4-18-2013 12:00 AM

Gait Retraining in Parkinson’s Disease: A Cognitive Cueing Approach

Stephanie J. Morrison, *The University of Western Ontario*

Supervisor: Dr. Sandi J Spaulding, *The University of Western Ontario*
A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Health and Rehabilitation Sciences

GAIT RETRAINING IN PARKINSON'S DISEASE: A COGNITIVE CUEING APPROACH

(Thesis format: Integrated Article)

by

Stephanie Morrison

Graduate Program in Health and Rehabilitation Sciences

A thesis submitted in partial fulfillment
of the requirements for the degree of
Masters of Science

The School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario, Canada

Abstract

Parkinson's disease (PD) is characterized by resting tremor, bradykinesia, rigidity, and postural instability. These cardinal symptoms commonly affect gait performance and therefore researchers have been investigating techniques to manage and treat gait impairment in individuals with PD. This thesis explores a progressive approach to gait rehabilitation using a novel intervention that combines traditional gait cueing techniques with motor learning approaches to facilitate self-cued gait improvement. Five participants with PD-related gait impairment completed the home-based gait training intervention. This intervention included video footage of each individual participant walking with and without verbal instructional cues, audio coaching, and practice periods. Participants were given the video to practice at home for two-weeks. Kinematic parameters of gait were assessed pre-intervention, at two weeks post-intervention, and at two months post-intervention. Results indicate that individuals with PD are capable of learning verbal-cueing strategies and utilizing these to generate long-term gait improvements through self-cueing.

Keywords

Parkinson's disease, gait retraining, cueing, video-feedback, motor learning

Co-Authorship Statement

This thesis is the primary work of Stephanie Morrison. Conception of the research question and design of the intervention presented in Chapter 2 was driven by Stephanie Morrison. A version of Chapter 2 will be submitted for publication in a peer-reviewed journal by authors Stephanie J. Morrison, Dr. Sandi J. Spaulding, Dr. Jeffrey D. Holmes, and Dr. Mary E. Jenkins. Each of the three co-authors contributed to designing the research methodology used to test the gait retraining intervention highlighted in Chapter 2, and facilitated the process of data collection. Dr. Spaulding also made valuable contributions to the process of data analysis and both Dr. Spaulding and Dr. Jenkins offered valuable improvement to this thesis through the process of iterative editing. Participants in the study (Chapter 2) were recruited from the outpatient neurology practice of Dr. Jenkins, without whose support this project would not have been possible.

Acknowledgments

Thank you to my supervisor, Dr. Spaulding, for believing in me from the beginning. I am so grateful for the experiences and events that have unfolded in my academic life over the past two years, and none of them would have happened without your initial faith that opened the doors of graduate education to me. Thank you to my entire supervisory committee, Dr. Holmes, Dr. Jenkins, and Dr. Spaulding, for believing in this project, for guiding it with careful insight, and for making the process of executing this study both enjoyable and enriching. Thank you to those faculty and students in the Interdisciplinary Movement Disorders Laboratory and the Rehabilitation Sciences Field who offered inspiration, encouragement, and, in some cases, editing support over the past two years. And, as always, thank you to my family and friends near, and far who share their joy, love, and light with me.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

1 An Introduction to Gait Impairment in Parkinson’s Disease: Problems and Solutions

Parkinson’s disease (PD) is a neurodegenerative disorder characterized by resting tremor, rigidity, slowness of movement, and postural instability resulting from loss of dopaminergic neurons in the pars compacta of the substantia nigra (Meissner et al., 2011). Estimations of PD prevalence vary, depending on which method is used to gather data, the age of a given population being measured, and the country or countries being surveyed; however, typical prevalence estimations range between 100 and 150 cases per 100 000 people (Abbruzzese, Pelosin, & Marchese, 2008; Dorsey et al., 2007; Harris, Koehoorn, & Teschke, 2011; Totaro et al., 2005). Canadian specific estimates of PD prevalence range considerably, from 69 to 248.9 cases per 100 000 people (Jones, Wayne Martin, Wieler, King-Jesso, & Voaklander, 2011). In 2012, Parkinson Society Canada estimated that more than 100 000 Canadians have PD (Parkinson Society Canada, 2012). According to Dorsey et al. (2007), the prevalence of PD has been growing since 2005, and is expected to continue growing through to 2030.

1.1 Gait Impairment in PD

PD negatively affects gait performance and balance, which can lead to falls and decreased quality of life (Grimbergen, Munneke, & Bloem, 2004; Shulman, 2010; Shulman et al., 2008). Gait impairment in PD is characterized by decreased stride length, slowed velocity, impaired cadence, and variable gait rhythm. Often, individuals with PD will also lose the normal heel-toe gait pattern and walk with a flat foot. As the disease progresses, the gait impairments worsen and individuals may develop a festinating gait pattern, with short-rapid steps, or freezing of gait, with hesitations and stoppages. Robust evidence suggests that individuals with PD who experience gait impairment may be able to maintain the ability to execute high quality gait patterns, with the aid of rehabilitation strategies such as visual or auditory cues, or verbal coaching (Morris, Iansek, Matyas, & Summers, 1996; Rochester et al., 2010; Rochester et al., 2005; Werner & Gentile, 2010).

1.2 Typical Management of PD

The cause of neuronal loss in the substantia nigra, which characterizes PD, has not been determined, and no cure for PD exists (Abbruzzese et al., 2008). Management of PD is symptomatically based, and focuses both pharmacologically and surgically on stimulation of the brain's dopaminergic system (Abbruzzese et al., 2008; Rochester, Nieuwboer, & Lord, 2011).

Pharmacological therapy typically employs either dopamine agonists to stimulate dopamine receptors in the brain, or levodopa (L-DOPA) based drugs, which are processed by the body to eventually produce dopamine (Archibald & Burn, 2008). While effective in treating many of the symptoms of PD, pharmacological therapy can cause serious side effects such as dyskinesia, hallucinations, drowsiness, and impaired impulse control (Archibald & Burn, 2008; Meissner et al., 2011). Further, the benefits of pharmacological therapy gradually fade between dosages ("wearing-off" phenomenon), and as the disease progresses. The result of these phenomena is that in later stages of PD effective dopaminergic treatment requires higher dosages of medication, which produce stronger side effects and more intense wearing-off symptoms (Abbruzzese et al., 2008; Archibald & Burn, 2008; Hely, Morris, Reid, & Trafficante, 2005; Meissner et al., 2011). Given the limitations and drawbacks of pharmacological therapy, researchers and clinicians have suggested the guideline that dopamine agonists and L-DOPA should be initiated in the treatment of PD only at the point when symptoms begin to interfere with daily living (Archibald & Burn, 2008).

In addition to pharmacological therapies to treat PD symptoms, there is strong support for motor rehabilitation based strategies to treat symptoms and improve the quality of life for individuals with PD (Abbruzzese et al., 2008; Archibald & Burn, 2008; Nieuwboer, Rochester, Muncks, & Swinnen, 2009; Rochester et al., 2011). A recent narrative review of randomized clinical trials investigating exercise and movement strategy training as therapeutic approaches to PD treatment argues that these are effective ways to manage many symptoms of PD that are not responsive to, or become resistant to, pharmacological therapy (Rochester et al., 2011). According to Rochester et al. (2011), a significant body of research evidence exists to support the theory that exercise and movement strategy training can, collectively, contribute to improvements in gait, posture, balance, and physical function, can reduce the risk of falling, can improve complex task performance, and can facilitate functional motor symptoms and the successful performance of activities of daily living.

A 2010 study by Werner and Gentile offers strong evidence to support the practice of using movement strategy training to improve gait in PD. Werner and Gentile tested two instructional strategies during intensive walking practice. One treatment group (n=6) received verbal instructions to “take big steps”, and a second treatment group (n=6) received the same verbal instructions with video feedback and performance cues between each of 15 walking performances. Both groups performed 15 walking trials during each of four training sessions occurring over a period of two weeks (two sessions per week). Though the authors did not identify differences between the two training groups, both groups showed improvement in stride length and gait velocity pre- to post-training, and all participants tested in retention tests as 3, 6, and/or 12 months (n=7) maintained stride length and gait velocity improvement above pre-training levels. Complimenting evidence highlighted in the review by Rochester et al., Werner and Gentile’s findings offer rationale for adopting of motor learning approaches to gait management and rehabilitation in PD.

1.3 Cueing Strategies for Gait Improvement in PD

Cueing strategies for gait improvement in PD include visual and auditory stimuli that provide spatial and/or temporal strategies to aid in gait regulation. Typical visual cues include stimuli such as lines taped to the floor that an individual is instructed to step over, or a moving laser point that an individual is instructed to walk towards (Azulay et al., 1999). Auditory cues included stimuli such as music with a consistent beat, or rhythmic sounds such as beeps. The individuals are instructed to walk matching the rhythm of the beat (McIntosh, Brown, Rice, & Thaut, 1997; Thaut et al., 1996) . Cueing can also refer to verbal instructional cues such as statements like “take long steps”(Fok, Farrell, McMeeken, & Kuo, 2011; Lehman, Toole, Lofald, & Hirsch, 2005). Though the specific mechanisms that make cueing approaches successful are still not clearly identified, researchers have hypothesized that visual cueing is effective because it focuses attention towards step execution (Morris et al., 1996; Praamstra, Stegeman, Cools, & Horstink, 1998). Additionally, researchers have hypothesized that auditory cueing may provide a compensatory rhythm that makes up for the loss of rhythm regulation caused by dopaminergic degeneration within the basal ganglia (McIntosh et al., 1997; Thaut et al., 1996).

A recent meta-analysis has confirmed the efficacy of both visual and auditory cueing techniques on gait kinematics in PD rehabilitation. In this meta-analysis, Spaulding et al. (2012) found that auditory cueing elicited significant improvements in cadence, stride length, and velocity in individuals with PD, while visual cueing improved stride length only. This meta-analysis included studies published in English up to September 2011 entered in the scientific databases EMBASE, Scopus, Medline, CINAHL, and PubMed. Most studies included in this meta-analysis measured gait kinematics in a laboratory setting immediately after cueing was applied; however, five of the 25 publications tested cueing interventions that had post-test measurements between two and five weeks.

Typically auditory, visual, and instructional cues are used to generate short-term improvement in gait kinematics (Spaulding et al., 2012). In 2011, Fok, Farrell, McMeeken, and Kuo published a systematic review of the effects of verbal instructional strategies used for gait improvement in individuals with mild to severe PD (Hoehn and Yahr 1.8 to 3.1). The Fok et al. review featured 13 studies of verbal instructional cueing that incorporated data from 149 participants. They concluded that “the empirical evidence in support of the benefits from verbal instructions is weak” (Fok et al., 2011, p.396). This conclusion resulted from the analysis that the positive effects of verbal cueing were short-term and limited to the specific cue “take big steps”. While some criticism of a rehabilitation strategy that offers only limited short-term benefits is warranted, short-term benefits are not reason enough to overlook the utility of verbal instructional cueing. Perhaps, as in our research, verbal cueing can be implemented in a different way, one that is designed to offer longer-term benefits. Researchers have begun to investigate various cueing protocols that offer long-term retention of gait improvements, and preliminary results are indicating that individuals with PD may be able to “learn” cueing strategies (Rochester et al., 2010; Werner & Gentile, 2010). The next phase of cueing research should focus on facilitating cue learning and promote self-cueing among individuals with PD.

1.4 Motor Learning in PD

Motor learning refers to a set of processes and experiences associated with practice that cause or enable an individual’s ability to perform a certain movement pattern (Nieuwboer et al., 2009; Schmidt & Lee, 2011). Motor learning can be seen as having three distinct and progressive stages: a cognitive stage in which movement instructions and feedback are being introduced and delivered, a refining stage where movement patterns are being improved upon usually with the help of external feedback, and an autonomous stage where the movement pattern becomes automatic and no longer requires significant cognitive capacity (Nieuwboer et al., 2009). The striatum region of the brain is known to be involved in the process of learning and, because PD is characterized by neurodegeneration in this specific brain region, early PD researchers questioned whether individuals living with PD were able to experience and benefit from motor learning strategies (Doyon, 2008; Doyon et al., 1998). More recently, convincing research has emerged to support the notion that despite the neuropathology of PD, individuals living with mild to moderate Parkinson's are capable of motor learning (Felix et al., 2012; Pendt, Reuter, & Muller, 2011; Rochester et al., 2010).

Researchers have only recently begun to consider motor learning in the context of PD; therefore, optimal conditions of practice for motor learning in PD have not been clearly identified. Traditional motor learning research in healthy populations is the best available evidence that can be used to inform approaches to motor learning in PD, with research in observational learning being of particular relevance for the specific task of gait rehabilitation. In Chapter 2 of this thesis, an experiment is described that tested a novel gait retraining intervention designed by the author of this thesis with consultation from the co-authors (S.J.S., M.E.J., J.D.H.).

1.5 Merging Cueing Approaches with Motor Learning Strategies

Observational learning is one technique used to facilitate motor learning and involves imitation of a motor pattern that is demonstrated by a model and intended to encourage motor skill acquisition (Ashford, Bennett, & Davids, 2006). A suitable model may be an expert performing the motor pattern of interest (an expert model), a novice in the midst of learning that same motor pattern (a learning model), or someone falling anywhere on the continuum between those two extremes. Some research in healthy populations suggests that learning models can be just as helpful as expert models in demonstrating a task to be learned (Pollock & Lee, 1992). Additional research in observational learning suggests that motor learning may actually be *optimized* by a learning model (McCullagh & Meyer, 1997), and by a model whose skill level resembles the observer's level (Braaksma, Rijlaarsdam, & van den Bergh, 2002). This principle has not been tested in Parkinson's populations; however, if transferable, it would imply that individuals with PD could successfully imitate motor patterns demonstrated by a learning model. Furthermore, the best approach to gait retraining through observational learning in this population may be use of learning models with PD.

Research in motor learning among healthy adults indicates that observational learning is particularly useful in acquiring motor patterns for complex tasks (Shea, Wright, Wulf, & Whitacre, 2000; Wulf, Raupach, & Pfeiffer, 2005; Wulf & Shea, 2002). This finding supports the theory of using an observational approach to gait retraining in PD, because of the inherent complexity of gait performance. This is especially true among individuals with PD who typically require extra attentional focus to execute best possible gait performances. Further support for the use of observational learning strategies in PD gait retraining comes from a literature review which suggested that the altered neural circuitry found in individuals with PD imposes a reliance on extra sensory information for motor learning (Nieuwboer et al., 2009). Modeling successful and high quality gait performances is one way to apply this theory to gait retraining in PD.

Compared to implicit motor learning, explicit motor learning is considered to be less dependent on the basil ganglia structures and therefore less affected by PD (Nieuwboer et al., 2009; Siegert, Taylor, Weatherall, & Abernethy, 2006). If the paradigm of observation learning provides visual feedback of *oneself* learning the task at hand, this approach will encourage a shift towards explicit motor learning. Examples of motor learning paradigms in Parkinson's rehabilitation have used both visual and auditory cueing strategies to shift attentional focus towards explicit motor learning (Azulay, Mesure, & Blin, 2006; Felix et al., 2012; Morris et al., 1996; Werner & Gentile, 2010). Not only have these strategies resulted in successful motor learning in the acquisition phase, they have also been shown to facilitate motor learning lasting beyond the removal of cues, and therefore facilitate retention.

Research into the effects of explicit motor learning through cueing strategies for gait improvement in PD is conclusive, and efficacy of these approaches no longer needs to be questioned. However, because visual and auditory cueing typically require assistive devices that can be impractical or unfeasible in some environments encountered in daily living, continuing research should focus on transferring principles and knowledge gained through cueing studies into rehabilitation strategies that might facilitate motor learning independent of external cueing devices. Moving from cueing studies to design and implementation of observational motor learning in Parkinsonian gait retraining has strong theoretical support. A large body of cueing research supports the idea that individuals with Parkinson's are capable of motor learning, and that they retain their capacity to execute motor programming for high quality gait performances. Observational learning in PD is a relatively new concept and, because motor learning experiments have typically been conducted among populations of healthy individuals and athletes, generalizations from traditional motor learning research to PD rehabilitation must be made cautiously. Utilizing motor learning approaches to gait retraining in PD is a theoretically sound approach, and should be explored in more direct clinical applications.

The following study (Chapter 2) was motivated by the above research in motor learning, specifically as it applies to PD. The author identified an opportunity to bridge the fields of sensory cueing in PD rehabilitation with the field of motor learning. The following intervention (Chapter 2) was designed to empower individuals with PD by shifting traditional cueing strategies into self-cueing strategies with the hypothesis that individuals with PD may continue to benefit from cueing without relying on external devices or people to provide the cueing stimulus. The product of the following intervention design may hereafter be considered “cognitive cueing”. It does not rely on the same attentional or sensory strategies used in traditional visual, auditory, and instructional cueing interventions, rather it was designed to use motor learning to facilitate skill acquisition of self-cueing.

References

Abbruzzese, G., Pelosin, E., & Marchese, R. (2008). Chapter 4: Current Problems and Strategies in motor Rehabilitation for Parkinson's Disease. In A. Fisher, M. Memo, F. Stocchi & I. Hanin (Eds.), *Advances in Alzheimer's and Parkinson's Disease* (Vol. 57, pp. 23-30). Italy: Springer.

Archibald, N., & Burn, D. (2008). Parkinson's disease. *Medicine, 36*(12), 630-635. doi: 10.1016/j.mpmed.2008.09.004

Ashford, D., Bennett, S. J., & Davids, K. (2006). Observational modeling effects for movement dynamics and movement outcome measures across differing task constraints: a meta-analysis. *J Mot Behav, 38*(3), 185-205. doi: 10.3200/JMBR.38.3.185-205

Azulay, J. P., Mesure, S., Amblard, B., Blin, O., Sangla, I., & Pouget, J. (1999). Visual control of locomotion in Parkinson's disease. *Brain, 122*(1), 10.

Azulay, J. P., Mesure, S., & Blin, O. (2006). Influence of visual cues on gait in Parkinson's disease: contribution to attention or sensory dependence? *J Neurol Sci, 248*(1-2), 192-195. doi: 10.1016/j.jns.2006.05.008

Braaksma, M. A. H., Rijlaarsdam, G., & van den Bergh, H. (2002). Observational learning and the effects of model-observer similarity. *Journal of Educational Psychology, 94*(2), 405-415. doi: 10.1037//0022-0663.94.2.405

Dorsey, E. R., Constantinescu, R., Thompson, J. P., Biglan, K. M., Holloway, R. G., Kieburtz, K., . . . Tanner, C. M. (2007). Projected number of people with Parkinson disease in the most populous nations, 2005 through 2030. *Neurology, 68*(5), 384-386. doi: 10.1212/01.wnl.0000247740.47667.03

Doyon, J. (2008). Motor sequence learning and movement disorders. *Curr Opin Neurol, 21*(4), 478-483. doi: 10.1097/WCO.0b013e328304b6a3

Doyon, J., Laforce, R., Jr., Bouchard, G., Gaudreau, D., Roy, J., Poirier, M., . . . Bouchard, J. P. (1998). Role of the striatum, cerebellum and frontal lobes in the automatization of a repeated visuomotor sequence of movements. *Neuropsychologia, 36*(7), 625-641.

Felix, K., Gain, K., Paiva, E., Whitney, K., Jenkins, M. E., & Spaulding, S. J. (2012). Upper extremity motor learning among individuals with Parkinson's disease: A meta-analysis evaluating movement time in simple tasks. *Parkinsons Dis, 2012*, 589152. doi: 10.1155/2012/589152

Fok, P., Farrell, M., McMeeken, J., & Kuo, Y.-L. (2011). The effects of verbal instructions on gait in people with Parkinson's disease: a systematic review of randomized and non-randomized trials. *Clinical Rehabilitation, 25*(5), 11. doi: 10.1177/0269215510387648

Grimbergen, Y. A. M., Munneke, M., & Bloem, B. R. (2004). Falls in Parkinson's disease. *Curr Opin Neurol, 17*(4), 405-415. doi: 10.1097/01.wco.0000137530.68867.93

Harris, M. A., Koehoorn, M., & Teschke, K. (2011). Ongoing challenges to finding people with Parkinson's disease for epidemiological studies: a comparison of population-level case ascertainment methods. *Parkinsonism Relat Disord, 17*(6), 464-469. doi: 10.1016/j.parkreldis.2011.04.007

Hely, M. A., Morris, J. G., Reid, W. G., & Trafficante, R. (2005). Sydney Multicenter Study of Parkinson's disease: non-L-dopa-responsive problems dominate at 15 years. *Mov Disord, 20*(2), 190-199. doi: 10.1002/mds.20324

Jones, C. A., Wayne Martin, W. R., Wieler, M., King-Jesso, P., & Voaklander, D. C. (2011). Incidence and mortality of Parkinson's disease in older Canadians. *Parkinsonism Relat Disord*. doi: 10.1016/j.parkreldis.2011.11.018

Lehman, D. A., Toole, T., Lofald, D., & Hirsch, M. A. (2005). Training with Verbal Instructional Cues Results in Near-term Improvement of Gait in People with Parkinson's Disease. *Journal of Neurology, 29*(1), 7.

McCullagh, P., & Meyer, K. N. (1997). Learning versus correct models: influence of model type on the learning of a free-weight squat lift. *Res Q Exerc Sport, 68*(1), 56-61.

McIntosh, G. C., Brown, S. H., Rice, R. R., & Thaut, M. H. (1997). Rhythmic auditory-motor facilitation of gait patterns in patients with Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry, 62*(1), 5.

Meissner, W. G., Frasier, M., Gasser, T., Goetz, C. G., Lozano, A., Piccini, P., . . . Bezard, E. (2011). Priorities in Parkinson's disease research. *Nat Rev Drug Discov, 10*(5), 377-393. doi: 10.1038/nrd3430

Morris, M. E., Iansek, R., Matyas, T. A., & Summers, J. J. (1996). Stride length regulation in Parkinson's disease. Normalization strategies and underlying mechanisms. *Brain, 119 (Pt 2)*, 551-568.

Nieuwboer, A., Rochester, L., Muncks, L., & Swinnen, S. P. (2009). Motor learning in Parkinson's disease: limitations and potential for rehabilitation. *Parkinsonism Relat Disord, 15 Suppl 3*, S53-58. doi: 10.1016/S1353-8020(09)70781-3

Parkinson Society Canada. (2012). Fact Sheet - March 2012, from http://www.parkinson.ca/atf/cf/%7B9ebd08a9-7886-4b2d-a1c4-a131e7096bf8%7D/PARKINSON_SOCIETY_CANADA_FACT SHEET MARCH 2012.PDF

Pendt, L. K., Reuter, I., & Muller, H. (2011). Motor skill learning, retention, and control deficits in Parkinson's disease. *PLoS One, 6*(7), e21669. doi: 10.1371/journal.pone.0021669

Pollock, B. J., & Lee, T. D. (1992). Effects of the model's skill level on observational motor learning. *Res Q Exerc Sport, 63*(1), 25-29.

Praamstra, P., Stegeman, D. F., Cools, A. R., & Horstink, M. W. (1998). Reliance on external cues for movement initiation in Parkinson's disease. *J Neurol Neurosurg Psychiatry, 121*(1), 11.

Rochester, L., Baker, K., Hetherington, V., Jones, D., Willems, A. M., Kwakkel, G., . . . Nieuwboer, A. (2010). Evidence for motor learning in Parkinson's disease: acquisition, automaticity and retention of cued gait performance after training with external rhythmical cues. *Brain Res, 1319*, 103-111. doi: 10.1016/j.brainres.2010.01.001

Rochester, L., Hetherington, V., Jones, D., Nieuwboer, A., Willems, A. M., Kwakkel, G., & Van Wegen, E. (2005). The effect of external rhythmic cues (auditory and visual) on walking during a functional task in homes of people with Parkinson's disease. *Arch Phys Med Rehabil, 86*(5), 999-1006. doi: 10.1016/j.apmr.2004.10.040

Rochester, L., Nieuwboer, A., & Lord, S. (2011). Physiotherapy for Parkinson's disease: defining evidence within a framework for intervention.

Schmidt, R. A., & Lee, T. D. (2011). *Motor Control and Learning : A Behavioral Emphasis* (5th ed.). Champaign, IL: Human Kinetics.

Shea, C. H., Wright, D. L., Wulf, G., & Whitacre, C. (2000). Physical and observational practice afford unique learning opportunities. *J Mot Behav, 32*(1), 27-36. doi: 10.1080/00222890009601357

Shulman, L. M. (2010). Understanding disability in Parkinson's disease. [Review]. *Mov Disord, 25 Suppl 1*, S131-135. doi: 10.1002/mds.22789

Shulman, L. M., Gruber-Baldini, A. L., Anderson, K. E., Vaughan, C. G., Reich, S. G., Fishman, P. S., & Weiner, W. J. (2008). The evolution of disability in Parkinson disease. *Mov Disord, 23*(6), 790-796. doi: 10.1002/mds.21879

Siegert, R. J., Taylor, K. D., Weatherall, M., & Abernethy, D. A. (2006). Is implicit sequence learning impaired in Parkinson's disease? A meta-analysis. *Neuropsychology, 20*(4), 490-495. doi: 10.1037/0894-4105.20.4.490

Spaulding, S., Barber, B., Colby, M., Cormack, B., Mick, T., & Jenkins, M. (2012). Cueing and gait improvement among people with Parkinson's disease: A meta-analysis. *Arch Phys Med Rehabil, 94*(3), 562 -570. doi: http://dx.doi.org/10.1016/j.apmr.2012.10.026

Thaut, M. H., McIntosh, G. C., Rice, R. R., Miller, R. A., Rathburn, G., & Brault, J. M. (1996). Rhythmic auditory stimulation in gait training for Parkinson's disease patients. *Mov Disord, 11*(2), 8. doi: 10.1002/mds.870110213

Totaro, R., Marini, C., Pistoia, F., Sacco, S., Russo, T., & Carolei, A. (2005). Prevalence of Parkinson's disease in the L'Aquila district, central Italy. [Comparative Study]. *Acta Neurol Scand, 112*(1), 24-28. doi: 10.1111/j.1600-0404.2005.00426.x

Werner, W. G., & Gentile, A. M. (2010). Improving gait and promoting retention in individuals with Parkinson's disease: a pilot study. *J Neurol, 257*(11), 1841-1847. doi: 10.1007/s00415-010-5619-z

Wulf, G., Raupach, M., & Pfeiffer, F. (2005). Self-controlled observational practice enhances learning. *Res Q Exerc Sport, 76*(1), 107-111.

Wulf, G., & Shea, C. H. (2002). Principles derived from the study of simple skills do not generalize to complex skill learning. *Psychon Bull Rev, 9*(2), 185-211.

Chapter 2

2 A Cognitive Cueing Approach to Gait Retraining In PD: Pilot Study Results

Introduction:

Gait impairment in Parkinson's disease (PD) is characterized by shortened step length, reduced velocity and variable gait rhythm. As the disease advances, gait may progress to a short shuffling "toe-steps" pattern. Gait impairment in PD is associated with increased disability and increased risk of falling in individuals who experience this condition (Bloem, Hausdorff, Visser, & Giladi, 2004; Grimbergen, Munneke, & Bloem, 2004; Josiah et al., 2012; Shulman, 2010). Given the importance of delaying and reducing the disability impact of PD, extensive research has focused on the application of external cues for gait improvement in people with mild to moderate PD (M. E. Morris, Iansek, Matyas, & Summers, 1996; Rochester et al., 2010; Rochester et al., 2005; Spaulding et al., 2012). Robust evidence indicates that individuals with PD who experience gait impairment maintain the ability to execute quality gait patterns when aided by external visual or auditory cues. To date, however, results have predominantly shown only short-term benefits of laboratory based external cueing (up to two hours), with some indication of longer-term retention after extensive laboratory-based cueing training (M. E. Morris et al., 1996; Rochester et al., 2010; Werner & Gentile, 2010).

Research into the positive short-term effects of external cueing for gait improvement in PD appears robust, and evidence for the efficacy of these approaches is strong (Spaulding et al., 2012). Additionally, it has become increasingly clear that individuals with mild to moderate PD are capable of undergoing the processes involved with motor learning, despite the neuropathology of this disease (Felix et al., 2012; Pendt, Reuter, & Muller, 2011; Rochester et al., 2010; Werner & Gentile, 2010). Though external cueing can be helpful for individuals with PD, it requires assistive devices that may be impractical or unfeasible in certain environments. Research should focus on applying principles of motor learning, which appear to be effective for people with PD, to facilitate self-cueing in PD. The purpose of this study was to determine the mid and long-term effects (two weeks and two months) of a novel home-based gait retraining intervention that combined cueing techniques and motor learning principals aimed at improving kinematic variables of gait and functional mobility.

Method:

Participants were recruited for this study from the practice of one of the authors (M.E.J.), a neurologist specializing in movement disorders. A convenience sample was collected based on the inclusion criteria of diagnosis with mild to moderate PD, reported PD related gait impairment, and ability to execute home-based practice. Patients were excluded if they had any indication of cognitive impairment, orthopedic, or other neurological conditions that would impair gait performance, or any medical conditions that would limit gait performance or practice (e.g., heart disease). None of the recruited participants had experiences using video-feedback for gait improvement. This study was approved by the Research Ethics Board at the University of Western Ontario (Approval # 18935E) and as per this approval each participant read a letter of information pertaining to the study and provided written informed consent prior to participation.

Six patients between the ages of 56 and 83 were recruited to participate; however, one dropped out of the study shortly after the initial pre-intervention visit, and data hereafter refers to the sample size of n=5. Table 1 offers a description of participant characteristics. PD symptoms of all participants were assessed by the recruiting clinical neurologist (M.E.J.) using the Unified Parkinson's Disease Rating Scale (UPDRS) which evaluates rigidity, slowness, tremor, gait and balance, and is correlated with disease severity (Shulman et al., 2008). Participants attended an initial pre-intervention laboratory visit during which baseline non-cued spatiotemporal parameters of gait were measured using a GAITRite® instrumented carpet (CIR Systems, Inc., Sparta, NJ) and intervention strategies were then established. Three non-cued walking trials were performed and mean calculations from these three trials were used for all calculations and descriptions. Functional mobility was assessed in a similar manner; participants completed the consecutive Timed-Up-And-Go (TUG) tests and a mean score was recorded. The TUG test involved participants standing from a seated position, walking three meters, turning around at a line on the ground, walking back to the starting point and sitting down. This test has been shown to have good test-retest reliability (r = 0.80; ((Huang et al., 2011)); and high interrater reliability (ICC ≥ 0.87; (S. Morris, Morris, & Iansek, 2001)) in people with PD.

Table 1

Participant Characteristics

	P1	P2	P3	P4	P5
Gender	Male	Female	Female	Male	Male
Age	83	56	72	72	73
UPDRS	46	22	26	33	33
Years with PD	5	6	12	10	9

Note. P1-P5 = Participant 1 – 5; UPDRS = Unified Parkinson's Disease Rating Scale measured "on" medication

After baseline testing, during the pre-intervention visit, participants were cued with verbal statements such as "take big steps" or "take long steps". Video of each participant walking with and without verbal cueing was captured during this laboratory session using a digital video camera (SONY DCR-TRV730), edited, formatted using iMovie (®Apple Inc.), and delivered to participants as a "video intervention". Interventions were delivered either as .M4V files burned onto a DVD, or as .M4V file transferred directly onto participant owned iPads (®Apple Inc.). For the cued gait portion of the video intervention, only footage of cues that were deemed to be beneficial for a particular participant was included in that participant's video intervention. See Table 2 for a description of the specific cues each participant was prescribed. This decision was after members of the research team reviewed footage from the pre-intervention visit.

Table 2

Prescribed Cues

	P1	P2	P3	P4	P5
Take big, long steps	✔		✔	✔	
Take long steps	✔				✔✔
Walk heel-toe, heel-toe					✔
Keep your head up			✔	✔	
Walk heel-toe with long steps	✔		✔	✔	
Bend at the Knee		✔✔✔			

Note: P1-P5 = Participant 1 – 5; number of ✔ represents the number of times a cue was prescribed for home use. Participants were prescribed one, two, or three cues, depending which cues were observed to be effective during the pre-intervention laboratory session. When less than 3 cues were deemed effective, one or more cues was prescribed more than once.

Participants received personalized video interventions created from a template, but featuring only video footage and cues catered to each individual. Participants watched approximately 50 seconds of their own non-cued and cued gait performance, followed by three minutes of practice with attention explicitly directed to execution of specific cue featured in the gait performance immediately preceding the practice period. Figure 1 provides an overview of the video-intervention structure and flow. The sequence of watching gait performance and practicing cued gait performance was repeated a total of three consecutive times, which amounted to an average video duration of 16 minutes and 33 seconds. See Table 3 for an accurate summary of the total time spent in each main component of the video-intervention.

Figure 1

Video Schematic

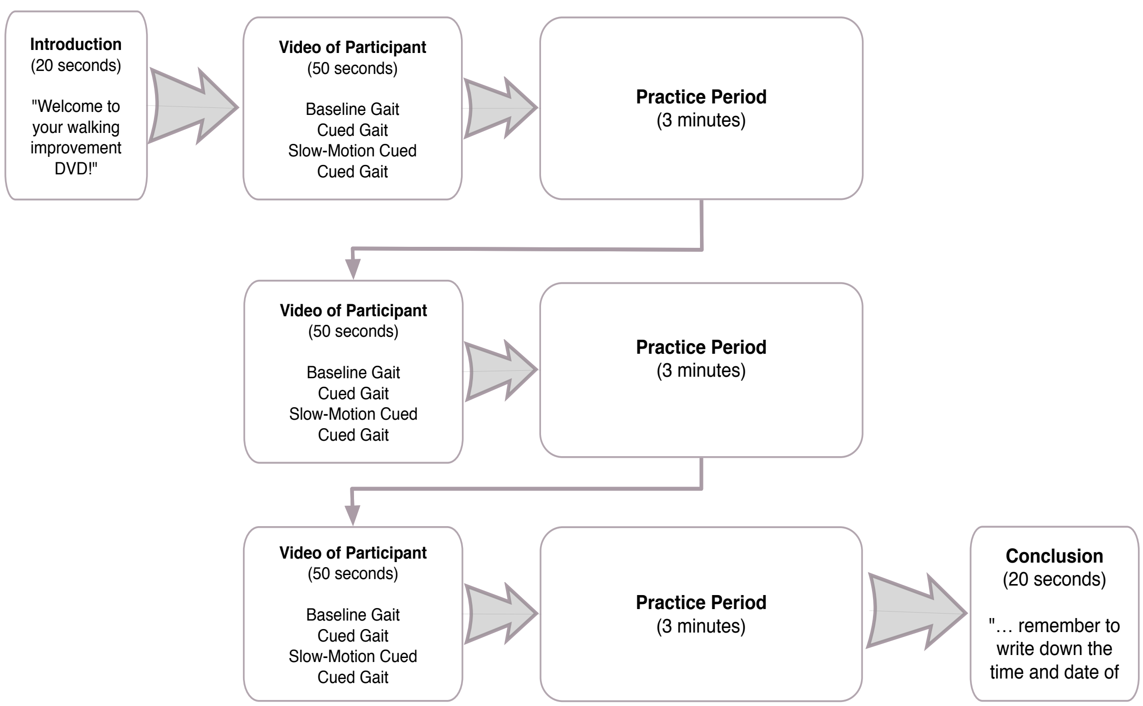


Figure1. Times indicated are an approximation of the duration of time allocated to each aspect of the intervention video.

Table 3

Time Allocation by Intervention Component (minutes:seconds)

	Viewing Gait Performance	Practice	Transition or Instruction	Total
P1	2:48	9:00	4:07	15:55
P2	2:03	9:00	4:55	15:58
P3	2:33	9:00	5:00	16:33
P4	2:48	9:00	4:58	16:46
P5	2:31	9:00	4:23	15:54
Average	2:34	9:00	4:59	16:33

Note. P1-P5 = Participant 1 – 5. The intervention featured each of the two main components (viewing gait and practicing gait) three times. Multiple brief transition and instructional periods were included in natural intermittent positions. The times displayed in the chart above represent the total time allocated to each of these sections accumulated throughout the entire video.

Participants were given instructions to practice with their video intervention every-other-day for a two-week period, and were asked to record the date and time of practice along with observations or feedback from the practice session. The purpose of recording practice details was twofold; it gave the authors important information about feasibility of this intervention, and the solicitation of specific details may have improved accuracy in reporting practice adherence. According to participants' practice journals, there was 100% adherence with the frequency and duration of the practice protocol. All participants reported engaging with their intervention seven times over two weeks, as directed by the researchers.

Participants were assessed in the laboratory for a post-intervention visit two weeks after receiving their video interventions. During this laboratory session non-cued spatiotemporal parameters of gait and functional mobility were recorded respectively using the GAITRite® instrumented carpet and TUG test in an identical manner as during the pre-intervention visit.

After the two-week post-intervention testing, participants were instructed to use their video intervention as frequently or infrequently as they wished, and were invited to return for a two-month follow-up session. The purpose of this follow-up was to test retention of any improvements made during the post-intervention stage. Participants were told that they *did not* have to use their video interventions at all during this follow-up period. After this two month unprescribed period four of five participants returned for a final laboratory session where non-cued spatiotemporal parameters of gait and functional mobility were measured in exactly the same manner as they had been measured in the pre- and post-intervention sessions.

Results:

As expected, analysis of gait kinematics during the initial pre-intervention visit showed that the verbal cueing strategies offered to participants were immediately effective in the short-term. Table 4 shows these effects. All five participants experienced step length increases during cued gait performances in the preliminary laboratory visit, with a mean step length increase of 10.18 cm.

Gait velocity decreased *during* cued gait performance in four of five participants. The decrease in velocity seen during initial cueing may be related to the principle described by Fitts' Law where speed and accuracy are inversely related (Schmidt & Lee, 2011). The inverse relationship between step length and gait velocity observed during the cueing phase of this study suggests that verbal cueing from researchers may have directed participants to focus on gait performance as a "cost" of gait speed. This observation suggests that attentional resources were divided between gait performances, and the act of thinking about the gait cueing strategy (Yogev-Seligmann, Rotem-Galili, Dickstein, Giladi, & Hausdorff, 2012).

Table 4

Non-Cued and Cued Gait Kinematics During the Pre-Intervention Session

	Step Length (cm)			Velocity (cm/s)		
	Non-Cued	Cued [a]	Δ	Non-Cued	Cued [a]	Δ
P1	47.3	56.3	*9.0*	94.3	83.0	*-11.3*
P2	67.4	78.5	*11.1*	122.0	110.5	*-11.5*
P3	62.6	66.2	*3.6*	96.2	82.7	*-13.5*
P4	61.0	69.9	*8.9*	115.4	111.1	*-4.3*
P5	57.8	75.9	*18.1*	99.4	111.6	*12.2*

Note. P1-P5 = Participant 1 – 5.

[a] Cued data represent measurements from only those cues that were prescribed for home-based practice in the video intervention

At the post-intervention visit, after having participated in two weeks of home-based training with the gait improvement DVD, all five participants had increased non-cued step length ($\bar{x}$ increase 6.42 cm / 10.77% change). Four of the five participants had increased gait velocity ($\bar{x}$ increase 16.13 cm/s / 15.07% change), and four of five participants had improved functional mobility as indicated by decreased TUG testing times ($\bar{x}$ decrease 1.18 seconds / 9.73% change). Table 5 provides an overview of these results, while Table 6 and Table 7 contain detailed data for all participants.

Four participants completed the 2-month follow-up visit, which measured retention following prolonged unprescribed cueing practice. All four participants who were measured at this time point had maintained step length improvements relative to pre-intervention levels ($\bar{x}$ improvement 2.45 cm / 3.90%). Three of four participants maintained improved gait velocity from pre-intervention levels ($\bar{x}$ improvement 10.97 cm/s / 9.94%), and all four participants maintained TUG score improvements from pre-intervention levels ($\bar{x}$ decrease 0.78 seconds / 4.20%). One participant was not measured at this time point due to pre-existing joint pain. Refer to Table 6 and Table 7 for a complete description of these 2-month results. Additionally, Appendix A presents a graphical representation of this data.

Table 5

Post-Intervention Summary of Results

	Step Length (cm)		Velocity (cm/s)		TUG Score (s)	
	2-Weeks	2-Months	2-Weeks	2-Months	2-Weeks	2-Months
P1	✔	Marginally Longer	Marginally Slower	Marginally Slower	✗	✔
P2	✔	✔	✔	✔	✔	✔
P3	✔	✔	✔	✔	✔	✔
P4	✔	✔	✔	✔	✔	Marginally Better
P5	✔	-	✔	-	✔	-

Note. P1-P5 = Participant 1 – 5; "✔" indicates > 3% improvement over baseline; "✗" indicates > 3% decrease in performance from baseline; "Marginal" indicates (±) < 3% change from baseline.

Table 6

Non-Cued Gait Kinematics Across Study Timeline

	Step Length (cm)			Velocity (cm/s)		
	Pre-Intervention	2-Weeks (% Δ)	2-Months (% Δ)	Pre-Intervention	2-Weeks (% Δ)	2-Months (% Δ)
P1	47.3	49.7	47.5	94.3	91.6	92.4
		(5.1)	(0.4)		(-2.9)	(-2.0)
P2	67.4	72.1	70.7	122.0	138.3[a]	135.6[a]
		(7.0)	(4.9)		(13.4)	(11.1)
P3	62.6	68.7	64.9	96.2	113.5[a]	107.5[a]
		(9.7)	(3.7)		(18.0)	(11.7)
P4	61.0	69.3	64.9	115.4	130.7[a]	123.4[b]
		(13.6)	(6.4)		(13.3)	(6.9)
P5	57.9	68.4	-	99.4	115.0[a]	-
		(18.1)	-		(15.7)	-

Note. P1-P5 = Participant 1 – 5; % Δ calculated relative to baseline measurement.
[a] Substantial change of ≥ 10 cm/s improvement as defined by Perera et al., (2006). [b] Small meaningful change of ≥ 5 cm/s improvement as defined by Perera et al., (2006).

Table 7

Functional Mobility (TUG) Changes Across Study Timeline

	TUG Test (s)		
	Pre-Intervention	2-Weeks (% Δ)	2-Months (% Δ)
P1	28.0	30.0 (7.1)	25.9 (-7.5)
P2	8.6	8.3 (-3.5)	8.3 (-3.5)
P3	12.0	11.1 (-7.5)	11.5 (-4.2)
P4	13.3	11.3 (-15.0)	13.1 (-1.5)
P5	11.5	10.0 (-13.0)	- -

Note. P1-P5 = Participant 1 – 5; % Δ calculated relative to baseline measurement. A negative change in TUG is an *improvement* (required less time to complete the task).

Discussion:

Results from the post-intervention and two-month follow-up time points support the need for further exploration of this novel home-based gait retraining intervention. This preliminary study highlights that individuals with mild to moderate PD are capable of using verbal cueing strategies to improving gait and sustain gait changes when engaging in a home-based program based on a motor learning paradigm of training. Further, results suggest that this relatively inexpensive and resource-light intervention may have empowered individuals with PD to self-cue and, thus, facilitated long-term gait improvements (lasting at least two months). The improvements in gait velocity observed in four of the five participants at the two-week time point, and three of the four participants at the two-month time-point are clinically meaningful, according to the standards set by Perera, Mody, Woodman, and Studenski (2006). Perera et al. investigated meaningful gait speed improvements in a population of older adults with mobility difficulties, subacute stroke survivors, and community-dwelling older people, and determined that a small meaningful change in gait velocity is ≥ 5 cm/s, while a substantial change in gait velocity is ≥ 10 cm/s. To our knowledge, there is no published research investigating meaningful gait velocity improvements in a Parkinson's specific population, to which we could compare our results. Stride length and gait velocity are two of the most common meaningful outcome measures used by researchers in PD gait rehabilitation, and given the nature of this study it was appropriate to employ these as outcome measures as well (Spaulding et al., 2012; Werner & Gentile, 2010)

Our results support the possibility of "cue learning" by individuals with PD, which was also observed by Werner and Gentile in their 2010 study. Specifically, Werner and Gentile noted that participants appeared to have learned cueing strategies after intensive laboratory practice in either of two groups. One group in Werner and Gentile's study received the verbal instruction to "take a big step", while the other group received this same verbal instruction in addition to videotape feedback of their own walking taken from an immediately prior gait performance. The results of their 2010 study indicated positive short-term effects with long-term retention of the two intensive gait retraining strategies among an initial group of 12 individuals with PD. The two training interventions used by

Werner and Gentile required approximately 360-minutes of laboratory-based training per patient, over a two-week period. Werner and Gentile appropriately acknowledged that this is far more time spent in clinical gait training than is typically available for an individual with PD. Our study addressed the need to investigate a gait training intervention that would be less demanding on clinical resources and, therefore, more feasible for clinical rehabilitation.

The home-based intervention tested in our study wove principles from the field of experimental motor learning, including guiding principles for practice distribution (Schmidt & Lee, 2011) and self-modeling in skill acquisition (Ashford, Bennett, & Davids, 2006; Braaksma, Rijlaarsdam, & van den Bergh, 2002; SooHoo, Takemoto, & McCullagh, 2004), with traditional cueing approaches commonly used in management and treatment of Parkinson's disease. By design, the intervention requires fewer resources and can be implemented at a relatively lower cost than traditional therapies that require research and/or clinic visits on a regular basis. This intervention also moved training out of a laboratory stetting and into a more natural environment, in order to offer an ecologically relevant rehabilitation protocol.

While the authors incorporated specific principles of motor learning into the current intervention design, the aim of this intervention was not to reach skill automaticity, as is the usual goal of motor learning and skill acquisition. Given the neurological underpinnings of PD we chose to use motor learning principles as tools to facilitate self-cueing, and thus incorporated observational learning through self-modeling in the intervention design. This approach appeared to teach participants strategies to control their own gait and, therefore, we consider the intervention a “cognitive cueing approach”. This term refers to the process whereby participants reported being able to cognitively recognize a decrease in gait quality, and choose to incorporate verbal cueing strategies in order to improve gait performance. This process resulted in improved non-cued gait performance in laboratory sessions that followed the 2-week intervention period and after 2-month unprescribed practice period.

The intervention tested in this study was novel and, therefore, it was appropriate to execute a pilot study. However, the small study population imposes a limitation, in that results reported here cannot be presumed to be generalizable. A necessary next step is to implement this intervention in a sample size large enough to detect statistically meaningful treatment effects. An additional limitation of the study may also include reliance on participant self-reporting of practice protocol adherence. Efforts were made to minimize the negative effects of self-reporting by soliciting specific details relating to the date, time, and experiences of each practice session. It should be noted that during the 2-week intervention period, participants reported 100% adherence to the practice protocol. If this reported adherence is not accurate and if, in fact, participants practiced less than reported, the implication would be positive, suggesting that the meaningful gait improvement reported in our results were achieved with less practice than the authors expected would be required.

The clinical implications for this gait improvement strategy are significant. If further testing in a larger sample size supports our preliminary results, this tool would help clinicians support their patients in an extraordinarily cost-effective way. The feasibility of this gait retraining approach is enhanced due to the minimal upfront costs, and small amount of time required for implementation. Further, it is easily updated as patients progress through the course of their disease, in either a positive or negative direction. This intervention indicated that patients are able to articulate and implement their own cueing strategies, and this method of involving patients in their own care is promising and should be pursued. Perhaps the most significant aspect of this gait retraining intervention was the observation that positive gait changes were muted, but not extinguished after a prolonged passive-practice period, indicating that even very little directed home-based practice may maintain meaningful long-term effects on gait improvement among individuals with PD. Further investigation of this strategy should be pursued. Future research should aim to maintain the intervention design as best as possible, so that findings can contribute to growth of the collective knowledge relevant to the clinical application of this intervention approach.

References

Ashford, D., Bennett, S. J., & Davids, K. (2006). Observational modeling effects for movement dynamics and movement outcome measures across differing task constraints: a meta-analysis. *J Mot Behav, 38*(3), 185-205. doi: 10.3200/JMBR.38.3.185-205

Bloem, B. R., Hausdorff, J. M., Visser, J. E., & Giladi, N. (2004). Falls and freezing of gait in Parkinson's disease: a review of two interconnected, episodic phenomena. *Mov Disord, 19*(8), 871-884. doi: 10.1002/mds.20115

Braaksma, M. A. H., Rijlaarsdam, G., & van den Bergh, H. (2002). Observational learning and the effects of model-observer similarity. *Journal of Educational Psychology, 94*(2), 405-415. doi: 10.1037//0022-0663.94.2.405

Felix, K., Gain, K., Paiva, E., Whitney, K., Jenkins, M. E., & Spaulding, S. J. (2012). Upper extremity motor learning among individuals with Parkinson's disease: A meta-analysis evaluating movement time in simple tasks. *Parkinsons Dis, 2012*, 589152. doi: 10.1155/2012/589152

Grimbergen, Y. A. M., Munneke, M., & Bloem, B. R. (2004). Falls in Parkinson's disease. *Curr Opin Neurol, 17*(4), 405-415. doi: 10.1097/01.wco.0000137530.68867.93

Huang, S.-L., Hsieh, C.-L., Wu, R.-M., Tai, C.-H., Lin, C.-H., & Lu, W.-S. (2011). Minimal Detectable Change of the Timed “Up & Go” Test and the Dynamic Gait Index in People With Parkinson Disease. *Physical Therapy, 91*(1), 8.

Josiah, A. F., Gruber-Baldini, A. L., Anderson, K. E., Fishman, P. S., Weiner, W. J., Reich, S. G., & Shulman, L. M. (2012). The effects of gait impairment with and without freezing of gait in Parkinson's disease. *Parkinsonism Relat Disord, 18*(3), 239-242. doi: 10.1016/j.parkreldis.2011.10.008

Morris, M. E., Iansek, R., Matyas, T. A., & Summers, J. J. (1996). Stride length regulation in Parkinson's disease. Normalization strategies and underlying mechanisms. *Brain, 119 (Pt 2)*, 551-568.

Morris, S., Morris, M., & Iansek, R. (2001). Reliability of Measurements Obtained with the Timed "Up & Go" Test in people with Parkinson Disease. *Physical Therapy, 81*(2), 810-818.

Pendt, L. K., Reuter, I., & Muller, H. (2011). Motor skill learning, retention, and control deficits in Parkinson's disease. *PLoS One, 6*(7), e21669. doi: 10.1371/journal.pone.0021669

Perera, S., Mody, S. H., Woodman, R. C., & Studenski, S. A. (2006). Meaningful change and responsiveness in common physical performance measures in older adults. *J Am Geriatr Soc, 54*(5), 743-749. doi: 10.1111/j.1532-5415.2006.00701.x

Rochester, L., Baker, K., Hetherington, V., Jones, D., Willems, A. M., Kwakkel, G., . . . Nieuwboer, A. (2010). Evidence for motor learning in Parkinson's disease: acquisition, automaticity and retention of cued gait performance after training with external rhythmical cues. *Brain Res, 1319*, 103-111. doi: 10.1016/j.brainres.2010.01.001

Rochester, L., Hetherington, V., Jones, D., Nieuwboer, A., Willems, A. M., Kwakkel, G., & Van Wegen, E. (2005). The effect of external rhythmic cues (auditory and visual) on walking during a functional task in homes of people with Parkinson's disease. *Arch Phys Med Rehabil, 86*(5), 999-1006. doi: 10.1016/j.apmr.2004.10.040

Schmidt, R. A., & Lee, T. D. (2011). *Motor Control and Learning : A Behavioral Emphasis* (5th ed.). Champaign, IL: Human Kinetics.

Shulman, L. M. (2010). Understanding disability in Parkinson's disease. [Review]. *Mov Disord, 25 Suppl 1*, S131-135. doi: 10.1002/mds.22789

Shulman, L. M., Gruber-Baldini, A. L., Anderson, K. E., Vaughan, C. G., Reich, S. G., Fishman, P. S., & Weiner, W. J. (2008). The evolution of disability in Parkinson disease. *Mov Disord, 23*(6), 790-796. doi: 10.1002/mds.21879

SooHoo, S., Takemoto, K. Y., & McCullagh, P. (2004). A Comparison of modeling and imagery on the performance of a motor skill. *J Sport Behav., 27*(4), 349-366.

Spaulding, S., Barber, B., Colby, M., Cormack, B., Mick, T., & Jenkins, M. (2012). Cueing and gait improvement among people with Parkinson's disease: A meta-analysis. *Arch Phys Med Rehabil, 94*(3), 562 -570. doi: http://dx.doi.org/10.1016/j.apmr.2012.10.026

Werner, W. G., & Gentile, A. M. (2010). Improving gait and promoting retention in individuals with Parkinson's disease: a pilot study. *J Neurol, 257*(11), 1841-1847. doi: 10.1007/s00415-010-5619-z

Yogev-Seligmann, G., Rotem-Galili, Y., Dickstein, R., Giladi, N., & Hausdorff, J. M. (2012). Effects of explicit prioritization on dual task walking in patients with Parkinson's disease. *Gait Posture, 35*(4), 641-646.

Chapter 3

3 Translating Research to Clinical Practice: Feasibility Considerations

One of the primary purposes of conducting the study featured in Chapter 2 was to assess the directionality of effects associated with the implementation of a novel gait retraining intervention. Another essential objective of this study was to determine the feasibility of this intervention from a clinician and researcher perspective, and from the perspective of participants receiving the intervention. The results section of Chapter 2 outlines the effects this intervention had on kinematic parameters of gait, and this chapter (Chapter 3) elaborates on the equally important feasibility considerations observed throughout the implementation of the previous study.

3.1 Logistics and Feasibility of Intervention Production

The design of the intervention tested in chapter two was created with feasibility considerations in mind. Specifically, it was created so that it would be clinically relevant and would not require unrealistic resources to create, produce, and support. By nature, the home-based video gait retraining intervention targets a clinically relevant problem, because gait disturbances in Parkinson's disease are associated with increased risk of falling, and decreased quality of life (Grimbergen, Munneke, & Bloem, 2004; Shulman, 2010; Shulman et al., 2008).

The intervention required only one laboratory session where appropriate verbal cues were established and video of participants walking was taken. This session lasted no longer than 60 minutes per participant. However, because this intervention was being tested as a research study, this initial laboratory visit required baseline testing that wouldn't be required in clinical treatment. It is, therefore, reasonable to estimate that the necessary duration for a *clinical* visit focused on preparing for this intervention would require a maximum of 45 minutes. A 45-minute physiotherapy visit is a normal length; therefore, this initial stage required to implement this intervention in a clinical setting should be considered feasible, from a time requirement perspective. While the initial study visit was supervised by a combination of three to four researchers and clinicians, in a treatment setting one clinician could fulfill two of the study roles (video operation and instructional cueing), while the third role (data collection) would be superfluous. In the case of this study, the fourth clinician / researcher present during laboratory visits was observing and / or supporting but did not have a specific role. Therefore, it is reasonable to estimate that one clinician could execute all of the tasks necessary to prepare a patient for this home-based training program within the constraints of one clinical visit.

Video footage of each participant was captured using a digital video recorder (Sony DCR-TRV730) and a simple tripod located 4.5 meters from the center of a 7 meter long GAITRite® instrumented carpet on which participants performed each of their walking trials. The camera was located at a height of 1.48 meters. One of the researchers moved the camera on its tripod pivot as participants walked along the GAITRite® carpet, in order to keep each subject in the center of the video frame. In a clinical setting this task could be performed by the clinician giving the verbal instructions, insofar as the patient walked without risk of falling. If a participant were ever known to have falling episodes during gait performance, it would be recommended that the clinician walk alongside the patient while another individual (a clinician or volunteer) operated the video camera.

Most of the software used to make the intervention videos in the Chapter 2 study came standard with a Mac OS X operating system (® Apple Inc.). Any clinician who uses a Macintosh operating system would, therefore, likely have these tools already available without additional cost. The video recorded during each participant's pre-intervention visit was imported into iMovie (® Apple, Inc.). This process was extraordinarily user-friendly and took approximately 15 minutes to complete using a FireWire 800/400 9-Pin to 4-Pin cable, which connected the video camera with the computer. Once an individual participant's video footage was loaded into iMovie, the authors identified appropriate video segments to incorporate into that participant's intervention. For each participant the researchers selected three 10 to 15 second video segments, each representing one of the cues that participants performed successfully in the laboratory. Additionally researchers identified one 10 to 15 second video segment of non-cued gait performance to use throughout the intervention video. This collaborative process took no longer than 10 minutes per participant and could have been completed independently by a clinician experienced in treating gait problems in PD.

Each video segments that was determined to be appropriate for use in the intervention was moved from its location in iMovie into an iMovie project template made by the researchers, and used for all participants (see Figure 1, Chapter 2). This iMovie template featured all of the introductory and transition slides, placeholders for the participant-specific video clips, and a three-minute countdown timer located three times throughout the video. Surprisingly, the authors found that iMovie did not include a user-friendly countdown timer tool and, therefore, a downloadable program by the name of *Countdown Maker* (Tasteful Works, Inc.) at a cost of $49 USD was used. The countdown timer was an important design aspect of the intervention, as it tracked time during the three practice periods, enabling participants to focus on gait without the additional task of time keeping. The process of making a video template required approximately three hours of upfront work, but once complete it could be used for every participant, and can be seen as a one-time “investment” in the intervention execution process.

The process of personalized intervention production that required the most time per participant was the element of embedding participant-relevant audio coaching into the intervention template. Each intervention featured embedded coaching during the cued gait video segments and again during the practice periods. The purpose of adding audio coaching to the cued gait segments was twofold. First, it provided an opportunity to focus attention towards the video (silent video would have been less engaging). Second, and more importantly, it enabled the researchers to highlight how a specific cue was facilitating improved gait and to contrast cued gait performance with non-cued gait performances. As an example of audio coaching, one video included the statement "…your walking looked great when you focused on taking long steps, watch yourself do it in the video here" during the first cued walking segment of the intervention. Another intervention included the comment "watch yourself walking again here, and see if you can keep this picture in your mind when you practice". This statement was embedded over video of a cued gait segment that immediately preceded a three minute practice period. Personalized audio coaching was also included in each of the three practice periods. At the one and two minute time points in each practice section participants were reminded of the specific verbal cue they had been instructed to focus on during that specific practice period and were given an update on practice time remaining. For example, one participant received the coaching: "Great job Tom[*]! You have two minutes remaining in this practice period; keep focusing on taking long steps, just long steps". Additionally, the interventions included embedded coaching at the conclusion of each practice period such as "All right Chelsea*, your first of three practice periods is over". Embedding the audio coaching took between 20 and 40 minutes for each participant, and was completed by the author S.J.M. Participant comments regarding the audio coaching suggested that this was a valuable component of

---

[*] Name changed to protect the identity of participants

the intervention and, therefore, authors would recommend including it in a clinical application.

Once the editing process was completed in iMovie, each video was saved as an .m4v file and transferred to DVD for participants' home use. This aspect of intervention production required some monetary investment, as a DVD writing program does not come standard with the Mac OS X operating system. The authors used *Aimersoft DVD Creator for Mac* (Aimersoft Studio, Inc.), a downloadable program available at a cost of $49 USD. The cost of the DVD discs used to record the intervention files was negligible, given the small sample size used in this study. Widespread use of this intervention in a clinical setting would require some consideration of the accumulating cost of DVD discs, however small the cost of an individual disc may be. In this study, two participants choose to use an iPad to interface with their video interventions, which negated the cost associated with DVD production. Encouraging use of personal tablet devices or computers could be a cost-saving option worth pursuing in a clinical setting.

A final logistic consideration relevant to the intervention tested in Chapter 2 related to delivering the intervention itself to participants. Three of the five participant interventions were personally delivered to participants by the author within 24 hours of the initial pre-intervention laboratory visit. One participant chose to pick up the intervention DVD from the laboratory 24 hours after completing the pre-intervention visit, while another participant received the intervention DVD five days after the initial pre-intervention visit due to a statutory holiday. All participants had between 14 and 15 days from the date of intervention delivery to the post-intervention (2-weeks) testing session. Each time the author delivered a participant's intervention to his or her home, the author previewed the video with the participant, and together the pair assessed appropriate practice areas and strategies in the home. In a clinical setting, intervention delivery would need to be considered. If a clinician were following a patient with frequent appointments, an intervention DVD may easily be delivered at a future visit. However, if a clinician were following a patient with long durations between follow-ups, we would recommend alternative delivery methods such as patient pick-up of the DVD whenever possible. Uploading the intervention video to an e-mail server or cloud-computing program is *not* recommended. Protection of patient confidentiality is always a primary concern, and by uploading video to an online entity the clinician or researcher risks losing control of this sensitive data.

3.2 Participant Adherence to Practice Protocol

An important consideration in the design phase of the gait retraining intervention tested in Chapter 2 was how the practice protocol could be optimized to facilitate practice adherence. A core component of the intervention related to the aspect of it being home-based and unsupervised. The purpose behind this design strategy was to facilitate gait improvements in a natural and relevant environment. Additionally, the home-based, unsupervised aspect of the intervention enabled it to be executed at a low-cost, which is important as cost can be a prohibitive factor in translating research interventions into clinical practice (Glasgow, Magid, Beck, Ritzwoller, & Estabrooks, 2005). The field of exercise research offers relevant strategies for promoting adherence to practice protocol when practice is unsupervised. While the gait training intervention tested in Chapter 2 was not prescribed for the purpose of exercise, the home-based and self-directed aspects of the practice protocol are relatable to those encountered in many exercise research interventions.

Courneya (2010) identified the differences between “traditional” exercise studies, where participants are supervised for all exercise sessions, and “contemporary” exercise studies, where participants execute all or part of an exercise protocol independently. The latter type of exercise study typically incorporates “behavioural support interventions” such as incentives, print materials, or telephone counseling to encourage practice adherence (Courneya, 2010). The Chapter 2 study utilized practice journals as behavioural support interventions. The practice journals encouraged practice adherence on an individual level, and were used to assess the feasibility of the protocol requirements by assessing whether participants could successfully incorporate home-based practice into their day-to-day lives.

All participants in the study outlined in Chapter 2 were asked to engage with their gait retraining DVD every other day for a two-week period. Specifically, the practice instructions stated:

- *Please watch your DVD and follow the practice instructions once every-other day.*
- *The DVD is approximately 15 minutes long. Please choose practice times when you expect to have 15 minutes of uninterrupted time.*
- *When the DVD instructs you to practice walking in your house, please choose a variety of routes and directions. You do not have to practice in the same place every time.*
- *Stay as focused as possible. Try not to let the phone, doorbell, or other people in your home interrupt you.*
- *Try to choose routes that avoid sharp or frequent turns.*

Participants recorded the date and time of each practice in the practice journal, and were asked to briefly reflect on their experience after each practice session. According to entries in the practice journals, all five participants practiced a total of seven times in the two-week intervention period, and all adhered to the “every-other-day” schedule. One participant modified practice protocol, choosing to watch the intervention DVD without practicing, and commenced nine minutes of walking practice immediately thereafter, despite researcher instructions otherwise.

Two participants consistently recorded practice times in the morning, one participant consistently recorded practice times in the evening, and two participants recorded varying practice times throughout the day. Comments from the later two participants indicated that each made conscious efforts to include practice in their schedules despite other ongoing life commitments. This “fitting-in” of practice suggests a high level of commitment from the participants and may imply that both participants recognized value in the intervention.

3.3 Participant Feedback

Feedback regarding the intervention and participants’ experiences throughout the intervention was collected from participants during laboratory visits after the two-week intervention period and after the two-month unprescribed practice period. The researchers conducted brief, unstructured interviews that were directed towards understanding the participants’ experiences using the intervention and determining participants’ perceptions of how, if at all, the intervention affected their walking. A content analysis was conducted, in which participant feedback was categorized as: results oriented feedback, positive aspects of the intervention, and areas of the intervention that could have been improved upon. The types of questions researchers asked during the unstructured interviews partially shaped the nature of these categories, but participants were strongly encouraged to respond to these questions with honesty, and were frequently reminded that any negative comments were welcome, and would help to improve future iterations of the intervention.

Two themes emerged from within the category of results oriented feedback participants shared. One theme relates to mobility improvements, and the other theme relates to a sense of empowerment that participants attributed to their participation in the intervention. Each of the five participants reported feeling that either their gait, specifically, or their mobility, generally, had improved through their experience with the intervention. At the two-month follow-up visit one participant reported that by incorporating cueing strategies he believed he experienced fewer freezing episodes and falls. All participants reported that either they or their spouse felt that the intervention had improved their walking. Both of the two female participants reflected on the feeling of empowerment that they experienced after participating in the study. One specifically commented that the self-cueing strategies she had learned gave her the feeling of “having control again”, and continued to elaborate on how the cueing strategies contributed to her self-esteem.

The majority of feedback from participants focused on various positive aspects of the intervention. When asked about the usefulness of receiving video feedback, participants expressed that they felt the video was helpful, and in most cases participants indicated that the contrasting video from “non-cued” gait to “cued” gait was a particularly useful and motivating aspect of the intervention. Four participants explicitly commented on using both the video images and cueing strategies to improve their walking outside of the intervention practice time. These comments illuminated the usefulness of the specific cueing strategies and suggested that participants became aware of their ability to shift from difficult or poor walking to improved walking. Participants also commented on the usefulness of the audio coaching that was embedded throughout the intervention, with specific feedback relating to the coaching embedded during each of the three-minute walking practice periods.

All participants were explicitly asked to give feedback on areas of the intervention that could have been improved upon. An emphasis was made on the nature of this research being part of a pilot study where constructive criticism was welcomed and would contribute to improvements in future iterations of the intervention. Only two participants commented on aspects of the intervention that could have been improved. One suggested that the two-week intervention period may have been too short stating that it may take “a littler longer than 2 weeks” to benefit from the video. This comment came after the two-month unprescribed practice period, at which point the participant had sufficient ability to reflect on the two-week intervention experience. Another participant noted that the DVD progressed too slowly, and that the slow motion sections of the cued gait footage were not necessary. The later comment came after being explicitly asked whether the slow motion segments were useful. Additionally, this participant used an iPad to engage with the intervention, which was reportedly “a little too touchy” to carry during walking, which was a problem because this participant hoped to practice with the intervention in an outdoor environment where the iPad could not be left behind.

3.4 Feasibility Summary

The home-based gait retraining intervention outlined in Chapter 2 offers an opportunity for clinicians to support the ongoing mobility challenges faced by individuals with PD at a very low cost. From a cost-effectiveness perspective, one of the most appealing aspects of this intervention is that once the intervention template has been made and the hard- and software have been purchased (camera, tripod, computer, movie editing program, DVD writing program), the intervention cost per patient is quite low. Additionally, many movement specialists (eg: physiotherapists and neurologists specializing in movement disorders) already use video cameras as clinical tools, and it is likely that the necessary equipment is easily accessible to clinicians who may like to employ this intervention approach. The home-based aspect of this intervention may be useful for patients who have trouble traveling into clinics for frequent rehabilitation sessions, and for clinicians who can use clinical time to consult, rather than train, patients.

Overall, the intervention had overwhelmingly positive responses from participants, and spouses who attended the research sessions. Participants reported feeling that the intervention improved their gait, but they also reported positive emotional effects such as a fortified sense of ability and a revived sense of empowerment. While not formally assessed in this research study, these qualitative aspects of the intervention appeared important to participants. Future studies should consider objectively assessing participants' attitudes towards their gait abilities before and after home-based gait retraining. It would also be worthwhile to consider if positive emotional experiences such as those conveyed by participants in the Chapter 2 study are related to the outstanding practice adherence self-reported throughout the study.

References

Courneya, K. S. (2010). Efficacy, effectiveness, and behavior change trials in exercise research. *Int J Behav Nutr Phys Act, 7*, 81. doi: 10.1186/1479-5868-7-81

Glasgow, R. E., Magid, D. J., Beck, A., Ritzwoller, D., & Estabrooks, P. A. (2005). Practical Clinical Trials for Translating Research to Practice: Design and Measurement Recommendations. *Med Care, 43*(6), 551-557. doi: 10.2307/3768172

Grimbergen, Y. A. M., Munneke, M., & Bloem, B. R. (2004). Falls in Parkinson's disease. *Curr Opin Neurol, 17*(4), 405-415. doi: 10.1097/01.wco.0000137530.68867.93

Shulman, L. M. (2010). Understanding disability in Parkinson's disease. [Review]. *Mov Disord, 25 Suppl 1*, S131-135. doi: 10.1002/mds.22789

Shulman, L. M., Gruber-Baldini, A. L., Anderson, K. E., Vaughan, C. G., Reich, S. G., Fishman, P. S., & Weiner, W. J. (2008). The evolution of disability in Parkinson disease. *Mov Disord, 23*(6), 790-796. doi: 10.1002/mds.21879

Chapter 4

4 Summary, Conclusions, and Future Directions

This thesis explored the impact and feasibility of an innovative home-based video gait retraining intervention designed to facilitate gait improvement in individuals with PD. Building from a strong foundation of research that has exposed positive effects of external cueing on gait in PD (as explored in Chapters 1 and 2), the intervention tested in Chapter 2 approached the verbal cueing rehabilitation strategy from a new angle, aiming to facilitate meaningful and long-term gait improvement. A theoretically robust intervention was designed by combining verbal cueing strategies with principles from the academic field of motor learning. As this thesis outlines, the resulting intervention is associated with preliminary positive results on gait kinematics and functional mobility, as well as tremendously positive feedback from participants and researchers with respect to the feasibility of implementation and use. Participants reported liking the intervention and their feedback suggests that it may have had a positive impact on self-efficacy and self-perception. An important aim of the intervention was to produce measurable gait improvements in individuals with PD, but the intervention appears to have surpassed this goal, facilitating individual empowerment, which may have important ramifications on how an individual copes with and manages PD diagnosis.

4.1 Conclusions

The first phase of the study presented in Chapter 2 included a comparison of baseline gait kinematics and functional mobility, measured in five participants before and after completion of a 2-week home-based gait retraining intervention. This comparison showed that from pre- to post- intervention, step length increased in all five of five participants ($\bar{x}$ increase 10.77%), gait velocity increased in four participants ($\bar{x}$ increase 15.07%), and TUG scores improved in four participants ($\bar{x}$ improvement 9.73%). The next phase of the study included a 2-month period of passive unprescribed practice, which four of the five participants completed. All four of these participants maintained improved step length compared to baseline measurement ($\bar{x}$ improvement 3.90%), three showed improved gait velocity ($\bar{x}$ improvement 9.94%), and all four showed improved TUG scores ($\bar{x}$ improvement 4.20%).

The quantitative results relating to gait kinematics and functional mobility changes observed across the study timeline described in Chapter 2, give credence to future testing of the video-intervention approach in a larger sample size. By establishing preliminary data, which suggests the intervention may produce positive outcomes in a group of individuals with mild to moderate PD, this thesis has laid the foundation for future hypothesis testing. The results of this study have added to evidence in support of the notion that people with PD are capable of motor learning, and we encourage further investigation of this topic.

4.2 Future Directions

The intervention discussed in this thesis may become a valuable rehabilitation tool; however, a necessary next step is further testing in a sample size large enough to detect treatment effects. This scaled-up testing may, then, determine if the results presented in this thesis are reproducible and if conclusions can be made to inform clinical practice. To accomplish this task, future research could include methodology that incorporates within-subjects or between groups analysis of variance model.

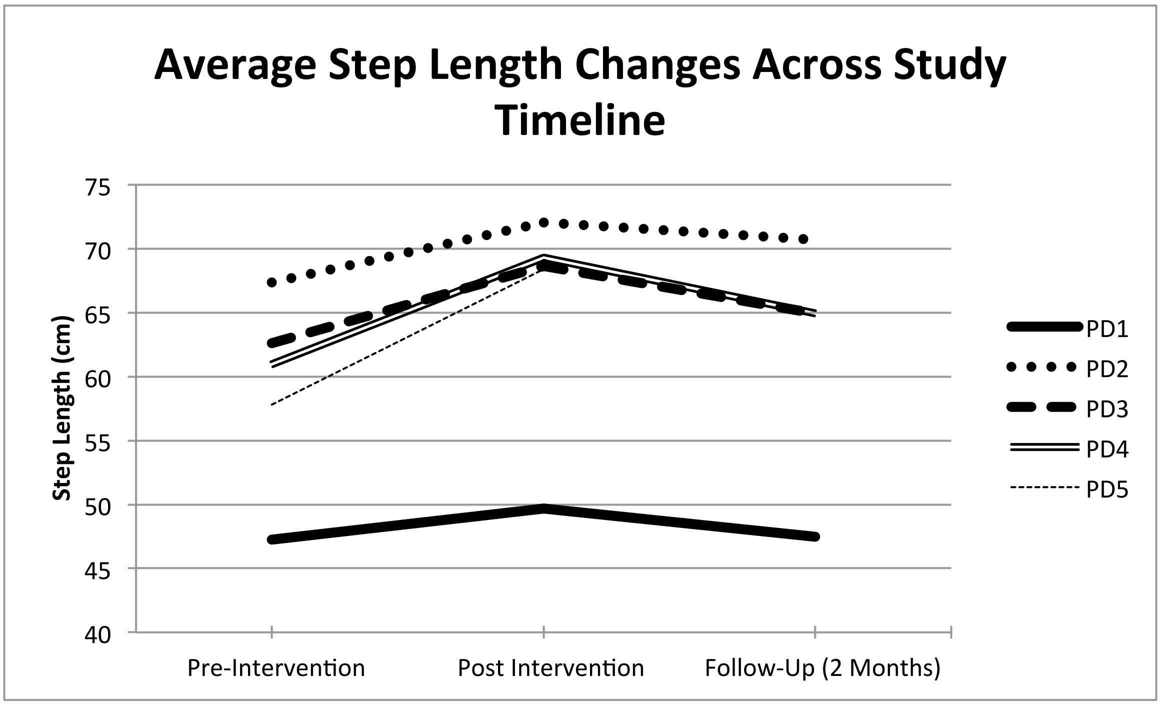
A future quantitative study may also consider a prospective cohort model that follows individuals with early PD, not yet showing gait impairment, monitoring how gait symptoms progress relative to a group of individuals not receiving preemptive gait training. This approach may be particularly appropriate given that a close review of the data presented in this thesis indicates that participants with worse gait at baseline may have benefited the least from participation. This would need to be carefully balanced with the reality that participants without gait impairment may exhibit little motivation to practice cueing strategies.

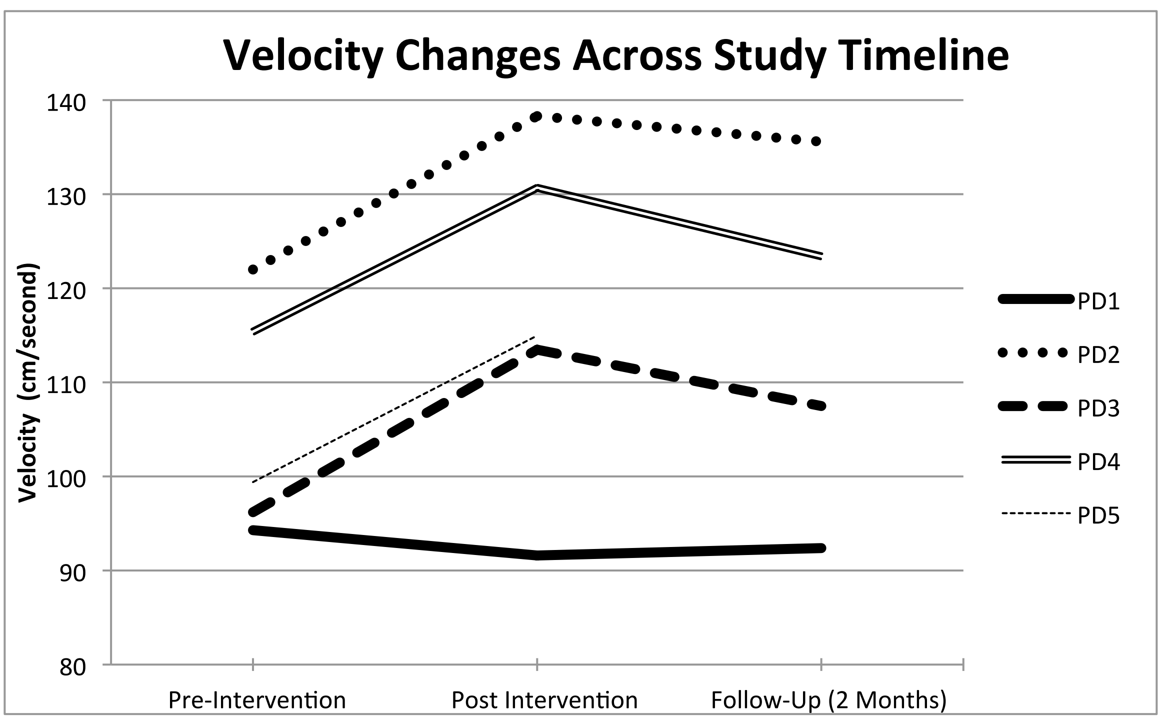
It would also be interesting and worthwhile to add a qualitative aspect to future studies investigating the effects of this intervention. After participating in this intervention many participants reported feeling a renewed sense of control over their own gait, which was sometimes accompanied by feelings of empowerment and optimism. These complex sentiments should be examined further through a qualitative lens. A mixed-methodological approach that would assess the emotional and/or psychological impacts of this intervention, while also examining its quantitative effects on gait would offer an enriched perspective on the clinical application of this home-based video gait retraining tool.

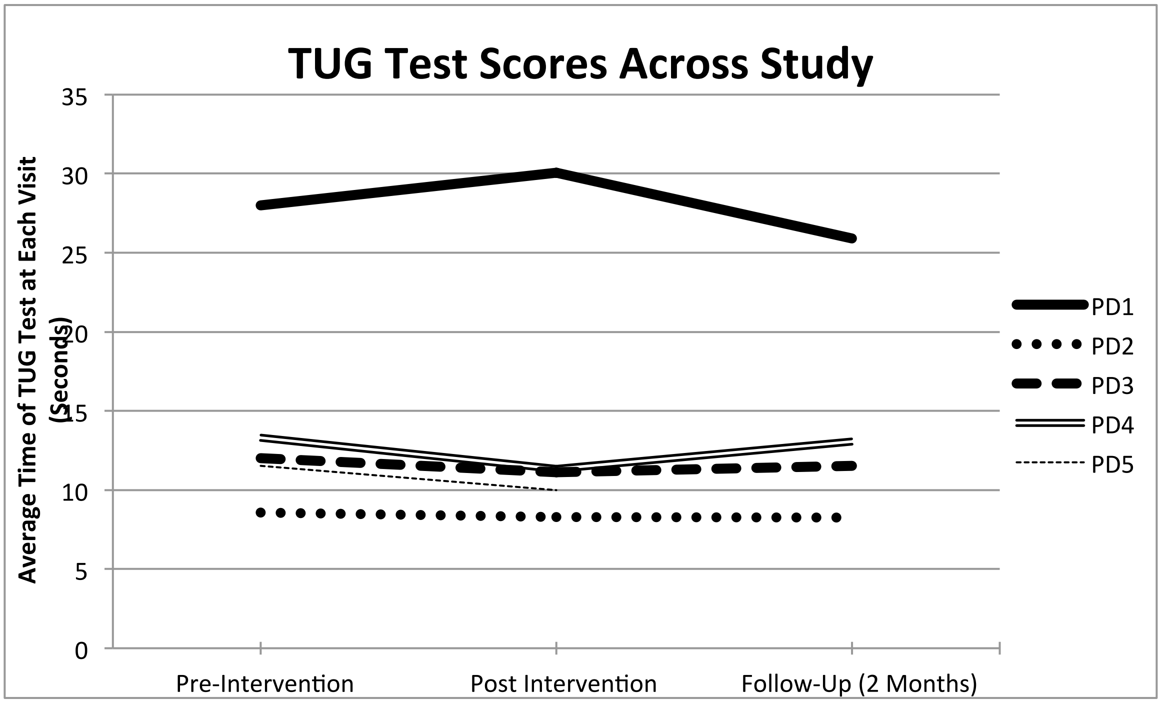
An important aspect in the design of the intervention presented in this thesis was its clinical relevance. Every effort should be made in future research investigating this strategy to ensure that the intervention remains clinically feasible and useful. In the case of this study, a clinical neurologist and two occupational therapists provided invaluable support and guidance in developing this intervention towards a clinically applicable endpoint. This perspective may also be achieved in future studies through consultation with an interdisciplinary team of rehabilitation clinicians.

Appendices

Appendix A: Graphical Representation of Data Presented in Chapter Two





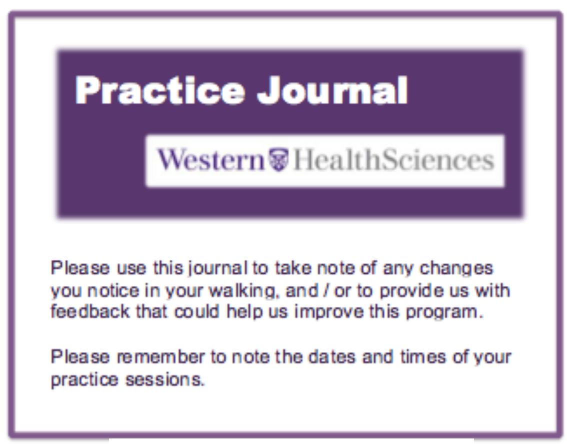

TUG Test Scores Across Study
Average Time of TUG Test at Each Visit (Seconds)
35
30
25
20
15
10
5
0
Pre-Intervention
Post Intervention
Follow-Up (2 Months)
PD1
PD2
PD3
PD4
PD5

Appendix B: Intervention Participation Materials

DVD Case Cover

DVD Case Back

DVD Front



Practice Journal Cover

Appendix C: Ethics Approval Forms

Research
Western

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Sandi Spaulding
Review Number: 18935E
Review Level: Delegated
Approved Local Adult Participants: 7
Approved Local Minor Participants: 0
Protocol Title: Gait Improvement in Parkinson's Disease: Retraining Using Video Feedback
Department & Institution: Health Sciences\Occupational Therapy, University of Western Ontario
Sponsor:
Ethics Approval Date: March 28, 2012 **Expiry Date:** April 30, 2013
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Western University Protocol		
Letter of Information & Consent		2012/03/22

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer to Contact for Further Information

[redacted]

This is an official document. Please retain the original in your files.

The **University** *of* **Western Ontario**
Office of Research Ethics
Support Services Building Room 5150 • London, Ontario • CANADA - N6G 1G9
PH: 519-661-3036 • F: 519-850-2466 • ethics@uwo.ca • www.uwo.ca/research/ethics

Research Western

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Sandi Spaulding
File Number:102414
Review Level: Delegated
Approved Local Adult Participants:7
Approved Local Minor Participants:0
Protocol Title: Gait Improvement in Parkinson's Disease: Retraining Using Video Feedback - 18935E
Department & Institution: Health Sciences\Occupational Therapy,Western University
Sponsor:
Ethics Approval Date: July 20, 2012 **Expiry Date:**April 30, 2013
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	The eligibility criteria has been revised to 40 years and older. Previously there was no upper age limit.	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Signature

Ethics Officer to Contact for Further Information

[redacted]

This is an official document. Please retain the original in your files.

The **University** *of* **Western Ontario**
Office of Research Ethics
Support Services Building Room 5150 • London, Ontario • CANADA - N6G 1G9
PH: 519-661-3036 • F: 519-850-2466 • ethics@uwo.ca • www.uwo.ca/research/ethics

Western Research — Research Ethics

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Sandi Spaulding
File Number:102414
Review Level: Delegated
Approved Local Adult Participants:7
Approved Local Minor Participants:0
Protocol Title: Gait Improvement in Parkinson's Disease: Retraining Using Video Feedback - 18935E
Department & Institution: Health Sciences\Occupational Therapy,Western University
Sponsor:
Ethics Approval Date: September 18, 2012 **Expiry Date:**April 30, 2013
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	Visit 2 will no longer happen as it has been found it is not needed.	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

S[redacted]

Ethics Officer to Contact for Further Information

[redacted]

This is an official document. Please retain the original in your files.

Western University, Support Services Bldg., Rm. 5150
1393 Western Rd., London, ON, N6G 1G9 t. 519.661.3036 f. 519.850.2466 www.uwo.ca/research/ethics

Curriculum Vitae

Name:	Stephanie Morrison
Post-secondary Education and Degrees:	Stanford University Stanford, California, USA 2004-2008 B.A. The University of Western Ontario London, Ontario, Canada 2011-2013 M.Sc. (Candidate)
Honours and Awards:	Western Graduate Research Scholarship Faculty of Health Sciences Funding Package 2011-2013 "Oral Presentation Award (Tree Category)" Health and Rehabilitation Sciences Graduate Student Society Research Form February 2013
Teaching Experience	Teaching Assistant – Occupational Therapy The University of Western Ontario 2011 - 2013

Publications:

Morrison, S. & Schuurman, J. (2012). Misguidance in Diabetes Nutrition: Food Labeling & Agency Recommendations. *Health Science Inquiry*, 3(1), 80-81.

Submitted Manuscripts:

Bornbaum, C.C., Day, A.M.B., Izaryk, K., Morrison, S.J., Ravenek, M.J., Sleeth, L.E., Skrakis-Doyle, E. Exploring Use of the ICF in Health Education: A Scoping Review. Disability and Rehabilitation. *Submitted March 29, 2013*

Manuscripts in Preparation

Morrison, S.J., Spaulding, S.J., Holmes, J.D., Jenkins, ME. (2103). Gait retraining in Parkinson's disease: A cognitive cueing approach. *Submission intended to: Movement Disorders. April 2013.*

Peer Reviewed Conference Abstracts / Presentations:

Morrison, S.J., Spaulding, S.J., Holmes, J.D. & Jenkins, M.E. (2013, February). Harnessing user-friendly technology and media platforms for gait improvement in Parkinson's disease: A clinical pilot study. Poster presentation. *Research to Action: Technology, Innovation & Health.* Hosted by: Aging Rehabilitation and Geriatric Care Research Center, Lawson Health Research Institute, St. Joseph's Health Care, Parkwood Hospital, and Faculty of Health Sciences at Western University.

Morrison, S.J., Spaulding, S.J., Holmes, J.D. & Jenkins, M.E. (2013, February). Gait improvement in Parkinson's disease: A clinical pilot study. Oral presentation. *Sowing Seeds of Ideas for Fruitful Trees.* Research Forum hosted by Health and Rehabilitation Sciences Graduate Student Society, Western University

Other Research Experiences:

Pilot Study: Sport Concussion Education Program - Evaluation of E-module Concussion Education Intervention in Grade 9 Students in Southwestern Ontario
[Collaborative role in data collection]

Pilot Study: The Effects of Virtual Reality Rehabilitation on Balance Following Acquired Brain Injury
[Collaborative role in data collection]

Randomized Crossover Study: Competition in learning: Effects of "Head-to-Head" tournament style competition in undergraduate anatomy learning.
[Collaborative role in data collection]