The Effect of Augmented Reality Visual Cues on Temporal-Distance Gait Parameters in Individuals with Parkinson's Disease: A Systematic Review

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Definitions & Background

Definitions

- ***Augmented Reality Visual Cues (ARVC)***:
  - Virtual visual cues projected into the environment/visual field to enhance gait
- ***Temporal-Distance Gait Parameters (TDGP)***:
  - Gait speed, stride length, cadence

Background

- Parkinson's Disease (PD) is a neurodegenerative disorder that can affect various aspects of gait[1-8]
- PD also affects voluntary movement which disrupts initiation of gait[1-8]
- Prior research has suggested that visual cues may be beneficial in limiting these gait impairments[1-8]

Background

- Augmented Reality superimposes a computer generated image onto the user's view of the real world[2,4,6,8]
  - Unlike virtual reality which composes a computer generated environment
- This technology can be used safely in any environment without necessarily being cosmetically noticeable to others[2,4,6,8]

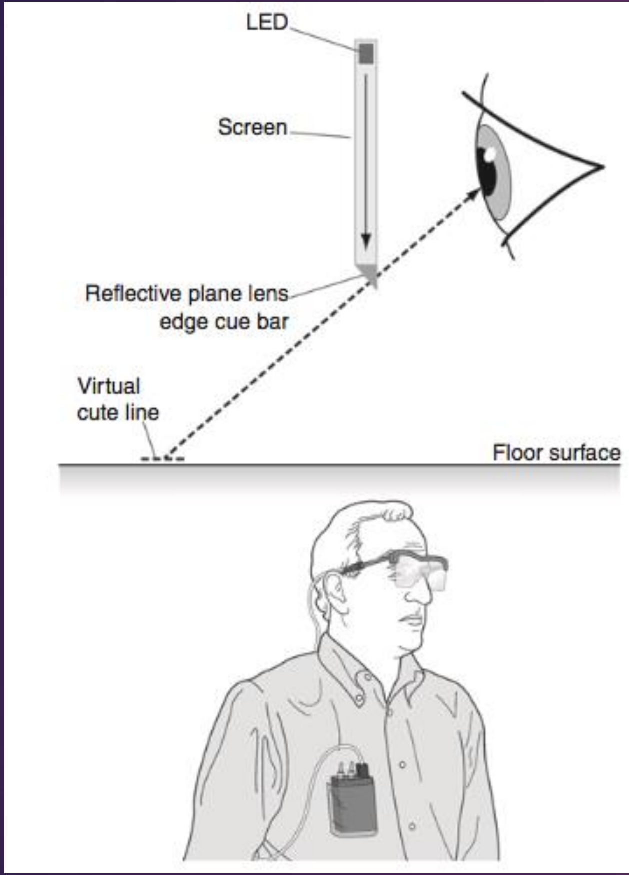


Fig. 2 Virtual reality glasses (VRG) and processing unit. Note the display screen in the right lens, which is placed below the patient's line of sight

Griffin HJ, et al.

McAuley J, et al.

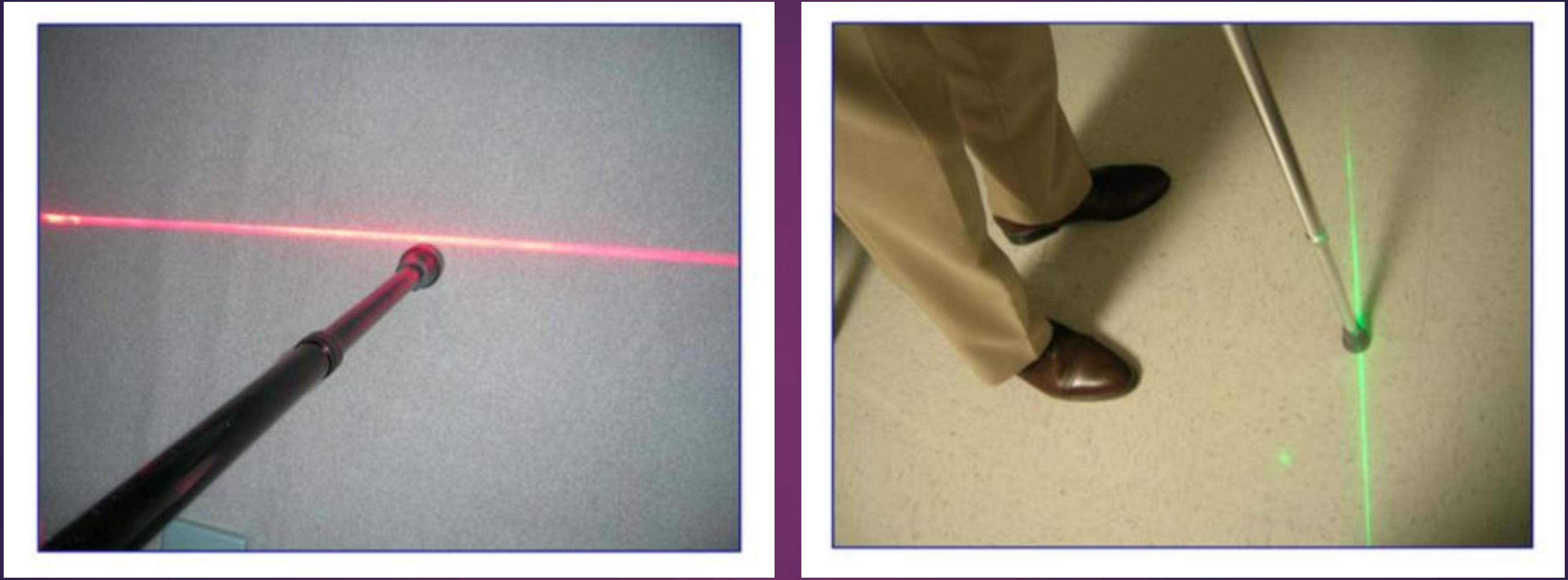


Figure I.
Canes with red and green light beams

Purpose

The purpose of this systematic review is to determine if augmented reality visual cueing (ARVC) improves the temporal-distance gait parameters (TDGP) in individuals with Parkinson's Disease (PD)

Search Criteria

Inclusion and Exclusion Criteria

Inclusion Criteria

- Virtual visual cues projected into the user's real-life environment or visual field to enhance quality of gait of individuals with PD

Exclusion Criteria

- Video games
- Immersive virtual reality (VR that gives the perception of a non-physical environment, user fully surrounded in engrossing environment of sound and images)
- Non immersive virtual reality (VR that utilizes screens)

Search Terms

(Augmented reality OR wearable computing OR wearable gait aid OR assistive technology OR visual gait cue*) AND Parkinson's Disease AND (Physical therapy OR physiotherapy OR Rehab*) NOT Auditory Feedback

Materials/Methods

Databases

- Cinahl
- Google Scholar
- Pubmed
- ProQuest

Search Limits

- English
- Human subjects
- Peer reviewed
- Dated 2007-2017

Selection Criteria

Sample Population
Diagnosis: Parkinson's Disease

Age Range: Adults

Gender: Male, Female

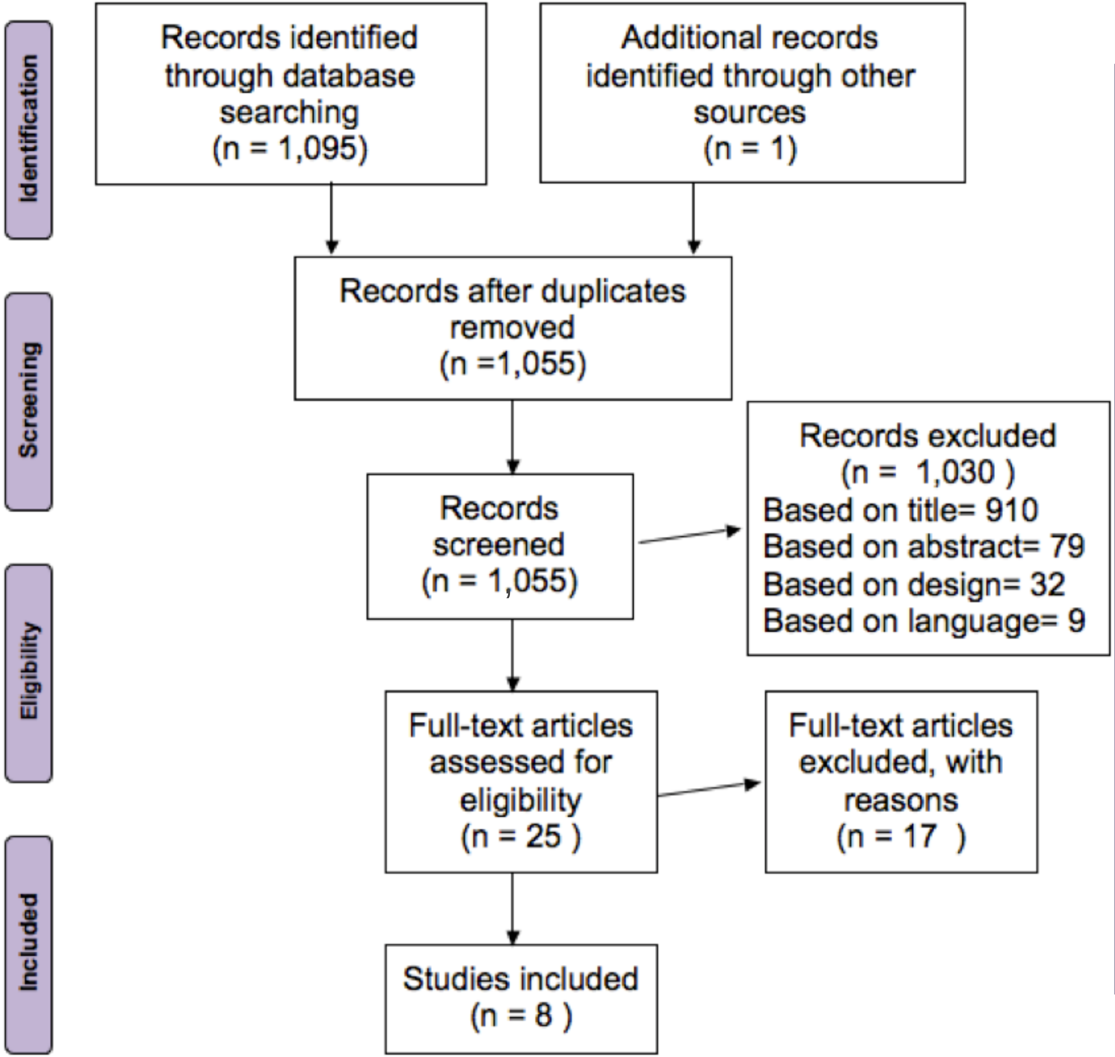
Comorbidities: Gait dysfunction (shuffling, freezing, speed), Balance, ADLs/QOL, visuospatial deficits, cardinal signs, cognitive impairments

Interventions and Comparators
Augmented reality visual cueing during gait

Outcomes
Temporal distance gait parameters: gait speed, stride length, cadence

Study Design
Scholarly peer-reviewed journal articles

PRISMA


Identification
Screening
Eligibility
Included
Records identified through database searching (n = 1,095)
Additional records identified through other sources (n = 1)
Records after duplicates removed (n =1,055)
Records screened (n = 1,055)
Records excluded (n = 1,030)
Based on title= 910
Based on abstract= 79
Based on design= 32
Based on language= 9
Full-text articles assessed for eligibility (n = 25)
Full-text articles excluded, with reasons (n = 17)
Studies included (n = 8)

Sackett Levels

Study	**Sackett Level**
1. McAuley J, Daly P, Curtis C.	**3B**
2. Espay AJ, Baram Y, Dwivedi AK, et al.	**3B**
3. Bryant MS, Rintala DH, Lai EC, et al.	**3B**
4. Ahn D, Chung H, Lee HW, et al.	**3B**
5. Badarny S, Aharon-Peretz J, Susel Z, et al.	**2B**
6. Ferrarin M, Rabuffetti M, Tettamanti M, et al.	**3B**
7. Griffin HJ, Greenlaw R, Limousin P, et al.	**3B**
8. Zhao Y, Nonnekes J, Storcken EJ, et al.	**2B**

Results

Results

- Sample size ranged from 7-26 subjects (130 total)
  - Subjects with PD (120) ranged from 53-85 y.o with H&Y stages 2-4
- Treatment parameters ranged from 1 session to 2 wks (60 min/day) in clinical settings
  - 4 studies “on”, 2 studies “off”, 2 studies “both”

Results

- 7 of 8 studies **(2B-3B)** had statistically significant gait speed improvements:
  - Average improvement of 14.68% (avg. pre-post, 0.79-0.85 m/s)
- 4 of 8 studies **(3B)** had statistically significant cadence improvements:
  - Average improvement of 8.82% (103.12-99.23 steps/min)
- 4 of 8 studies **(2B-3B)** had statistically significant stride length improvements:
  - Average gain of 13.55% (81.28-88.90 cm)

Results

- **Epson Moviero BT-200** appeared most effective in improving TDGP
  - Smart gait-aid system consisting of FOG detection and movement recognition subsystem
- Responds to 3 types of activities:
  - Projects visual patterns on the floor when FOG is detected
  - Redraws visual cue as user walks to always appear close
  - Adjust interval of visual cue following movement of user’s head

Results: Secondary Outcomes

- 1 had statistically significant improvement in FOGQ
- 4 had improvements in # of freezing episodes
  - 3 statistically significant
- 1 found significant improvement in UPDRS scores post-intervention
- 1 found significant improvement in TUG scores while wearing device

Results: User Review

Positive user reviews:

- Self reported gait improvement
  - 4/8 studies
- Lasting improvement after device removal
  - 1/8 studies

Negative user reviews:

- Technophobia
  - 1/8 studies
- Bulkiness of the device
  - 2/8 studies

Discussion

Research Limitations

- Low to moderate preliminary evidence in support of ARVC for TDGP improvement
  - Sackett Level 2B-3B
  - Grade C
- Small samples
- Widely varied devices
- Training parameters
- Lack of control groups
- Lack of long-term follow up research

Clinical Relevance

- Many ARVC devices are:
  - Commercially available
  - Relatively inexpensive
- Assistive device recommendation:
  - Immediate benefits on TDGP
- Improvements in FOG, UPDRS scores, and TUG times
- Possible long term effects

Commercial Availability

Device	Price	Availability
Epson Moviero BT-200	$699.00	Amazon and many online retailers
Google Glass	~$1,500	Limited availability Expected to release a new version within the next few years
Lasercane	$199 (Medicare covers $15 for canes)	Walmart and many online retailers

Future Research

- Determine optimal training parameters using ARVC
- Sensor and projection types
- Training vs long-term use
- Subjective measures
  - Cosmesis, QOL
- Long term follow-up

Take Home Message

- ARVC: virtual visual cues projected into the user's environment or visual field
- Low to moderate preliminary evidence in support of improvements in temporal-distance gait parameters
- Secondary outcome measures (FOG, UPDRS, TUG)
- Commercial availability
- Assistive device recommendations

Thank You!

Questions?

References

1. McAuley J, Daly P, Curtis C. A preliminary investigation of a novel design of visual cue glasses that aid gait in Parkinson's disease. *Clin Rehabil*. 2009;23(8):687-695. doi:10.1177/0269215509104170.
2. Espay AJ, Baram Y, Dwivedi AK, Shukla R, Gartner M, Gaines L, Duker AP, Revilla FJ. At-home training with closed-loop augmented-reality cueing device for improving gait in patients with Parkinson disease. *J Rehabil Res Dev*. 2010;47(6):573-581. doi:10.1682/jrrd.2009.10.0165.
3. Bryant MS. Rintala DH, Lai EC, Protas EJ. A pilot study: Influence of visual cue color on freezing of gait in persons with Parkinson's disease. *Disabil Rehabil Assist Technol*. 2010;5(6):456-461. doi.org/10.3109/17483107.2010.495815.
4. Ahn D, Chung H, Lee HW, Kang K, Ko PW, Kim NS, Park T. Smart Gait-Aid Glasses for Parkinson's Disease Patients. *IEEE Trans Biomed Eng*. 2016:1-10. doi:10.1109/tbme.2017.2655344.
5. Badarny S, Aharon-Peretz J, Susel Z, Habib G, Baram Y. Virtual reality feedback cues for improvement of gait in patients with Parkinson's disease. *Tremor Other Hyperkinet Mov (N Y).* 2014;4:225. doi:10.7916/D8V69GM4.
6. Ferrarin M, Rabuffetti M, Tettamanti M, Pignatti R, Mauro A, Albani G. Effect of optical flow versus attentional strategy on gait in parkinson's disease: A study with a portable optical stimulating device. *J Neuroeng and Rehabil*. 2008;5(3). doi:10.1186/1743-0003-5-3.
7. Griffin HJ, Greenlaw R, Limousin P, Bhatia K, Quinn NP, Jahanshahi M. The effect of real and virtual visual cues on walking in parkinson's disease. *J Neurol*. 2011;258(6):991-1000. doi:10.1007/s00415-010-5866-z.
8. Zhao Y, Nonnekes J, Storcken EJ, Janssen S, van Wegen EEH, Bloem BR, Dorresteijn LDA, Jeroen P. van Vugt JJP, Heida T, van Wezel RJA. Feasibility of external rhythmic cueing with the google glass for improving gait in people with parkinson's disease. *J Neurol.* 2016;263(6):1156-1165. doi:10.1007/s00415-016-8115-2.

Appendix

Unified Parkinson's Disease Rating Scale (UPDRS)

- 42 questions broken down into 4 parts:
  - **Part I**: Mental, behavior and mood
  - **Part II:** Activities of daily living both on and off medications
  - **Part III:** Motor evaluation of disability
  - **Part IV**: Complications of treatment
- Includes 2 additional parts:
  - **Part V:** Modified Hoehn & Yahr staging
  - **Part VI:** Schwab and England activities of daily living scale
- Comprehensive, practical, and easy to administer scale that can be used across all patients regardless of severity, medication treatment, or age
- A score of 199 on the UPDRS scale represents the worst (total disability) with a score of zero representing (no disability)

http://img.medscape.com/fullsize/701/816/58977_UPDRS.pdf

Binocular, transparent smart glasses (Epson)

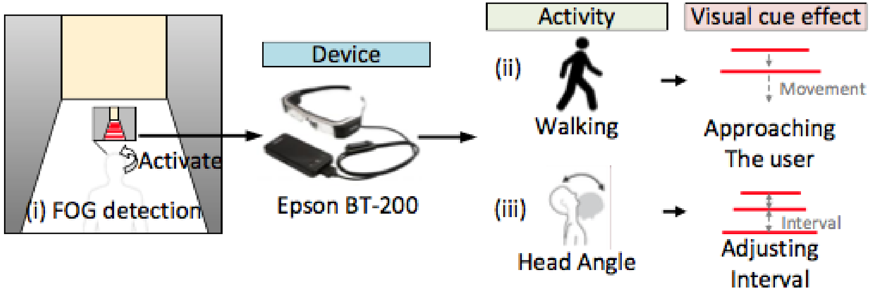


Fig. 1: Smart gait-aid system consisting of freezing of gait (FOG) detection and movement recognition subsystems.

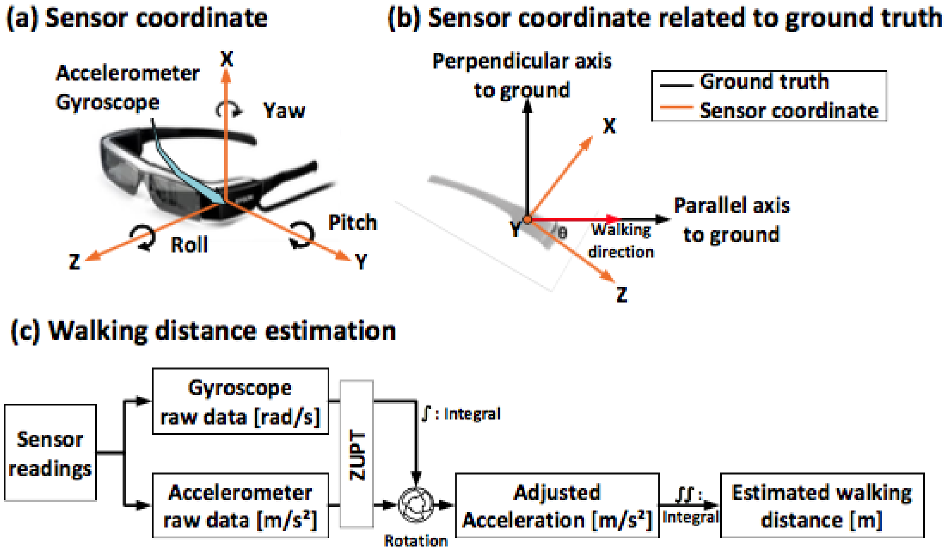
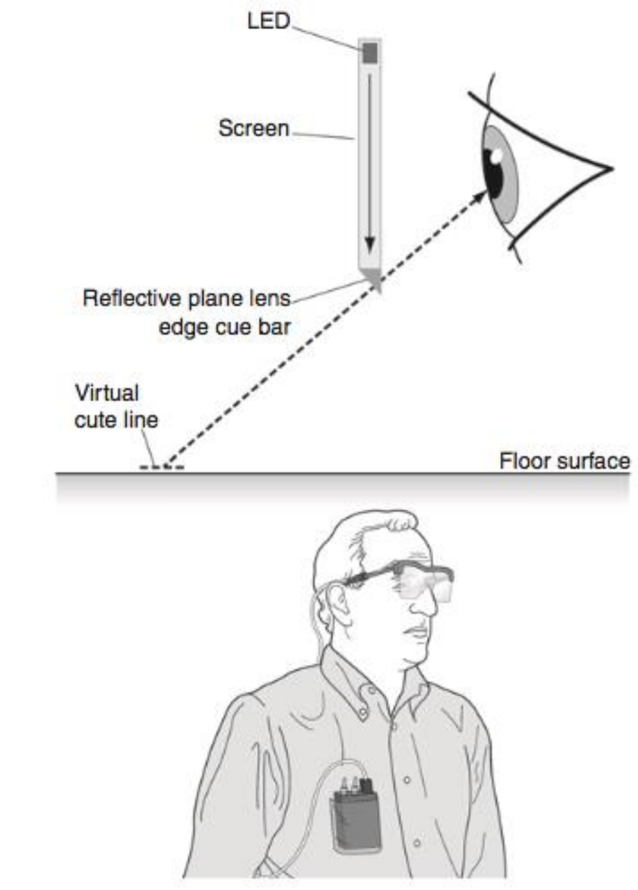


Fig. 2: (a) Sensor coordinates (3D) where the z-axis is the wearer's gaze direction; (b) sensor and global coordinates (2D) with respect to the gaze and walking direction, respectively; and (c) walking distance estimation that transforms sensor readings from into global coordinates.

Ahn D, et al.



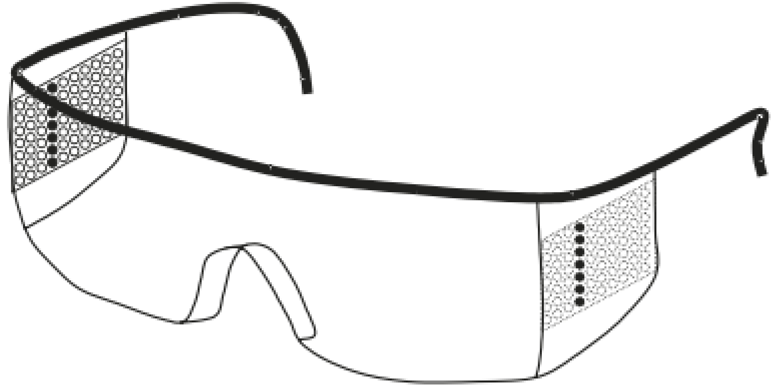


Figure I
Schematic drawing of the Optical Stimulating Glasses.

McAuley JH, et al.

Ferrarin M, et al.

Fig. 2 Virtual reality glasses (VRG) and processing unit. Note the display screen in the right lens, which is placed below the patient's line of sight

Griffin et al.

Figure 1.
Virtual (augmented) reality goggles used in this study containing built-in LCD screen, which projects flo or til es wh en s ubjects ar e moving, and earphones that sound step-matched cue as determined by connected sensor strapped at belt.

Espay, et al.

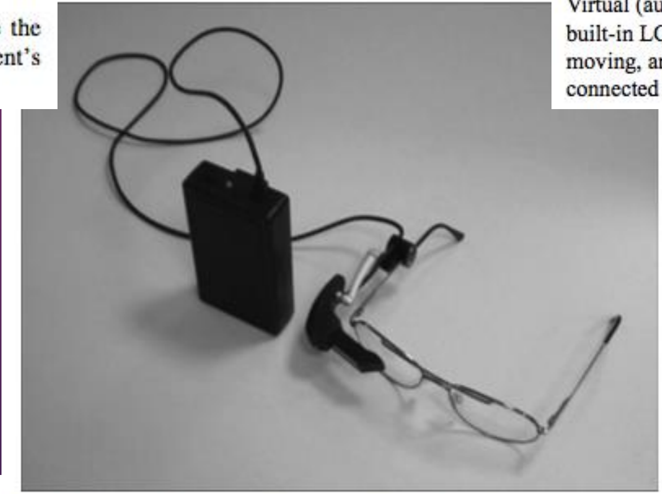
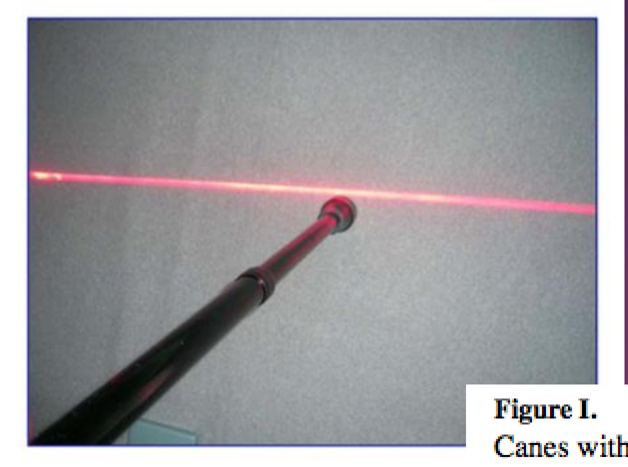


Figure 1. **Visual-feedback Virtual Reality Device Used in Tests.**

Badarny et al.

Bryant MS, et al.



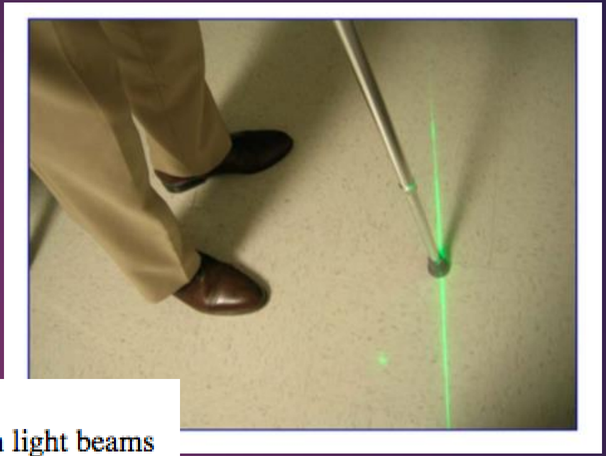


Figure I.
Canes with red and green light beams

Zhao et al.