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\(^1\)\(^-\)\(^8\)
Augmented Reality superimposes a computer generated image onto the user’s view of the real world\textsuperscript{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\textsuperscript{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.
Figure I.
Canes with red and green light beams
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

Records identified through database searching (n = 1,095)

Additional records identified through other sources (n = 1)

Records after duplicates removed (n = 1,055)

Records excluded (n = 1,030)
- Based on title = 910
- Based on abstract = 79
- Based on design = 32
- Based on language = 9

Records screened (n = 1,055)

Full-text articles assessed for eligibility (n = 25)

Full-text articles excluded, with reasons (n = 17)

Studies included (n = 8)
## Sackett Levels

<table>
<thead>
<tr>
<th>Study</th>
<th>Sackett Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. McAuley J, Daly P, Curtis C.</td>
<td>3B</td>
</tr>
<tr>
<td>2. Espay AJ, Baram Y, Dwivedi AK, et al.</td>
<td>3B</td>
</tr>
<tr>
<td>3. Bryant MS, Rintala DH, Lai EC, et al.</td>
<td>3B</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Device</th>
<th>Price</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epson Moviero BT-200</td>
<td>$699.00</td>
<td>Amazon and many online retailers</td>
</tr>
<tr>
<td>Google Glass</td>
<td>~$1,500</td>
<td>Limited availability&lt;br&gt;Expected to release a new version within the next few years</td>
</tr>
<tr>
<td>Lasercane</td>
<td>$199 (Medicare covers $15 for canes)</td>
<td>Walmart and many online retailers</td>
</tr>
</tbody>
</table>
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
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?


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)

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.
Figure 1
Schematic drawing of the Optical Stimulating Glasses.

McAuley JH, et al.

Ferrarin M, et al.
Figure 1. Visual-feedback Virtual Reality Device Used in Tests.

Virtual (augmented) reality goggles used in this study containing built-in LCD screen, which projects floor tiles when subjects are moving, and earphones that sound step-matched cue as determined by connected sensor strapped at belt.

Griffin et al.

Espay, et al.

Badarny et al.
Figure I.
Canes with red and green light beams

Zhao et al.