The Effect of Eye-Movement Training on Gait and Activities of Daily Living in Patients with Parkinson’s: A Pilot Study

by

Elizabeth Moulton

A thesis submitted to the School of Nursing
In conformity with the requirements for
the degree of Master of Science

Queen’s University
Kingston, Ontario, Canada
(August, 2015)

Copyright © Elizabeth Moulton, 2015
Abstract

Medication and surgery, the traditional treatments for Parkinson’s disease, can have serious side effects for Parkinson’s patients. Nurses need low-risk and effective treatments for their patients. Some of the brain areas associated with bradykinesia, one of Parkinson’s diseases cardinal symptoms, can be trained using cognitive-training programs. The objective of this study was to test the effect of anti-saccade eye-movement training on bradykinesia and the ability to perform the activities of daily living in participants with Parkinson’s disease. Anti-saccade eye-movement training asks participants to ignore a stimuli and look in the opposite direction, which trains their ability to exert control over their own movements.

A convenience sample of participants with Parkinson’s disease (N = 10) was recruited for this study. Over the span of 12 days, participants conducted a baseline data collection, which measured demographics; ability to complete activities of daily living (ADLs) and gait; used an eye-movement training program for 10 consecutive days; and then returned for a second data collection, which measured ADLs and gait.

The results of the study include detailed notes on barriers to adherance, such as understanding the program, using the tablet and finding time to train; changes that had to be made to scheduling; and difficulties with collecting motion-capture data from this population. The ADLs questionnaires had perfect scores pre- and post-intervention for all except one participant, and the change in gait speed was not significant.

Anti-saccade eye-movement training is a feasible intervention for this population given enough teaching and support. There was no significant change in walking speed or ADLs. The program requires modifications in order to increase the effect. This may include adaptive programming, improved feedback and more adaptive technologies. Also, using a more sensitive measure of ADLs may be beneficial and should be considered for future studies.
Co-Authorship

Dr. Rosemary Wilson, RN (EC), PhD (Toronto), School of Nursing, Queen’s University

Dr. Kevin Deluzio, PhD, Department of Mechanical and Materials Engineering, Queen’s University

Dr. Christina Godfrey, RN, PhD, School of Nursing, Queen’s University

Dr. Katie Goldie, RN, PhD (University of British Columbia), School of Nursing, Queen’s University
Acknowledgements

There are many people without whom this thesis would not have seen the light of day. I would like to express my gratitude to my thesis supervisors, Dr. Rosemary Wilson and Dr. Kevin Deluzio. Their guidance and support on this interdisciplinary venture were very much appreciated. Thank you for all your time and effort throughout this process.

I would like to thank my thesis committee members, Dr. Christina Godfrey and Dr. Katie Goldie. Thank you for your feedback and support, which made this project possible.

I would also like to thank the members of the Centre for Neurosciences, in particular, Dr. Aarlenne Khan, who were willing to collaborate with me on this project. Thank you to all the participants who gave their time in order to make this project happen.

Lastly, I wish to also thank Zack for his help and my family and friends for keeping me sane amid my academic endeavours.
# Table of Contents

Abstract.................................................................................................................................................. ii

Co-Authorship .......................................................................................................................................... iii

Acknowledgements ................................................................................................................................. iv

List of Figures ........................................................................................................................................ viii

List of Tables .......................................................................................................................................... ix

List of Equations ..................................................................................................................................... x

List of Abbreviations ............................................................................................................................ xi

Chapter 1 Introduction ........................................................................................................................... 1
  Problem Statement .................................................................................................................................. 1
  Theoretical Framework .......................................................................................................................... 2
  Purpose .................................................................................................................................................. 4
  Research Questions ............................................................................................................................... 4

Chapter 2 Literature Review .................................................................................................................. 5
  Background on Parkinson’s Disease .................................................................................................... 5
  Symptoms .............................................................................................................................................. 5
  Cognitive Training and Parkinson's Symptoms .................................................................................. 7
  Cognitive Training ............................................................................................................................... 11
  Eye-Movement Training ...................................................................................................................... 12
  Bradykinesia ......................................................................................................................................... 14
  Activities of Daily Living .................................................................................................................... 15
  Hypotheses .......................................................................................................................................... 17

Chapter 3 Methodology .......................................................................................................................... 19
  Research Design ................................................................................................................................. 19
  Sampling .............................................................................................................................................. 19
  Measures ............................................................................................................................................. 21
  Intervention ......................................................................................................................................... 24
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
<td>25</td>
</tr>
<tr>
<td>Analysis of Feasibility</td>
<td>28</td>
</tr>
<tr>
<td>Analysis of Activities of Daily Living</td>
<td>30</td>
</tr>
<tr>
<td>Analysis of Gait Characteristics</td>
<td>30</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>31</td>
</tr>
<tr>
<td>Ethical Considerations</td>
<td>31</td>
</tr>
<tr>
<td>Chapter 4 Results</td>
<td>33</td>
</tr>
<tr>
<td>Demographics</td>
<td>33</td>
</tr>
<tr>
<td>Feasibility Questionnaire</td>
<td>34</td>
</tr>
<tr>
<td>Feasibility Researcher Notes</td>
<td>36</td>
</tr>
<tr>
<td>Tablet Data</td>
<td>41</td>
</tr>
<tr>
<td>Katz Activities of Daily Living</td>
<td>43</td>
</tr>
<tr>
<td>Gait Variables</td>
<td>44</td>
</tr>
<tr>
<td>Chapter 5 Discussion</td>
<td>46</td>
</tr>
<tr>
<td>Recruitment</td>
<td>46</td>
</tr>
<tr>
<td>Demographics</td>
<td>48</td>
</tr>
<tr>
<td>Tablet Training</td>
<td>49</td>
</tr>
<tr>
<td>Feasibility of Data Collection</td>
<td>57</td>
</tr>
<tr>
<td>Effect of Training on Gait and ADLs</td>
<td>59</td>
</tr>
<tr>
<td>Limitations</td>
<td>60</td>
</tr>
<tr>
<td>Implications and Recommendations</td>
<td>61</td>
</tr>
<tr>
<td>References</td>
<td>65</td>
</tr>
<tr>
<td>Appendix A Supplementary Table</td>
<td>73</td>
</tr>
<tr>
<td>Appendix B Demographics Questionnaire</td>
<td>75</td>
</tr>
<tr>
<td>Appendix C Feasibility Questionnaire</td>
<td>76</td>
</tr>
<tr>
<td>Appendix D Katz Activities of Daily Living</td>
<td>77</td>
</tr>
<tr>
<td>Appendix E Marker Set</td>
<td>78</td>
</tr>
<tr>
<td>Appendix F Participant Instructions</td>
<td>79</td>
</tr>
</tbody>
</table>
Appendix G  Researcher Experience ................................................................. 80
Appendix H  Pipeline ......................................................................................... 81
Appendix I  Ethics Approval ............................................................................... 91
Appendix J  Acknowledgement Amendment / Approval Letter .......................... 93
Appendix K  Recruitment Speech ..................................................................... 94
Appendix L  Recruitment Handout .................................................................. 95
Appendix M  Recruitment Advertisement .......................................................... 96
Appendix N  Effect Size Calculations ............................................................... 97
Appendix O  Sample Feedback Graph ............................................................... 99
Appendix P  Recommendations .......................................................................100
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parkinson’s Motor Symptoms</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Interaction Between Eye-Movement Training and Cognitive Processes</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Concept Map of Anti-Saccade Eye-Movement Training, Cognitive Function, Parkinson’s Motor Symptoms and ADLs</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>Relation Between Bradykinesia and Stride Variables</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Relationship between Gait Variables and ADLs</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>Concept Map of Anti-Saccade Eye-Movement Training, Cognitive Function, Parkinson's Motor Symptoms and ADLs with Hypotheses</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>Marker Placement Guide</td>
<td>27</td>
</tr>
<tr>
<td>8</td>
<td>Time for Stimulus and Instructions</td>
<td>43</td>
</tr>
<tr>
<td>9</td>
<td>Factors which can be Altered to Improve Adherence</td>
<td>57</td>
</tr>
<tr>
<td>10</td>
<td>Feedback given at the end of a training session</td>
<td>99</td>
</tr>
<tr>
<td>11</td>
<td>Recommendations Associated with the Good Adherence Concept Map</td>
<td>100</td>
</tr>
</tbody>
</table>
List of Tables

Table 1. Summary of Brain-Area Involvement (adapted from Munoz & Everling, 2004; Everling & Fischer, 1998) .......................................................................................................................... 10
Table 2. Tablet Variables Collected ............................................................................................................ 30
Table 3. Participant Demographics ........................................................................................................... 34
Table 4. Feasibility Questionnaire Breakdown .......................................................................................... 35
Table 5. Research Notes ............................................................................................................................ 37
Table 6. Tablet Data .................................................................................................................................... 41
Table 7. Gait Variables Mean and t-Test ................................................................................................... 44
Table 8. Summary of Brain-Area Involvement for Eye-Movement Training and Symptoms ................. 73
Table 9. Leg Marker Names and Positions ................................................................................................. 78
Table 10. Pelvis Marker Names and Positions ............................................................................................ 78
Table 11. Recommendations ..................................................................................................................... 101
List of Equations

Equation 1. Relationship between gait variables .................................................................................. 14
Equation 2. Equation for Cohen's $d$ .................................................................................................. 45
Equation 3. Equation for the pooled standard deviation ...................................................................... 97
Equation 4. Pooled standard deviation for walking speed ..................................................................... 97
Equation 5. Cohen's $d$ for walking speed ......................................................................................... 97
Equation 6. Pooled standard deviation for left step length ............................................................... 98
Equation 7. Cohen's $d$ for left step length ......................................................................................... 98
Equation 8. Pooled standard deviation for right step length ............................................................ 98
Equation 9. Cohen's $d$ for right step length ...................................................................................... 98
List of Abbreviations

3D  3-dimentional
ADLs  activities of daily living
BMI  body mass index
CNSF  Canadian Neurosciences Foundation
df  Degrees of Freedom
HDH  Hotel Dieu Hospital
IND  indeterminate
KGH  Kingston General Hospital
m  metre
m/s  metres per second
min  minute
MMSE  Mini-Mental State Exam
MOCA  Montreal Cognitive Assessment
ms  millisecond
PIGD  postural instability and gait difficulty
ppi  pixels per inch
SF-36 PF  Short Form 36
Sig  Significance
TD  tremor dominant
Chapter 1

Introduction

Problem Statement

Parkinson’s disease is the most common neurodegenerative disease after Alzheimer’s and affects approximately 1% of the population over 60 (Nutt & Wooten, 2005). There are an estimated 100,000 Canadians living with Parkinson’s disease today, a number that is expected to rise dramatically over the next 30 years, as the percentage of the population over the age of 65 doubles (Parkinson Society of Canada, 2003). The annual cost of Parkinson’s disease to Canadian society is an estimated $558.1 million; the majority of this ($391.7 million) is related to the indirect cost of long-term disability (Parkinson Society of Canada, 2003).

Current guidelines focus primarily on the pharmacological and surgical treatments for Parkinson’s disease (Canadian Neurological Sciences Federation [CNSF], 2012). This leaves nurses few evidence-based interventions that are non-invasive and non-pharmacological; both general practitioners and Parkinson’s nurse specialists are often key resources for patients with Parkinson’s and their family members (Parkinson Society of Canada, 2003).

Nurses need evidence-based interventions to decrease Parkinson’s symptoms, increase patients’ abilities to complete activities of daily living (ADLs) and decrease the impact of Parkinson’s disease on the patients and society. Current interventions for motor symptoms include dopaminergic medication; surgical lesions to the brain and deep brain stimulation (DBS); and physical, occupational and speech therapy. Interventions specific to nursing include providing information to the patients and their families and coordinating care (CNSF, 2012; Hagell, 2007; Reynolds, Wilson-Barnett & Richardson, 2000). As well, nurses schedule
medication timings and provide dietary advice to maximize the medication’s effectiveness; nurses teach patients purposeful activities to reduce their tremors and how to concentrate on their gait in order to eliminate the shuffling (Szigeti, 1988; Hagell, 2007; Reynolds et al., 2000). Nurses also play a role in advising patients about exercise, rehabilitation and sexual dysfunction, and they provide support for patient’s families (Reynolds et al., 2000). In addition to the existing nursing interventions, nurses need to be active in the development of alternative interventions. Interventions such as cognitive training are within the scope of nursing practice. Nurses are the ideal health care providers to introduce cognitive training to the Parkinson’s population because nurses are trained to teach patients, are available to patients when they have questions, and are able to assist patients in integrating new treatments into their daily routine.

As noted above, there are a variety of drug and surgical therapies available to patients with Parkinson’s that have been proven beneficial. However, these interventions have a wide range of side effects, such as motor fluctuations, nausea and lightheadedness for medications and infection or intracranial hemorrhage for surgery (CNSF, 2012). Motor-training programs such as progressive resistance training, tai chi and treadmill training also exist. Progressive resistance training results in increased muscle strength; tai chi has shown mixed results for gait improvements, and treadmill training shows promise for improving gait (Amano, Roemmich, Skinner & Hass, 2013). While motor training holds potential, both medications and surgery can be costly interventions (CNSF, 2012; Amano et al., 2013).

**Theoretical Framework**

Given the impact of Parkinson’s disease, the expense and side effects of traditional therapies and the paucity of evidence-based nursing interventions, it is important to develop interventions that are effective, low risk, inexpensive and evidence based. Cognitive training
holds promise by fulfilling these requirements and targeting one of Parkinson’s disease’s most debilitating symptoms, bradykinesia (slowness of movement).

Cognitive training using anti-saccade eye movements can be administered with a program that requires patients to control their eye movements by suppressing the automatic reaction of looking at a stimulus (a saccade) and voluntarily looking in a different direction (an anti-saccade). This allows the patient to train the ability to suppress unwanted movements and develop the ability to move when they desire to do so. These simple eye movements target the sections of the brain that are involved in motor control (Munoz & Everling, 2004; Everling & Fischer, 1998), and training these sections of the brain with repeated use will bring them back under the patient’s control (Dyckman & McDowell, 2005; Kiyota & Fujiwara, 2010).

Anti-saccade eye-movement training makes use of a number of areas of the brain, which are also affected by bradykinesia (Pahwa, 2013; Munoz & Everling, 2004; Everling & Fischer, 1998). Training using eye movements should increase a person’s internal (or top-down) control, which is a person’s ability to voluntarily control their movements regardless of external stimuli. Exerting top-down control over the regions of the brain involved in bradykinesia may allow patients to prevent bradykinesia from occurring. In 2004, Dyckman & McDowell saw significant improvement in the top-down control of eye movements in young adults after a week of anti-saccade eye-movement training. These results were repeated in a 2010 study using healthy elderly adults who trained for 10 days (Kiyota & Fujiwara, 2010). Eye-movement training can also be delivered at low cost via computer and is low risk; furthermore, registered nurses can recommend it as an intervention for their patients from a wide variety of practice environments.

Anti-saccade eye-movement training has not been used in a clinical setting and has not been extensively researched in the Parkinson’s population. As such, it is important to explore the feasibility of using eye-movement training in the Parkinson’s population. Participant’s ability to
use the training program and any barriers that they face will be useful for informing future studies and can be used when integrating cognitive training into clinical practice.

**Purpose**

The purpose of this study was to evaluate the feasibility of using an innovative program, which trains the users to complete certain eye movements, and to test the effect of this cognitive training on motor symptoms in the Parkinson’s population. Specifically, it looked at a simple eye-movement task that uses anti-saccade eye movement, in which the participant moves their eyes away from a stimulus instead of towards it, to increase top-down control. As a result of increased top-down control, the participants will have decreased bradykinesia and an increased ability to perform the ADLs. Participants for this study are classified by severity using the Hoehn and Yahr scale, which ranges from 1 to 5. Participants were limited to individuals who ranked from 1 to 3 on the scale since a severity of 4 or 5 would make individuals unable to complete the study.

**Research Questions**

This study addressed three primary research questions.

(1) How do participants with Parkinson’s disease, who rank from 1 to 3 on the Hoehn and Yahr scale, find the experience of using a tablet to complete a daily eye-movement training program?

(2) How can researchers create a feasible gait collection protocol for participants with Parkinson’s disease, who rank from 1 to 3 on the Hoehn and Yahr scale, without placing undue demand on the participants?

(3) In participants with Parkinson’s disease, who rank from 1 to 3 on the Hoehn and Yahr scale, what is the effect of 10 days of eye-movement training on bradykinesia and activities of daily living?
Chapter 2

Literature Review

Background on Parkinson’s Disease

Parkinson’s disease is a neurological disorder that shares many symptoms with other basal ganglia disorders. However, Parkinson’s disease is currently diagnosed based on its cardinal symptoms: bradykinesia, freezing, tremors, rigidity and loss of postural reflexes (Pahwa, 2013; Parkinson Society of Canada, 2003; CNSF, 2012; Jankovic, 2008).

Symptoms

**Bradykinesia.** Bradykinesia is slowness of movement. In the literature, it is sometimes used interchangeably with the term akinesia, although akinesia refers more specifically the inability to initiate movement. While bradykinesia is not exclusive to Parkinson’s disease, it is one of the most characteristic features. Bradykinesia includes difficulty with planning, initiating and executing movements. It also contributes to difficulty with performing sequential and simultaneous tasks. It is important to note that the severity of most Parkinson’s symptoms, such as bradykinesia, is highly dependent on the patient’s emotional state. As a result, immobile patients may be able to move suddenly, such as a reflex or in crisis situations (Jankovic, 2008). There are eight areas of the nervous system which when damaged can manifest the symptom of bradykinesia. From the basal ganglia, they are: (1) substantia nigra pars reticulata, (2) caudate nucleus, (3) globus pallidus pars externa, (4) globus pallidus, and (5) subthalamic nucleus. From outside the basal ganglia, they are (6) the cerebellum, (7) supplementary motor cortex, and (8) motor cortex (Pahwa, 2013).
**Freezing.** Freezing is a form of akinesia and is closely related to bradykinesia. It is also referred to as motor block and is one of the most disabling symptoms of Parkinson’s disease (Jankovic, 2008). Approximately half of the Parkinson’s population has reported freezing. Freezing occurs mostly in the legs but has also been known to occur in the arms and eyes. There are five subtypes of freezing: (1) start hesitation, where the patient has difficulty instigating movement; (2) turn hesitation, where the patient has difficulty changing directions once movement is initiated; (3) hesitation in tight quarters, where the patient has difficulty moving when in tight spaces; (4) destination hesitation, where the patient has difficulty moving beyond a pre-selected destination; and (5) open-space hesitation, where the patient has difficulty moving in open areas (Jankovic, 2008; Moretti, Torre, Antonello, Esposito, & Bellini, 2011). Evidence suggests that freezing occurs when there is damage to one or more of the following four areas of the brain: (1) the basal ganglia (though which portion of the basal ganglia has not been determined), (2) the thalamus, (3) the noradrenergic locus coeruleus, and (4) the acetylcholinergic pedun-nuclei (Pahwa, 2013).

**Tremors at Rest.** Tremors are common in patients with Parkinson’s and result in the commonly observed supination-pronation or “pill-rolling” tremor. Tremors are unilateral and are most prominent in the distal part of the extremity. The tremors are categorized as rest tremors because they will disappear with action or during sleep (Jankovic, 2008). Tremors are one of the least understood symptoms of Parkinson’s disease. There are four areas of the brain which may be involved when the symptom is present. Some research indicates that tremors are the result of damage to (1) the globus pallidus and (2) subthalamic nucleus. Other research suggests that tremors are the result of malfunctions in either in (3) the thalamus or (4) the motor cortex (Pahwa, 2013).
**Rigidity.** Rigidity is an increase in resistance during passive movement. It may occur either proximally (shoulders and hips) or distally (wrists and ankles) and may be associated with pain. In the late stages of Parkinson’s disease, rigidity can lead to postural deformities and is associated with musculoskeletal pain (Jankovic, 2008). There are three areas of the brain that may be involved with the symptom of rigidity. Some evidence suggests that damage to (1) the basal ganglia contributes to the symptom of rigidity, the particular portions of the basal ganglia have not been identified. In addition, there is strong evidence that (2) the motor cortex and (3) the spinal cord motor neurons play a role (Pahwa, 2013).

**Loss of Postural Reflexes.** Loss of postural reflexes is also referred to as postural instability and is a symptom that is not usually manifested until the late stages of Parkinson’s disease. Loss of postural reflexes is, along with freezing gait, one of the most common causes of falls in the Parkinson’s population. Of this population, an estimated 38% experience falls with up to 13% falling more than once a week (Jankovic, 2008). Only the (1) globus pallidus section of the basal ganglia has been implicated in causing a loss of postural reflexes when it is damaged. In the brain stem, both the (2) pedunculopontine nucleus and the (3) locus coeruleus have shown evidence of being associated with loss of postural reflexes when they are damaged (Pahwa, 2013).

**Cognitive Training and Parkinson’s Symptoms**

Bradykinesia, freezing, tremors, rigidity and loss of postural reflexes are caused by neurological deficits. Anti-saccade eye-movement training involves a series of brain areas, which control the patient’s attention and reaction to their environment. These brain areas are: from the frontal cortex (1) the frontal eye field, (2) the supplementary eye field, and (3) the dorsolateral prefrontal cortex; from the parietal cortex (4) the posterior parietal cortex and (5) the lateral intrapartietal area; from the basal ganglia (6) the substantia nigra pars reticulata, (7) caudate
nucleus, (8) globus pallidus pars externa, (9) subthalamic nucleus, and (10) putamen; (11) superior colliculus; (12) thalamus; (13) lateral geniculate nucleus; (14) anterior cingulated; (15) insula; (16) visual cortex; and (17) cerebellum. Evidence shows that bradykinesia can be linked to the dysfunction of eight different areas of the nervous system, which are listed above. Five of these areas overlap with the 17 areas of the brain that are used when a participant performs an anti-saccade eye movement (Pahwa, 2013; Munoz & Everling, 2004; Everling & Fischer, 1998). Freezing, though similar to bradykinesia, can only be linked to the dysfunction of four different areas of the nervous system, as indicated above; only two of these areas are also affected by anti-saccade eye movements (Pahwa, 2013; Munoz & Everling, 2004; Everling & Fischer, 1998). Tremors have been linked to the dysfunction of four different areas of the nervous system, as indicated above; two of these areas are also affected by anti-saccade eye movements (Pahwa, 2013; Munoz & Everling, 2004; Everling & Fischer, 1998). The symptom of rigidity can be linked to the dysfunction of three different areas of the nervous system, as indicated above; one of these areas is affected by anti-saccade eye movement (Pahwa, 2013; Munoz & Everling, 2004; Everling & Fischer, 1998). Loss of postural reflexes is unique, in that none of the three different areas of the nervous system it is linked to is affected by anti-saccade eye movements (Pahwa, 2013; Munoz, & Everling, 2004; Everling & Fischer, 1998).

Given the overlap of the brain areas involved, it is reasonable to conclude that training with anti-saccade eye movements will have some effect on all of the aforementioned motor symptoms, with the exception of loss of postural reflexes. This is due to the fact that repeated use of these brain areas with the simple task of anti-saccade eye movements should increase top-down control in these areas. However, the largest effect should be seen on bradykinesia, as it has the largest number of problem areas targeted by eye-movement training. Figure 1 summarizes the motor symptoms and brain area involvement. Table 1 provides a summary of the areas of the
brain involved. A more detailed breakdown of the areas of the nervous system can be found in Table 8 in Appendix A.

Figure 1. Parkinson’s Motor Symptoms (developed using Pahwa, 2013; Munoz & Everling, 2004; Everling & Fischer, 1998)
# Table 1. Summary of Brain-Area Involvement (adapted from Munoz & Everling, 2004; Everling & Fischer, 1998)

<table>
<thead>
<tr>
<th></th>
<th>Eye-Movement Training</th>
<th>Parkinson’s Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Munoz&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Everling&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Frontal Cortex</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Parietal Cortex</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Basal Ganglia</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Brain Stem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Areas</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Number of brain areas used</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

**Legend:**
- Fully Engaged
- Partially Engaged
- Not Engaged

**Notes:**
- a. A 2003 summary of the areas of the brain recruited by eye-movement training.
- b. A 1998 summary of the areas of the brain recruited by eye-movement training.
- c. The specific areas of the basal ganglia have not been determined.

An X indicates that there is involvement from that portion of the brain, a number indicates how many subsections of that portion of the brain are involved.

A 2004 systematic review by Munoz & Everling compiled the clinical work done with anti-saccade eye-movement tasks. There are a number of psychiatric and neurological disorders including attention deficit hyperactivity disorder (ADHD), schizophrenia, Tourette’s syndrome and Parkinson’s which affect an individual’s ability to complete the anti-saccade task. As a result, this task can be used when screening for these conditions. While anti-saccade eye-movement
training has been used to try to increase control of eye movements, there are no studies related to its effect on gross-motor movements.

**Cognitive Training**

The underlying neurological process theory to support eye-movement training is *top-down and bottom-up control*. According to this theory, there are two types of neurological processes: top-down control and bottom-up control. Top-down control is when a person makes a decision on whether to take action based on the external stimuli they are receiving. This ability is lost when a patient with Parkinson’s develops bradykinesia, freezing or rigidity due to neurological deterioration. While the intent is there, the ability to translate the intent into action is missing (Moretti et al., 2011; Gazzaley & D’Esposito, 2007). Bottom-up control occurs when a person reacts automatically to stimuli; Parkinson’s does not impair this type of control. When a person jumps in surprise or looks towards something that has suddenly appeared in their field of vision, there is no initial intent, simply the reaction followed by the person realizing that they have acted (Gazzaley & D’Esposito, 2007). In this case, the attention of the individual is dominated by the stimuli that is the most intense, not the stimuli that is most relevant to the individual’s goals (Ruff, 2013). This relationship is shown in Figure 2.

![Figure 2. Interaction Between Eye-Movement Training and Cognitive Processes (developed using Moretti et al., 2011; Gazzaley & D’Esposito, 2007; Ruff, 2013)]
**Eye-Movement Training**

When a participant is exposed to eye-movement training, they are presented with a screen and told to focus on a certain point. A visual target will appear in the participant’s peripheral vision, which will often result in the bottom-up reaction of looking towards the stimuli, also known as a saccade movement. The training asks the participant to first suppress the saccade movement towards the stimuli, an act that will require top-down control. Secondly, the training requires the participant to perform an anti-saccade movement, looking in the opposite direction of the stimuli, which also requires top-down control in order to complete the movement (Munoz & Everling, 2004).

The neurons that control saccade and anti-saccade eye movements are located in several regions of the brain, including the cerebral cortex, the frontal cortex, the basal ganglia, the thalamus, the superior colliculus, the brainstem reticular formation and the cerebellum. Within the cerebral cortex, the parietal cortex acts as an interface between sensory and motor processing and projects information to the frontal cortex and the superior colliculus. In the frontal cortex, the frontal eye field and the supplementary eye field guide decision making and sequencing of saccades, and the dorsolateral prefrontal cortex guides executive function and special working memory and suppresses reflex responses. The frontal cortex also projects information to the caudate nucleus in the basal ganglia which—in conjunction with the substantia nigra pars reticulata, the globus pallidus and the subthalamic nucleus—connects to other sections of the brain and inhibits reflexes in the superior colliculus and the thalamus (Munoz & Everling, 2004; Everling & Fischer, 1998). Top-down control appears to be modulated in the frontal and parietal cortices, which work with the sensory and motor sections of the brain such as the basal ganglia (Munoz & Everling, 2004; Ruff, 2013). A patient with Parkinson’s sudden ability to move in an emergency indicates that these pathways for top-down control are likely still intact, but their
inability to voluntarily control movement the majority of the time indicates that they are routinely unable to access these pathways. Given that the frontal cortex and the basal ganglia are active in both top-down control and anti-saccade eye movements, the training of anti-saccade eye movement should result in the adaptation of the brain to facilitate top-down control as shown in Figure 3.

**Figure 3. Concept Map of Anti-Saccade Eye-Movement Training, Cognitive Function, Parkinson’s Motor Symptoms and ADLs**

In a 2004 study, Dyckman & McDowell trained a group of healthy young adults with anti-saccade eye movements for two weeks. Each daily training session consisted of 200 trials (anti-saccade eye movements). The young adults experienced a significant improvement (6.3%) in anti-saccade performance between baseline and the end of the first week. However, there were no significant differences between the performance at the end of the first week and the performance at the end of the second week. The occurrence of a plateau after seven days of
training is possibly due to a ceiling effect, caused by the fact that participants could not exceed 100% correct responses. A 2010 study by Kiyota and Fujiwara used healthy elderly adults who had received anti-saccade eye-movement training. As a result of the training, a significant decrease in anti-saccade errors was seen with an average of 10 days of training. The dose required to affect gross-motor functions is still under investigation; however, 10 days has been set as a precedent for change to occur in healthy elderly participants and, thus, provides a starting point for testing. Determine the optimal dose of training and determining if continued training is required to retain the effect are, for the moment, outside of the scope of this study.

**Bradykinesia**

Bradykinesia is of special importance when considering patients in the early stages of Parkinson’s disease, as it is the first of the symptoms to appear (Carpinella et al., 2007). The speed a person walks at is the result of two factors: their step length or stride length and cadence. Step length is the distance, in the forward direction, between the same spot on two consecutive footprints, for example measuring from the heel of the left footprint to the heel of the right footprint. When the right step length is added to the left step length, the result is the stride length. Cadence is the number of steps taken in a set amount of time, usually one minute (Levine, 2012). This relationship between gait speed, stride length and cadence can be expressed mathematically as:

\[
gait\_speed(m/s) = \frac{stride\_length \times cadence(steps/min)}{120}
\]

**Equation 1. Relationship between gait variables**

In the early stages of Parkinson’s, as seen in Figure 4, both the step length and the gait speed are altered—they decrease (Morris, Iansek, Matyas, & Summers, 1996; Dillmann et al., 2014, Carpinella et al., 2007). Evidence suggests that the patient’s ability to control their cadence
is not altered during the first stages of Parkinson’s disease, though in some cases it is used to compensate for a decreased step length (Morris et al., 1996; Dillmann et al., 2014; Carpinella et al., 2007).

Figure 4. Relation Between Bradykinesia and Stride Variables (developed using Morris et al., 1996; Dillmann et al., 2014, Carpinella et al., 2007)

**Activities of Daily Living**

Independence with ADLs is also a major concern for patients who are newly diagnosed with Parkinson’s disease, as they are more likely to have a decrease in ADLs abilities relative to their healthy age-matched peers. In addition, Hariz & Forsgren (2011) subdivided their participants with Parkinson’s based on their symptoms, into tremor dominant (TD), indeterminate (IND) or postural instability and gait difficulty (PIGD) subtypes. The participants with the PIGD subtype were more prevalent and showed significantly more difficulty completing both personal and instrumental ADLs compared to the TD subtype, when measured using the ADL-taxonomy scale which measures seven categories of personal activities and five categories of instrumental activities (Hariz & Forsgren, 2011). This suggests that the changes in gait caused by Parkinson’s have a greater effect on ADLs than its other symptoms.
Decreased gait speed is one of the components of gait difficulty, which has been examined individually in relation to ADLs. A study looking at the correlation between gait speed and the ability to independently complete ADLs found that the slower the gait speed, the more likely it is that an individual will not be able to complete the ADLs without assistance. This study included both in and out patients from a geriatric unit using the mean of three 2-metre walks as the measure of gait speed and the Barthel Index to measure ADLs. Specifically, participants with a gait speed of less than 0.25 m/s were more likely to be dependent in one or more ADL functions; participants with a gait speed between 0.35 and 0.55 m/s were more likely to be independent in all ADL functions, and participants with a gait speed greater than 0.55 m/s did not maintain independence. This same study did not note any impact of cognitive function on gait speed (Potter, Evans, & Duncan, 1995).

The correlation between slow gait speed and poor capacity to complete ADLs has been established for illnesses other than Parkinson’s. Green et al. researched patients with severe aortic stenosis, the majority of which have slow gait speed, and found that decreased gait speed was independently associated with poor independence in the ADLs as measured by the Katz ADL Index. The study considered a gait speed of less than 0.5 m/s to be slow and greater than 0.5 m/s to be preserved. Of the participants with slow gait speed, 32% were dependant in at least one ADL. Participants’ decreased gait speed was not explained by other clinical tools (e.g., Society of Thoracic Surgery score, measures of frailty) (Green et al., 2012).

Finally, a prospective cohort study by Guralnik, Ferrucci, Simonsick, Salive, and Wallace (1995) showed that poor function in the lower extremities, including decreased gait speed, of persons who did not have a disability was predictive of the development of a disability, which included increased disability with ADLs at the four-year follow-up. This puts patients with Parkinson’s at great risk of becoming dependant in many facets of their lives as the disease
progresses. Given the relationship between gait speed and ADLs it is reasonable to test the relationship shown in Figure 5, that improving gait speed should result in better ADLs.

Figure 5. Relationship between Gait Variables and ADLs

Hypotheses

This study uses three hypotheses to address the research question: In participants with Parkinson’s disease, who rank from 1 to 3 on the Hoehn and Yahr scale, what is the effect of eye-movement training on bradykinesia and activities of daily living? They are:

(1) Participants with Parkinson’s who receive 10 days of anti-saccade eye-movement training will have an increase in gait speed and step length;

(2) An increase in gait speed and step length in participants with Parkinson’s will have a positive correlation with an improved activities-of-daily-living score; and

(3) Participants with Parkinson’s who receive 10 days of anti-saccade eye-movement training will have an increased activities-of-daily-living score.

Figure 6 relates research hypotheses to the concept map.
Hypothesis 3 was important to include in the event that an improvement in ADLs was seen but an improvement in gait speed and step length was not.
Chapter 3

Methodology

Research Design

This project was completed using a single group pre-post experimental design. This design allowed comparison of an individual’s gait and ADLs scores with and without the eye-movement intervention. This study was run in conjunction with a larger study, *The effect of saccadic eye movement training on cognitive function in healthy adults and Parkinson’s disease patients* (Elsaeid et al., 2015). Both studies used the same intervention but had different questions and measured different outcome variables.

Sampling

The target population for this study was participants with Parkinson’s disease who rated from 1 to 3 on the Hoehn and Yahr scale (Metman, & Kompoliti, 2010). Participants who are at stage 1 on the Hoehn and Yahr scale experience unilateral involvement; indicating one side of their body is predominantly affected, with minimal or no functional impairment. Stage of 2 indicates bilateral or midline involvement, without impairment of balance, and stage 3 indicates the first sign of impaired righting reflex, which is shown when an individual needs help recovering after a sharp pull on their shoulders. Participants who are at stage 4 or 5 on the Hoehn and Yahr scale are at the severe stage of the illness and would not be able to complete the mobility testing, as stage 4 indicates that the disease is severe and debilitating, and stage 5 indicates that the participant is confined to a bed or wheelchair (Metman & Kompoliti, 2010).

The inclusion criteria for this trial were:
(1) diagnosed Parkinson’s disease, with a severity rating from 1 to 3 on the Hoehn and Yahr scale;

(2) able to speak, understand and read English; and

(3) able to walk 10 metres unassisted.

The exclusion criteria were:

(1) Mini-Mental State Exam (MMSE) score of 25 or less, which is outside of the normal range for participants with stage 1 to 3 Parkinson’s;

(2) any injury to or disability of the lower body that would render them unable to walk 10 metres unassisted; and

(3) inability to read content on the tablet screen.

The sample consisted of both males and females since Parkinson’s affects both sexes. However, the incidence of Parkinson’s is higher in men, who represent approximately 60% of the Parkinson’s population whereas women represent approximately 40% of the population (Nutt & Wooten, 2005; Van Den Eeden et al., 2003). Though symptom presentations differ by sex, gait difficulties are present in both groups, affecting 60.0% of males and 45.5% of females (Scott, Borgman, Engler, Johnels, & Aquilonius, 2000). Consequently, it is important to look at the effect of eye-movement training on both sexes.

A convenience sample was used that included patients with Parkinson’s disease who live in Kingston and the surrounding community. Participants were recruited sequentially through a number of venues: a presentation at the Parkinson’s Society of Canada local support group, posters at local community centres, participants from previous studies conducted at the Centre for Neurosciences who were willing to be contacted for research purposes, online advertisements, a local paper and word of mouth.
Hertzog (2008) recommends that a sample size of 10–20 participants per group is sufficient to conduct a post hoc power analysis. A sample of one group of 10 participants was recruited for this study. This was logistically feasible, given the time it takes to record motion-capture data (2 hours of data collection per person), the expense involved (approximately $50 per hour of lab time, and 2 hours of lab time required for each participant, costing a total of $1,000) and the number of Parkinson’s patients who met the inclusion criteria within the Kingston area.

**Measures**

Basic demographic data was collected for all participants. The first measure explored was scores from the MMSE (Folstein, Folstein & McHugh, 1975; Kurlowicz & Wallace, 1999; Nasreddine et al., 2005). This measure was used to determine if a participant would be included in the study. Once this was determined, a custom feasibility questionnaire, step length (Levine, 2012), gait speed (Levine, 2012) and Katz Activities of Daily Living Index (Reijneveld, Spijker & Dijkshoorn, 2007; Katz, Ford, Moskowitz, Jackson & Jaffe) were measured; the last three measures served as the dependent variables of the hypotheses being tested.

**Demographic Data.** The demographic data that was collected included: sex, age, height, weight, income range and whether the participant lived alone. See Appendix B for the demographics questionnaire used in this study. Height and weight data were used in the processing of the gait data. Visual3D™, the program used to create a digital model of the lower limbs, requires the entry of the subject’s height and weight. The program then allowed for the calculation of a number of gait variables including walking speed and step length.

**Mini-Mental State Exam.** The MMSE is a standard test developed by Psychological Assessment Resources Inc. to screen for cognitive impairment, and while it is not diagnostic, it can suggest the need for further testing (Nasreddine et al., 2005). The test has five components: (1) orientation, for example “what is the date?”, (2) registration, for example “listen carefully, I
am going to say three words. You say them back after I stop. Ready? Here they are … HOUSE (pause), CAR (pause), LAKE (pause). Now repeat those words back to me.”; (3) attention and calculation, for example “begin at 100 and count back by 7”; (4) recall, for example “can you remember the three words I asked you to remember?”; and (5) language, for example “Please read this and do what it says. (Shows participant the words on the stimulus form) CLOSE YOUR EYES.” If a person had difficulty completing the MMSE, it is likely that they would have been unable to complete the training and data-collection process (Folstein et al., 1975; Kurlowicz & Wallace, 1999). The cut-off score for the MMSE is 26, meaning that any participant with a score of 25 or lower has mild cognitive impairment. This tool, when used to screen for Alzheimer’s disease, has a sensitivity of 78% and a specificity of 100% (Nasreddine et al., 2005).

**Feasibility Questionnaire.** In order to investigate barriers, participants were asked to rate a set of seven statements (with a five-point Likert scale: 1 = “I don’t agree at all” to 5 = “I totally agree”) regarding the user-friendliness of the intervention. Two statements covered the convenience of the program, two covered the learning curve of the intervention, two covered technical problems that could interfere with the training and the final statement covered the entertainment value. There is also a section at the bottom of the questionnaire, which asks for any comments that the participants had regarding the experience. The questionnaire is found in Appendix C.

**Step Length.** Step length was determined as the distance between two consecutive footprints, measured from the heel of one footprint to the heel of the next footprint (for example from the heel of the left foot to the heel of the right). A reflective marker on the shoe at the superior edge of the calcaneus indicated the heel of the foot with two additional markers placed on the shoe above the medial calcaneus and the lateral calcaneus. Since step length can also be measured from toe to toe, a second set of markers was placed between the heads of the 2nd and
3rd metatarsal, on the head of the 1st metatarsal and on the head of the 5th metatarsal. These six markers allowed for a model of the foot to be created in Visual3D™ (2015), software that analyses 3-dimensional (3D) movement data.

In order to measure the distance between the feet, different events in the gait cycle were isolated. The gait events included heel strike, the moment when the foot first touches the force platform, and toe off, when the foot leaves the force platform. This gait event detection is more difficult in participants with Parkinson’s, as their shuffling gait can result in both feet being on the same force platform at the same time, obscuring heel strike and toe off. To circumvent this difficulty one clean heel strike and toe off was found for each leg of each participant. The pattern of the marker movement surrounding heel strike and toe off was compared to their movements during the rest of the walking trial. This allowed for the detection of heel strike and toe offs regardless of whether there was clean force data. Once gait events were identified, the distances for both left and right step length were determined.

**Gait Speed.** Gait speed was determined by the displacement of one of the markers. In order to be measured correctly, the distance and time were determined between the first occurrence of a gait-cycle event and the final occurrence the same event at the end of the movement trial. This resulted in displacement and time being measured for the length of each walking trial and gave the average gait speed for approximately a 5-metre walk.

**Activities of Daily Living.** Measurement of ADLs was used to determine if the changes in the participant’s movement had a meaningful effect on the participant’s day-to-day life. The Katz Index assesses 10 ADLs: (1) eating and drinking, (2) sitting down on and getting up from a chair, (3) getting into or out of bed, (4) getting dressed or undressed, (5) going to another room on the same floor, (6) going up or down the stairs, (7) leaving or entering the house, (8) moving about outside the home, (9) washing your face and hands, and (10) washing your entire body.
The Katz Index asks the participant to categorize their ability to do the 10 activities as (A) without difficulty, (B) with some difficulty, (C) with great difficulty or (D) only with the help of others. The Katz Index is included in Appendix D. This tool has been tested in Amsterdam across three ethnic groups: Dutch, Turkish and Moroccan (Reijneveld et al., 2007). The tool showed good internal consistent reliabilities for all ethnic groups (P > 0.05). The Katz Index correlated strongly with the Organization for Economic Co-operation and Development (OECD) long-term limitations in mobility scale (0.64) and the SF-36 Physical Functioning (-0.60) (Reijneveld et al., 2007). The ADLs of the Katz Index are based on the steps that a disabled older adult transitions through as they regain function, which also coincides with the progression of a developing child. Each one-point increase on the scale of 0 to 10 indicates an activity of daily living that the individual is no longer able to do and, thus, is a clinically important change (Reijneveld et al., 2007; Katz et al., 1963).

**Intervention**

Participants were instructed how to use the eye-movement training program, which was installed on a tablet (a Samsung Galaxy™ Tab 4) issued to them for the duration of the study. The anti-saccade eye-movement task is an established task, which has been used in studies for a wide age range of both neurologically intact and impaired participant groups for decades (Munoz & Everling, 2004; Everling & Fischer, 1998; Mirsky et al., 2011; Munoz, Broughton, Goldring, & Armstrong, 1998; Pelsch, Hemraj, Garcia, & Munoz, 2011).

The program was customized for the tablets being used by the primary researcher of the parent study. The program could be used by participants with varying levels of visual acuity as the size of the stimulus presented was based on the size of text font that the participant was able to read on the computer screen. The Samsung Galaxy™ Tab 4 has a 10-inch screen with 149 points per inch (ppi). Participants used the eye-movement training program for 10 consecutive
days. Each day they were presented with 180 trials, which took approximately 30 minutes. The tablet automatically proceeded through the 10 required days. The program was designed so that the participant could only train for the prescribed amount of time each day (i.e., they could not train all 10 days on the same day). They were able to train however they wished (e.g., all 30 minutes at the same time, 10 minutes at a time three times a day, etc.) The time spent training each day was automatically saved onto the tablet and was collected by the investigator at the end of the training. In order to improve adherence, the participants were informed that their use of the program would be recorded and reviewed by the researcher. The tablet was also programmed to remind the participants of their training once a day. The tablet also recorded the participant’s success rate. This data is being used the study run by Elsaeid et al. (2015).

Finally, the eye-movement training used in this study had not previously been used to train gross-motor movements. While 10 days of training with 30 minutes a day has appeared effective in studies looking at changes in anti-saccade eye movement in healthy young adults, there is a lack of evidence demonstrating what dose and frequency will cause changes in gross-motor movements (Dyckman & McDowell, 2004). This pilot began to fill this knowledge gap.

**Procedure**

When a potential participant contacted the primary investigator, the individual was screened for some of the basic inclusion criteria: having Parkinson’s, being able to walk 10 metres unassisted and being able to read content on a tablet, and any questions they had were answered. If the individual was still interested and approved to participate, an appointment for baseline data collection was booked. In order to facilitate the participant’s access to the facility, either the cost of parking or the cost of cab fare was provided by the primary investigator.
The baseline data collection began with the participant being asked to sign a consent form and any questions they had were answered. Next, the MMSE was administered and the stage of their Parkinson’s was assessed in order to finish assessing the inclusion and exclusion criteria.

The testing at the Hotel Dieu Hospital (HDH) Human Mobility Research Lab included completing the demographics questionnaire, the Katz ADLs Index and a motion-capture session. For the motion-capture session, the participant was instructed to wear comfortable shoes and to wear the same shoes to both motion-capture sessions. The full marker set used in the data collection is shown in Figure 7. This marker set is a standard marker set used in the lab; only the feet were required to calculate the outcome measures. A table of the marker names and their placements is found in Appendix E.
Figure 7. Marker Placement Guide

The participant was then asked to stand still for a static calibration while being recorded by the Qualisys™ camera system, which is comprised of 11 Oqus cameras from Qualisys Motion Capture Systems (www.qualisys.com). The participant was then asked to walk a distance of 5 metres at their normal self-selected walking speed in the centre of the lab space while being recorded. A sample of the instructions given to each participant is in Appendix F. During each data-capture session, each participant completed the distance five times and had the option to rest.
in between trials. This produced a minimum of five complete gait cycles for each of the participants.

It was expected that the time required for data collection for this pilot study would not exceed 1.5 hours per participant for the pre-intervention collection and 1 hour per participant for the post-intervention collection. The participants were offered rest periods during the data collections as well as water, coffee or tea. The participants were clearly informed that they could call a stop to the data collection at any time and that this would not affect the treatment that they received. During the data collection, there was a chair stationed at both ends of the capture volume, and a researcher walked alongside them. The participants were encouraged to make use of the chairs between their five walking trials should they become fatigued. At all times, the participants had the option of having a family member or friend present when being screened and during data collection.

After the 10 days of training, the participants returned to the HDH Human Mobility Research Lab. The data collection included gait data, Katz ADLs score and a feasibility questionnaire. At this point, the participant had finished the study and was thanked for their participation. The data was then analysed as discussed in the next section.

**Analysis of Feasibility**

As this study is a pilot, it was important to consider the feasibility of the eye-movement training intervention and the data-collection procedure. In order to determine if the regime was feasible for participants, a questionnaire was administered, the researcher kept detailed notes and the program recorded the participant’s adherence.

**Questionnaire.** The five-point scale on which the participants rated the statements concerning the training program was collapsed into three categories: agree, neutral and disagree.
The mode and ranges were determined for each statement in order to compare between statements and link them to the notes left in the commentary section.

**Researcher Notes.** The primary investigator also kept notes on various aspects of the data collection. These aspects include: (1) any difficulty arranging for the participant to come to the lab, (2) any difficulty completing the motion-capture session, (3) any difficulty completing the eye-movement session, (4) any frustration with the tablet/program, (5) any concerns with being able to complete the training program, (6) any contact with the researcher outside the data-collection sessions, and (7) any miscellaneous problems. See Appendix G for the blank Researcher Experience form. These notes were condensed and combined with the commentary from the Feasibility Questionnaire for analysis.

**Tablet Data.** The actions taken by the program and the actions taken by the participant were recorded on the tablet and were loaded into the Matlab computer program, version 8.1.0.604 (2013). Matlab was then used to view and manipulate the data. The variables that were considered for this study are listed in Table 2.
Table 2. Tablet Variables Collected

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total days trained</td>
<td>There is one file compiled for each day trained which holds the particulars for that session.</td>
</tr>
<tr>
<td>Instruction speed</td>
<td>Participant is given the instructions to either look away from the stimuli, perform an anti-saccade movement, or to look towards it - a saccade movement. The amount of time the instruction is on the screen is determined randomly within a certain range and is recorded for each trial.</td>
</tr>
<tr>
<td>Stimulus speed</td>
<td>The stimulus stays on the screen for the participant to perform a saccade or an anti-saccade movement for varying amounts of time. The amount of time the stimulus is on the screen is determined randomly within a certain range and is recorded for each trial.</td>
</tr>
<tr>
<td>Size of the stimulus</td>
<td>The size of the stimulus varies for each participant based on the font size that they can read. The height of the stimulus is equal to the size of the font that they can read plus four pixels. The size of the stimulus is recorded for each participant.</td>
</tr>
</tbody>
</table>

Analysis of Activities of Daily Living

The Katz ADLs Index is scored from 0 to 10, with 0 being the highest level of impairment. The average impairment for the 10 participants was calculated at baseline and at the 10-day mark and the means were compared.

Analysis of Gait Characteristics

In order to analyse the gait characteristics, the program Visual3D™ Version 5 was used (2015). Visual3D™ is software, developed by C-Motion in Maryland, USA, which allows for the analysis of 3D data regardless of the hardware used for collection. It allowed the primary investigator to create biomechanics models, analyse the data and create reports.

Pipeline. In order to increase the speed of data processing and reduce the risk of errors, Visual3D™ users can create a pipeline, which takes the program through the predetermined steps.
of processing the data with little user intervention. The complete pipeline and an explanation of each step are found in Appendix H.

**Gait Speed.** A set of five movement trials for each of the 10 participants resulted in 50 movement trials collected at baseline and 45 trials for the 10-day mark.

**Step Length.** Given five movement collections for each of the 10 participants, there were 150 step lengths calculated for baseline and 135 for the 10-day mark.

**Statistical Analysis**

Descriptive statistics and a test for normality were run for each of the variables collected in order to provide a summary and an overview of the data. In addition, paired sample $t$-tests were performed between baseline and follow-up for three variables: walking speed, left step length and right step length. This test was selected because it was anticipated that the data would be normally distributed and the data was collected from the same group of participants at different points in time.

In order to facilitate future research, effect size for the three $t$-tests was calculated. From the effect size, the sample size required to show significant results was calculated.

**Ethical Considerations**

Ethics approval was received for this study from Queen’s University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board, file number 6014085. The letter of approval can be found in Appendix I and the Amendment Acknowledgement/Approval Letter can be found in Appendix J.

**Informed Consent.** Participants provided informed consent before being enrolled in the study. In order to accomplish this, the principal investigator provided an in-depth explanation of all the study procedures. Samples of the recruitment speech, recruitment handout and recruitment advertisement can be found in Appendices K, L and M respectively. The explanations covered
both the data collections and the intervention, and the principle investigator answered any questions that the potential participant had. Participants were informed that they were free to revoke informed consent at any time during the study. Participants were also informed that this study was being run in conjunction with a larger study and that they were welcome to participate in only one of the studies instead of both at the same time.

**Data Storage.** There were two types of data collected: electronic files containing gait data and electronic records containing forms for questionnaires and the Katz ADLs Index. The gait data is stored on the HDH Human Mobility Research Lab cloud, a server that can only be accessed by researchers with the password. The cloud security meets the hospital’s standards for patient-data storage. The questionnaires and the Katz ADLs Index were collected with a computer owned by the HDH Human Mobility Research Lab and uploaded to the cloud. Furthermore, participants were assigned an anonymized participant number, which was used on all files instead of their name.
Chapter 4

Results

The results for this study will be presented in six sections. First will be the demographics, which give an overview of the study population. Next, results from the feasibility questionnaire and feasibility researcher notes will illustrate how the participants reacted to the study and intervention as well as practical issues faced along the way. The tablet data will be explored in order to give a better understanding of what data can be accessed from the tablets, such as the days spent training and the speed of the program. Finally, the Katz ADLs Index and the Gait Variables will be investigated.

Demographics

The participants were primarily male (60%) and had a range of 17 years with the youngest being 64 and the oldest being 81. The mean BMI of participants was 26.9 (SD ± 3.8). Of the participants, 70% had a BMI which was associated with either a normal weight or being overweight. The final 30% had a BMI of 30 or greater, thus considered obese.

On the Hoehn and Yahr scale participants represented all three stages of Parkinson’s disease within the predetermined range. However, the majority fell into the first two stages. Moreover, the majority of participants (60%) scored a perfect 30 on the MMSE. The lowest score was 27 resulting in a range of 3. The MMSE score was the only demographics variable which was not normally distributed, D(10) = 0.35, p < .05.

For household income, the majority of participants fell between $35,000 and $74,999 per year income category. When asked if they lived with someone who could help them with their ADLs, 60% of participants said yes. One participant (10%) answered that they had someone visit
to help around the house for 1 hour per week. A complete overview of participant demographics is provided in Table 3.

### Table 3. Participant Demographics

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Variables</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Female</td>
<td>4 (40)</td>
</tr>
<tr>
<td>Age</td>
<td>60 to 69</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>70 to 79</td>
<td>5 (50)</td>
</tr>
<tr>
<td></td>
<td>80 to 89</td>
<td>1 (10)</td>
</tr>
<tr>
<td></td>
<td>Mean Age 71 ±5.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age Range 64–81 years</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>18.6 to 24.9</td>
<td>3 (30)</td>
</tr>
<tr>
<td></td>
<td>25 to 29.9</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>&gt; 30</td>
<td>3 (30)</td>
</tr>
<tr>
<td>Hohen and Yaher Scale</td>
<td>1</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2 (20)</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mean Score 29.3 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>Household income</td>
<td>$25,000 to $34,999</td>
<td>1 (10)</td>
</tr>
<tr>
<td></td>
<td>$35,000 to $49,999</td>
<td>3 (30)</td>
</tr>
<tr>
<td></td>
<td>$50,000 to $74,999</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>$75,000 to $99,999</td>
<td>1 (10)</td>
</tr>
<tr>
<td></td>
<td>Prefer not to say</td>
<td>1 (10)</td>
</tr>
<tr>
<td>Live with someone</td>
<td>Yes</td>
<td>6 (60)</td>
</tr>
<tr>
<td>Has someone visit</td>
<td>Yes</td>
<td>1 (10)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>4 (40)</td>
</tr>
<tr>
<td></td>
<td>Not Applicable</td>
<td>5 (50)</td>
</tr>
</tbody>
</table>

*Note. N = 10*

**Feasibility Questionnaire**

The feasibility questions were designed to receive feedback from the research question regarding how the participants found the experience of using a tablet to complete a daily eye-movement training program. The complete questionnaire can be found in Appendix C. All 10
participants answered all of the questions. Nine of the ten participants answered the questionnaire at the follow-up data collection, and one of the participants answered the questionnaire when returning the tablet, having decided not to continue with the study. A summary of the responses to the feasibility questionnaire is found in Table 4.

**Table 4. Feasibility Questionnaire Breakdown**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Disagree n (%)</th>
<th>Neutral n (%)</th>
<th>Agree n (%)</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was easy to find the time to train</td>
<td>1 (10)</td>
<td>0 (0)</td>
<td>9 (90)</td>
<td>5</td>
</tr>
<tr>
<td>Working with a tablet was convenient</td>
<td>1 (10)</td>
<td>2 (20)</td>
<td>7 (70)</td>
<td>5</td>
</tr>
<tr>
<td>It was easy to learn the program</td>
<td>2 (20)</td>
<td>1 (10)</td>
<td>7 (70)</td>
<td>5</td>
</tr>
<tr>
<td>It was easy to use the program</td>
<td>3 (30)</td>
<td>0 (0)</td>
<td>7 (70)</td>
<td>5</td>
</tr>
<tr>
<td>There were no technical issues with the program</td>
<td>3 (30)</td>
<td>1 (10)</td>
<td>6 (60)</td>
<td>4</td>
</tr>
<tr>
<td>There were no technical issues with the tablet</td>
<td>2 (20)</td>
<td>1 (10)</td>
<td>7 (70)</td>
<td>5</td>
</tr>
<tr>
<td>The training was entertaining</td>
<td>3 (30)</td>
<td>5 (50)</td>
<td>2 (20)</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note. N = 10*

Participants tended to agree with the statements in the questionnaire with the exception of the final statement “The training was entertaining.” Despite this, the range of answers for all the statements except the first was 4, indicating participant’s answers spanned the entire possible range. The answers given to the statement “It was easy to find the time to train” only had a range of 3, as no participant disagreed completely.
Feasibility Researcher Notes

The following is an amalgamation of the researcher notes collected on the form in Appendix G and the comments from the comments section of the Feasibility Questionnaire in Appendix C. This data covers the first two research questions, which address the feasibility aspects of the study: the condensed results are presented in Table 5.
Table 5. Research Notes

<table>
<thead>
<tr>
<th></th>
<th>Tablet Difficulties</th>
</tr>
</thead>
</table>
| 1 | Participants had difficulty understanding instructions about the tablet while it was moving at regular speed, suggested slowing it down or having drawings of the different steps  
   | Participant had difficulty following the instructions for the anti-saccade task  
   | Participant wanted an example of what we wanted them to do with the tablet  
   | Participant needed cuing to remember the next step of the training |
| 2 | After the vision test, the size was still too small  
   | Participant was confused as to the difference between the vision test and the real test  
   | Participant stated “I did not realize there was an end to the vision test the first 2 days so I had to start the 10 days over.” |
| 3 | Tremor caused problems with using the touch pad  
   | Hand tremor made it difficult for participant to work the touch pad  
   | Participant had difficulty with the touch screen  
   | Participant complained that the test would move on if he accidentally touched the wrong part of the screen |
| 4 | Had to start over after the fourth day, she was dragging her fingers and aborting the program  
   | Participant kept accidentally aborting the program  
   | Participant kept accidentally going back to the main screen  
   | Participant said that on two of the days the program moved on to the next trial before he could select the box with the opening in the right direction. |
| 5 | Participant had never used a computer, even had trouble turning the tablet on and off  
   | Participant stated that “There were an awful lot of programs in the tablet, I was expecting only the training program and as a result had difficulty finding the program.”  
   | Participant stated “When the name came up and I pressed the button to start it wouldn't start all the time.” |
| 6 | Images were moving too quickly, ended up doubling the time from 5 seconds to 10  
   | Participant had difficulty with tests that went by too quickly  
   | Participant complained that the training went too quickly  
   | Speed of the disappearing images was too fast  
   | Participant found that it was “Very fast at some points”  
   | Participant stated that it was “so darn fast, half the time couldn’t get my finger on the keyboard, might be a slow learner.” |
Participant stated that he couldn’t use a tablet at baseline testing because he never had before.

Participant said she wasn’t a computer person.

Took an hour to teach the participant how to use the tablet.

Participant had trouble learning the eye-movement training program but once she learned it she thought that it was easy to work with.

Participant reports “I had some minor problems adjusting to the tablet but was able to work through them.”

Participant initially reported that he was very non-technological and that it would take him a while to learn the program.

At the end, the participant said that he was surprised how easy it was. He expected to have a lot more trouble.

Participant “Thought that I would have trouble with the tablet but it was surprisingly easy.”

Participant found that he got faster over time.

Frustrating, his wife had to nag him to the point that she said they might end up in divorce and would we pay the lawyer’s fees?

Participant wanted to throw the tablet out a window.

Participant found the training frustrating rather then enjoyable.

Participant “Found the experience difficult and frustrating”

Participant stated “Frustrated at first not to see if I was doing well. Then I saw scores after practices after a few days.”

Participant was “Frustrated to keep on being told each day ‘You can do better!’”

Participant found that “The comment at the end saying you can do better was frustrating, I put my best in and wasn't sure what I was doing wrong”

Participant found that “The feedback at the end was unclear, and didn’t have enough input to find the information helpful.”

Participant wanted to be able to keep training after the study finished.

Participant asked to drop out 3 days after receiving the tablet, unwilling to troubleshoot, said that one day it took her 3 hours, did not contact primary investigator for help prior to dropping out.

Participant stated that his wife was much more comfortable with computers than him.

Participant liked that the tablet warned him it was going to die and that it didn’t let him over train.

Liked having the practice, allowed him to get into the mood each day.

Participant stated that “Everything went smooth[,] did it the same time each day.”

Found that the difficulty of the training remained the same over the 10 days.
### Scheduling

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1 | Initially participants were becoming tired when tests were done back to back  
  | Participants were tiring from back-to-back testing  
  | Participant suggested doing testing on 2 days  
  | Participant initially asked to do the testing together, until he started with the gait portion then he decided to split it up  
  | Participant preferred to do all the testing together since it was quite a ways into Kingston |
| 2 | Causes for rescheduling (1) delayed completion of the pretest, (2) delayed completion of the training due to trouble with the tablet  
  | Had to delay testing due to not finishing baseline testing (computer crashed)  
  | Changed to scheduling the post test from the initial contact to a couple days after they had been given the tablet |
| 3 | Testing took longer at baseline than follow-up  
  | Participant stated that eye-movement testing was harder and more tiring then the gait testing |
| 4 | Two participants were snow birds and had to wait for them to get back to participate  
  | Participant wanting to chat added time  
  | Participant took longer because of chatting  
  | Participant’s slow movements around the lab added time to collection |

### Gait collection

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1 | Participant had trouble standing straight due to scoliosis  
  | Difficulty palpating knees due to varicose veins and scar tissue  
  | Had difficulty palpating the participant’s knees because she was too unstable to bend them  
  | Participant was unsteady on his feet and unable to bend knees for palpation |
| 2 | Participant had to hang onto counter while standing to have the markers placed  
  | Participant was unsteady on her feet and had to hold onto something while standing to have their markers placed  
  | Participant was unsteady on feet during marker placement  
  | Participant was unsteady, stayed within an arms reach and encouraged use of the sit-stand stool |
| 3 | Wet shoes caused markers to loose adhesion  
  | Participant was more comfortable with looser shorts, compensated by taping up the shorts above the clusters  
  | Participant seemed to walk on a curve instead of in a straight line |
### Eye-lab collection

1. First couple of participants took as much as 3 hrs on the eye test
   - Difficulty getting participant calibrated
   - Participant had difficulty with the calibration for the eye-movement
   - Participant had difficulty with calibration due to fatigue
   - Difficulty calibrating the eye-testing when participant was tired

2. Mat lab crashed
   - Eye-lab’s computer stopped working
   - Eye-testing instructions had to be re-explained at follow-up

### Miscellaneous Logistics

1. Participant had trouble scrolling on the questionnaire iPad
   - Participant needed primary investigator next to him to help answer questions on the iPad
   - Primary investigator had to be on hand when the participant was answering questionnaires on the iPad to help
   - Needed to be on hand to help participant fill out iPad questionnaire
   - Participant kept accidentally turning the iPad off by resting the edge with the on/off button against the table
   - Participant held down too long on the check box on the iPad and had a hard time getting the answer to register
   - Participant had difficulty scrolling up and down on the iPad

2. Participant had an increase in knee pain between baseline and follow-up visits
   - Participant used cane for uneven surfaces but not in the lab
   - Participant was anxious before coming to participate in the study
   - Participant stated that he was worried about the study the week before it started.
Tablet Data

Total Days Trained. The target number of days to train was 10. The mean number of days spent training was 8.30 (±3.30) and the mode was 10. The minimum number of days trained was 0, as one individual was unable to operate the tablet and did not finish a complete day of training; the maximum number of days trained was 11 as there was technical difficulties with one of the tablets and the maximum of 10 training days was not set correctly. The total days trained was significantly not normal (D(9) = 0.35, p < .05), as would be expected from such a small sample. A summary of the days trained per participant is presented in Table 6.

Table 6. Tablet Data

<table>
<thead>
<tr>
<th>Participant</th>
<th>Days trained</th>
<th>Size of Stimuli (Pixels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>49</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>37</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>34</td>
</tr>
</tbody>
</table>

Note. n = 9. Participant 7 chose to withdraw from the study. As a result there is no tablet data available.

Tablet Speed. There are two speeds to be considered with regards to the tablet program, the instruction and stimuli speeds.
The minimum time that the instructions could appear was 1100 milliseconds (ms) and the maximum time that the instructions could appear was 1599 ms. The program generated the length that the instructions remained on the screen randomly within this range. The mean length of time the instructions stay on screen for any session was in the mid 1300s.

The minimum time that the stimulus could appear on the screen was 34 ms and the maximum time was 1000 ms. The mean amount of time the stimulus stayed on screen decreased regularly, at pre-determined intervals, starting with 650 ms and ending at 383 ms over the 10 days of training.

Figure 8 presents a sample of the time data that can be taken from the tablet. The time spent on screen for the instructions (green) and the stimulus (blue) are graphed for a typical training session completed by one of the participants. This access to trial-by-trial data opens possibilities for data analysis in future studies.
Figure 8. Time for Stimulus and Instructions

Size of the Stimulus. The mean size of the stimulus presented was 33.89 pixels (±7.114). The minimum size was 24 pixels and the maximum was 49 pixels for a range of 24. The size of the stimulus is significantly normally distributed, (D(9) = 0.22, p > .05). A summary of the stimuli sizes chosen by the participants can be seen in Table 6.

Katz Activities of Daily Living

Data was collected for all 10 participants at baseline but only from 9 at the follow-up. The means for baseline and follow-up were just below the perfect score of 10 at 9.90 (SD ± 0.316) and 9.78 (SD ± 0.667) respectively. The median for both baseline and follow-up was 10. The percentiles for 25, 50 and 75%, at both baseline and follow-up, were 10. The Katz score at
baseline has a range of one since its maximum is a score of 10 and its minimum is a score of 9. The Katz score at follow-up has a range of 2 since its maximum is a score of 10 and its minimum is a score of 8. The Katz score totals at baseline and follow-up were both significantly not normal.

**Gait Variables**

Walking speed as well as the right and left step lengths were collected from all 10 participants at baseline; however, only 9 participants completed the gait collection at follow-up. All of the gait variables were found to be normally distributed.

**t-Test.** A paired samples $t$-test was conducted for the three sets of variables: comparing walking speed at baseline to follow-up, comparing left step length at baseline to follow-up, and comparing right step length at baseline to follow-up. A summary of the gait variable descriptive and $t$ values can be found in Table 7.

**Table 7. Gait Variables Mean and $t$-Test**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>$t$</th>
<th>df</th>
<th>Sig</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking Speed – Baseline (m/s)</td>
<td>1.01 (0.12)</td>
<td>-1.746</td>
<td>8</td>
<td>0.301</td>
<td>0.13</td>
</tr>
<tr>
<td>Walking Speed – Follow-up (m/s)</td>
<td>1.03 (0.17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Step Length – Baseline (m)</td>
<td>0.59 (0.07)</td>
<td>-1.106</td>
<td>8</td>
<td>0.119</td>
<td>0.00</td>
</tr>
<tr>
<td>Left Step Length – Follow-up (m)</td>
<td>0.59 (0.07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Step Length – Baseline (m)</td>
<td>0.59 (0.06)</td>
<td>-0.654</td>
<td>8</td>
<td>0.531</td>
<td>0.00</td>
</tr>
<tr>
<td>Right Step Length – Follow-up (m)</td>
<td>0.59 (0.09)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* df = degrees of freedom; Sig = significance
There was no significant difference between the baseline mean and follow-up mean for any of the three measures. In all three cases, the $t$ value is negative, indicating that the first mean, the one taken at baseline, is smaller than the second mean, which was measured at follow-up.

**Effect Size.** Given the mean and standard deviation of each of the variable sets, the effect size for each was calculated using Cohen’s $d$.

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

**Equation 2. Equation for Cohen’s $d$**

The calculations can be seen in Appendix N. The effect size for walking speed ($d = 0.13$) was less than the suggested small effect size of 0.2; the effect size for left and right step length were both non-existent, as the mean did not change ($d = 0.00$).
Chapter 5
Discussion

This study was a feasibility assessment of the evaluation of the effect of anti-saccade eye-movement training on gait and ADLs in participants with Parkinson’s disease. This discussion will centre primarily on the feasibility of using the intervention for a larger study. It will also consider the results of the hypothesis posed.

Recruitment

The recruitment process posed some challenges due to the population characteristics of the geographical area being recruited from and the study’s strict inclusion and exclusion criteria. A large portion of recruitment occurred from Parkinson’s monthly support-group meetings which were hosted in the evening. While recruitment was planned to begin in January, the first two meetings were cancelled due to inclement weather. Once meetings recommenced in March, they were poorly attended due to difficult travel conditions and potential participants being out of the country for the winter season. However, participants were also successfully recruited via word of mouth, as many of the participants knew one another.

Exclusion Criteria. When the study was initially designed, there were two exclusion criteria:

(1) have a body mass index (BMI) over 30; or

(2) have a Montreal Cognitive Assessment (MOCA) score of 25 or less, which is outside of the normal range for patients with stage 1 to 3 Parkinson’s

BMI was initially included because the gait characteristics of obesity include both a slower walking speed and lower cadence, which add confounding variables to the analysis of the
patient’s gait (Hills, Hennig, Byrne & Steele, 2001). This was not expected to pose a problem as individuals with Parkinson’s disease tend to have significantly lower BMIs than controls with the majority of the Parkinson’s population having BMIs under 30 (van der Marck et al., 2012). However, excluding patients with BMIs over 30 became problematic when 30% of the participants the study was able to recruit fell into this category.

MOCA is a 10-minute 30-point screening tool, which detects mild cognitive impairment. The cut-off score for MOCA was 26, meaning that any participant with a score of 25 or lower has mild cognitive impairment. The specificity for the MOCA is 87%, which is slightly lower than the specificity of the MMSE. However, MOCA’s sensitivity to detect mild cognitive impairment was excellent (90%) and considerably better than that of the MMSE (Nasreddine et al., 2005; Hoops et al., 2009), which is why it was chosen as an additional measure to exclude individuals with mild cognitive impairment. However, upon testing the participants who were recruited 30% had a score of less than 26. Participants with a score of less than 26 were no less able to complete the training.

Had BMI and the MOCA score remained exclusion criteria for the study 4 of the 10 participants who were recruited would not have been able to complete the study. As a result it was decided that the exclusion criteria were too strict for the population available to recruit from.

Due to the changes in inclusion/exclusion criteria and challenges with study recruitment, the target sample size was reduced from 20 to 10 which was still sufficient for the purposes of this study.

**Attrition.** One participant dropped out of the study three days after receiving the tablet. The participant reported over the phone that the program had taken 3 hours of her time one day, despite the fact that the program is designed to run for a maximum of 30 min. When the primary investigator offered to have a researcher come to her home to troubleshoot, the participant
declined and asked to have a researcher come and collect the tablet. The participant’s demographics were not significantly different from the other participants, and she was not the least experienced with a tablet. While other participants expressed frustration with the tablet this was the only occasion where the participant spent so long with the tablet on a single day. When the tablet was returned to the lab there was no indication of malfunction and given that the participant declined the offer to have a researcher troubleshoot with them the cause of the problem was not determined.

**Demographics**

This study aimed to acquire a sample that was representative of the Parkinson’s population who are ranked from stage 1 to 3 on the Hoehn and Yahr scale. The Parkinson’s population consists of 60% males (Nutt & Wooten, 2005; Van Den Eeden et al., 2003). According to StatsCanada, 79% of people who report having Parkinson’s and are still living at home are 65 or older and the average age of diagnosis is 66.2 years (Wong et al., 2014). Also, 84% of those with Parkinson’s rely on help from informal caregivers such as family or friends (Wong et al., 2014).

The participant sample of this study has a sex distribution of 60% male, consistent with that of the target population. The youngest participant was 64 years old, with the average age being 71. The average age is 5 years older than the average age of diagnosis, as described by Wong et al. (2014), which is reasonable given that the sample was limited to participants who were in the first three stages of Parkinson’s with the majority of those recruited (80%) falling into the first two stages. Only one participant reported receiving outside help around the house, while 60% reported living with someone who could assist with ADLs. This corresponds to Wong et al.’s (2014) finding that a large amount of informal help is provided by family and friends.

Household income was collected to determine if financial strain was inhibiting participants from adapting to life with Parkinson’s disease and completing ADLs due to an unsafe or unfit
environment. Statistics Canada (2012) estimates that $29,510 is sufficient for a family of four to live on in Kingston. Given that 8 participants reported a household income between $35,000 and $99,999 (with 1 participant between $25,000 and $34,999 and 1 choosing not to disclose), it is reasonable to conclude that none of our participants would be considered under financial hardship.

**Tablet Training**

In order for any intervention to have an effect, participants must adhere to it. For the anti-saccade eye-movement training, this study found that good adherence to the program is dependent on three main factors: a reasonable time commitment, the entertainment value of the program, and the participant’s ability to access the program properly.

**Time Commitment.** The time commitment for this study, 20 to 30 minutes of training a day for 10 days, was found to be a reasonable amount of time for this population. This is based on the results of the Feasibility Questionnaire, where nine of the participants agreed that it was easy to find the time to train, that 60% of participants completed 10 days of training with a mean 8.30 days completed, and an adherence rate of 90%.

As a result, the amount of time trained does not have to be decreased to promote adherence. It may also be feasible to increase either the amount of training per day or the number of days trained. This is supported by a study conducted by Shatil et al. (2010) which explored unprompted adherence to a home-based computerized cognitive-training program delivered to patients with multiple sclerosis (MS). Participants in that study were instructed to train three times a week, 20 to 30 minutes each time, for 12 weeks. Overall 71.2% of participants adhered to the training program with 37.3% of the participants completing all 24 training sessions. It is encouraging that though this study had a smaller sample size than the MS study (n = 59) both our adherence and completion rates were higher than those observed by Shatil et al. (2010).
**Entertainment Value.** Although, it is not essential that the medical treatments prescribed to participants be entertaining, the Feasibility Questionnaire item “the training was entertaining” received more disagreement than agreement and 50% of participants indicated a neutral response. However, adherence ought to increase as the entertainment value goes from not entertaining to perfectly neutral and then to entertaining. This is supported by a study conducted by Zimmermann et al. (2014) where the cognitive benefits of a computer-based, cognitive-training program was compared to the benefits of a computer sports game with motion-capturing controllers in Parkinson’s patients after 4 weeks of training. The study showed similar benefits from both training regimes for attention, working memory, inhibition and planning but greater improvement in attention for those participants who trained with the sports game. A possible explanation for this outcome was suggested as being that the sports game was entertaining and that patients were more motivated to play the games than undergo cognitive-specific training.

Another study by Pompeu et al. (2012) found that balance exercise therapy and game-based motor cognitive training had similar effects on ADLs, as measured by the Unified Parkinson’s Disease Rating scale (UPDRS). They did, however, posit that game-based motor cognitive training may improve motivation, and thus adherence, in the long term by avoiding the monotony of repetitive exercises. As such, the elements that increase and decrease the entertainment value of this study’s eye-movement training program should be carefully considered and improved upon where possible.

Participant feedback given about the program included many comments about frustration, which prevented them from enjoying the training. One participant reported that they found the training frustrating rather than enjoyable while another wrote that they “Found the experience difficult and frustrating.” Another participant stated that she frequently wanted to “throw the
tablet out of a window.” Specific areas of frustration were identified as the speed at which the training program was set and the type of feedback given.

There was a good deal of participant commentary on how frustrating the speed of the training was, with six comments on how the speed made the training difficult. One of the first participants had to have the speed of the software program reduced after the first couple of days. His wife brought the tablet in for adjustment and told the researchers that she had been nagging at her husband to do his training to the point that they were “on their way to divorce.” Fortunately, after working with the slower program, the participant was happy to do the training each day without being asked or nagged.

Despite implementing a slower setting on the program, there were still comments from other participants on the subject. One participant told the primary investigator that it was “so darn fast, half the time couldn’t get my finger on the keyboard, might be a slow learner.” Another participant wrote that it was “Very fast at some points.”

While it may be difficult to implement, one option that could remedy this obstacle would be to have the program increase or decrease the overall speed of the trials based on the participant’s success rate. A similar technique was used in Shatil et al’s (2010) study, which used a cognitive-training program for individuals with MS. The program used a cognitive evaluation when the participant began in order to individualize the training regimen. The difficulty level of the training was continually adapted based on the participant’s performance in order to keep them in their comfort zone and avoid frustration. Bherer et al. (2008) used a similar adaptive program to successfully train dual-task capabilities in seniors. Adaptive computer programs have been shown to produce better results than computer programs which train the same tasks but are non-adaptive. Holmes et al. (2009) used an adaptive working memory (WM) training program with children experiencing learning difficulties. The adaptive training program set the difficulty of
each task by matching it to the child’s current memory span on a trial-by-trial basis. The adaptive program was then compared to a program with the same tasks but with fixed difficulty levels regardless of the child’s previous score. Holmes et al. (2009) found significant improvements in all four measures of WM for the adaptive training group while the non-adaptive training group only showed significant improvement in one of the four measures.

Applying these techniques to the anti-saccade eye-movement training program could decrease participants’ frustration by assuring a certain success rate. The study by Holmes et al. also suggests that there may be an increase the effectiveness of the intervention if it is delivered in an adaptive format. This could be due to a couple of factors. If the trials are moving too quickly, the participant may not have the chance to respond to the stimulus presented and may not have the opportunity to try an anti-saccade eye movement. Slowing the program to their speed would allow them to attempt more anti-saccades over a training session. Adaptive training could also result in participants working harder as they are less frustrated by the training.

For many of the participants, the frustration was linked not only to the speed of the program or the learning curve but also to the feedback that they received at the end of each training session. One participant wrote that he was “Frustrated at first not to see if I was doing well. Then I saw scores after practices after a few days.” Another wrote that he was “Frustrated to keep on being told each day ‘You can do better!’” A different participant explained that the comment at the end saying you can do better was frustrating because he felt that he had put his best in and he wasn’t sure what he was doing wrong. A separate participant wrote that “The feedback at the end was unclear, and didn’t have enough input to find the information helpful.” Figure 10 in Appendix O shows the feedback graph presented to participants at the end of the training session.
The feedback provided for the anti-saccade eye-movement training program needs to be increased in quality and frequency. Feedback every 20 trials, for a total of nine during the training, and one at the end should give the participant enough encouragement and correction without being overwhelming. Shatil et al. (2010) integrated feedback into their training by providing a detailed graphic and verbal feedback after each training task. Holmes et al.’s study (2009) used the feedback they provided to also motivate children experiencing learning difficulties. The features included positive verbal feedback; displaying the user’s best scores; and accumulating points which allowed the children to play a game, unrelated to the cognitive training, at the end of the training session. Frequent verbal or score-based feedback could be integrated into the anti-saccade eye-movement training to decrease frustration and increase enjoyment.

**Access to the Program.** The Parkinson’s population face difficulty with accessing the anti-saccade eye-movement training program as a result of both hardware and software barriers. The program was loaded onto a tablet in order to facilitate the participants using it at home, which meant that participants needed to use the touch screen to manipulate the program. Multiple participants found that the tremors in their hands made it difficult for them to operate the touch screen properly. For example, one participant complained that the program would move onto the next step if he accidentally touched the wrong part of the screen. Another participant had to start her training over on the fourth day after she had received the tablet after realizing that accidentally dragging her fingers over the screen was causing the program to abort. She was not the only one who faced this issue, with at least two others reporting having this problem before learning to avoid this issue. There was also one participant who reported that on two days the program would move onto the next trial before he could make his selection of the appropriate
box. As a researcher was not present when this occurred, it is not possible to say if tremors played a role in this problem, but they are a possibility.

A possible solution would be to make the program available to the participants on their home computer, if they have one, so that they can use a mouse or keyboard if desired. The participants may also benefit from the introduction of adaptive technologies when using the anti-saccade eye-movement training program. In 2009, Cunningham et al. completed a review of assistive technologies for individuals with Parkinson’s disease. From the literature, they found that the presence of a tremor could make the use of a touch screen difficult, and they identified six issues which the elderly and disabled reported when trying to use a computer. They are: (1) difficulty keeping hand steady when navigating, (2) slipping off menus, (3) losing the cursor, (4) moving in the wrong direction, (5) running out of room on the mouse pad, and (6) the mouse ball getting stuck. The authors went on to discuss adaptive technologies such as a mouse adaptor which suppresses the effect of tremors, an adapted trackball system which holds the user’s hand steady, and software which freezes the cursor on the screen when the user begins to click. New assistive technologies continue to be generated with improvements, such as the adaptive path smoothing via B-spline (APSS) program tested by Bani Hashem et al. (2014). The APSS software automatically enhanced mouse control based on the user’s tremor level and type. When APSS was tested by a group with Parkinson’s disease, the participants found it both easy to use and useful. These assistive technologies could remove the hardware barriers that individuals with Parkinson’s face and allow them to make full use of computerized cognitive-training interventions.

The software barriers included both being able to learn and understand the steps of the program and being able to set the vision test properly. One common commentary to arise when participants were learning to use the tablet was that it was difficult to understand the instructions
and what was expected of them when the program was being run at its regular speed. This led to the participants having difficulty navigating the program and completing the anti-saccade tasks.

One of the participants wrote that “There were an awful lot of programs in the tablet, I was expecting only the training program and as a result had difficulty finding the program.” Another participant suggested that being able to slow down the program, so that they could be taken through it one step at a time, would be a good idea. Another suggested that they would find it easier if there was an example, such as a set of pictures, which showed them what we wanted them to do. A few of the participants required cuing from a researcher to remind them what to do for the next step in the training.

It is possible that implementing the participant’s suggestion of step-by-step pictures and allowing them to keep the instructions with them would decrease the difficulty of teaching the program and reduce the need for cuing when the participant took their tablet home. It is also important to train the researchers who introduce the participants to the program how to provide proper teaching for this population. The Florida Library Association produced a guide on how to adapt computer training to older adults (Bean & Laven, 2003) when they ran across difficulties integrating seniors into their normal computer classes. They advise that older adults require much more repetition and practice in order for new skills to become automatic, with extra practice time and exercises to review being important. They recommend introducing new terms for concepts such as “icons” instead of associating the concept with a term that already holds a different meaning. Paper handouts need to be senior-friendly with step-by-step instructions that use clear, concise wording.

The second software difficulty that impacted access was the vision test, which is one of the first steps taken when setting the participant up with the program. The participant would see the question: “Can you read this sentence?” If the participant selected “No,” the size of the font
would be increased. When they selected “Yes,” the size of the font would be recorded and that font would be used to decide the size of the stimuli presented. The initial problem with the vision test was that the participants were selecting “Yes” too early. They were just able to make out the words instead of being able to read it comfortably. This was addressed by having one of the researchers present when the participant took the test so that they could make sure that the participant understood that they should be able to read the sentence comfortably.

In the future it would be a good idea to clarify the instructions of the vision test presented on the screen, to begin with a larger font size, and customize the display of the program for older adults. A participatory design effort, which was specifically aimed at developing a user-friendly web page for older users, developed recommendations for the visibility of web pages (Ellis & Kurniawan, 2000). The recommendations included sans serif fonts such as Arial or Helvetica, dark type on a light background and 14-point fonts. The recommended font size is supported in a study by Bernard et al. (2001) which found that seniors, ranging in age from 62 to 83, had greater reading efficiency and faster reading time when using a 14 font versus a 12. Participants also preferred the 14 font.

The other problem that participants faced with regards to the vision test was not knowing how it fit into the overall training, which is a part of the initial instructions. While it was supposed to be set once and then not redone for the duration of the training one participant wrote: “I did not realize there was an end to the vision test the first 2 days so I had to start the 10 days over.”

A complete summary of the factors that affect good adherence can be found in Figure 9.
Feasibility of Data Collection

In terms of collecting high-quality data from the Parkinson’s population, there were several areas that required consideration and often changes.

**Scheduling.** Initially, when participants agreed to participate in this study, they were scheduled for both the gait and eye-movement data collections on the same day and dates for both the baseline and follow-up tests were chosen. This was done with the hopes of minimizing the time commitment of traveling to HDH multiple times. However, there were major alterations in the scheduling procedure part way through.

While the first four participants had their tests scheduled back to back, it was found that this caused problems with the eye-movement data collection due to fatigue. On more than one occasion, this led to the participant being unable to complete the eye-lab testing and having to
return the next day to complete it when rested. One of the participants suggested scheduling the testing over two days, which led to a change in the study procedure.

Going forward, the primary investigator offered the participants the option of either completing testing on the same day or over two days; with the recommendation being two days for the baseline test. This successfully addressed the issue of fatigue which—when measured in five areas: general, physical, reduced motivation, reduced activity and mental—has been shown to be significantly greater in individuals with Parkinson’s disease than in aged matched controls (Lou et al., 2001). The majority of the following participants chose to test over two days at baseline. There were two who asked to do both sections of the baseline testing in one day. One of these individuals changed his mind partway through the gait testing, which occurred first, and asked to reschedule the eye-testing portion so that he could do it on a separate day. The other participant opted to complete gait and eye-lab testing back to back in order to reduce commuting time. The researchers were very careful to ensure that the participant had time to take breaks.

Though initially both baseline and follow-up visits were booked during the same initial phone call, several of the participants had to have their follow-up visits rescheduled. There were two primary causes for rescheduling, delayed completion of the pretest and delayed completion of the training program due to difficulties with the tablet. Delayed completion of the pretest either occurred due to fatigue or technical issues with the computer used to collect the eye-movement tests. As a result, the procedure changed to calling the participant to book the follow-up two or three days after the participant had been given the tablet. This had the added benefit of allowing the primary researcher to check if the participant was experiencing any difficulties with the training program.

**Gait Collection.** One of the reoccurring challenges with the gait collection was that of placing markers on the hips and knees. A couple of the participants were unable to stand straight
due to scoliosis, which made the placement of hip markers more of a challenge. Placing markers on the knees was difficult for several participants because they had varicose veins around their knees. One participant, in particular, had varicose veins, scar tissue and tenderness around his knee, which hampered the primary investigator’s ability to locate the anatomical landmarks of the knee. In addition, it is normal to have a participant bend their knees, while standing, when locating the distal ends of the femur. A large number of the participants were not steady enough on their feet to do this. In this study the markers on the hips and knees were not needed to calculate the outcome measures.

The participants’ unsteadiness was a cause of concern and led to extra caution in two areas. The first was while markers were placed on the knees and the hips, which required the participant to stand. In order to compensate for the participants’ instability, they were asked to hold onto the wall or the counter, or one of the researchers helped them to stay standing. The second was during the standing and walking trials. At least one participant had a moment of instability during the standing trial. As a result, she was encouraged to use the sit-stand stools positioned at either end of the room when not walking. One of the researchers remained close by at all times when participants were doing the walking trials, particularly for those individuals who had not been steady on their feet during the marker placement. Fortunately, there were no falls during the data collections.

These difficulties need to be considered when 3D motion-capture systems are being used to evaluate movement in the Parkinson’s population, which is becoming more frequent as costs decrease and researchers attempt to quantify measures of Parkinson’s severity (Das et al., 2011).

**Effect of Training on Gait and ADLs**

While the mean gait speed increase between baseline and follow-up was 0.02 m/s, it was not statistically or clinically significant. There was also no change between the means for left and
right step lengths. The effect size for the change in gait speed was small (0.13). Changes to the program, as discussed above, and/or increasing the training regime may result in an increased effect.

Regarding hypotheses two and three, there was no measureable change in the ability of participants to complete ADLs. This is because there was only one participant who did not score perfectly on their ADLs at both the baseline and then again when follow-up measures were taken. It is possible that a broader measure of ADLs and functional abilities, such as the United Parkinson’s Disease Rating Scale produced by the Movement Disorders Society, may reveal a change due to training. However, there were no changes in the 10 ADLs measured by the Katz Index. It is also possible that the sample specifics, particularly participants who are in the first 3 stages of Parkinson’s disease and those who still live at home, screened out individuals who would have difficulties with ADLs. Potter et al. (1995) found that ADLs function decreased when participants reached a gait speed of less than 0.25 m/s, whereas the sample for this study maintained an average of over 1.00 m/s at baseline.

**Limitations**

The notable limitation of this study was the small sample size. Because of logistical factors such as the size of the available participant population and time to collect the data, a sample size of 10 was collected. This means that sample characteristics such as stage of the disease could not be included in the analysis as confounding factors because there were not enough participants in each sub-group to draw any conclusions.

Another limitation is the fact that there was no control group of either healthy or with Parkinson’s. The lack of a control group means that any changes seen in gait or ADLs could have been the result of the regular progression of the disease or of participants becoming more comfortable in the lab environment. Because the intervention was only tested with individuals
with Parkinson’s disease, the results of the feasibility research questions can only be applied to this population. A study with different populations will have to be aware that their participants may face different difficulties while using the training program and participating in data collections.

Finally, this study was limited by the short intervention time. It is possible that the particular population needs a longer intervention time. It would be optimal to complete several months of training with periodic gait collections to measure for change in the variables over time. It is also possible that a longer study would show that the deterioration of gait speed, step length and ADLs is less for participants who do the training compared to a control group.

**Implications and Recommendations**

**Implications for Further Research.** One of the implications of the findings of this study is that tablet and computer-based interventions are feasible for the Parkinson’s population. With support from those responsible for the intervention, the majority of the participants are able to adapt to the use of the tablet program and use it successfully on a daily basis. Another implication is that further research is needed to determine if there is an effect on gross-motor movements. While this pilot establishes the feasibility of such research, future investigations may need to involve longer training regimes, custom programming and larger sample sizes. Future research should also consider looking for a correlation between improved scores on the eye-movement training and improvements in gait variables.

Finally, when collecting data from individuals with Parkinson’s disease, researchers need to be aware of their limitations. In particular, finding the anatomical landmarks for joints can be challenging. Also, when designing the protocol, researchers need to ensure that the gait tasks are not too strenuous and that the participant is able to take a rest if needed.
**Recommendations for Program Improvements.** This study showed that a decrease in training time is not necessary to increase adherence and that, if needed, it may be reasonable to increase the amount of training per day or the number of days trained. In the future, slowing the speed of the program by using adaptive programming and increasing the quality of feedback given to participants should decrease frustration.

In the future, assistive technologies should be explored to remove the hardware barriers that participants face with computer use. Step-by-step pictures should be provided to participants to help guide them through the program, and researchers who are introducing the program to participants should be specifically trained about how to best assist seniors in learning to use computers. The program’s display should be customized to the preferences of older adults, and the instructions for the vision test should be clarified. A summary of the recommendations made in this study, as they relate to the conceptual framework, can be found in Appendix P.

**Clinical Use.** Cognitive training via computer programs is a type of intervention that may become available to clinical nurses. It falls within the scope of nursing practice and could give nurses, both general practitioners and Parkinson’s nurse specialists, a non-pharmacological intervention to help their patients. A nurse in the primary-care setting could easily advise that their patients access this type of intervention from home via a website to complete regular training. It could also be easily implemented in a long-term care facility on a common computer or introduced to patients with a tablet on a short-term medical floor to later be continued at home via the patient’s personal computer.

Another implication to be drawn from this study is that Parkinson’s patients can successfully use computer-based interventions. Examples of computer-based interventions above and beyond cognitive training include using computer programs as teaching tools, as fitness trackers, or for communication with health care professionals. Nurses in the clinical and research
fields should consider technological based interventions for seniors as this study has shown that, with enough teaching and support, they can successfully integrate it into their daily lives.
References


Kurlowicz, L., & Wallace, M. (1999). The Mini Mental State Examination. *try this: Best Practice in Nursing Care to Older Adults from the Hartford Institute for Geriatric Nursing, (3)


Table 8. Summary of Brain-Area Involvement for Eye-Movement Training and Symptoms

<table>
<thead>
<tr>
<th>Eye-Movement Training</th>
<th>Parkinson’s Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Munoz\textsuperscript{a}</td>
</tr>
<tr>
<td>Frontal Cortex</td>
<td></td>
</tr>
<tr>
<td>Frontal Eye Field</td>
<td>X</td>
</tr>
<tr>
<td>Supplementary Eye Field</td>
<td>X</td>
</tr>
<tr>
<td>Dorsolateral prefrontal cortex</td>
<td>X</td>
</tr>
<tr>
<td>Parietal Cortex</td>
<td></td>
</tr>
<tr>
<td>Posterior parietal cortex</td>
<td>X</td>
</tr>
<tr>
<td>Lateral Intraparietal area</td>
<td>X</td>
</tr>
<tr>
<td>Basal Ganglia</td>
<td></td>
</tr>
<tr>
<td>Substantia Nigra Pars Reticulata</td>
<td>X</td>
</tr>
<tr>
<td>Caudate Nucleus</td>
<td>X</td>
</tr>
<tr>
<td>Globus Pallidus Pars Externa</td>
<td>X</td>
</tr>
<tr>
<td>Globus Pallidus (GPi)</td>
<td>X</td>
</tr>
<tr>
<td>Subthalamic Nucleus</td>
<td>X</td>
</tr>
<tr>
<td>Putamen</td>
<td>X</td>
</tr>
<tr>
<td>Brain Stem</td>
<td></td>
</tr>
<tr>
<td>Locus Coeruleus</td>
<td></td>
</tr>
<tr>
<td>Pedunculopontine Nucleus</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Superior Collicus</td>
<td>X</td>
</tr>
<tr>
<td>Thalamus</td>
<td>X</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Munoz et al., 2008
\textsuperscript{b} Everling et al., 2009
\textsuperscript{c} Only the Substantia Nigra Pars Reticulata shows significant involvement in the symptoms of Parkinson’s disease.
<table>
<thead>
<tr>
<th></th>
<th>Eye-Movement Training</th>
<th>Parkinson’s Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Munoz&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Everling&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lateral Geniculate Nucleus</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Anterior cingulated</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Insula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Cortex / Area 17</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Supplementary Motor Cortex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Cortex</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Spinal Cord Motor Neurons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noradrenergic locus coeruleus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylcholinergic pedun-nuclei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of brain areas used</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Number of brain areas also used by eye-movement training</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

**Notes:**

a. A 2003 summary of the areas of the brain recruited by eye-movement training.

b. A 1998 summary of the areas of the brain recruited by eye-movement training.

c. The specific areas of the basal ganglia have not been determined.
Appendix B

Demographics Questionnaire

Date of birth _____________________

Sex:  Male _____  Female _____

Height ______

Weight ______

What was your total household income before taxes during the past 12 months?

_____ Less than $25,000
_____ $25,000 to $34,999
_____ $35,000 to $49,999
_____ $50,000 to $74,999
_____ $75,000 to $99,999
_____ $100,000 to $149,999
_____ $150,000 or more
_____ Prefer not to say

Help at home

a. Do you live with someone who can help you with your activities of daily living?
   Yes _____  No ______

b. If no, do you have someone who visits to help you with your activities of daily living?
   Yes _____  No ______

c. If yes, on average, how many hours per week do they spend helping with your activities of daily living?
   Hours = ______
# Appendix C

## Feasibility Questionnaire

<table>
<thead>
<tr>
<th></th>
<th>1 I disagree completely</th>
<th>2 I disagree somewhat</th>
<th>3 I neither agree or disagree</th>
<th>4 I agree somewhat</th>
<th>5 I agree completely</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was easy to find the time to train</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with a tablet was convenient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It was easy to learn the program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It was easy to use the program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There were no technical issues with the program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There were no technical issues with the tablet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The training was entertaining</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Comments:
Appendix D

Katz Activities of Daily Living

You will now be asked about some activities that some people find difficult to perform.

Some of the following questions may resemble previous ones, but they are actually slightly different. We hope you will answer these questions. Please indicate whether you can do these things without any difficulty, with some difficulty, with great difficulty, or only with the help of others.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Without any difficulty</th>
<th>With some difficulty</th>
<th>With great difficulty</th>
<th>Only with the help of others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating and drinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting down on and getting up from a chair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting into or out of bed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting dressed or undressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Going to another room on the same floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Going up or down the stairs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaving or entering the house</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving about outside the home</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing your face and hands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing your entire body</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E

Marker Set

Table 9. Leg Marker Names and Positions

<table>
<thead>
<tr>
<th>Marker Names</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1MH</td>
<td>L1MH</td>
</tr>
<tr>
<td>R23MH</td>
<td>L23MH</td>
</tr>
<tr>
<td>R5MH</td>
<td>LSMH</td>
</tr>
<tr>
<td>RFCS</td>
<td>LFCS</td>
</tr>
<tr>
<td>RFCL</td>
<td>LFCL</td>
</tr>
<tr>
<td>RFCM</td>
<td>LFCM</td>
</tr>
<tr>
<td>RFAL</td>
<td>LFAL</td>
</tr>
<tr>
<td>RTAM</td>
<td>LTAM</td>
</tr>
<tr>
<td>RSK1</td>
<td>LSK1</td>
</tr>
<tr>
<td>RSK2</td>
<td>LSK2</td>
</tr>
<tr>
<td>RSK3</td>
<td>LSK3</td>
</tr>
<tr>
<td>RSK4</td>
<td>LSK4</td>
</tr>
<tr>
<td>RTC</td>
<td>LTTC</td>
</tr>
<tr>
<td>RFAX</td>
<td>LFAX</td>
</tr>
<tr>
<td>RFLE</td>
<td>LFLE</td>
</tr>
<tr>
<td>RFME</td>
<td>LFME</td>
</tr>
</tbody>
</table>

* The marker on the Medial Femoral Head may be removed after the static trial. The bold markers are the ones that are needed for this study’s outcome variables.

Table 10. Pelvis Marker Names and Positions

<table>
<thead>
<tr>
<th>Pelvis</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIAS</td>
<td>RIAS</td>
</tr>
<tr>
<td>LICTP</td>
<td>RICTP</td>
</tr>
<tr>
<td>LIPS</td>
<td>RIPS</td>
</tr>
<tr>
<td>LIAS</td>
<td>Anterior Superior Iliac Crest</td>
</tr>
<tr>
<td>LICTP</td>
<td>Pelvis Marker</td>
</tr>
<tr>
<td>LIPS</td>
<td>Posterior Superior Iliac Crest</td>
</tr>
</tbody>
</table>

78
Appendix F

Participant Instructions

Prior to the data collection:

• Please bring a pair of shoes that you would normally wear outside of the house. These may be walking shoes or runners; however, we ask that you avoid high heels.

During the data collection:

• Stand on this tile (with a force platform) in a comfortable neutral stance.
• Start at the line taped on the floor (located just outside the capture volume).
• On my question “Ready?” tell me out loud if you are ready to start the trial.
• On my signal “Go” walk in a straight line from your starting position to the line taped on the floor at the other end of the room (just outside the other end of the capture volume). Walk at whatever speed feels normal and comfortable to you.
• If one of the markers falls off while you are walking keep going.
• When you reach the taped line at the end of the room, stop.
• At this point you are welcome to sit down and rest.
• When you are ready, let me know. I will give you the signal, and you will walk again in the opposite direction.
• If at any point you are having difficulty or would like to stop, please let me know.
### Appendix G

#### Researcher Experience

<table>
<thead>
<tr>
<th>Subject ID: Prk00</th>
<th>Start time</th>
<th>End time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Was there difficulty arranging for the participant to come to the lab?
- Did the participant have difficulty completing the motion-capture session?
- Did the participant have difficulty completing the eye-movement session?
- Did the participant express any frustration with the tablet/program?
- Did the participant express any concerns with being able to complete the training program?
- Did the participant contact investigators outside of data collections for help with tablet/program? Why?
- Miscellaneous problems faced by researcher (i.e., took more than the scheduled time, equipment not working).
Appendix H

Pipeline

The pipeline used for processing consisted of the following steps:

1. Opens a new file in Visual3D™
2. Uses the processed force data for the remaining steps
3. Uses the processed marker data for the remaining steps
4. Determines which folder path to use to find the model template
5. Determines which folder path to use to find the data
6. Opens all the files with nwalk in the name
7. Changes to Model Builder Mode
8. Creates a skeletal model using the file with static in the name from the data folder
9. Applies the model template from the model template folder path
10. Asks the user to input the participant’s height
11. Asks the user to input the participant’s weight
12. Assigns the model created to all the movement trials
13. Selects all the active files
14. Interpolates, fills in any gaps in the target data
15. Runs a lowpass filter on the target data
16. Runs a lowpass on the force data
17. Runs the recalc pipeline
18. Switches to event processing mode
19. Creates automatic gait events, including left and right heel strike and toe off
20. Asks the user to add tags to the movement files that only have left or right gait events
21. Selects the files that are tagged as RightOnly
22. Creates the event LHS (left heel strike) where the signal patterns are similar to those in another walking trial
23. Creates the event LTO (left toe off) where the signal patterns are similar to those in another walking trial
24. Selects the files that are tagged as LeftOnly
25. Creates the event RTO (right toe off) where the signal patterns are similar to those in another walking trial
26. Creates the event RHS (right heel strike) where the signal patterns are similar to those in another walking trial
27. Selects all the active files
28. Computes the Gait Temporal Distance values including left and right step length and gait speed.

The actual pipeline script is below:

(1) File_New

(2) Set_Use_Processed_Analog
    /USE_PROCESSED=TRUE

(3) Set_Use_Processed_Targets
    /USE_PROCESSED=TRUE
(4) Set_Pipeline_Parameter_To_Folder_Path
/PARAMETER_NAME=TEMPLATE_FOLDER
/PARAMETER_VALUE=C:\Users\C-Motion\Documents\Parkinsons\Data

(5) Set_Pipeline_Parameter_To_Folder_Path
/PARAMETER_NAME=DATA_FOLDER
/PARAMETER_VALUE=

(6) File_Open
/FILE_NAME=::*DATA_FOLDER&*nwalk*.c3d
/SUFFIX=
/SET_PROMPT=File_Open

(7) Switch_to_Model_Builder_Mode

(8) Create_Hybrid_Model
/CALIBRATION_FILE=::*DATA_FOLDER&*static*.c3d
/SUFFIX=
/RANGE=ALL_FRAMES
(9) Apply_Model_Template

/MODEL_TEMPLATE=::TEMPLATE_FOLDER&PrkModelScott_13Feb2015.mdh
/CALIBRATION_FILE=::CALIBRATION_FILE
;

(10) Set_Subject_Height

!/CALIBRATION_FILE=
!/HEIGHT=
;

(11) Set_Subject_Weight

!/CALIBRATION_FILE=::CALIBRATION_FILE
!/WEIGHT=
;

(12) Assign_Model_File

/CALIBRATION_FILE=::CALIBRATION_FILE
/MOTION_FILE_NAMES=ALL_FILES
!/REMOVE_EXISTING_ASSIGNMENTS=FALSE
;

(13) Select_Active_File

/FILE_NAME=ALL_FILES
!/QUERY=
;

(14) Interpolate

/SIGNAL_TYPES=TARGET
!/SIGNAL_NAMES=
!/SIGNAL_FOLDER=ORIGINAL
!/RESULT_SUFFIX=
85

! /RESULT_FOLDER=PROCESSED
! /MAXIMUM_GAP=10
! /NUM_FIT=3
! /POLYNOMIAL_ORDER=3
;

(15) Lowpass_FILTER
/SIGNAL_TYPES=TARGET
! /SIGNAL_NAMES=
/SIGNAL_FOLDER=PROCESSED
! /RESULT_SUFFIX=
! /RESULT_FOLDER=PROCESSED
! /FILTER_CLASS=BUTTERWORTH
! /FREQUENCY_CUTOFF=6.0
! /NUM_REFLECTED=6
! /TOTAL_BUFFER_SIZE=6
! /NUM_BIDIRECTIONAL_PASSES=1
;

(16) Lowpass_FILTER
/SIGNAL_TYPES=ANALOG
! /SIGNAL_NAMES=
/SIGNAL_FOLDER=ORIGINAL
! /RESULT_SUFFIX=
! /RESULT_FOLDER=PROCESSED
! /FILTER_CLASS=BUTTERWORTH
/FREQUENCY_CUTOFF=15.0
/NUM_REFLECTED=0
/TOTAL_BUFFER_SIZE=100
! /NUM_BIDIRECTIONAL_PASSES=1
;
(17) Recalc
;

(18) Switch_to_Event_Processing_Mode
;

(19) Automatic_Gait_Events
! /FRAME_WINDOW=8
! /USE_TPR=TRUE
;

(20) Pipeline_Breakpoint
/PAUSE_MESSAGE= Add LeftOnly and RightOnly Tags.
;

(21) Select_Active_File
/FILE_NAME=RightOnly
! /QUERY=
;

(22) Event_TPR_Signal
/SIGNAL_TYPES=KINETIC_KINEMATIC
/SIGNAL_FOLDER=LFT
/SIGNAL_NAMES=ProxEndPos
/PATTERN_FILE=C:\Users\C-Motion\Documents\Parkinsons\Data\Prk001\Pre\nwalk0003.c3d
/PATTERN_TYPE=KINETIC_KINEMATIC
/PATTERN_SIGNAL=ProxEndPos
/PATTERN_FOLDER=LFT
/PATTERN_EVENT_NAME=LON
! /PATTERN_EVENT_INSTANCE=1
! /SELECT_X=FALSE
! /SELECT_Y=FALSE
(23) Event_TPR_Signal
/SIGNAL_TYPES=KINETIC_KINEMATIC
/SIGNAL_FOLDER=LFT
/SIGNAL_NAMES=ProxEndPos
/PATTERN_FILE=C:\Users\C-Motion\Documents\Parkinsons\Data\Prk001\Pre\nwalk0003.c3d
/PATTERN_TYPE=KINETIC_KINEMATIC
/PATTERN_SIGNAL=ProxEndPos
/PATTERN_FOLDER=LFT
/PATTERN_EVENT_NAME=LOFF
!/PATTERN_EVENT_INSTANCE=1
!/SELECT_X=FALSE
!/SELECT_Y=FALSE
/SELECT_Z=TRUE
!/TPR_WINDOW=7
!/TOLERANCE=20.0
/EVENT_NAME=LTO
;

(24) Select_Active_File
/FILE_NAME=LeftOnly
!/QUERY=
;

(25) Event_TPR_Signal
/SIGNAL_TYPES=KINETIC_KINEMATIC
/SIGNAL_FOLDER=RFT
(26) Event_TPR_Signal
/SIGNAL_TYPES=KINETIC_KINEMATIC
/SIGNAL_FOLDER=RFT
/SIGNAL_NAMES=ProxEndPos
/PATTERN_FILE=C:\Users\C-Motion\Documents\Parkinsons\Data\Prk001\Pre\nwalk0001.c3d
/PATTERN_TYPE=KINETIC_KINEMATIC
/PATTERN_SIGNAL=ProxEndPos
/PATTERN_FOLDER=RFT
/PATTERN_EVENT_NAME=RON
! /PATTERN_EVENT_INSTANCE=1
! /SELECT_X=FALSE
! /SELECT_Y=FALSE
/SELECT_Z=TRUE
! /TPR_WINDOW=7
! /TOLERANCE=20.0
/EVENT_NAME=RHS
;

(26) Event_TPR_Signal
/SIGNAL_TYPES=KINETIC_KINEMATIC
/SIGNAL_FOLDER=RFT
/SIGNAL_NAMES=ProxEndPos
/PATTERN_FILE=C:\Users\C-Motion\Documents\Parkinsons\Data\Prk001\Pre\nwalk0001.c3d
/PATTERN_TYPE=KINETIC_KINEMATIC
/PATTERN_SIGNAL=ProxEndPos
/PATTERN_FOLDER=RFT
/PATTERN_EVENT_NAME=ROFF
! /PATTERN_EVENT_INSTANCE=1
! /SELECT_X=FALSE
! /SELECT_Y=FALSE
/SELECT_Z=TRUE
! /TPR_WINDOW=7
! /TOLERANCE=20.0
/EVENT_NAME=RTO
;
(27) Select_Active_File
/FILE_NAME=ALL_FILES
!/QUERY=
;

(28) Metric_Compute_Temporal_Distance
!/GLOBAL_RESULT_METRIC_FOLDER=TEMPORAL_DISTANCE
/CALCULATE_PER_FILE=TRUE
!/CREATE_ALL_INSTANCES=FALSE
!/RIGHT_FOOT_LOCATION=KINETIC_KINEMATIC::RFT::ProxEndPos
!/LEFT_FOOT_LOCATION=KINETIC_KINEMATIC::LFT::ProxEndPos
!/HEIGHT=METRIC::PROCESSED::HEIGHT
/RHS_EVENT=RHS
/LHS_EVENT=LHS
/RTO_EVENT=RTO
/LTO_EVENT=LTO
!/STRICT_EVENT_SEQUENCE_VALIDATION=FALSE
!/INCLUDE_EVENTS=
!/EXCLUDE_EVENTS=
!/EVENT_INSTANCE=0
!/COMPUTE_SPEED=TRUE
!/COMPUTE_STATURES_PER_SECOND=TRUE
!/COMPUTE_STRIDE_WIDTH=TRUE
!/COMPUTE_STRIDE_LENGTH=TRUE
!/COMPUTE_CYCLE_TIME=TRUE
!/COMPUTE_STEP_LENGTH=TRUE
!/COMPUTE_STEP_TIME=TRUE
!/COMPUTESTANCE_TIME=TRUE
!/COMPUTE_SWING_TIME=TRUE
!/COMPUTE_STEPS_PER_MINUTE=TRUE
!/COMPUTE_STRIDES_PER_MINUTE=TRUE
!/COMPUTE_DOUBLE_LIMB_SUPPORT_TIME=TRUE
!/COMPUTE_RIGHT_INITIAL_DOUBLE_LIMB_SUPPORT_TIME=TRUE
!/COMPUTE_RIGHT_TERMINAL_DOUBLE_LIMB_SUPPORT_TIME=TRUE
!/TREADMILL_SPEED=
!/LEFT_TREADMILL_SPEED=
!/TREADMILL_DIRECTION=
;
Appendix I

Ethics Approval
QUEEN'S UNIVERSITY HEALTH SCIENCES & AFFILIATED TEACHING HOSPITALS RESEARCH ETHICS BOARD


Federalwide Assurance Number: #FWA00004184, #RE00001173

Current 2014 membership of the Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board:

Dr. A.F. Clark, Emeritus Professor, Department of Biomedical and Molecular Sciences, Queen's University (Chair)

Dr. H. Abdallah, Professor, Department of Medicine, Queen's University

Dr. R. Britton, Professor, Department of Emergency Medicine, Queen's University

Dr. M. Evans, Community Member

Mrs. J. Hadacca, Community Member

Mr. D. McNaughton, Community Member

Mr. S. Rakland, Privacy Officer, ICES-Queen's Health Services Research Facility, Research Associate, Division of Cancer Care and Epidemiology, Queen's Cancer Research Institute

Dr. M. Sawhney, Assistant Professor, School of Nursing, Queen's University

Dr. A. Singh, Professor, Department of Psychiatry, Queen's University

Dr. J. Walla, Assistant Professor and Clinical Geneticist, Department of Pediatrics, Queen's University and Kingston General Hospital

Mrs. K. Weideman, LL.B. and Adjunct Instructor, Department of Family Medicine (Bioethics)

Dr. J. Whiteney, Community Member
Appendix J

Acknowledgement Amendment / Approval Letter

Amendment Acknowledgment/Approval Letter

January 08, 2015

Ms. Elizabeth Moston
School of Nursing
Queen’s University

RE: File #6014005 NURS-341-14 The Effect of Eye-Movement Training on Gait and Activities of Daily Living in Patients with Parkinson’s – A Pilot Study

Dear Ms. Moston:

I am writing to acknowledge receipt of the following:

- Request for a change in recruitment strategies as the neurologist who was going to assist in the recruitment of participants at the Movement Disorder Clinic at Kingston General Hospital is no longer able to due to time constraints;
- Request to recruit from the Parkinson’s Society of Canada - Kingston Chapter’s support meeting;
- Request to recruit by advertising using Facebook, Kijiji and the community section of the online Whig Standard;
- Request to also recruit, if needed, from the geriatric outpatient clinics at Providence Care with the distribution of the recruitment handout;
- A copy of the script for recruitment speech;
- A copy of the recruitment advertisement.

I have reviewed these amendments and hereby give my approval. Receipt of these amendments will be reported to the Queen’s University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board.

Yours sincerely,

[Signature]

Albert Clark, Ph.D.
Chair
Health Sciences Research Ethics Board
Appendix K

Recruitment Speech

Script for recruitment speech

-Good day, my name is Elizabeth Moulton, I’m an RN and a master’s student at Queen’s University.

- We are recruiting participants for a research study investigating the usefulness of a computer-training program for patients with Parkinson’s disease.

- We are looking for participants who have Parkinson’s disease; are able to speak, understand and read English; can use a tablet computer; and can walk 10 metres unassisted.

- The study is 10 days long.

- You will be asked to visit the lab at Hotel Dieu Hospital on the first and last day.

- We’ll measure your walking speed and foot placements, and you will be asked to complete questionnaires about your normal daily activates and your experience using our training program.

- While participating in the study you may continue all medications and treatments as directed by your health-care provider.

- Any questions?
Appendix L

Recruitment Handout

We are currently recruiting participants for a research study investigating the usefulness of a computer-training program for patients with Parkinson’s disease. Interested participants who have Parkinson’s disease, are able to speak, understand and read English, and can walk 10 metres unassisted are eligible.

The study is 10 days long with an in-lab visit at Hotel Dieu Hospital on the first and last day. As a participant your walking speed and foot placements will be recorded as you walk at your normal walking speed.

While participating in the study, you may continue all medications and treatments as directed by your health-care provider.

For more information, please contact Elizabeth Moulton at 43eam@queensu.ca

Elizabeth Moulton RN, BScN is a MScN student in the School of Nursing at Queen’s University.
Appendix M

Recruitment Advertisement

MScN student in the School of Nursing at Queen’s University is recruiting participants for a research study on the usefulness of a computer-training program for patients with Parkinson’s disease. Participants must have Parkinson’s disease; be able to speak, understand and read English; and be able walk 10 metres unassisted.

Study is 10 days long with in-lab visits at Hotel Dieu Hospital on the first and last day. How you walk will be recorded as you walk at your normal walking speed.

Participants may continue all medications and treatments as directed by their health-care provider.

Contact Elizabeth Moulton at 43eam@queensu.ca
Appendix N

Effect Size Calculations

Equations Used

\[ SD_{pool} = \sqrt{\frac{SD_1^2 + SD_2^2}{2}} \]

Equation 3. Equation for the pooled standard deviation

Walking Speed

\[ SD_{pool} = \sqrt{\frac{0.12^2 + 0.17^2}{2}} \]
\[ d = \frac{1.01 - 1.03}{0.15} \]
\[ d = -0.02 \]
\[ d = 0.15 \]
\[ d = -0.13 \]

Equation 5. Cohen's \( d \) for walking speed

Equation 4. Pooled standard deviation for walking speed
Left Step Length

\[
SD_{pool\ left} = \sqrt{\frac{0.07^2 + 0.07^2}{2}}
\]

\[
SD_{pool\ left} = \sqrt{\frac{0.0049 + 0.0049}{2}}
\]

\[
SD_{pool\ left} = \sqrt{\frac{0.0098}{2}}
\]

\[
SD_{pool\ left} = \sqrt{0.0049}
\]

\[
SD_{pool\ left} = 0.07
\]

d = \frac{0.59 - 0.59}{0.07}

d = \frac{0}{0.07}

d = 0

Equation 7. Cohen's \(d\) for left step length

Equation 6. Pooled standard deviation for left step length

Right Step Length

\[
SD_{pool\ right} = \sqrt{\frac{0.06^2 + 0.09^2}{2}}
\]

\[
SD_{pool\ right} = \sqrt{\frac{0.0036 + 0.0081}{2}}
\]

\[
SD_{pool\ right} = \sqrt{\frac{0.0117}{2}}
\]

\[
SD_{pool\ right} = \sqrt{0.00585}
\]

\[
SD_{pool\ right} = 0.08
\]

d = \frac{0.59 - 0.59}{0.08}

d = \frac{0}{0.08}

d = 0

Equation 9. Cohen's \(d\) for right step length

Equation 8. Pooled standard deviation for right step length
Appendix O

Sample Feedback Graph

Figure 10. Feedback given at the end of a training session
Appendix P

Recommendations

Figure 11. Recommendations Associated with the Good Adherence Concept Map
<table>
<thead>
<tr>
<th>Factor</th>
<th>Recommendation</th>
</tr>
</thead>
</table>
| 1      | - A decrease in training time is not necessary to increase adherence  

- It is reasonable to try increasing either the amount of training per day or the number of days trained |
| 2      | - Slowing the program to participants’ speed via adaptive programming should decrease frustration and allow for more successful anti-saccade movements |
| 3      | - Frequent verbal or score-based feedback should be integrated into the program to decrease frustration and increase enjoyment |
| 4      | - Assistive technologies should be explored to remove the hardware barriers that individuals with Parkinson’s face and allow them to make full use of the program |
| 5      | - Provide step-by-step pictures to the participants  

- Train the researchers who introduce the participants to the program on how to properly teach this population |
| 6      | - Clarify the instructions of the vision test  

- Begin with a larger font size  

- Customize the display of the program for older adults |