tip (28 vs. 8) during a 400-yard walk appears to be a substantial difference that has practical implications for the cane users; frequent cane sticking may frustrate the traveler, thus increasing stress level during travel. No significant difference in travel time among the cane tips was observed in this study, partly due to the fact that most of the participants chose not to stop their forward movement even when their cane tip was stuck. However, this is not a safe practice when traveling in an unfamiliar environment. In an unfamiliar environment, cane users tend to stop/pause their forward movement momentarily when their cane gets stuck on the walking surface (while they bring their cane back to rhythmic swinging) in fear of colliding with unexpected obstacles/hazards. In such situations, higher frequency of sticking may lead to longer travel time as well.

*Limitations and Recommendations*

One of the limitations of the study is related to the change in depth and consistency of snow conditions from one condition to the next resulting from snow plowing by the residents. However, noticeable snow plowing during the trials occurred only for one of the participants. Another limitation results from the small convenience sample, which limits the generalizability of the study findings. Future studies may include an investigation of how cane sticking affects veering in a more open space (e.g., parking lot). In addition, conducting a similar study with obstacles randomly placed in one's travel path may be helpful in understanding how sticking affects cane users' ability to detect obstacles. Such study would also shed more light on how cane sticking affects travel time in an environment that the traveler is not familiar with. Furthermore, investigation of how different cane techniques and different cane-holding methods affect cane sticking may be useful.

## 5. References


Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Mahwah, NJ: Lawrence Erbaum Associates, Inc.

Couturier, J & Ratelle, A (2010). Teaching orientation and mobility for adverse weather conditions. In W. Wiener, R. Welsh & B. Blasch (Eds.), *Foundations of orientation and mobility* (3rd ed. Volume 2). New York, NY: American Foundation for the Blind.

Erdfelder, E., Faul, F., & Buchner, A. (1996). Gpower: A general power analysis program. *Behavior Research Methods, Instruments, & Computers, 28* (1), 1-11.

LaGrow, S., Kjeldstad, A., & Lewandowski, E. (1988). The effects of cane-tip design on three aspects of nonvisual travel. *Journal of Visual Impairment & Blindness*, *82*, 13-16.

LaGrow, S., & Long, R. (2011). *Orientation and mobility: Techniques for independence* (2nd ed.). Alexandria, VA: Association for Education and Rehabilitation of the Blind and Visually Impaired.

Lillie, C. (1987). The effects of cane tip design when using the constant contact cane technique. Unpublished master's thesis, Western Michigan University, Kalamazoo, MI.

Pietrowicz, D. (1987). *The effect of the marshmallow tip on cane sticking rates on a group of visually impaired veterans in a rural travel setting*. Unpublished master's thesis, Western Michigan University, Kalamazoo, MI.

Robertson, L. E. (1987). *The effects of cane tip design and cane technique on sticking.* Unpublished master's thesis, Western Michigan University, Kalamazoo, MI.

Wall, R. (2001). An exploratory study of how travelers with visual impairments modify travel techniques in winter. *Journal of Visual Impairment & Blindness, 95*, 752-756.

Wang, W. (1991). *The effects of cane-tip design on nonvisual travel in rural areas*. Unpublished master's thesis, Western Michigan University, Kalamazoo, MI.

Welsh, R., & Wiener, W. (1976). Travel in adverse weather conditions. In E. Hill & P. Ponder (Eds.), *Orientation and mobility techniques: A guide for the practitioners* (pp. 98-109). New York: American Foundation for the Blind.