Doctoral Dissertation Defense Announcement

Lara I Riem, B.S.

“INVESTIGATING THE EFFECTS OF VISUAL FIELD MOVEMENTS ON BALANCE CONTROL IN MULTIPLE SCLEROSIS USING VIRTUAL REALITY”

Candidate for Doctor of Philosophy in Biomedical Engineering

Graduate School of Biomedical Engineering
Marquette University and Medical College of Wisconsin

Thursday April 15th, 2021 at 1:00 PM (CST)

Committee in Charge:
Brian Schmit, PhD (Advisor); Biomedical Engineering
Scott Beardsley, PhD (Advisor); Biomedical Engineering
Tanya Onushko, PhD; Biomedical Engineering
Allison Hyngstrom, PhD; Physical Therapy
Gerald Harris, PhD; Biomedical Engineering

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Doctoral Dissertation
INVESTIGATING THE EFFECTS OF VISUAL FIELD MOVEMENTS ON BALANCE CONTROL IN MULTIPLE SCLEROSIS USING VIRTUAL REALITY

This dissertation examines how movement of the visual field affects balance control in people with Multiple Sclerosis (MS). Balance control is an important focus of MS gait rehabilitation research due to the increased risk of falls with disease progression. Heterogeneous demyelination of the central nervous system produces a myriad of sensory impairments which may alter sense of foot placement, control of the center of mass, and interpretation of self-motion during static and dynamic balance. The visual system provides a cornucopia of information, in which redundancies in visual cues and spatial information could allow for the performance of tasks despite damage. However, alterations in the utilization and perception of visual motion and visual referencing of one’s self may indicate potential balance impairments in MS and provide new avenues for rehabilitative regimens.

Our central hypothesis is that people with MS use visual information more than healthy controls to account for body position in space and movement relative to the environment during balance control. Specifically, virtual reality was utilized to analyze response to visual motion of the entire visual field and the impact of blocking the lower periphery and presenting information of body position via avatars. Additionally, we evaluated how visual motion is perceived in MS during object motion to investigate the potential confound of additional environmental motion on self-motion perception. Dynamic and static balance control was characterized during challenging walking and standing tasks in people with MS and age-matched neurologically intact individuals (controls) using virtual reality. During standing balance, patients with MS increased postural sway in response to medial lateral visual oscillations compared to controls, this included increased sway in the anterior posterior direction as well as reduced sway when the lower peripheral reference of self was occluded. During ambulation, patients with MS exhibited decreased stability in the presence of both object and simulated self-motion, while controls only demonstrated reduced stability to simulated self-motion. Finally, the ability to visually reference one’s self and augmentation of such through use of virtual avatars improved dynamic balance in people with MS.

The results indicate an increased reliance of visual self-referencing and increased instability in the presence of environmental motion in people with MS. The results will have a positive impact by providing a framework for understanding how visual deficits and possible changes to visual processing in MS impact dynamic balance. This will facilitate the development of proactive rehabilitation techniques that expose participants to situations which challenge their balance via the sources of visual impairments, compared to reactive regimens that seek to correct the symptoms without targeting the specific changes in sensorimotor processing that lead to the dysfunction.
Lara I. Riem, B.S.

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From: [REMOVED] [REMOVED]

**Bar Admissions**

**Education**

Marquette University & Medical College of Wisconsin | Ph.D. Candidate Biomedical Engineering | May 2018 – Anticipated Completion April 2021 | GPA [REMOVED]

Dissertation: “Investigating the effects of visual field movements on balance control in Multiple Sclerosis using virtual reality”, Defense Scheduled: April 15th, 2021

Marquette University | Bachelor’s Degree | Sept. 2015 - May 2018 | GPA [REMOVED]

Major: Bioelectronics Engineer

University of Wisconsin Baraboo | Youth Options Program | May 2014 – Aug. 2015 | GPA [REMOVED]

Dean’s highest honor list
Youth Options offered through Baraboo High School

Baraboo District Ambulance Training Center | Emergency Medical Technician | Summer 2015

**Professional Experience**

American Medical Technologies, Milwaukee WI | March 2020 – present

Software Engineer and Technical Patent Writer/ Registered Patent Agent
Research Projects

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Graduate Student Lead: Development and implementation of multi-institutional virtual reality addition to commercial Balance Tutor Apparatus  
Jan 2020 – present

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Graduate Student Lead with Direct Mentorship of Undergraduate Student: The effect of perceived visual manipulations to physical perturbations of the walking surface on dynamic balance in people with Stroke  
Sept 2019 – present

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Dissertation Research: The role of visual self-referencing and augmented visual feedback in balance control in persons with Multiple Sclerosis  
May 2019 – Jan 2021

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Dissertation Research: The effect of visual object motion and simulated self-motion on dynamic balance control in Multiple Sclerosis  
May 2019 – Jan 2021

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Graduate Student Lead with Direct Mentorship of Undergraduate Student: The Effect of Visual Manipulations on Dynamic Balance Control from Physical Perturbations of the Walking Surface  
May 2019 – Dec 2020

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Graduate Student Lead with Direct Mentorship of Undergraduate Student: Implementation and Importance of a Low-Cost Avatar for Gait in a Virtual Environment  
May 2019 – Sept 2019

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Research Assistant: Gait Entrainment to Vertical Support Surface Oscillations in Stroke Participants  
May 2018 – Sept 2019

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Dissertation Research: Anterior Posterior Postural Balance Control to Medial Lateral Visual Field Movements in Multiple Sclerosis  
May 2018 – Sept 2019

• Journal Publication in review

Marquette University, Milwaukee WI  
Research Assistant: Dynamic Rehabilitation via Pseudorandom Translations of the Support Surface in Multiple Sclerosis  
May 2017 – Nov. 2019

Marquette University and Medical College of Wisconsin, Milwaukee WI  
Graduate Student Lead: The Effect of Discrete Visual Perturbations on Balance Control during Gait  
Sept. 2018 – Sept. 2019

• Publish and presented via podium in 2020 at 42nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)
Marquette University, Milwaukee WI  
**Senior Design Capstone**: Finger Individuation Device  
Sept. 2017 – May. 2018

Marquette University, Milwaukee WI  
**Research Assistant**: Dynamic EMG Control of Powered Below-Knee Prostheses  
May 2016 – Dec. 2018

Marquette University, Milwaukee WI  
**Fleck Fellowship**: Inducing Compensatory Changes in Gait similar to External Perturbations using an Immersive Head Mounted Display  
- Publish and presented via podium in 2018 at IEEE Conference on Virtual Reality and 3D User Interfaces in Germany  
May 2016 – Dec. 2018

### Teaching Experience

Marquette University and Medical College of Wisconsin, Milwaukee WI

- **Teaching Assistant**: BIEN 4280: Biocomputing Design Lab  
  Fall 2018
- **Teaching Assistant**: BIEN 4290: Biocomputer Engineering Design  
  Spring 2019/2020

### Honors and Awards

- **Greater Milwaukee Foundation-Harry and Martha Walsh Scholarship**, Marquette University  
  2018
- **Fleck Fellowship**, Marquette University  
  2016

### Peer Reviewed Conference Proceedings / Publications


Conference Abstracts (* Indicates Podium Presentation)


Manuscript Reviewer

- PLOS One