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TRANSPORTATION RESEARCH BOARD

Implications of Technologies for Visually Impaired Pedestrians

Tuesday, September 17, 2019
2:00-3:30 PM ET

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REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Provide an overview of the demographics and characteristics of the visually impaired population and discuss the implications of technologies developed to aid this population

Learning Objectives

At the end of this webinar, you will be able to:

- Describe demographics of the visually impaired and identify the implications for user interfaces
- Determine meaningful measures of improvement in wayfinding or safety for travelers who are visually impaired
- Describe the benefits and disadvantages of subjective evaluation of technologies
- Discuss the necessity for human factors testing

Implications of Technologies for Visually Impaired Pedestrians

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Moderator: Robert Wall Emerson[3]

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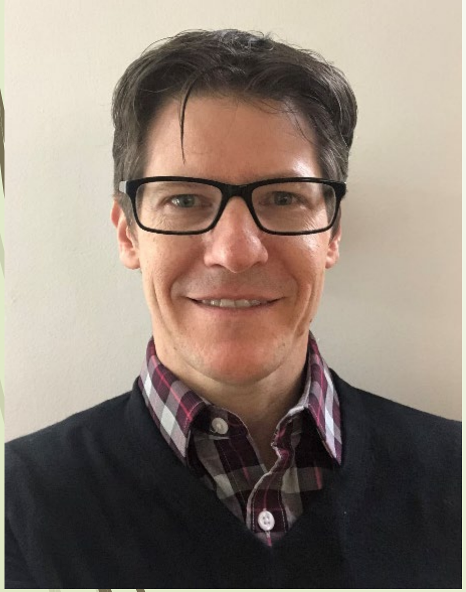
Introductions

Billie Louise Bentzen

Janet Barlow



Alan Scott

Robert Wall Emerson

Who are you designing for?

- Who is blind—definitions
- Demographics of blindness
- Characteristics of travel by people who are visually impaired

Definitions

- Blind:
  - Not able to see;
  - Not enough useful vision to be able to complete most tasks visually
- Legally blind (eligible for benefits based on blindness):
  - 20/200 or worse visual acuity in the better eye with correction (what a person with typical vision sees at 200 feet, this person can only see at 20 feet, or less), or
  - Visual field of 20 degrees or less
- Low vision: visual acuity of better than 20/200, but has difficulty accomplishing or cannot accomplish visual tasks even with prescribed corrective lenses

Definitions

- Visually impaired or vision disabled:
  - No commonly accepted definition
  - Usually used to include the entire spectrum, from total blindness to low vision

Demographics--measures

- Many different kinds of measures give different answers
  - US census data—every 10 years; based on individual responses to one question; entire population

    Are you blind or do you have serious difficulty seeing, even when wearing glasses?
  - National Health Interview Survey—periodically; based on individual responses to two questions (2002, 2008, 2014, 2017); sample, from which estimates of the whole population are generated
    1. Do you have trouble seeing, even with glasses or contact lenses?
    2. Are you blind, or unable to see at all?
- Various medical reports—always result in under-reporting, because many people never seek medical help

Demographics--Prevalence

- In the U.S., prevalence rate for visual impairment is 2.9% for adults over 40
  - Prevalence of about 4 million in 2010 projected to be 7 million in 2030 and 12.5 million in 2050
- Prevalence rate for blindness is .903%, or 1,288,275 people over 40 (2010)
- Most people who are visually impaired become so after the age of 65
- Prevalence by age
  - 65-74 -- 4.3%
  - >74 -- 10.0%

Demographics--other

- Income—27.7% of visually impaired adults are below the poverty line
- Employment—10% unemployed--about 3 times as high for visually impaired adults (16-64), as for the general population, averaging across years
- Education—16% have less than a high school education
- Travel aid—
  - 2-8% use a long cane
  - About 2% use a dog guide

Demographics—Leading causes of visual impairment

- In the U.S., based on 2010 census of 142,648,393 adults over 40,
  - 24,409,978 had cataracts—reduced acuity; sensitivity to glare; may be reversible
  - 7,685,237 had diabetic retinopathy—reduced acuity; holes in visual field; not reversible
  - 2,719,379 had glaucoma—reduced visual field; not reversible
  - 2,069,403 had age-related macular degeneration—Reduced acuity; not reversible

Characteristics of visual function

- Many causes of visual impairment also result in:
  - Impaired color vision—reduced ability to see differences in hue
  - Reduced contrast sensitivity—reduced ability to see differences in light/dark ratio
  - Increased need for light to see, especially for reading
  - Increased light sensitivity—especially to glare

Impacts of demographics

- Most visually impaired travelers are over the age of 65
  - May not be comfortable with technology, including smart phones
  - May have difficulty learning to use technology
  - May have additional difficulties in travel
  - Are likely to have age-related hearing loss
- Many visually impaired travelers have low income and may not be able to afford technology
- Many use aids such as a long cane or dog guide that fully occupy one hand

Characteristics of travel

- May use some residual vision for travel
  - Vision may be quite variable
  - Vision based systems inaccessible, need voice output at very least
  - Touch screens difficult to use, if at all
  - Understanding layout of kiosks (e.g., ticket purchase machines) can be difficult
  - Unable to quickly discern layout of large spaces, location of specific targets or objects

Impact of characteristics

- May use long cane for mobility
  - Skilled users readily detect most obstacles and level changes
  - Proficiency in use of long cane varies widely
  - The angle of the cane in relation to the walking surface changes as the cane moves from one side to the other
    - Can't assume that the cane is directly in front of the traveler
  - Altering the cane, for example by adding technology, may change the balance and increase the weight
    - Increases fatigue
  - Using cane in one hand limits ability to use hand-held devices
  - Head height objects are not detected by the cane

Impacts of vision loss on travel with technology

- Paying attention to information from technology as can make it harder for visually impaired travelers to recognize other important environmental information
  - Moving vehicles
  - Drop-offs and obstacles

Impacts of vision loss on travel with technology

- Travelers who are blind have a tendency to veer
  - Can't assume that a travelers who starts off headed in the right direction will continue on that trajectory
  - Need to consider recovery from veering
    - If traveler veers outside the range of the technology
    - If traveler uses technology when in a dangerous situation such as crossing a street

Impacts of vision loss on travel with technology

- Travelers who are blind may have difficulty pointing or orienting a device to point straight ahead
  - Will assume that information from technology is relevant to straight ahead, in the direction they are traveling, even if they are pointing a device somewhat off to one side or the other
  - May loose confidence in information provided by the technology if it doesn't seem to take them where they expect to go—into an intersection instead of straight across a street

Impacts of vision loss on travel with technology

- Travelers who are blind may have difficulty holding a device level
  - If a device needs to be level in order to provide accurate information, it may provide inaccurate information, or no information
    - May result in travel in an unintended direction
    - May result in loss of confidence in the technology

Impacts of vision loss on travel with technology

- Travelers who are blind may change direction while waiting or trying to figure out where they are
  - If the technology assumes they are headed in the direction they were headed when they stopped moving forward, it will provide inaccurate information
    - May result in travel in an unintended direction
    - May result in loss of confidence in the technology

Impacts of vision loss on travel with technology

- Travelers who are blind may have trouble knowing when information they get is incorrect
  - Need to know when to reject information, for example, when using GPS in an urban canyon
  - Need to recognize that they've turned, and the information may not be correct
    - May result in travel in an unintended direction
    - May result in loss of confidence in the technology

Impacts of vision loss on travel with technology

- Travelers who are blind need precise, accurate, and concise verbal directions, using terminology that is familiar to them.
  - Developers can’t assume that technology can say, for example, ”Turn right,” unless both the traveler’s location and direction of travel are certain
  - Travelers don’t listen to long directions or explanations
  - Travelers in an unfamiliar environment may want detailed information
  - Travelers in a familiar environment may want minimal information

Impacts of vision loss on travel with technology

- Travelers who are blind are often reluctant to ask for directions
  - They may not know when someone is close to them
  - They can't determine whether the person they ask is likely to know the answer
  - They can't determine whether the person they ask is "safe"

Impacts of vision loss on travel with technology

- A technology is not likely to be used if it has left the traveler feeling confused
- A technology is not likely to be used if it hasn't taken travelers where they want to go
- A technology is not likely to be used if it has led the traveler into a dangerous or uncomfortable situation
- A technology that continues to provide information when it is used improperly, for example, putting it in a pocket, will provide wrong, possibly dangerous, information

The benefits and pitfalls of subjective evaluation of technologies

Clarifying the term

- Subjective evaluation gathers information such as a person's likes, dislikes, and personal experiences with the technology
- May take the form of a structured survey
  - Having multiple choice questions
  - Requiring ratings, perhaps of different technologies, or how much improvement a technology offered
  - Having open ended questions
- May take the form of a focus group

Benefits

- Can be more expansive and encompassing than measures of observable performance of participants, or of a technology
- Can capture information researchers had not considered as relevant to the topic being studied

Pitfalls

- Can suffer from bias
- Can be influenced by situational factors and fluctuate widely, even within an individual
- Can be uncorrelated with independent, objective measures of the topic being studied
- Can be difficult to aggregate and interpret as they are often expressed in ordinal scales, if on any scale at all

Guidelines for good subjective evaluations

- Ideally, subjective evaluation is used in conjunction with more objective measures
- Be sure that participants have had actual experience with the technology—preferably in performing real tasks in the kind of environment in which the technology is intended to be used
- Surveys
  - Be sure questions are not ambiguous
  - Be sure ratings are not so fine-grained that participants have difficulty answering
- Focus groups
  - Guide discussion using specific questions
  - Get quantifiable responses in which participants do not influence each other by having written responses, or asking participants to close their eyes, if they have some vision, and responding by gestures
  - Provide a time for collaborative brainstorming

Designing human factors research in the natural environment

Human Factors Research

- During the design and development process for devices, interventions, or systems, ongoing input and assessment from people who are blind can help ensure that accessibility is an ongoing development consideration.
- This approach will help to avoid the necessity of difficult and expensive retrofitting at some later time in order to comply with the ADA.

Human Factors Research

- How things perform in the lab or in other highly controlled environments is not always how they perform in the real world.

- Testing in the real world is essential

Human Factors Research

- Effective research will include consideration of a number of factors:
  - Participant Safety & Ethical Conduct of Research
  - Selection of Measures
  - Participant Selection
  - Selection of Research Strategy and Design
  - Site Selection
  - Statistical Analysis
  - Additional Testing Considerations

Human Factors Research

- Design of human factors research thus necessitates many, many considerations and decisions.
- Each design consideration and decision will affect the validity of the research.
- Research design and analysis are domains of knowledge requiring expertise.
- For many design projects, a human factors researcher will be needed to credibly and accurately evaluate the technology.

Human Factors Research

- Participant Safety & Ethical Conduct
  - Throughout all aspects of research design and testing, attention must be given to how to ensure an appropriate level of safety while obtaining data that will validly address the research questions.
  - Ethical conduct of human factors research requires approval of an Institutional Review Board (IRB).
    - If you are not at a research institution that has an IRB, IRB approval can be provided by a private IRB firm.

Human Factors Research

- Selection of Measures
  - Determine the critical components of a task that the device, intervention, or system is being designed to assist with or the problem that is trying to be alleviated.
    - Remember, involvement of those with visual disabilities during the design and development phases will help to identify the root/critical challenges and help ensure that design is focused on them throughout.

Human Factors Research

- Selection of Measures
  - Research tasks and measures must provide opportunity to directly, effectively, and validly assess whether the device, intervention, or system does in fact support improvements specific to the problem that is trying to be addressed.
  - Moreover, it is critical to understand the full scope of the task from the perspective of a traveler with a visual impairment, and to use multiple measures in order to more fully evaluate each participant’s experience.

Human Factors Research

- Participant Selection
  - Given the task that the device, intervention, or system is being designed to assist with, what are the characteristics of those who can be reasonably expected to make use of the system and benefit?
  - With the characteristics of those in the target population identified, recruitment must then produce a sampling of the range of sensory levels and movement abilities to robustly test the device, intervention, or system.

Human Factors Research

- Selection of Research Strategy and Design
  - Demonstrating that a device, intervention, or system leads to a participant successfully completing a task does not alone demonstrate the value of the device or system.
  - In the design of research, consideration should be paid to how to document the magnitude of any improvements the device or system provides, and document a variety of effects the system may have.

Human Factors Research

- Selection of Research Strategy and Design
  - In order to effectively evaluate the effects of a system, one needs “enough” data.
  - This is a matter of:
    - effectively representing the population.
    - having sufficient statistical power to reveal the effects of the system that may exist.
    - effectively assessing and documenting performance in a natural environment under a range of conditions which naturally occur.

Human Factors Research

- Site Selection
  - Site selection should be focused on finding a location at which the challenges, barriers, or obstacles for which the system is designed are in fact present to a moderate or perhaps even moderately-high degree.
  - In the “real world,” users are likely to make use of the device or system within some range of environments, and thus site selection should also include effort to include some such variability in environmental features.

Human Factors Research

- Statistical Analyses
  - A plan for how data will be analyzed and/or evaluated should be a part of the research design phase.
    - How will data be analyzed?
    - What research questions are to be answered with data, and how will that be done?
    - How will the data allow for documenting participant performance with the device or system, and also document the magnitude of any improvements supported by the system?
    - How much is “enough” data with respect to statistical power?

Human Factors Research

- Additional Testing Considerations
  - To train or not to train?
    - If participants are given extensive information and/or training, will their performance represent how a typical user would perform?
    - What level of training or user proficiency will be typical?
    - In what ways will users readily attempt to use the device, and what are the effects of using it in such varied ways?
    - And, does using the device as intended introduce additional obstacles or otherwise negatively impact user behavior or safety?

Human Factors Research

- Additional Testing Considerations
  - What if the technology or system which is being evaluated doesn't function as designed? (Design or functional problem not in any way the result of user behaviors.)
    - It is important not to document a "best-case scenario" regarding participant performance when the device works as intended, if the device sometimes does not work as intended.
    - Furthermore, it is important to document the effects of such functional failures on participant behavior.

Human Factors Research

- Final Consideration:
  - Seek out ways to involve individuals with expertise in critical domains:
    - Low Vision and Blindness Studies
    - Orientation & Mobility
    - Research Design and Analysis

Questions

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Panelists Presentations

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