Executive function assessment and intervention post-stroke: building and translating the evidence into practice

Valérie Poulin

Faculty of Medicine
School of Physical and Occupational Therapy
McGill University
Montreal, Quebec, Canada

April 2014

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy.

DEDICATION

To David and Alicia

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Deficits in executive functions (EF), such as planning, problem-solving and inhibition affect up to 75% of individuals with stroke and may compromise their ability to successfully return to community living and to work. Detection and effective treatment of these disorders is thus critical. Studies over the past decade have provided evidence of substantial gaps in our knowledge on how to effectively manage EF impairment post-stroke (Bayley et al., 2007; Canadian Stroke Network, 2008; Korner-Bitensky, Barrett-Bernstein, Bibas, & Poulin, 2011). To address these gaps there has been growing attention and research into the management of EF impairment post-stroke. The studies conducted as part of this thesis were designed to address some of these gaps specific to EF assessment and intervention research, and to promote increased use of evidence-based practices for the management of executive dysfunction post-stroke.

The first manuscript provided a critical review of 17 performance-based EF tools that can be used across the continuum of stroke care to evaluate the daily consequences of executive dysfunction. The next step was to conduct a systematic review to identify and critically appraise the evidence for the use of specific EF interventions post-stroke. The systematic review of EF interventions described in the second manuscript identified different treatment approaches that were showing promise in helping persons with stroke to cope with EF deficits. The preliminary evidence on specific EF skill retraining suggested that structured, individualized and intense computerized EF training could improve targeted EF impairments (Stablum, Umilta, Mogentale, Carlan, & Guerrini, 2000; Westerberg et al., 2007). The evidence from studies on cognitive strategy training also supported the use of explicit strategies applied to ecologically relevant problems to improve some EF impairments (e.g., planning and problem-solving) and, possibly, real-world activities (Man, Soong, Tam, & Hui-Chan, 2006; Schweizer et al., 2008). However, further research was required to compare the impact of these different intervention approaches on a variety of outcomes.

Accordingly, a pilot randomized controlled trial was conducted to determine the feasibility and preliminary efficacy of two promising interventions, a strategy-training approach – the Cognitive Orientation to daily Occupational Performance (CO-OP) approach which is based on the use of meta-cognitive problem-solving strategies to achieve self-selected functional goals – and a computer-based EF training program (see Manuscript 3). Our findings provide preliminary evidence supporting the feasibility and efficacy of using both CO-OP and Computerized EF training for select patients with executive dysfunction post-stroke. EF impairments and participation in everyday life were differentially impacted by the interventions.

Finally, another important goal of my doctoral work was to enhance knowledge translation in the area of EF. As explained in the fourth manuscript, the thesis led to the creation of a series of web-based interactive learning modules on EF assessment and intervention, as well as user-friendly pocket cards designed to summarize EF rehabilitation best-practices for clinicians. These e-learning modules address the need to enhance expertise in the management of EF disorders post-stroke.

RÉSUMÉ

Les déficits des fonctions exécutives (FE) comme la planification, la résolution de problèmes et l'inhibition touchent jusqu'à 75% des personnes ayant subi un accident vasculaire cérébral (AVC) et perturbent la réalisation des activités quotidiennes et rôles sociaux, pouvant ainsi compromettre le retour à domicile ou au travail. La détection et la prise en charge de ces déficits est donc primordiale. Plusieurs études réalisées au cours des dix dernières années ont toutefois indiqué des lacunes importantes dans les connaissances reliées à la prise en charge de la dysfonction exécutive post-AVC (Bayley et al., 2007; Canadian Stroke Network, 2008; Korner-Bitensky et al., 2011), ce qui a mené à des efforts accrus en recherche afin de combler les lacunes dans ce domaine. Les études menées dans le cadre de cette thèse visaient à contribuer aux connaissances sur l'évaluation et le traitement des personnes ayant des déficits des FE, ainsi qu'à promouvoir une utilisation accrue de pratiques fondées sur les données probantes dans la prise en charge de la dysfonction exécutive post-AVC.

Le premier manuscrit présente une revue critique de 17 évaluations des FE basées sur la performance de tâches fonctionnelles qui peuvent être utilisées au cours du continuum de soins post-AVC afin d'évaluer les conséquences de la dysfonction exécutive dans le quotidien. L'étape suivante a consisté à réaliser une revue systématique afin d'identifier et d'apprécier le niveau d'évidences supportant l'utilisation d'interventions pour améliorer les FE après un AVC. La revue systématique décrite dans le deuxième manuscrit a permis d'identifier différentes approches de traitement prometteuses pour la prise en charge de la dysfonction exécutive post-AVC. Des évidences limitées mais encourageantes suggèrent que l'utilisation d'un entraînement intensif, structuré et individualisé des FE à l'ordinateur peut améliorer les FE ciblées (Stablum et al., 2000; Westerberg et al., 2007). D'autres approches basées sur des stratégies cognitives suggèrent que l'utilisation de stratégies explicites appliquées à des situations concrètes de la vie quotidienne peuvent améliorer certains déficits des FE (ex.: résolution de problèmes et planification) et,

possiblement, la réalisation des activités quotidiennes (Man et al, 2006; Schweizer et al., 2008). Cependant, des recherches additionnelles demeuraient nécessaires afin de comparer l'impact respectif de ces approches d'intervention sur différentes mesures de résultats.

Un essai clinique randomisé pilote a donc été réalisé afin de déterminer la faisabilité et l'efficacité préliminaire de deux interventions prometteuses, l'une reposant sur l'utilisation de stratégies cognitives – l'approche Cognitive Orientation to daily Occupational Performance (CO-OP) dans laquelle la personne apprend à utiliser des stratégies de résolution de problèmes pour atteindre ses propres buts en termes d'activités fonctionnelles – et l'autre consistant en un programme d'entraînement des FE à l'ordinateur. Les résultats obtenus fournissent des évidences préliminaires appuyant la faisabilité et l'efficacité de chaque intervention auprès de certains groupes de patients ayant une atteinte des FE. Des améliorations spécifiques à chaque intervention ont été notées dans les déficits des FE ainsi que la participation dans les activités quotidiennes.

Finalement, un autre objectif important était de favoriser le transfert des connaissances dans le domaine des FE. Tel qu'expliqué dans le quatrième manuscrit, mon travail de thèse a mené à la création d'une séries de modules d'apprentissage en ligne sur l'évaluation et le traitement des FE, ainsi que de cartes en format de poche résumant les meilleures pratiques cliniques auprès des personnes ayant une atteinte de FE post-AVC. Ces modules et outils d'apprentissage en ligne ont été créés en réponse au besoin d'accroître l'expertise des cliniciens dans la prise en charge de la dysfonction exécutive post-AVC.

ACKNOWLEDGMENTS

I will always remain extremely grateful to all of the people who guided and supported me throughout the pursuit of my doctorate.

Firstly, I would like to express my deepest gratitude towards my doctoral supervisor, Dr. Nicol Korner-Bitensky and to my co-supervisor Dr. Deirdre Dawson. They offered me incalculable support and exceptional supervision over the past five years, and helped me to develop on a professional and personal level so that I could become a better researcher, teacher, and therapist. I thank my supervisor Dr. Korner-Bitensky for having confidence in me from the beginning and for having motivated me to initiate an original project, which truly addressed my clinical concerns and my research interests. Her great generosity and availability at every stage of my PhD helped me to face every challenge and to see my projects through successfully. I also had the chance to benefit from the expertise of my co-supervisor Dr. Dawson, who guided me through the exciting world of executive functions and also provided a learning environment that was supportive and stimulating for me. I consider myself privileged that I had the opportunity to work with these two exceptional mentors.

I am equally privileged to have had Dr. Louis Bherer as a member of my supervisory committee. His insightful comments always brought me to push my reflections further. The support and feedback from Dr. Bherer and his graduate students – Maxime Lussier and Francis Langlois – also played an important role in the development of my computer-based executive function intervention.

I also want to thank all the wonderful faculty at the School of Physical and Occupational Therapy at McGill University, especially Dr Isabelle Gelinas and Dr Eva Kehayia, for their feedback and guidance during the key moments of my doctorate. I also thank all the other graduate students who shared my journey throughout the course of my PhD, notably Anita Petzold and Dr. Anita Menon. In addition, even at a distance, I had the chance to participate in enriching exchanges and to benefit from the friendly support of the other students in Dr. Deirdre Dawson's laboratory, notably Amanda, Anne, Emily, and Lisa.

My thesis could never have been completed without the involvement of the many participants in my research projects. I am extremely grateful towards all of the persons with stroke, their families as well as the occupational therapists who gave generously of their time and energy. I would also like to highlight the excellent collaboration of the clinicians, clinical coordinators and the program managers at the different recruitment sites.

I would also like to acknowledge the help of many dedicated and competent colleagues and research assistants. All the evaluations of the participants in the pilot randomized controlled trial were completed by Karyne Dion. Anita Petzold assisted in preparing a focus group with occupational therapists and provided guidance and feedback for the development of the e-learning modules on executive function. Annabel McDermott, Tatiana Ogourtsova, Angela Kim and Kathryn Marvin assisted with content development and/or revision of some sections of the e-learning modules on executive function. The translation of several passages of the acknowledgements was performed by Jacquelyn Sundberg.

I would also like to thank my new colleagues at the Department of Occupational Therapy at the Université du Québec à Trois-Rivières for the warm welcome and their moral support in these last stages of my doctorate.

I also want to acknowledge the generous financial support from the Fonds de Recherche du Québec – Santé (PhD fellowship: $109,627), the Richard and Edith Strauss Canada Foundation (knowledge translation grant: 15 000$), McGill Provost's Graduate fellowship ($5000), the Ordre des Ergothérapeutes du Québec ($1000), the Canadian Stroke Network, the Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain and the Réseau provincial de recherche en adaptation-réadaptation.

Finally, it is essential to thank my family members who were always there to share my joys and to encourage me to face all of the challenges that I encountered. In particular, my parents Yvette and Viateur, who always believed in me and who supported me generously in every stage of my life. A big thank you as well to my parents-in-law Lise and Louis-Marie for having taken such good care of my daughter Alicia when I had to devote time to my thesis. Two years ago, life effectively gave me the most extraordinary gift: my daughter Alicia, who brings me joy and who teaches me great lessons of wisdom every day. Thank you for your love and your contagious energy. Finally, no words could express all of my gratitude to my husband David. Thank you for your love and your invaluable moral support, and also for the countless hours dedicated to helping me enter data and edit this thesis. Thank you for having been a stable foundation for our family life throughout the past years. It is with great emotion and gratitude that I dedicate this thesis to you today.

STATEMENT OF ORIGINALITY

This thesis presents original work that I conducted under the guidance of my supervisors. As further described in Chapter 1, the general topic of the thesis came from my clinical interests related to the management of executive dysfunction post-stroke; an area of stroke research that had been underexplored and that warranted further attention. This thesis led to the publication of two literature reviews in internationally read journals that synthesized the evidence on ecologically based executive function assessment (*Manuscript 1, Chapter 2*), and on the efficacy of executive function interventions specific to the population with stroke (*Manuscript 2, Chapter 3*). The key findings from these reviews were also helpful in guiding the development and implementation of my pilot randomized controlled trial (RCT) on executive function intervention post-stroke (*Manuscript 3, Chapter 4*). A unique contribution of this pilot RCT was to provide preliminary evidence on the feasibility and relative efficacy of two novel interventions involving *cognitive strategy training* versus *computerized training of specific executive function skills* in persons with executive function deficits post-stroke. To my knowledge, there are no published studies that compared the benefits of using these top-down and bottom-up cognitive rehabilitation approaches in persons with executive dysfunction post-stroke. Finally, the thesis also contributed to promoting evidence-based practices for the management of executive dysfunction post-stroke through the creation of a series of interactive e-learning modules on executive function assessment and interventions for clinicians (*Manuscript 4, Chapter 5*).

CONTRIBUTIONS OF CO-AUTHORS

The following manuscripts were included in this thesis and were written by me with guidance from my supervisors and my thesis committee:

Manuscript 1	Poulin, V., Korner-Bitensky, N., & Dawson, D. R. (2013). Stroke-specific executive function assessment: a literature review of performance-based tools. *Aust Occup Ther J, 60*(1), 3-19. doi: 10.1111/1440-1630.12024
Manuscript 2	Poulin, V., Korner-Bitensky, N., Dawson, D. R., & Bherer, L. (2012). Efficacy of executive function interventions after stroke: a systematic review. *Top Stroke Rehabil, 19*(2), 158-171. doi: 10.1310/tsr1902-158
Manuscript 3	Poulin, V., Dawson, D., Bherer, L., Lussier, M., & Korner-Bitensky, N. Comparison of two novel interventions for adults experiencing executive dysfunction post-stroke: a pilot study. *To be submitted to Neuropsychological Rehabilitation journal.*
Manuscript 4	Poulin, V., Dawson, D., & Korner-Bitensky, N. (2013). Creation of e-learning modules specific to management of executive function post-stroke. *Published online on the Stroke Engine website at*: http://strokengine.ca/intervention/index.php?page=topic&id=90 and http://strokengine.org/elearning/executivefunction/

I took the lead in all aspects of this work including conceptualizing the research questions, literature reviews, writing the grant proposals, ethics application, data collection, data analyses and interpretation of results, as well as writing the research papers.

As primary supervisor, Dr. Nicol Korner-Bitensky oversaw and guided the entire process from design of studies to writing and approving all four manuscripts (*Manuscripts 1 to 4*) included in the thesis. She also provided expertise in the domain of knowledge translation.

Dr. Deirdre Dawson (co-supervisor) provided guidance and expertise in the domains of executive function assessment and intervention after acquired brain injury. She also offered advice in research methodology, design, analyzes and interpretation of results. She also co-authored the four manuscripts (*Manuscripts 1 to 4*).

Dr Louis Bherer (supervisory committee member) provided expertise and counselling related to cognition and executive function. He also offered suggestions and advices for the development of the computer-based executive function training program described in *Manuscript 3* and for the choice of outcome measures related to executive function impairment. He participated in critically reviewing two of the four manuscripts (*Manuscripts 2 and 3*). Specifically, *Manuscript 2* describes a systematic review on the effectiveness of executive function interventions post-stroke. *Manuscript 3* presents the findings from a pilot randomized controlled trial comparing two promising interventions – Cognitive Orientation to daily Occupational Performance (CO-OP) versus Computer-based Executive Function training – to improve executive function and functional skills after stroke.

For *Manuscript 3*, Mr. Maxime Lussier, PhD candidate in Psychology, also provided feedback and guidance on the development of the computer-based executive function intervention tested in this study. He developed one of the computerized tasks that was used for the training.

CHAPTER 1: INTRODUCTION

PREAMBLE

My interest in the rehabilitation of persons with cognitive deficits post-stroke started with my Master's degree in Clinical Sciences at the Université de Sherbrooke in 2005. The project consisted in evaluating the validity of using proxies' responses to estimate social participation – as measured using the Assessment of Life Habits – of persons unable to respond themselves because of cognitive impairment or other post-stroke disabilities. The findings obtained from 40 caregiver–person with stroke dyads provided support for the use of proxy information to estimate social participation of persons with stroke (Poulin & Desrosiers, 2008). This project allowed me to gain a deep understanding of the concept of participation and also the importance of going beyond impairment and disability measures and addressing broader health outcomes to correctly evaluate clients' overall functioning and needs, to establish meaningful therapeutic goals, and to plan effective interventions in accordance with a client's preferences and priorities (Poulin & Desrosiers, 2009).

After completing my Master's degree, I worked as an occupational therapist in a specialized stroke unit for two years. The rehabilitation of persons with executive dysfunction post-stroke appeared to me as a very stimulating challenge; an area of stroke research that had been understudied and warranted greater attention. One of my clinical concerns was to be able to better evaluate the daily consequences of executive function (EF) disorders on real-world activities that were important to my clients. Another key question was about the most effective intervention approaches to help my clients cope with EF impairments and improve performance of real-world activities at home and in the community. As I discussed these issues with colleagues working in stroke rehabilitation and started looking at the literature in this area, it became obvious that we needed more specific guidelines related to the management of clients with executive dysfunction post-stroke. This was the beginning of my PhD journey in 2008...

BACKGROUND

Definition and epidemiology of stroke

Each year, approximately 50 000 Canadians experience a stroke (Heart and Stroke Foundation of Canada (HSFC), 2013) and sixty percent of stroke survivors are left with a permanent disability (Public Health Agency of Canada (PHAC), 2009). In 2009, it was estimated that more than 300 000 Canadians were living with the sequelae of stroke (PHAC, 2011). This number is expected to grow in the next decades as the population ages and the prevalence of important risk factors for stroke, such as diabetes, hypertension and cardiovascular diseases, increases. Also, although three-quarters of all strokes occur in people aged 65 years and older (National Institute of Neurological Disorders and Stroke, 2004), the incidence of stroke in younger patients has been found to increase in the last decades (Johansson, Norrving, & Lindgren, 2000; Wolf, Baum, & Conner, 2009).

A stroke is a sudden loss of brain function that is caused by the interruption of blood flow to the brain due to a blood clot (ischemic stroke) or by uncontrolled bleeding to the brain (hemorrhagic stroke) (HSFC, 2012). About eighty percent of all strokes are ischemic (HSFC, 2013). Depending on the location and the extent of brain damage, a broad range of physical, sensory, perceptual, cognitive and emotional impairments can occur which, in turn, may, lead to activity limitations and participation restrictions that require rehabilitation. The majority of strokes are classified as being neurologically mild to moderate (Wolf et al., 2009). Although these patients have no or minimal residual physical deficits they are also likely to experience persistent disability and difficulty with more complex activities (e.g., driving, work or recreational activities) as a result of other, more subtle sequelae, such as fatigue, depression and impairment in cognitive functions (Tellier & Rochette, 2009; Wolf et al., 2009).

The impact of stroke on cognition

Among individuals with stroke, 20% to 75% show cognitive impairments (Hachinski et al., 2006; Patel, Coshall, Rudd, & Wolfe, 2002; Rasquin, Verhey, van Oostenbrugge, Lousberg, & Lodder, 2004a; Riepe, Riss, Bittner, & Huber, 2004; Tatemichi et al., 1994). The term "vascular cognitive impairment" has been proposed to describe all forms of cognitive impairment due to cerebrovascular disease (O'Brien et al., 2003). Several studies have stressed the importance of cognition in the prediction of functional recovery (Hershkovitz & Brill, 2007; Heruti et al., 2002; Lesniak, Bak, Czepiel, Seniow, & Czlonkowska, 2008) and social participation after stroke (McDowd, Filion, Pohl, Richards, & Stiers, 2003). Cognition includes acquiring, processing and using information (Cicerone et al., 2000; Duchek, 1991; Toglia, Golisz, & Goverover, 2009). Cognitive impairments may interfere with safety, efficiency and independence in everyday activities and may affect a person's ability to respond to new or unexpected situations. A stroke can impact on various areas of cognition, including attention, orientation, memory, language, praxis, gnosis, visual-spatial/perceptual function, and EF (Ponsford, 2004). Individuals with "vascular cognitive impairment" most commonly exhibit impairments of attention, processing speed and EF (Desmond et al., 1999; Hochstenbach, Mulder, van Limbeek, Donders, & Schoonderwaldt, 1998; Lesniak et al., 2008; Looi & Sachdev, 1999; Roman, 2003; Srikanth et al., 2003; Tatemichi et al., 1994).

Executive function and stroke

Disorders in EF represent one of the most common cognitive sequelae of stroke, occurring in an estimated 19 to 75 percent of survivors (Lesniak et al., 2008; Riepe et al., 2004; Zinn, Bosworth, Hoenig, & Swartzwelder, 2007). EF is a construct proposed to describe those higher order regulatory cognitive processes that determine goal-directed and purposeful behaviors (Anderson, Jacobs, & Anderson, 2008; Cicerone et al., 2000) and while many definitions exist, is generally accepted to involve the interplay of various components such as initiation, planning, sequencing, monitoring, problem-solving, divided attention, flexibility, working memory and inhibition (Anderson, 2008; Godefroy & Stuss, 2007; Lezak, 1989; Stuss, 2009). The frontal lobes of the brain, especially the prefrontal cortex, are known to be highly involved in executive functioning (Stuss, 2009). Although "executive functions" and "frontal lobes" are sometimes treated as synonymous in the literature, several researchers make a clear distinction between these terms (Cicerone, Levin, Malec, Stuss, & Whyte, 2006; Stuss, 2009). Stuss (2009) proposes that the frontal lobe functions have four functional domains that follow anatomy and evolutionary development including: (1) energization regulating functions – referring to the initiation and sustaining of behavior; (2) emotional/behavioural self-regulatory functions; (3) meta-cognitive processes – referring to self-reflection about one's cognitive processes, beliefs and experiences; and (4) *executive* cognitive functions. According to this classification, the *executive* functions represent a specific category of frontal lobe functions mediated primarily by the lateral prefrontal cortex (PFC) and defined as "high-level cognitive functions providing control and direction of more automatic lower-level abilities" (Stuss, 2009; p. 8).

Although EFs depend to a large extent on the integrity of the prefrontal cortex, they can also be impaired by various network disconnections resulting from white matter damage or impairment of other brain regions (Stuss et al., 2002). The complexity of EF makes them very sensitive to brain changes resulting from stroke (Levine, Turner, & Stuss, 2008). Furthermore, although some spontaneous recovery may occur, particularly in the first six months (Lesniak et al., 2008; Rasquin et al., 2004a), persistent deficits are frequently observed (Rasquin et al., 2004a). These deficits affect participation in rehabilitation (Skidmore et al., 2010) and play a critical role in recovery post-stroke (Lesniak et al., 2008) with a higher risk of functional dependence (Lesniak et al., 2008; Pohjasvaara et al., 2002), failure to return to work (Ownsworth & Shum, 2008) and poor social participation (McDowd et al., 2003).

Practice guidelines related to cognitive and executive function impairment post-stroke

When I started planning my PhD project in 2008, numerous practice guidelines related to cognitive and EF impairment post-stroke were emerging (Bates et al., 2005; Duncan et al., 2005; Intercollegiate Stroke Working Party, 2004; Lindsay et al., 2008). Overall, most indicated the need for screening of the patient upon hospital admission using a standardized tool that measures important cognitive domains including EF. Most also indicated that a patient with potential deficits should be examined using more in-depth cognitive assessments to determine the severity of impairment and impact of deficits on functioning in everyday activities and that, when necessary, cognitive rehabilitation be initiated (Lindsay et al., 2008). Specifically, with respect to EF assessment, a number of researchers working in the area of neuroscience were starting to recognize the need to use measures that closely reflect real-world activities, that is "ecologically valid" EF assessments (Burgess et al., 2006; Chan, Shum, Toulopoulou, & Chen, 2008), in addition to the traditional "paper and pencil" assessments that only focus on impairment. It had been suggested that real-world EF assessments would provide a more accurate representation of the person's daily life difficulties related to executive dysfunction (Burgess et al., 2006). However, identifying the tools that were most useful for clinicians working in stroke rehabilitation was challenging, as there was no published review of these EF measures and their stroke-specific psychometric properties. The first manuscript of this thesis specifically addressed this gap in knowledge (also see Chapter 2).

The stroke best practice guidelines available in 2008 also indicated that patients with evidence of cognitive impairment should receive appropriate cognitive rehabilitation interventions, but did not specify which specific interventions were effective for the management of executive dysfunction (Lindsay et al., 2008). Cognitive rehabilitation has been defined as a "systematic, functionally oriented service of therapeutic activities derived from the assessment and understanding of the patient's brain-behavioural deficits" (Cicerone et al., 2000; p: 1596-1597), and which aims to improve dysfunctional cognitive processes and everyday life functioning (Robertson & Fitzpatrick, 2008). Cognitive rehabilitation also involves identifying and addressing individuals' needs and meaningful goals (Cicerone et al., 2000, 2005; Lindsay et al., 2008). According to these guidelines, cognitive rehabilitation should be designed to achieve changes that improve the person's functional status in areas of life that are deemed important to the patient (Duncan et al., 2005; Lindsay et al., 2008). The limited evidence available suggested that some interventions appeared to be effective for the treatment of apraxia, unilateral spatial neglect, attention and memory disorders (Lindsay et al., 2008), but there were no recommendations specific to executive dysfunction post-stroke because of a lack of evidence in this area. The recommendations of a 2003 Canadian Stroke Network Consensus Conference on areas of clinical rehabilitation research that required greater attention and research funding also indicated a major gap in our knowledge on treatment of cognitive impairment post-stroke (Bayley et al., 2007). In response to the identified gap, in 2008 the Canadian Stroke Network (a Canadian Institutes of Health Research (CIHR) funded Network of Centers of Excellence) announced a call for proposals on the impact of vascular disease and stroke on cognitive impairment (Canadian Stroke Network, 2008).

During the course of my thesis work, the number of studies on cognitive interventions post-stroke has grown. The second manuscript of this thesis describes the most recent evidence on the efficacy of EF interventions post-stroke (also see Chapter 3).

Executive function interventions beyond stroke: exploring promising avenues

Given the paucity of research on EF intervention post-stroke, I decided to investigate interventions found to be effective in other populations with EF impairments, specifically aging and traumatic brain injury (TBI). Several studies conducted in healthy older adults used computer-based tasks to retrain EF which tend to decline with age (Basak, Boot, Voss, & Kramer, 2008; Bherer et al., 2005, 2008; Dahlin, Nyberg, Backman, & Neely, 2008;

Davidson, Zacks, & Williams, 2003; Kramer, Larish, & Strayer, 1995; Kramer, Larish, Weber, & Bardell, 1999; Lyrette, 2009). They showed that cognitive training can significantly reduce age-related deficits in specific executive processes such as performing two tasks concurrently (also referred to as dual-task training) (Bherer et al., 2005, 2008; Kramer et al., 1995, 1999; Lyrette, 2009), working memory (i.e. short-term maintenance and manipulation of information) (Dahlin et al., 2008) and inhibition (i.e. stopping or suppressing an habitual/automatic response) (Davidson et al., 2003; Lyrette, 2009).

The findings on dual-task training from Bherer and colleagues (2008) were particularly relevant since they noted significant improvement in executive processes required to coordinate two tasks (i.e. dual-tasking) and some transfer of training effects to untrained computerized tasks after only six one-hour intervention sessions. Forty-four older adults were randomly assigned to the computerized dual-task training group or the control group. In the dual-task training, participants learned to perform two visual discriminating tasks concurrently. "One visual task was to identify the color of an X appearing on the screen (yellow or green). The second visual task was to identify which of two letters (B or C) was presented on the computer screen." (Bherer et al., 2008, p. 197). Continuous individualized feedback was provided to enhance performance. Significant training effects were noted in the experimental group (eta squared (η2)[1]: 0.58 to 0.66), compared to the control group (η2: 0.03 to 0.07), and the training benefits were generalized to new computerized tasks (Bherer et al., 2008). Similar training effects were also reported in their previous study of dual-task training involving a visual and an auditory task (Bherer et al., 2005). One of the challenges that was identified was the need for future research to determine whether these interventions may improve performance on everyday cognitive abilities and real-world tasks, in addition to enhancing performance on laboratory-based tasks (Basak et al., 2008).

[1] Interpretation of η^2 (eta squared statistic): $\eta^2 < 0.06$ (small effect); $0.14 \geq \eta^2 \geq 0.06$ (medium effect); $\eta^2 > 0.14$ (large effect) (Cohen, 1988)

Concomitantly, a growing body of evidence from studies in adults with TBI was supporting the efficacy of meta-cognitive problem-solving strategies when improvement in everyday functioning is the goal (Kennedy et al., 2008). Interventions based on meta-cognitive strategies teach individuals to regulate their behaviour and solve problems by using systematic step-by-step procedures which may include, for example, generating goals, self-monitoring performance and adjusting the plan based on feedback (Kennedy et al., 2008). In a typical treatment session, under the guidance of a therapist, the individual learns these steps and how to apply them. A meta-analysis from Kennedy and colleagues (2008), including results from five RCTs in individuals with TBI, indicated that the use of meta-cognitive strategies may improve problem-solving in functional activities. Similarly, the results from an earlier systematic literature review on cognitive rehabilitation (Cicerone et al., 2005), including several studies reported by Kennedy and colleagues (2008), supported the use of training in formal problem-solving strategies after TBI. A few studies on meta-cognitive interventions also provided some indications that the skills learned during training transferred to untrained real-world tasks (Dawson et al., 2009a; Fasotti, Kovacs, Eling, & Brouwer, 2000; Levine et al., 2000). Generalization and transfer of skills in real-life situations appeared to be enhanced when interventions focused on personally relevant areas of functioning and were conducted in the person's own physical environment (Dawson et al., 2009a).

A promising intervention reflecting these key principles of problem-solving training is the Cognitive Orientation to daily Occupational Performance (CO-OP) approach, which is based on the use of meta-cognitive problem-solving strategies to achieve self-selected functional goals (Polatajko & Mandich, 2004). This intervention, originally developed for paediatric use in children with Developmental Coordination Disorder (DCD), aims to facilitate skill acquisition, cognitive strategy use, and generalization and transfer of skills to everyday life (Polatajko & Mandich, 2004). The use of a global problem-solving strategy (i.e. define the goal, develop plans*,* carry out the plans and verify goal attainment) forms the basis of the approach, with other specific strategies integrated as needed. At the time I started my PhD work, the CO-OP intervention had been successfully adapted for adults with TBI and had shown positive effects in a pilot study including three individuals with executive dysfunction, 5 to 20 years post-TBI (Dawson et al., 2009a). After the intervention comprising 20 one-hour sessions in the participant's environment, clinically significant changes were noted for 7 of 9 trained individualized goals and for 4 of 7 untrained individualized goals (Dawson et al., 2009a), based on self-reported assessment using the Canadian Occupational Performance Measure (COPM) (Law et al., 2005). These improvements were maintained at a three-month follow-up and importantly were corroborated by the ratings of the significant others (Dawson et al., 2009a). Researchers went on to adapt the CO-OP intervention for adults with chronic stroke (McEwen, Polatajko, Davis, Huijbregts, & Ryan, 2010a; McEwen, Polatajko, Huijbregts, & Ryan, 2009; McEwen, Polatajko, Huijbregts, & Ryan, 2010b). Using a single-case AB design with follow-up in three persons with stroke, McEwen and colleagues (2009) found improvements in 7 of 9 functional goals at 1-month follow-up, as rated by an independent evaluator conducting ratings from video-recorded performances. In a subsequent multiple baseline single-case study with two replications, they also noted indications of transfer to untrained tasks following a maximum of 10 one-hour intervention sessions (McEwen et al., 2010b). However, the studies from McEwen and colleagues focused on motor skill acquisition and did not investigate the efficacy of the CO-OP intervention in persons with executive dysfunction post-stroke (McEwen et al., 2009, 2010b). Considering the potential of the CO-OP, it was deemed important to verify whether this novel meta-cognitive problem-solving intervention would also be beneficial for treating executive dysfunction post-stroke. The third manuscript of this thesis describes the effects of this intervention in individuals with EF impairments following stroke. Specifically, we compared the benefits of this top-down rehabilitation approach with a bottom-up remedial training approach involving computerized EF training in a pilot randomized controlled trial (see Chapter 4).

Translating the evidence into practice

As I was gaining a clearer understanding of the evidence on EF assessment and intervention post-stroke during the course of my thesis work, it became imperative to implement knowledge translation strategies to move this evidence into clinical practice, especially given that our recent Canada-wide survey determining stroke rehabilitation practices of 663 occupational therapists (Korner-Bitensky, Barrett-Bernstein, Bibas & Poulin, 2011) had shown a very low prevalence of use of specific assessments and interventions that address EF. Therefore, I undertook to develop web-based e-learning modules that would provide the latest evidence on EF assessment and intervention post-stroke, as further described in Chapter 5.

RESEARCH OBJECTIVES

The overall objective of this thesis was to contribute to the knowledge concerning ecologically based EF assessment and intervention post-stroke, and to promote evidence-based practices for the management of executive dysfunction post-stroke.

The specific research objectives were fourfold:

<u>Objective 1</u>: To identify and critically appraise standardized performance-based measures of EF according to the specific EF components assessed, the psychometric properties specific to a stroke population and their clinical utility This review of EF assessments focused on measures that reflect real-world activities and that allow clinicians to identify the functional implications of EF deficits post-stroke. (See Chapter 2 of dissertation; manuscript entitled "*Stroke-specific executive function assessment: a literature review of performance-based tools*").

<u>Objective 2</u>: To conduct a systematic review on the effectiveness of EF interventions according to stage of stroke recovery in order to identify

promising intervention approaches and inform the design of a pilot intervention study (described in objective 3) (Chapter 3 of dissertation; manuscript entitled "*Efficacy of executive function interventions after stroke: a systematic review*").

Objective 3: To determine the feasibility and preliminary efficacy of two promising interventions, the CO-OP intervention – a problem-solving approach that entails guiding participants to set self-selected functional goals, develop plans, carry out their plans and verify goal attainment – and a computer-based EF training program in persons with EF deficits in the sub-acute phase after stroke. The specific objectives of this pilot study were: 1) to test the feasibility of participant recruitment and retention, the acceptability of assessment and intervention procedures, and the adherence to the interventions; 2) to compare the preliminary efficacy of CO-OP versus COMPUTER training in improving EF impairment; and, in improving performance and satisfaction with performance, in participant-chosen everyday activities immediately after the intervention and one month later; and, 3) to explore the relative efficacy of these interventions in producing transfer of training effects; specifically, improved performance, and, satisfaction with performance, in untrained participant-chosen everyday activities and in measures of instrumental activities of daily living (IADLs), social participation, self-efficacy for performing everyday activities and EF symptoms in everyday life, immediately after the intervention and one month later (Chapter 4 of dissertation; manuscript entitled *"Comparison of two novel interventions for adults experiencing executive dysfunction post-stroke: a pilot study").*

Objective 4: To create multi-modal web-based modules to provide the latest evidence on EF assessment and treatment post-stroke, in order to enhance clinicians' awareness of best practices for the management of executive dysfunction post-stroke (Chapter 5 of dissertation entitled *"Creation of e-learning modules specific to management of executive function post-stroke"*; please also see the Stroke Engine website at http://strokengine.ca/intervention/index.php? page=topic&id=90 and http://strokengine.org/elearning/executivefunction/ for the online learning modules on EF assessment and intervention).

BRIDGING MANUSCRIPT

As explained in Chapter 1, the complexity of EF makes them very sensitive to brain changes resulting from stroke (Levine, Turner, & Stuss, 2008). Given the high prevalence and the serious functional consequences of EF disorders post-stroke, all individuals with stroke should be quickly screened and/or assessed for EF problems periodically throughout the stages of stroke care (Lindsay et al., 2010, 2013). Several health care professionals may be involved in the assessment of persons with executive dysfunction post-stroke, such as neuropsychologists, occupational therapists, speech-language pathologists, clinical nurse specialists, psychiatrists and neurologists (Eskes et al., 2013a). In various countries, occupational therapists are the health care professionals typically involved in assessing the impact of cognitive and EF impairment on an individual's ability to perform everyday activities. Yet, a Canadian survey of occupational therapists working in stroke rehabilitation (Korner-Bitensky, Barrett-Bernstein, Bibas, & Poulin, 2011) revealed that, while occupational therapists commonly appraise their clients' cognitive and EF abilities through observation of activities of daily living, the majority use *non-standardized* functional assessments. To increase clinicians' awareness of *standardized performance-based EF assessments that closely reflect everyday activities*, a comprehensive literature review was performed to identify and critically appraise these tools according to the EF components assessed, their stroke-specific psychometric properties and clinical utility. This review is further described in *Manuscript 1* and was recently published in the Australian Occupational Therapy Journal (Poulin, Korner-Bitensky, & Dawson, 2013).

CHAPTER 2: *Manuscript 1*.

Stroke-specific executive function assessment: a literature review of performance-based tools

From: Poulin, V., Korner-Bitensky, N., & Dawson, D. R. (2013). **Stroke-specific executive function assessment: a literature review of performance-based tools**. *Aust Occup Ther J, 60*(1), 3-19. doi: 10.1111/1440-1630.12024

Valérie Poulin, PhD candidate, OT, School of Physical and Occupational Therapy, McGill University, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Montreal, Quebec.

Nicol Korner-Bitensky, PhD, OT(c), Associate Professor, School of Physical and Occupational Therapy, McGill University, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Montreal, Quebec.

Deirdre R. Dawson, PhD, OT Reg. (ON), Associate Professor, Department of Occupational Science & Occupational Therapy & Graduate Department of Rehabilitation Sciences University of Toronto, Senior Scientist, Rotman Research Institute, Baycrest, Associate Member, Heart and Stroke Foundation Centre for Stroke Recovery, Toronto, Ontario.

Correspondence:
Valérie Poulin
School of Physical and Occupational Therapy, McGill University
3630 Promenade Sir-William-Osler
Montreal, Quebec, H3G 1Y5
Email: valerie.poulin2@mail.mcgill.ca
Telephone: (514) 398-5457
Fax: (514) 398-4874

Acknowledgments

This literature review was carried out with financial support from the Richard and Edith Strauss Canada Foundation. Valérie Poulin is also supported by a PhD fellowship award from the Fonds de recherche du Québec - Santé.

ABSTRACT

Background/Aim: Executive function (EF) should be an integral component of post-stroke assessment. However, a Canada-wide survey of occupational therapists on stroke rehabilitation practices found a rare use of EF assessments. Performance-based EF assessments that closely reflect real-world activities are useful in identifying individuals who will face difficulties when returning to home and community activities. To increase clinicians' awareness of these tools, a literature review was conducted to identify performance-based measures of EF and their stroke-specific psychometric properties.

Methods: The review identified 17 performance-based tools and 41 studies that reported their psychometric properties specific to stroke. Each tool was critically appraised according to the EF components assessed, the level of functioning assessed (i.e. impairment, activity or participation), the environment within which the assessment is conducted and, the tool's psychometric properties and clinical utility. Standard criteria were used to evaluate the tools' psychometric properties. The findings were compiled in a Stroke-Specific Executive Function Toolkit.

Results: The assessments that demonstrated the strongest evidence of reliability and validity were the Executive Function Performance Test, the Multiple Errands Test and the Assessment of Motor and Process Skills (AMPS). Only the AMPS has been adequately evaluated for its ability to detect change. In terms of clinical utility, the Kettle Test has the shortest administration time (i.e. less than 20 minutes) and requires limited equipment.

Conclusions and significance of the study: The Stroke-Specific Executive Function Toolkit provides clinicians with useful information that should facilitate identification of appropriate EF tools for use across the continuum of stroke care.

Keywords: assessment, ecological, executive function, stroke

INTRODUCTION

Disorders in executive function (EF) represent one of the most common cognitive sequelae of stroke, occurring in an estimated 19 to 75 percent of survivors (Lesniak, Bak, Czepiel, Seniow, & Czlonkowska, 2008; Riepe, Riss, Bittner, & Huber, 2004; Zinn, Bosworth, Hoenig, & Swartzwelder, 2007) depending on the domains measured and definition of executive function used. Globally, EF refers to "high-level cognitive functions that provide control and direction of lower-level, more automatic functions" (Stuss, 2009, p. 8) and encompasses cognitive processes including: initiation, planning, sequencing, monitoring, problem-solving, divided attention, flexibility, working memory and inhibition (Anderson, 2008; Godefroy & Stuss, 2007; Lezak, 1989; Stuss, 2009). EF deficits play a critical role in recovery post-stroke (Lesniak et al., 2008) with a higher risk of functional dependence (Lesniak et al., 2008), failure to return to work (Ownsworth & Shum, 2008) and poor social participation (McDowd, Filion, Pohl, Richards, & Stiers, 2003).

Given the prevalence of EF disorders and their strong association with limitations in everyday life, it is crucial for rehabilitation professionals to be astute at recognizing, assessing and treating post-stroke EF deficits. Yet, according to our Canada-wide survey of 663 occupational therapists working in stroke rehabilitation (Korner-Bitensky, Barrett-Bernstein, Bibas, & Poulin, 2011), less than 1% use standardized EF assessments during the course of rehabilitation. Instead, most use generic cognitive screening tools such as the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). Similar findings of the MMSE being the most widely used tool were reported by Koh, Hoffmann, Bennett and McKenna (2009) in their survey of 102 Australian occupational therapists working in stroke rehabilitation. This gap in EF assessment practices warrants attention.

One possible reason for the finding that occupational therapists are not using standardized EF assessments lies in the nature of the assessments themselves. Increasingly people working in neuroscience are recognizing the limitations of traditional measures of EF (Burgess et al., 2006; Chan, Shum, Toulopoulou, & Chen, 2008; Chaytor & Edgecombe, 2003). Traditional measures, largely pencil and paper tasks, typically demand discrete responses to single events (e.g., card sorting tasks) whereas many situations in everyday life require complex, multi-step processes including setting goals and sub-goals, making plans, executing these in the context of multiple contextual constraints while employing continual inhibition of irrelevant stimuli (Chan et al., 2008). Chan et al. (2008) also note that humans process and respond to abstract versus meaningful material quite differently. In a general review of theories and assessments of EF, Chan et al. (2008) suggest that EF assessments should be critiqued on how well they assess functioning (i.e. impairment, activity or participation levels from the International Classification of Functioning, Disability and Health {World Health Organization (WHO, 2001)}) and on how closely they approximate the real-world. To elucidate, assessments can occur in a lab setting, virtual or simulated real-world environment, or real-world environment; the real-world being considered the most ecologically valid (Chaytor & Edgecombe, 2003).

Occupational therapists are typically involved in the assessment of, and intervention to improve real-world performance. We posit that tests that identify difficulties that people have in real life that is, ecologically valid tests, are most valuable for assessing EF. Identifying the tools that are most useful for occupational therapists working in stroke rehabilitation may be challenging, as there is currently no synopsis of the EF measures and their stroke-specific psychometric properties. Therefore, the objective was to conduct a comprehensive literature review to identify the stroke-specific psychometric properties of performance-based EF assessment tools, in which the performance closely reflects everyday behaviours, and create a STROKE-SPECIFIC EXECUTIVE FUNCTION

TOOLKIT. We also set out to describe these tools according to: (1) the specific EF components assessed; (2) the level of functioning assessed; (3) the environment within which the assessment is conducted (i.e. lab-based, simulated real-world environment or actual real-world environment); (4) the tool's psychometric properties assessed specifically in a stroke population; and, (5) clinical utility.

METHODS

Search strategy

A comprehensive review of the scientific literature on ecological EF assessment post-stroke was performed with the guidance of a health sciences librarian by searching MEDLINE, PsychINFO, CINAHL and EMBASE databases from their inception to July 2011. The following MeSH terms *(in italics)* and keywords were used for Medline and these were tailored slightly for the other databases: *stroke (MeSH)* or *cerebrovascular disorders (MeSH)* or *brain injuries (MeSH)* or brain injury or cerebrovascular accident AND *executive function (MeSH)* or *problem solving (MeSH)* or executive control or executive or dysexecutive or dysexecutive syndrome AND *psychometrics (MeSH)* or *outcome assessment (health care) (MeSH)* or measurement or assessment or evaluation or reliability or validity AND *activities of daily living (MeSH)* or activit* or naturalistic or ecological or function* or real world or real life or daily life or daily living. To identify additional EF tools, the reference lists of all articles retrieved were reviewed.

Inclusion/exclusion criteria

Studies were eligible if they were published in English or French and included psychometric evaluation of ecologically valid measures of EF and/or cognition in a stroke population or mixed samples including persons with stroke. Assessment tools were eligible for inclusion if they had a performance-based component that closely reflects real-world activities. The focus was specifically on 'EF' measures, but the term 'cognition' provided for inclusion of many general cognitive assessments that also evaluate some components of EF. A broad operational definition of EF was used based on published EF definitions encompassing nine components: *initiation* (Anderson, 2008; Grieve & Gnanasekaran, 2008), *planning* (Anderson, 2008), *sequencing* (Lezak, 1989), *problem-solving* (Luria, 1966), *monitoring* (Stuss, 2009), *working memory* (Van der Linden, Poncelet, & Majerus, 2007), *inhibition* (Grieve & Gnanasekaran, 2008), *divided attention* (Ponsford, 2008) and *flexibility* (Anderson, 2008) (see Asimakopulos et al. (2012) and the above mentioned references for definitions of the nine EF components).

From the first search a number of measures were identified. These were included as keywords for a further search of electronic databases (i.e. MEDLINE, PsychINFO, CINAHL, EMBASE, Health and Psychosocial Instruments (HAPI) and Mental Measurements Yearbook) to identify additional publications describing their psychometric properties. Some studies did not contain complete information about the clinical utility of the tools (i.e. the extent to which a tool is accessible, practicable, appropriate and acceptable to clinicians and clients (Smart, 2006)). To obtain this information, searches were conducted on the Google search engine, as well as on the HAPI and the Mental Measurements Yearbook, references were searched, and where necessary, original authors were contacted. Textbooks pertaining to cognitive assessment in occupational therapy and neuropsychology were also consulted primarily to find information on the clinical utility of the tools.

Classification of executive function tools

Once the search was complete, each tool was classified according to the EF components evaluated, the level of functioning assessed, the environmental context, the psychometric properties specific to a stroke population, as well as its clinical utility. The classification of each tool was done by the first author and confirmed by the co-authors. The reader is referred to the Stroke Engine Assess website at www.strokengine.ca for definitions of psychometric properties and the description of statistical evaluation criteria for outcome measures. Assessment tools were further categorized as: 1) specific assessments of EF; or, 2) general assessments with an EF component.

RESULTS

A total of 1593 publications were retrieved from the initial database search. Once duplicate and unrelated articles were discarded, and inclusion criteria applied, 24 full-text articles remained eligible. These articles were reviewed to identify assessment tools that stated they evaluated some components of EF and that had a performance-based component that closely reflects real-world activities: 11 were found. Six additional EF tools were retrieved from the reference lists of these papers. Further electronic database searches and a hand search of the reference lists of the retrieved papers yielded a total of 41 studies that examined their psychometric properties. The majority of studies were conducted specifically on a stroke population (n=21) or in persons with acquired brain injury including stroke (n=14); the remaining 6 were carried out with mixed samples with varying diagnoses (e.g., schizophrenia, mild cognitive impairment, etc.) that included persons with stroke. We elected to include these studies because the content was highly pertinent; however, it is possible that the results may vary from those that would have been found in a sample of only stroke survivors.

Properties and characteristics of each tool are described in Tables 2.1 and 2.2 which comprise the STROKE-SPECIFIC EXECUTIVE FUNCTION TOOLKIT. Table 2.1 includes data on the 13 assessments that are specifically designed to target EF: Table 2.2 describes the four general assessments with an EF component. Most tools take 30 minutes or more to administer and provide detailed information to help understand the nature of the person's everyday EF problems, plan intervention strategies or to measure change in patient functioning following intervention. One exception is the Kettle Test (Hartman-Maeir, Harel, & Katz, 2009a) which takes less than 20 minutes to administer and as such it might be useful as a screening tool to assist in identifying patients who require further assessment.

Executive function components assessed

The components of EF assessed by each tool were determined by reviewing the contents of published papers to identify explicit statements regarding the domains and the various forms of validity (e.g., content, concurrent, convergent); by examining the sub-scores that can be derived; and, finally, by the research team's analysis of each tool's item content.

The most common EF components evaluated by the 17 tools include planning (n = 13), sequencing (n = 13), problem-solving (n = 11) and monitoring (n = 10), while the least frequently assessed components are divided attention (n = 2) and flexibility (n = 3). Fourteen of the tools evaluate three or more EF components: none evaluate all components. It should be noted that tools in the category of general assessments with an EF component, such as the Assessment of Motor and Process Skills (AMPS- Fisher & Bray Jones, 2010a, 2010b), provide information on global functional cognitive performance but do not allow "fractionation" of specific EF processes.

Functioning

For each tool, the level of functioning (i.e., impairment, activity and participation) was defined according to the ICF classification (WHO, 2001), where impairment refers to problems in body function, activity corresponds to the execution of a task and participation refers to involvement in a real-life situation.

While all 17 assessments measure "*activity limitations*", two were also deemed to measure participation – the ADL Profile (Dutil, Bottari, Vanier, & Gaudreault, 2005) and the AMPS (Fisher & Bray Jones, 2010a, 2010b) – as they include *chosen* and familiar real-life activities of daily living (ADL) that can be performed in the person's home (e.g., cooking) and community environment (e.g., shopping).

Test Environment / Context

Of the 13 EF-specific assessments (see Table 2.1), nine include tasks that are conducted in a naturalistic environment with real-life materials, and thus are classified as "*real-world"*. Three simulate work-related tasks and instrumental ADLs using tabletop tasks or virtual reality technology and are thus classified as "*simulated real-world*". Only one "*laboratory-based*" assessment was identified: the Behavioural Assessment of the Dysexecutive Syndrome (BADS) (Wilson, Alderman, Burgess, Emslie, & Evans, 1996; Wilson, Evans, Emslie, Alderman, & Burgess, 1998), which comprises six tabletop tests designed to predict everyday executive problems and a questionnaire on everyday executive functioning. In the category of general assessments with an EF component (see Table 2.2), two of the four involve "*real world*" tasks, while the remaining two are "*simulated real-world*".

Psychometric properties

Tables 2.1 and 2.2 summarize each tool's psychometric properties specific to a stroke population using standard criteria adapted from Andresen (2000), McDowell and Newell (1996) and Salter et al. (2005). The criteria for ratings of reliability, validity and responsiveness are described in Appendix 2.1.

Reliability

Nine tools have some reliability data available for the population with stroke, with inter-rater reliability (n = 7) and internal consistency (n = 4) being the most commonly reported. None of the EF-specific assessments and only two of the four general assessments with an EF component have reported test-retest reliability: the AMPS (Fisher & Bray Jones, 2010a, 2010b), an observational assessment of motor and process skills and how these impact on performance of daily life tasks; and the Virtual Environment Technology (VET)-based cognitive assessment program (Ku et al., 2009), a virtual shopping simulation that evaluates cognitive and behavioural abilities.

Validity

Most of the tools have shown adequate validity, with several types of testing reported (e.g., known groups, construct convergent validity, etc.). In the category of EF-specific assessments, the tools with the strongest evidence of validity to assess everyday EF post-stroke include the Executive Function Performance Test (EFPT) (Baum et al., 2008), which documents the level of assistance required to successfully perform four daily life tasks, and the Multiple Errands Test (MET) (Shallice & Burgess, 2001), a real-life multi-tasking test carried out in a mall-like setting or shopping center. Two EF-specific assessments require further validation in the population with stroke: the Complex Task Performance Assessment, a work-related EF assessment recently developed and tested in a small pilot study (Wolf, Morrison, & Matheson, 2008) and the Rabideau Kitchen Evaluation-Revised (Neistadt, 1992) that has some evidence of convergent validity in persons with stroke but was primarily validated in those with traumatic brain injury. In the category of general assessments, the AMPS currently has the strongest validity, with several studies addressing its construct, concurrent and predictive validity.

Responsiveness

Responsiveness, or the ability of a measure to detect change accurately when it has occurred (De Bruin, Diederiks, de Witte, Stevens, & Philipsen, 1997), has been formally addressed only in the AMPS (Fisher & Bray Jones, 2010a, 2010b), which was found to be responsive to change following rehabilitation interventions in several studies (Bjorkdahl, Nilsson, Grimby, & Sunnerhagen, 2006; Tham, Ginsburg, Fisher, & Tegnér, 2001; Wæhrens & Fisher, 2007; Yoo, Jung, Park, Kim, & Jeon, 2009). There is also minimal evidence of responsiveness for three other tools that have been used to detect change in EF intervention studies: the MET (Shallice & Burgess, 2001), Virtual MET (Rand, Rukan, Weiss, & Katz, 2009a; Rand, Weiss, & Katz, 2009b) and Executive Secretarial Task (Lamberts, Evans, & Spikman, 2010).

Clinical utility

Most of the assessments include daily life tasks that are feasible to accomplish within a clinical setting and require limited equipment, whereas the virtual reality tests such as the VET-based cognitive assessment program (Ku et al., 2009) and the Virtual MET (Rand et al., 2009a) require more complex equipment. The administration time ranges from less than 20 minutes to several hours, with 12 of the tools taking an hour or less to administer. The assessment with the shortest administration time (i.e. less than 20 minutes) is the Kettle Test, which is designed to assess cognitive skills through the task of preparing two hot beverages (Hartman-Maeir et al., 2009a).

In terms of training requirements, while most of the tests require no or little formal training (e.g., reading the administration manual), others such as the AMPS (Fisher & Bray Jones, 2010a, 2010b) and the ADL profile (Dutil et al., 2005) must be administered by an occupational therapist who has completed an intensive training workshop (i.e. 3-day workshop for the ADL Profile and 5-day training and calibration workshop for the AMPS). Specific qualifications, such as formal training in the administration of clinical assessments or a degree to practice in the healthcare, are also required by some companies for test purchase (e.g., for the BADS). Finally, it should be noted that the information on therapist training is not clearly reported for several measures.

DISCUSSION

This literature review identified 17 performance-based EF tools available for use with individuals who have experienced a stroke. Given the high prevalence and serious functional consequences of executive disorders post-stroke, it is important for clinicians to incorporate the use of such measures into their daily practice, especially when determining readiness for community reintegration and activities related to return to work, driving, childcare etc. We have created the STROKE-SPECIFIC EXECUTIVE FUNCTION TOOLKIT to facilitate clinicians' identification of appropriate ecological EF tools for use across the continuum of stroke care.

The clinician's choice of an assessment tool will depend, amongst other things, on the purpose for which the tools is being used (e.g., quick screening to identify a possible EF disorder, estimation of future outcomes, and/or evaluation of treatment effects); the tool's psychometric properties; the client's characteristics (e.g., severity of cognitive deficits); and the practical constraints of the local clinical context. In this review, the assessments that demonstrated the strongest evidence of reliability and validity specific to a stroke population were the EFPT (Baum et al., 2008), the MET (Shallice & Burgess, 2001) and the AMPS (Fisher & Bray Jones, 2010a, 2010b), with only the AMPS adequately evaluated for its ability to detect patient change (see Appendix 2.1 for the standards used to evaluate the evidence of reliability, validity and responsiveness). Because the AMPS requires in-depth specialized training, it is less accessible for widespread use. Also, in the context of acute care, clinicians generally have only short periods of time to screen patients and as such might want to turn to quickly administered tests, such as the Kettle Test (Hartman-Maeir et al., 2009a). It is noteworthy that some tests (e.g., the Naturalistic Action Test (NAT) (Schwartz, Segal, Veramonti, Ferraro, & Buxbaum, 2002)) have been adapted to accommodate specific client characteristics including motor hemiparesis, aphasia or poor memory. To evaluate EF abilities in clients with communication disorders, clinicians may also consider adapting task instructions (as suggested in the administration manual of the ADL Profile (Dutil et al., 2005)), using communication aids (e.g., gesture or pictures) and allowing both written and verbal responses, but these accommodations should be taken into consideration when rating performance and interpreting test results. As we point out in the clinical utility section of the STROKE-SPECIFIC EXECUTIVE FUNCTION TOOLKIT, it is important to consider the client's linguistic, cognitive, psychological and motor impairments (e.g., apraxia, perceptual problems, etc.) and how they may affect task performance and thus the accuracy of the EF assessment.

There are also other ecologically valid performance-based EF assessments that are currently available, but have not yet been studied in a stroke population. These include measures such as the Instrumental Activities of Daily Living Profile (Bottari, Dassa, Rainville, & Dutil, 2009a, 2009b, 2010), an alternate version of the ADL Profile (Dutil et al., 2005), and the Test of Functional Executive Abilities (Bamdad, Ryan, & Warden, 2003), which requires the examinee to obtain specific pieces of information using a variety of resources. Further studies are needed to confirm the reliability, validity and responsiveness of these measures in those with stroke. As explained by Salter et al. (2005), a measurement instrument may behave differently in different samples or assessment situations, and should therefore be "tested for use in the population within which it will be applied (p. 195)".

We encourage clinicians to select EF measures judiciously recognizing that it is extremely difficult to measure executive dysfunction. Some people with impairment in EF will be able to perform normally on some of these assessments if their impairments are mild. As well, observed errors must be considered in the broader context of overall test performance as healthy adults often show performance errors that are similar to those made by people with stroke (Bottari & Dawson, 2011). Nevertheless, use of performance-based measures of EF represents an important step forward (Burgess et al., 2006).

Overall, by using performance-based EF assessments the clinician is better able to assess how a patient will manage when faced with real-world activities. This is in sharp contrast to results provided by paper and pencil EF assessments which often leave the clinician unsure of how a patient will perform important daily roles. In addition, ecologically based EF assessment results are often simpler to understand for family and carers who can observe a concrete activity that the patient was previously able to do and now has difficulty with: the clinician can then help the family better understand strategies such as compensation or remediation and the positive impact these therapies will have on performance of activities. Indeed, there is mounting evidence that EF-specific interventions are effective when carefully matched to the patient's deficits, residual strengths and goals (Poulin, Korner-Bitensky, Dawson, & Bherer, 2012).

Limitations

While every effort was made to ensure that all relevant performance-based EF assessments were retrieved, it is possible that our search may have missed some publications, especially those in other languages. Also, the determination of whether an assessment assesses impairment, activity or participation was not made from empirical data but from the authors' analysis of the contents of each assessment.

CONCLUSION

Considering that EF is an integral component of post-stroke assessment (Lindsay et al., 2010; National Stroke Foundation, 2010), all patients with potential deficits should be examined using standardized tools. Performance-based EF assessments that closely reflect real-world activities may provide useful information for identifying individuals who are likely to face difficulties when returning to community roles; for designing and selecting appropriate EF interventions; and, finally, for evaluating the real-life outcomes of cognitive/EF rehabilitation (Lewis, Babbage, & Leathem, 2011). In brief, depending on their specific needs and clientele, clinicians may choose from the 17 tools described in the TOOLKIT, with the caveat that they should exert caution when interpreting the results from tests with more limited psychometric evidence.

Table 2.1: Executive function-specific assessments

Assessment	***Executive function components*** Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	***Level of functioning & Environment***	***Description***	***Reliability***	***Validity***	***Clinical utility***
ADL Profile *(Dutil et al., 2005)*	X	X	X	X	X					➢ Activity and Participation ➢ Real world	Documents repercussions of EF deficits on independence in everyday activities. Includes 20 personal and instrumental activities of daily living tasks; 17 are assessed through performance-based observation and 3 via a semi-structured interview. **Scoring:** Each task is scored on 4 operations (formulating a goal, planning, carrying out the task, verifying goal attainment) and on a 4-point scale from 3-independent to 0-dependent. The task score is the lowest score given to any one operation. **Population studied:** Traumatic brain injury and stroke.	**Test-retest** *No evidence in stroke.* **Inter-rater** *Adequate:* Mean kappa = 0.58-0.68 for 3 tasks: preparing a hot meal, eating and obtaining information (Dell'Aniello-Gauthier, 1994). **Internal consistency** *No evidence in stroke.*	**Content validity** *Adequate:* Established through literature reviews & consultation with expert researchers and clinicians (Dell'Aniello-Gauthier, 1994). **Construct validity** *Adequate:* Convergent Significant correlations between 5 tasks of the ADL Profile related to personal care and corresponding tasks of the Functional Independence Measure (Kendall's tau c = 0.40-0.73; p<.001) (Gervais, 1995). **Criterion validity** *No evidence.* **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Performance of daily living tasks. **Time**: Depending on the patient's ability and the number of tasks assessed - may take up to 7 hours conducted over several sessions (Dutil et al., 2005) **Therapist training**: Can be administered by an occupational therapist; 3-day training recommended. **Cost and ordering information:** www.caot.ca *or* http://www.leseditionsemersion.com/articles.php?lng=fr&pg=6.

Assessment	*Executive function components* Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Behavioural Assessment of the Dysexecutive Syndrome (BADS) *(Wilson et al., 1996; 1998)*		X	X	X	X		X		X	➢ Activity ➢ Lab-based	Designed to predict everyday problems arising from executive dysfunction. **Battery of 6 tests:** Rule Shift Cards, Action Program, Key Search, Temporal Judgement, Zoo Map and Modified Six Elements. (Also included is the Dysexecutive Questionnaire (DEX)). **Scoring:** Profile score from 0 (low performance) to 4 (high performance) calculated for each subtest. Overall profile score of all subtests is converted to a standardized score. **Population studied**: healthy controls; neurological disorders including stroke; schizophrenia.	**Test-retest** *No evidence in stroke.* **Inter-rater** *No evidence in stroke.* **Internal consistency** *No evidence in stroke.*	**Construct validity** *Adequate:* Known Groups Significant differences between brain injury (including stroke) and control groups ($p < 0.05$) (Boelen, Spikman, Rietveld, & Fasotti, 2009; Spikman, Boelen, Lamberts, Brouwer, & Fasotti, 2010; Wilson et al., 1998) Ecological validity In acquired brain injury including stroke: Moderate correlations with the DEX ratings of significant others ($r=-0.62$; $p<0.001$) but not with the patients' ratings (Wilson et al., 1998). **Criterion validity** *No evidence in stroke.* **Responsiveness** *Not responsive (minimal evidence):* No significant treatment effects detected with the BADS in a randomized controlled trial on strategy training for executive dysfunction post-acquired brain injury (including stroke) (Spikman et al., 2010). **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Seated in front of a table **Time**: ≈30 minutes (Strauss, Sherman, & Spreen, 2006) **Concern**: Rule out apraxia and aphasia **Therapist training**: Can be administered by neuropsychologists and related service personnel trained in the administration of clinical assessments. Pearson only sells this test to people of certain qualification levels. **Cost and ordering information**: http://www.pearsonassessments.com/HAIWEB/Cultures/enus/Productdetail.htm?Pid=015-8054350&Mode=summary

Assessment	*Executive function components* Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Complex Task Performance Assessment (CTPA) *(Wolf et al., 2008)*		X			X		X		X	➢ Activity ➢ Simulated real world	6 simulated clerical work tasks administered simultaneously to evaluate multi-tasking: completing an inventory control worksheet, answering phone messages, responding to appropriate phone messages and time and event prospective memory tasks. **Scoring:** Two overall scores – 1) Task accuracy; 2) Performance efficiency (ratio of the sum of tasks completed + number of executive decisions made divided by total time) **Population:** Mild stroke	**Test-retest** *No evidence.* **Inter-rater** *No evidence.* **Internal consistency** *No evidence.*	**Construct validity** *Minimal evidence from a small pilot study:* <u>Known groups</u> Significant differences between the mild stroke group and the healthy controls ($p<0.05$) (Wolf et al., 2008). <u>Convergent</u> No significant correlations with Delis Kaplan Executive Function scores (Wolf et al., 2008). **Criterion validity** *No evidence.* **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Seated **Time**: One-hour time limit (Wolf et al., 2008). **Concerns**: Rule out aphasia **Therapist training**: Not reported **Cost and ordering information:** Available from author: wolft@msnotes.wustl.edu

Assessment	*Executive function components*: Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Execution of a Cooking Task *(Chevignard et al., 2000; 2008)*			X	X	X	X	X	X		➢ Activity ➢ Real world	Two standardized activities of daily living involving multi-tasking: baking a cake and cooking an omelet for 2 persons. **Scoring**: Errors are counted and classified (i.e. control errors, context neglect, environment adherence, purposeless actions and displacement, dependency and behavioural disorders). **Population studied**: Acquired brain injury including stroke.	**Test-retest** *No evidence.* **Inter-rater** *Excellent:* Spearman correlation coefficient: Total number of errors r_s=0.852, p<0.0001 (Chevignard et al., 2008). **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* <u>Known Groups</u>: Patients made significantly more errors than controls (p=0.0001) (Chevignard et al., 2008). <u>Convergent</u> Correlated to severity of brain injury and to the results of executive function tests, such as the Six Elements Task. <u>Ecological Validity</u> Moderate correlation with the "cognition" factor of the Dysexecutive Questionnaire (r=0.573, p=0.01), which suggests that performance on the cooking task reflects executive functioning in daily life (Chevignard et al., 2008). **Criterion validity** *No evidence.* **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Seated in front of a table, standing and moving around the room **Concern**: Rule out apraxia and aphasia **Time**: ≈ 60 minutes (Chevignard et al., 2008) **Therapist training**: None specified **Cost and ordering information:** See *Chevignard et al. (2008)* for test instructions.

Assessment	*Executive function components*									*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
	Initiation	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**					
Executive Function Performance Test *(Baum et al., 2003; 2008)*	X	X	X		X					➢ Activity ➢ Real world	4 standardized instrumental activities of daily living tasks (simple cooking, telephone use, medication management, and bill paying) with graded cues provided as needed. **Scoring**: Initiation, organization, sequencing, safety and judgment, and completion are evaluated on a scale from 0 (no cue) to 5 (do for the participant) Total score from 0 to 25. **Population studied**: Stroke (acute & chronic stages)	**Test-retest** *No evidence.* **Inter-rater** *Excellent:* ICC = 0.79 to 0.94 (Baum et al., 2008) **Internal consistency** *Adequate to excellent:* Cronbach's alpha= 0.77 to 0.94 (Baum et al., 2008)	**Construct validity:** *Adequate* <u>Known Groups</u> Significant differences between the moderate stroke group, mild stroke group and control participants ($p<0.05$) (Baum et al., 2008). **Criterion validity:** *Adequate to excellent* <u>Concurrent validity</u> Chronic stroke: Moderate correlations with tests assessing working memory, verbal fluency, and attention ($r \geq 0.39$) and with the Functional Independence Measure ($r=-0.40$) and the Functional Assessment Measure ($r=-0.68$) (Baum et al., 2008). Acute stroke: Moderate correlations with 3 of the 13 Delis-Kaplan Executive Function System Scaled Scores ($r=-0.47$ to -0.57) and the Short Blessed Test ($r=0.55$) (Wolf, Stift, Connor, & Baum, 2010), and with the Assessment of Motor and Process Skills (Spearman's rho = 0.61) (Cederfeldt, Widell, Elgmark Andersson, Dahlin-Ivanoff, & Gosman-Hedström, 2011) **Responsiveness:** *No evidence in stroke.* **Floor and ceiling effects:** *No evidence.*	**Testing Situation**: Seated in front of a table, standing and moving around the room **Time**: 30-45 minutes **Concern**: Rule out apraxia and aphasia **Therapist training**: Reading test manual **Cost and ordering information**: Free test manual: http://www.rehabmeasures.org/Lists/RehabMeasures/Admin.aspx

Assessment	*Executive function components*									*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
	Initiation	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**					
Executive Secretarial task (EST) *(Lamberts et al., 2010)*	X	X	X	X	X	X				➢ Activity ➢ Real world	Consists in a series of secretarial assignments which require the organization, initiation, and prioritization of multiple tasks. **Scoring:** 3 subscores: 1) initiative (i.e. all actions the person has initiated) (/13); 2) prospective (i.e. all actions correctly accomplished in a later stage) (/8); 3) executive (i.e. all actions correctly carried out) (/24) Total score out of 45. **Population:** Stroke & acquired brain injury (ABI)	**Test-retest** *No evidence.* **Inter-rater** *No evidence.* **Internal consistency** *No evidence.*	**Construct validity:** *Adequate* Known Groups Significant differences between acquired brain injury and control groups (p<0.00) (Lamberts et al., 2010). Divergent validity Not correlated with the 15 Words test and the Trail Making test A (Lamberts et al., 2010). **Criterion validity:** *Adequate* Concurrent validity Correlated with the Behavioural assessment of the dysexecutive syndrome (r=.44; p<.01) and the Dysexecutive Questionnaire (r=-.29 to -.31; p<.05) (Lamberts et al., 2010). Sensitivity/Specificity Moderate sensitivity (71%) and specificity (75%) (Lamberts et al., 2010). **Responsiveness:** *Minimal evidence* Ability to detect treatment effects in a clinical trial on strategy training for executive dysfunction post-ABI; treatment group had significantly better scores vs control at follow-up (p<0.05) (Spikman et al., 2010). **Floor and ceiling effects:** No evidence.	**Testing Situation**: Seated in front of a table, moving around the room and the neighbouring offices **Time**: 3 hours (Lamberts et al., 2010) **Concern**: Rule out aphasia **Therapist training**: Not reported **Cost and ordering information**: Available from author: k.f.lamberts@med.umcg.nl

Assessment	*Executive function components* **Initiation**	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Generation and execution of script: making a cake *(Baguena et al., 2006)*	X	X	X		X				X	➢ Activity ➢ Real world	1) Patients carry out a "script *generation* task" whereby they have to describe the steps to make a chocolate cake; 2) Then, they make the cake, which corresponds to the "*execution*" task. **Scoring:** 1) Quantitative grid: Errors are counted and classified (e.g., omission, estimation error, etc…) 2) Qualitative grid: Initiation, organization, sequencing, safety and judgment, and completion evaluated on a scale from 0 to 3 3) Calculation of an anosognosis score **Population:** Chronic stroke & traumatic brain injury	**Test-retest** *No evidence.* **Inter-rater** *No evidence.* **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* <u>Known Groups</u> Significant differences between healthy controls and persons with acquired brain injury for the "execution task" ($p \leq 0.0003$) but not for script generation, suggesting that the "execution" task is more sensitive to executive dysfunction (Baguena et al., 2006) <u>Convergent</u> Generation task significantly correlated with tests of language, verbal fluency, attention and planning. Execution task significantly correlated with EF tests. Script generation and execution tasks significantly correlated with the Neuropsychiatric Inventory assessing behavioral problems (Baguena et al., 2006). **Criterion validity** *No evidence.* **Responsiveness** *No evidence.* **Floor and ceiling effects** Ceiling effects for the script generation task, particularly in healthy controls. (Baguena et al., 2006).	**Testing Situation**: Standing and/or sitting, moving around the room **Time**: ≤ 1 hour (Baguena et al., 2006) **Concern**: Rule out aphasia and apraxia **Therapist training**: None specified **Cost and ordering information**: See *Baguena et al. (2006)* for test instructions and scoring.

Assessment	***Executive function components***									***Level of functioning & Environment***	***Description***	***Reliability***	***Validity***	***Clinical utility***
	Initiation	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**					
Multiple Errands Test (MET) *(Shallice & Burgess, 1991)* ***Various versions:*** ***MET Simplified version (MET-SV)*** *(Alderman, Burgess, Knight, & Henman, 2003)* ***MET Hospital version (MET-HV)*** *(Knight, Alderman, & Burgess, 2002)*	X	X	X	X	X	X	X			➢ Activity ➢ Real world (carried out in a mall-like setting or shopping center)	Different versions were developed for use in specific hospitals (MET-HV & BMET), in a small shopping plaza (MET-SV) and in a virtual reality environment (<u>VMET described later</u>). For each of the versions, 12 tasks must be performed (e.g., purchasing specific items and collecting specific information) within the constraints of 9 rules. **Scoring:** Several criteria such as number of tasks completed accurately, task failures, interpretation failures, omissions, other inefficiencies, rule breaks, requests for help, strategy use & time to completion. **Population:** brain injury including stroke	**Test-retest** *No evidence.* **Inter-rater** *Adequate to excellent:* BMET: ICC=0.71-0.88 (Dawson et al., 2009b). *Excellent:* MET-HV: ICC=0.81-1.00 (Knight et al., 2002). **Internal consistency** *Adequate:* MET-HV: Cronbach's alpha=0.77 (Knight et al., 2002).	**Construct validity** *Adequate:* <u>Known Groups</u> Differentiates persons with acquired brain injury and healthy controls (Alderman et al., 2003; Dawson et al., 2009b; Knight et al., 2002). **Criterion validity** *Adequate to excellent:* <u>Concurrent</u> Significantly correlated with measures of EF and daily life skills, which also supports its <u>ecological validity</u> (Alderman et al., 2003; Dawson et al., 2009b; Knight et al., 2002). <u>Predictive and ecological validity</u> MET-HV: discharge MET total error score predicts participation in the community 3 months later (Maeir, Krauss, & Katz, 2011). <u>Sensitivity and specificity</u> MET-HV: High sensitivity (85%) and specificity (95%) (Knight et al., 2002).	**Testing situation:** Walking to move into and around the mall/hospital. **Concerns**: Requires sufficient language skills (i.e. writing and reading). Some subtasks may need to be adapted depending on the rehabilitation setting (Knight et al., 2002). **Time**: BMET: ≈ 60 minutes (Dawson et al., 2009b). **Therapist training**: BMET: The administration manual provides explicit instructions for the examiner (Dawson et al., 2009b).

Assessment	*Executive function components* Initiation Planning Sequencing Problem-solving Monitoring Inhibition Working memory Divided attention Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Baycrest MET (BMET) (Dawson et al., 2009b)					MET-SV: High sensitivity (82%) and specificity (95.3%) (Alderman et al., 2003). **Responsiveness** *Minimal evidence*: Performance on Modified MET significantly improved following EF rehabilitation in a pilot study **(**Novakovic-Agopian et al., 2010). MET-HV: Has been used to detect changes in a pre-post study on multi-tasking training in a virtual supermarket (Rand et al., 2009b). **Floor and ceiling effects** MET-SV: No floor effects among healthy controls; only one person made no error (Alderman et al., 2003).	**Cost and ordering information**: MET-SV & MET-HV: See *Alderman et al., 2003* and *Knight et al., 2002* for test instructions. BMET: Available from author: ddawson@rotman-baycrest.on.ca

Assessment	*Executive function components* Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Virtual Multiple Errands Test (VMET) *(Rand et al., 2009a; Raspelli et al., 2009)*		X	X	X	X		X*	X*		➢ Activity ➢ Simulated real world; virtual mall constructed to simulate a supermarket	Virtually simulated version of the MET – a real-life multi-tasking test carried out in a mall-like setting. **Scoring:** Scoring is similar to that of the MET: (i.e. partial and complete mistakes of completing a task, total number of mistakes, non-efficiency, rule breaking and use of strategies) (Rand et al., 2009a). **Population studied**: Stroke and Parkinson's disease	**Test-retest** *No evidence.* **Inter-rater** *No evidence.* **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* <u>Known groups</u> Differentiates patients with stroke and healthy participants (p<0.000) (Rand et al., 2009a). <u>Ecological Validity</u> High correlation with the real MET (r=.77 for total number of mistakes) (Rand et al., 2009a). **Criterion validity** *Adequate:* <u>Concurrent validity</u> Correlated with Zoo Map profile score (r=-.87, p<0.002) (Rand et al., 2009a). **Responsiveness** *Minimal evidence*: Has been used to detect change in a pre-post study on multi-tasking training in a virtual supermarket (Rand et al., 2009b). **Floor and ceiling effects** No evidence.	**Testing Situation**: Standing or sitting opposite to television monitor. **Time**: Not clearly reported. **Concern**: Requires sufficient language skills including writing and reading (Raspelli et al., 2009). **Therapist training:** Not reported. **Cost and ordering information:** Not specified. Virtual reality equipment required.

*according to Raspelli et al., 2009

Assessment	***Executive function components***									***Level of functioning*** ***&*** ***Environment***	***Description***	***Reliability***	***Validity***	***Clinical utility***
	Initiation	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**					
Naturalistic Action Test *(Schwartz et al., 2002)*		X	X				X			➢ Activity ➢ Real world	Assesses everyday action impairment associated with damage to higher cortical functions. **3 primary tasks:** Prepare toast and coffee; wrap a gift; pack a lunchbox and schoolbag. **Scoring**: For each task, 2 types of scores (accomplishment of necessary steps & errors) are combined into one score from 0 to 6. The total score is the sum of the 3 tasks scores. **Population studied**: Stroke and traumatic brain injury	**Test-retest** *No evidence.* **Inter-rater** *Excellent:* (weighted kappas= 0.95 to 1.0; percent agreement =70-100%) (Schwartz et al., 2002) **Internal consistency** *Adequate:* Cronbach's alpha = 0.75 (Schwartz et al., 2002)	**Construct validity:** *Adequate* Known Groups Differentiates healthy controls and persons with acquired brain injury (p<.001) (Schwartz et al., 2002) Convergent Correlated with measures of arousal/processing speed (r = -0.68), attention (r = 0.61), and working memory (r = -0.40 and r = 0.36). **Criterion validity:** *Adequate* Concurrent validity Significant correlations with the Functional Independence Measure (FIM) Physical (r = 0.37 to 0.72) and the FIM Cognitive (r = 0.51 to 0.72) Predictive validity Predicts Instrumental Activities of Daily Living scores at 6 months post-discharge (r = 0.58) (Schwartz et al., 2002). **Responsiveness** *No evidence.* **Floor and ceiling effects** Scores were distributed across the whole range (0 to 18) (Schwartz et al., 2002).	**Testing Situation**: Seated in a U-shaped table with materials placed within reach. **Time**: ≈45 minutes (Schwartz et al., 2002) **Concern**: Test procedures accommodate those with hemiparesis, most forms of aphasia or poor memory. **Therapist training**: Little training required. **Cost and ordering information**: Free test manual: http://www.ncrrn.org/assessment/nat

Assessment	*Executive function components*									*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
	Initiation	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**					
Observed tasks of daily living-revised (OTDL-R) *(Diehl et al., 2005)*				X						➢ Activity ➢ Real world	Performance-based test of everyday problem-solving including 9 tasks related to medication use, telephone use and financial management. **Scoring:** Responses to most questions are scored as correct (1) *or* incorrect (0). The total score ranges from 0 (cannot obtain the correct answer with cues) to 28 (able to answer correctly all of the questions). **Population studied**: older adults, persons with schizophrenia and brain injuries (including stroke).	**Test-retest** *No evidence.* **Inter-rater** *No evidence.* **Internal consistency** *No evidence in stroke.*	**Construct validity** *Adequate:* <u>Known Groups</u> Significant difference between patients with brain injury and community dwelling older adults ($p<0.001$) (Goverover & Josman, 2004). <u>Convergent</u>: Correlated with measures of categorization (Toglia's Category Assessment: $r = 0.51$, $p<0.05$) and deductive reasoning (Deductive Reasoning test: $r = 0.80$, $p<0.01$) in persons with brain injury (Goverover & Hinojosa, 2002; also see Goverover, 2004**)**. **Criterion validity** *No evidence in stroke.* **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Seated **Time**: ≈25-30 minutes (Diehl et al., 2005) **Concern**: Rule out apraxia and aphasia **Therapist training:** Test instructions & training videos: http://www.phhp.ufl.edu/marsiskelab/otdl/otdl.html **Cost and ordering information:** http://www.phhp.ufl.edu/marsiskelab/otdl/otdl.html

Assessment	*Executive function components*									*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
	Initiation	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**					
Rabideau Kitchen Evaluation-Revised (RKE-R) (Neistadt, 1992; 1994)			X							➢ Activity ➢ Real world	Assesses functional sequencing ability in a meal preparation task: preparing a cold sandwich with two fillings and a hot instant beverage. Graded cues provided as needed. **Scoring:** This task is broken down into 40 component steps. Scores for each step range from 0 (no assistance) to 3 (total assistance). Total score from 0 to 120. **Population studied**: mainly traumatic brain injury (TBI) but also stroke	**Test-retest** *No evidence in stroke.* **Inter-rater** *No evidence in stroke.* **Internal consistency** *No evidence.*	**Construct validity** *Minimal evidence in stroke:* <u>Convergent</u>: Moderate to strong associations with neuropsychological measures involving memory, visuospatial skills, attention, and executive functioning (Yantz, Johnson-Greene, Higginson, & Emmerson, 2010). **Criterion validity** *No evidence in stroke.* **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence in stroke.*	**Testing Situation**: Standing and moving around the room. **Time**: ≈30-45 minutes **Concern**: Rule out apraxia. The scoring procedures do not consider issues of wheelchair accessibility. **Therapist training:** None specified. Easy to administer, but scoring may be long. **Cost and ordering information:** See *Neistadt (1992)* for test instructions.

Assessment	*Executive function components* Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Virtual Action Planning Supermarket (VAP-S) *(Klinger et al., 2004; 2006)*		X								➢ Activity ➢ Simulated real world	Simulates a medium-sized supermarket; it assesses the ability to plan a task of purchasing 7 items of a shopping list. **Scoring:** 8 variables are recorded: total task time, total distance, number of items purchased, number of correct and incorrect actions, number of pauses, combined duration of pauses and time to pay **Population studied**: Stroke, mild cognitive impairment (MCI), schizophrenia and Parkinson's disease	**Test-retest** *No evidence.* **Inter-rater** *No evidence.* **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* <u>Known groups</u> Differentiates persons with stroke, schizophrenia and MCI (p=.0001). The VAP-S predicted group membership of 71.3% of the participants (Josman Klinger, & Kizony, 2008). **Criterion validity** *Adequate:* <u>Concurrent validity</u> Population with stroke: Significant associations with the key search subtest from the BADS (r=-0.44, 0.40 & 0.47), suggesting that the VAP-S requires planning ability (Josman et al., 2006) **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Seated in front of a table (21 inches from computer monitor). **Time**: not reported. **Concern**: Participant must be able to use the keyboard keys and the mouse. **Therapist training:** Not reported. **Cost and ordering information:** No information available.

Table 2.2: General assessments with an executive function component

Assessment	*Executive function components*: Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Assessment of Motor and Process Skills (AMPS) (Fisher & Bray Jones, 2010a, 2010b) http://www.ampsintl.com/	X	X	X	X	X					➢ Activity and Participation ➢ Real world	Observational assessment of motor and process skills (16 motor and 20 process skill items) and how these impact on performance of daily life tasks. **Scoring:** 4-point Likert scale from 1 (Marked deficient performance) to 4 (Competent: the task is performed without evidence of increased effort, decreased efficiency, or lack of safety) **Populations studied:** Patients for whom there is concern about activities of daily living task performance, including those with stroke	**Test-retest** *Excellent:* Motor subscore: r=0.88 to 0.91; Process subscore: r=0.86 to 0.90 (Doble, Fisk, Lewis, & Rockwood, 1999; Fisher & Bray Jones, 2010a, 2010b). **Inter-rater** *No evidence.* **Internal consistency** *Excellent:* Rasch equivalent of	**Construct validity:** *Excellent* <u>Known Groups</u> Differentiates patients with stroke and healthy controls (Bernspang & Fisher, 1995). No clinically meaningful difference between persons with right or left stroke (Rexroth, Fisher, Merritt, & Gliner, 2005). <u>Factorial validity</u> Stroke: Confirmatory factor analysis showed that motor, perceptual and cognitive factors explain 64% of the variance in functional autonomy as measured with the AMPS (Mercier, Audet, Hébert, Rochette, & Dubois, 2001). <u>Convergent validity</u> Stroke: Moderate relationships between various cognitive assessments and the AMPS process scale and skills (Kizony & Katz, 2002). **Criterion validity:** *Excellent* <u>Concurrent</u> Stroke: Moderate associations with the Large Allen Cognitive Levels: r=0.57 for	**Testing Situation**: Performance of daily living tasks (cannot be administered to patients who are confined to bed). **Time**: ≈40 minutes **Therapist training**: Administered by an occupational therapist; 5-day training and calibration workshop required **Cost and ordering information:** http://www.ampsintl.com/

Assessment	*Executive function components* Initiation / Planning / Sequencing / Problem-solving / Monitoring / Inhibition / Working memory / Divided attention / Flexibility	*Level of functioning & Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
				Cronbach's alpha: r=0.92 for motor score; r=0.91 for process score (Fisher & Bray Jones, 2010a, 2010b).	motor subscore; r=0.66 for process subscore (Marom, Jarus, & Josman, 2006). <u>Predictive validity</u> Older adults with varying diagnoses including stroke: Scores on the AMPS correctly identified those who failed the on-road evaluation or needed additional evaluation 87% of the time (Dickerson, Reistetter, & Trujullo, 2010). Predicts the need for assistance to live in the community (Fisher & Bray Jones, 2010a, 2010b). **Responsiveness:** *Adequate* Acquired brain injury including stroke: Responsive for measuring changes following rehabilitation (Bjorkdahl Nilsson, Grimby, & Sunnerhagen, 2006; Wæhrens & Fisher, 2007) and in pilot intervention studies on awareness (Tham Ginsburg, Fisher, & Tegnér, 2001) or constraint-induced therapy (Yoo, Jung, Park, Kim, & Jeon, 2009). If 2 AMPS measures differ by more than 0.5 logit, there is a 93% chance that the difference is significant (Fisher & Bray	

Assessment	*Executive function components* **Initiation**	**Planning**	**Sequencing**	**Problem-solving**	**Monitoring**	**Inhibition**	**Working memory**	**Divided attention**	**Flexibility**	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
													Jones, 2010a, 2010b) **Floor and ceiling effects:** No evidence	
Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES) *(MacDonald & Johnson, 2005)*		X	X	X		X				➢ Activity ➢ Simulated real world	Assesses high level cognitive communication skills in 4 verbal reasoning tasks: 1. Plan an event; 2. Schedule a work day; 3. Decide on a gift; 4. Build a case to solve a common problem **Scoring:** 1) Time to completion; 2) Accuracy of the solution [scale from 0 (no viable solution) to 5 (best possible solution)]; 3) Reasons given for the solution [scale from 0 (no adequate rationale) to 5 (fully adequate rationale)]. **Population studied**: Stroke & acquired brain injury (ABI)	**Test-retest** *No evidence.* **Inter-rater** *Excellent:* kappas = 0.81-0.86 for accuracy subtest; 0.85 for reasons subtest (Macdonald & Johnson, 2005) **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* Known Groups Significant differences between the ABI and control participants (p<0.01) (Macdonald & Johnson, 2005). **Criterion validity** *Adequate:* Sensitivity/Specificity Sensitivity = 0.88; specificity = 0.83 (Macdonald & Johnson, 2005). **Responsiveness** *No evidence.* **Floor and ceiling effects** 22% of the healthy control group obtained perfect accuracy and rationale scores on all four sub-tests.	**Testing Situation**: Seated **Time**: ≈50 minutes; can be conducted over several sessions (Macdonald & Johnson, 2005). Time limit of 20 minutes per sub-test (Isaki & Turkstra, 2000). **Concern**: Requires sufficient language skills. **Therapist training**: Not reported **Cost and ordering information:** www.ccdpublishing.com

Assessment	*Executive function components* Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
Kettle Test (KT) *(Hartman-Maeir et al., 2005; 2009a)*			X	X			X			➢ Activity ➢ Real world	Assesses basic and higher-level cognitive skills in a functional context (i.e. preparing 2 different hot beverages). **Scoring:** The task is broken down into 13 steps that are scored on a 4-point scale (0 – performance intact; 4 – received physical assistance or demonstration). Total score from 0 to 52. **Population studied**: Geriatric stroke population	**Test-retest** *No evidence.* **Inter-rater** *Excellent:* Spearman correlation coefficients (r_s=0.85 to 0.92, p≤0.001) (Hartman-Maeir et al., 2009a). **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* <u>Known Groups</u> Differentiates patients with stroke and control participants (p<0.001) (Hartman-Maeir et al., 2009a). <u>Convergent</u> Moderate correlations with Functional Independence Measure (FIM) (r=-0.66) and cognitive and perceptual tests (r=-0.48 to -0.58) (Hartman-Maeir et al., 2009a). <u>Ecological Validity</u> Correlated with Motor Scale of Functional Independence Measure (r=-0.75), Safety Rating Scale of the Routine Task Inventory (r=-0.57) and Instrumental Activities of Daily Living Scale (r=-0.51) (Hartman-Maeir et al., 2009a). **Criterion validity** *No evidence.* **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Seated in front of a table, standing and moving around the room. **Time**: ≈5-20 minutes **Concern**: Rule out apraxia. **Therapist training**: No formal training required but the examiner should have some experience in observational evaluation of functional performance. **Cost and ordering information:** Free test manual: http://www.rehabmeasures.org/Lists/RehabMeasures/DispForm.aspx?ID=939

Assessment	*Executive function components* Initiation	Planning	Sequencing	Problem-solving	Monitoring	Inhibition	Working memory	Divided attention	Flexibility	*Level of functioning* *&* *Environment*	*Description*	*Reliability*	*Validity*	*Clinical utility*
***Virtual Environment Technology (VET)*-based cognitive assessment program** (Kang et al., 2008; Ku et al., 2009)		X		X			X			➢ Activity ➢ Simulated real world	Virtually simulated shopping experience that evaluates both cognitive and behavioural aspects of performing daily activities. **Scoring:** The program involves 3 stages (performance, attention and executive indices) that are graded according to their level of difficulty and cognitive factors to be assessed. **Population studied**: Patients with sub-acute and chronic stroke	**Test-retest** *Adequate to excellent:* correlation coefficients = 0.528 to 0.926, p<.05 (Ku et al., 2009). **Inter-rater** *No evidence.* **Internal consistency** *No evidence.*	**Construct validity** *Adequate:* <u>Known groups:</u> Significant differences between patients with stroke and healthy controls (p<0.0001) (Kang et al., 2008). <u>Ecological Validity</u> Moderate correlation between VET executive index and the "adaptive intelligence quotient score" from the Kim's Frontal-Executive Neuropsychologic Test, which was obtained from a family caregiver using a questionnaire on adaptation and executive function in real life (y=0.596, p=0.001) (Ku et al., 2009). **Criterion validity** *Adequate:* <u>Concurrent validity</u> Significant correlations with neuropsychological tests (Ku et al., 2009). **Responsiveness** *No evidence.* **Floor and ceiling effects** *No evidence.*	**Testing Situation**: Standing or sitting on a rotating chair. **Time**: Not reported. **Concern**: Unfamiliarity with computer program, physical factors and simulator sickness syndrome may lead to less stable results (Ku et al., 2009). Requires sufficient reading abilities. **Therapist training:** Not reported. **Cost and ordering information:** Not reported but specific virtual reality equipment required.

Appendix 2.1:
Criteria for ratings of reliability, validity and responsiveness

Standards for rating reliability data *(in Salter et al., 2005)*

Internal consistency (split-half or Cronbach's a statistics):
Excellent: ≥ 0.80; Adequate: 0.70 – 0.79; Poor: < 0.70

Test-retest and inter-rater (correlation coefficients or kappa statistics):
Excellent: ≥ 0.75; Adequate: 0.4 – 0.74; Poor: < 0.40

Standards for evaluating the evidence of validity and responsiveness *(adapted from Salter et al. (2005), McDowell & Newell (1996) and Andresen (2000))*

Excellent: most major forms of testing reported with excellent values

Adequate: several types of testing or several studies reported with adequate values

Poor / Minimal evidence: minimal information reported and/or evidence from pilot studies

No evidence: no studies and/or no information available

Conflicting: 2 or more studies showing different findings

BRIDGING MANUSCRIPT

The first manuscript in Chapter 2 provided a review of 17 ecologically valid performance-based EF tools that were critically appraised according to the EF components assessed, the tool's psychometric properties specific to stroke and clinical utility. The overall purpose was to synthesize these findings into a *Stroke-Specific Executive Function Toolkit* to facilitate clinicians' identification of appropriate EF tools for quick screening or more in-depth assessment of a person's executive functioning in daily life. The results of these assessments should be used to assist with selection and development of appropriate intervention strategies that are carefully matched to the client's everyday EF problems, residual strengths and goals (Eskes et al., 2013a).

Accordingly, the next logical step for this thesis was to identify and appraise the evidence for the use of specific EF interventions post-stroke. Specifically, the second manuscript consisted in a systematic review on the effectiveness of EF interventions according to stage of stroke recovery. This review was published in the *Topics in Stroke Rehabilitation* journal in 2012.

CHAPTER 3: *Manuscript 2*.

Efficacy of executive function interventions after stroke: a systematic review

From : Poulin, V., Korner-Bitensky, N., Dawson, D. R., & Bherer, L. (2012). **Efficacy of executive function interventions after stroke: a systematic review**. *Top Stroke Rehabil, 19*(2), 158-171. doi: 10.1310/tsr1902-158

Valérie Poulin, MSc, PhD candidate in Rehabilitation Science, School of Physical and Occupational Therapy, McGill University, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Montreal, Quebec.

Nicol Korner-Bitensky, PhD, Associate Professor, School of Physical and Occupational Therapy, McGill University, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Montreal, Quebec.

Deirdre R. Dawson, PhD, Associate Professor, Department of Occupational Science & Occupational Therapy & Graduate Department of Rehabilitation Sciences University of Toronto, Senior Scientist, Kunin-Lunenfeld Applied Research Unit, Baycrest Centre, Associate Member, Heart and Stroke Foundation Centre for Stroke Recovery, Toronto, Ontario.

Louis Bherer, PhD, Professor, Department of Psychology, University of Québec at Montreal, Montreal, Quebec.

Correspondence:
Valérie Poulin
School of Physical and Occupational Therapy, McGill University
3630 Promenade Sir-William-Osler,
Montreal, Quebec, H3G 1Y5
Email: valerie.poulin2@mail.mcgill.ca
Telephone: (514) 398-5457   Fax: (514) 398-4874

Acknowledgments

Valérie Poulin is supported by a PhD fellowship award from the Fonds de la recherche en santé du Québec, Louis Bherer is supported by a junior career award from the Fonds de la recherche en santé du Québec and Nicol Korner-Bitensky was supported by a senior career award from the Fonds de la recherche en santé du Québec (2005-2010) and by the Canadian Stroke Network during preparation of this manuscript.

ABSTRACT

Purpose: Disorders in executive functions are common post-stroke and play a critical role in predicting functional recovery. To establish best practice recommendations it is necessary to appraise the evidence regarding specific executive function interventions post-stroke. This systematic review aims to determine whether executive function intervention is more effective than no/alternative intervention in improving executive functions and functional abilities in the acute, subacute and chronic stages post-stroke.

Method: A systematic review was performed up to January 2011 of MEDLINE, CINAHL, PsychINFO, OTseeker and Cochrane databases. Eligible studies needed to include a cognitive intervention to remediate executive function impairments post-stroke or to improve functional tasks compromised by these impairments. Methodological quality of randomized trials was rated by two authors. The level of evidence for each intervention, according to stage of recovery, was determined.

Results: Ten studies met inclusion criteria, one evaluating treatment in the subacute and nine in the chronic stage. Limited evidence from the one study in the subacute stage (level 2b) and nine studies (including three randomized controlled trials) in the chronic stage (level 2a) support using remedial (e.g., computerized working memory training) and compensatory interventions (e.g., problem-solving strategies, paging system) for improving executive functioning and, possibly, functional abilities.

Conclusion: These promising findings suggest that persons with stroke may possibly benefit from specific executive function training and learn compensatory strategies to reduce the consequences of executive impairments. Further research is needed in acute and subacute stroke, when the impact of treatment is potentially great and where few studies have been undertaken.

Key words: stroke, executive function, intervention, systematic review

INTRODUCTION

Disorders in executive functions represent one of the most common cognitive sequelae of stroke, with reported occurrence in 19 to 75 percent of patients, depending on the domains measured and definition of executive function that is used (Lesniak, Bak, Czepiel, Seniow, & Czlonkowska, 2008; Nys et al., 2007; Pohjasvaara et al., 2002; Rasquin et al., 2004b; Riepe, Riss, Bittner, & Huber, 2004; Zinn, Bosworth, Hoenig, & Swartzwelder, 2007). Executive functions refer to "high-level cognitive functions that provide control and direction of lower-level, more automatic functions" (Stuss, 2009, p. 8) and encompass a number of cognitive processes including: initiation, planning, sequencing, monitoring, solving problems, performing two tasks concurrently, switching, inhibition and working memory (Ardila, 2008; Fuster, 2002; Godefroy & Stuss, 2007; Happaney, Zelazo, & Stuss, 2004; Stuss, 2009). Although executive functions depend to a large extent on the integrity of the prefrontal cortex, especially the lateral prefrontal cortex (Stuss, 2009), they can also be impaired by various network disconnections resulting from white matter damage or impairment to other brain regions (Stuss et al., 2002). The complexity of executive functions makes them very sensitive to brain changes resulting from stroke (Levine, Turner, & Stuss, 2008). Furthermore, although some spontaneous recovery may occur, particularly in the first six months (Lesniak et al., 2008; Rasquin et al., 2004b), persistent deficits are frequently observed (Rasquin et al., 2004b). Deficits affect participation in rehabilitation (Skidmore et al., 2010) and play a critical role in recovery post-stroke (Lesniak et al., 2008) with a higher risk of functional dependence (Lesniak et al., 2008; Pohjasvaara et al., 2002), failure to return to work (Ownsworth & Shum; 2008) and poor social participation (McDowd, Filion, Pohl, Richards, & Stiers, 2003). Executive functions are therefore of great concern to clinicians and researchers involved in cognitive rehabilitation post-stroke.

According to recent stroke best practice guidelines, cognitive rehabilitation should be based on the results of an assessment with standardized measurement instruments and designed to achieve changes that improve functional status in areas of life that are important to the patient (Duncan et al., 2005; Lindsay et al., 2010; National Stroke Foundation, 2010). Different approaches are suggested (Cicerone et al., 2000; Evans, 2009; Wilson, 2009). Some are oriented toward *targeted remediation* of specific executive processes (Cicerone et al., 2000; Wilson, 2009), for example, through retraining on computer-based tasks. Others focus on teaching people to use their residual skills more efficiently or to *compensate for their difficulties through the use of strategies*, such as cognitive strategies to improve problem-solving (Cicerone et al., 2000; Evans, 2009; Wilson, 2009). *External compensatory mechanisms*, such as electronic paging systems or environmental modifications, are also used in an attempt to improve the accomplishment of daily activities (Cicerone et al., 2000; Evans, 2009; Wilson, 2009).

To provide clinicians with specific guidelines regarding executive function rehabilitation post-stroke, it is necessary to identify and compare the effectiveness of these various interventions in the different stages of stroke recovery. The evidence from previous systematic reviews on cognitive rehabilitation in adults with acquired brain injury tends to support the use of training in formal problem-solving strategies with individuals with executive disorders after traumatic brain injury (TBI) (Cicerone et al., 2000, 2005; Kennedy et al., 2008). However, recommendations specific to the population with stroke cannot be formulated on the basis of the findings from these reviews. A systematic review by Chung, Pollock, Campbell, Durward and Hagen (2010) also broadly examines the impact of cognitive rehabilitation for executive dysfunction after acquired brain injury, but does not specifically focus on stroke. The clinical and demographic differences between populations with TBI and stroke (i.e. in terms of age, comorbidities, lesion location, pattern of pathology and resultant cognitive and executive function deficits (Ponsford, 2004)) have been observed to lead to differential assessment findings and treatment effects. For example, Dawson and colleagues (2009b) found differential performance between people with TBI and stroke on the Multiple Errands Test, which assesses executive functioning using a complex shopping task (Dawson et al., 2009b). Fish, Manly, Emslie, Evans and Wilson (2008a) observed better maintenance of treatment benefits following the use of an electronic aid for memory and planning in participants with TBI, compared to those with stroke who were generally older and had poorer executive functioning. Fish et al. (2008a) hypothesize that aetiology might be a potential moderator of other factors known to be important such as lesion location and age. Thus, it may be that some important differences in treatment effects specifically for clients with stroke have not been reported due to the use of combined samples. For this reason, it is prudent to examine the effectiveness of executive function interventions specific to those with stroke.

Thus, this systematic review identifies and appraises the evidence for the use of executive function interventions according to stage of stroke recovery (i.e. acute, subacute and chronic). Using the *PICO* format (i.e. *P*opulation, *I*ntervention, *C*omparison, and *O*utcome) (Guyatt & Rennie, 2002), a specific research question was formulated as follows:

> In persons experiencing executive function deficits post-stroke, is executive function intervention more effective than no intervention or an alternative intervention in improving executive functions and functional abilities in daily life in the *acute*, *subacute* and *chronic* stages of stroke recovery?

[where the *acute*, *subacute* and *chronic* stages were defined, respectively, as *early weeks post-stroke*, *rehabilitation phase* and *more than six months post-stroke*, according to the 2010 Canadian Stroke Best Practice Guidelines (Lindsay et al., 2010) and the www.strokengine.ca guidelines that refer to timing of rehabilitation interventions.]

METHODS

Eligibility criteria

Randomized controlled trials (RCTs), pre-post-design studies, single-subject studies, cohort studies and case-control studies published in English or French were considered for inclusion if conducted in adults (18 years or over) experiencing executive function deficits after ischemic or hemorrhagic stroke (including also those with ruptured aneurysm). Given the limited number of studies that focus specifically on executive function interventions post-stroke, it was deemed relevant to use a "broader" definition of stroke in order to include all relevant studies for this population. Studies with mixed etiology groups (e.g., traumatic brain injury or tumor) were excluded unless participants with stroke comprised 50 percent or more of the sample, or separate data for those with stroke were available. The intervention needed to be a *cognitive intervention* (not primarily physical or pharmacological) *to remediate executive function impairments* post-stroke or *to improve functional tasks compromised by impairments in executive function*. While attentional processes are involved in executive functioning, interventions directed exclusively at attention deficits post-stroke have been reviewed (Lincoln, Majid, & Weyman, 2000) and, as such, were excluded. Interventions offered individually or in groups, and that involved components such as computerized cognitive training, problem-solving and strategy formation techniques, goal management training, or other compensatory strategies and external aids for overcoming everyday executive problems, were all considered. Finally, to be included, studies needed to have an outcome that measured some aspect of executive functioning through neuropsychological/psychological tests or performance of daily activities.

Search strategy

A comprehensive review of the scientific literature was performed by searching PsychINFO, CINAHL and MEDLINE databases from their inception to January 2011. Articles related to executive function interventions for persons with stroke were searched by combining the following key terms: *stroke or cerebrovascular accident or cerebrovascular disorders* AND *executive function or executive control or problem solving or cognition or cognitive ability or cognitive impairment* AND *rehabilitation or cognitive therapy or cognitive training or cognitive rehabilitation or training or intervention.* In addition, the Cochrane database (Cochrane Database of Systematic Review, 2011) and the Cochrane Central Register of Controlled Trials (CENTRAL, 2011) were explored using *executive function*, *problem solving* and *stroke.* The Occupational Therapy (OT) Seeker database was also explored using the *intervention category* "*cognition*". To identify additional studies, the reference lists of all articles retrieved were reviewed. Publications by major authors working in the area of cognitive rehabilitation were also sought using the ISI Web of Science database.

Study selection and data collection process

The overall process for selecting studies is shown in Figure 3.1. Once duplicates were deleted, titles and abstracts of articles were reviewed to identify those that met the inclusion criteria. Full text copies of the selected articles (including those labelled as uncertain) were obtained to further verify eligibility. Each study was summarized in a data abstraction form according to design, participants' characteristics and stage of recovery, experimental intervention and comparison, outcomes, and methodological quality.

Assessment of study quality

RCTs were appraised for methodological quality using the Physiotherapy Evidence Database (PEDro) Scale. The PEDro Scale rates the study quality according to ten criteria including randomization; concealed allocation; baseline comparability; blinding of subjects, assessors and therapists; intention-to-treat analysis; and, adequacy of follow-up; out of a possible total score of 10. PEDro scores are interpreted as follows: scores from 6 to 10 indicate high methodological quality, 4 to 5 corresponds to "fair" quality, and below 4, "poor" (Foley, Teasell, Bhogal, & Speechley, 2003). Two authors rated each RCT independently using the PEDro Scale and when discrepancies arose these were discussed and the study was re-reviewed to determine a final score. Case-control and cohort studies were evaluated using the framework provided by the Newcastle-Ottawa Scale (NOS) (Wells et al., 2011), but no scoring was performed. The NOS evaluates quality in terms of selection of study participants, comparability of the groups and ascertainment of the study exposure and outcomes (Wells et al., 2011).

Data analysis

Once eligible articles were identified, the possibility of performing a meta-analysis was examined. However, considering the methodological and the clinical heterogeneity among the studies, it was deemed inappropriate to combine their results into a meta-analysis (Wright, Brand, Dunn, & Spindler, 2007) (see Results section for further explanation). The findings were therefore analyzed in a qualitative synthesis where studies were grouped according to stage and intervention approaches (i.e. remediation of specific executive processes, training in compensatory cognitive strategies or external compensatory approach). The level of evidence for each intervention, according to stage of recovery was determined using a scale ranging from 1a (strong evidence) to 5 (no evidence), based on Sackett's levels of evidence (Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000) and adapted to consider the methodological quality of the RCTs (see *Table 3.1* and consult www.strokengine.ca for a full description of the levels of evidence).

RESULTS

Of the 1539 articles identified, 10 contained studies that met the inclusion criteria including two RCTs (Man, Soong, Tam, & Hui-Chan, 2006; Westerberg et al., 2007), one randomized crossover trial (Fish et al., 2008a), four single-subject design studies (Evans, Emslie, & Wilson, 1998; Fish, Manly, & Wilson, 2008b; Honda, 1999; Vallat et al., 2005), two pre-post design studies (Rand, Weiss, & Katz, 2009b; Schweizer et al., 2008) and one pre-post controlled group study (Stablum, Umilta, Mogentale, Carlan, & Guerrini, 2000) (*see Table 3.2*). These studies showed heterogeneity in terms of the *components of executive functions targeted by the interventions* (i.e. different executive processes and skills such as working memory versus problem solving); *type of intervention* (i.e. computerized training, compensatory cognitive strategies or external aids); *types of outcome measures* (e.g., laboratory-based tasks, neuropsychological tests versus self-reported measures of instrumental activities of daily living (IADLs)) and, in *time since stroke* (i.e. no study in acute, one in subacute and nine in chronic).

ACUTE STROKE

No studies in persons with acute stroke met the inclusion criteria.

Conclusion: There is currently no evidence (level 5; see Table 3.1) on the efficacy of executive function interventions for improving executive functions and everyday functional abilities in the acute stage post-stroke.

SUBACUTE STROKE

There is only one pre-post controlled group study (Stablum et al., 2000) that contributes to the evidence on executive function rehabilitation in the subacute phase post-stroke. This study evaluated the efficacy of computerized dual-task training to improve specific executive functions such as the *ability to coordinate two actions* (also referred to as *dual-tasking*). Nine adults with anterior communicating artery (ACoA) aneurysm rupture received computerized dual-task training over five sessions performed once a week while nine healthy adults formed the no-treatment control group (Stablum et al., 2000). The dual-task training involved co-ordinating the execution of two responses: participants had to identify the position (right or left) of two letters on the screen, and then to determine whether the two letters were the same or different. Response times for this dual-task were compared at baseline and at 3-month follow-up in each group and were also measured immediately post-intervention and at 12-month follow-up in the intervention group. In addition, a questionnaire on cognitive failures in daily life, the Cognitive Failures Questionnaire (CFQ) (Broadbent, Cooper, FitzGerald, & Parkes, 1982) along with a battery of neuropsychological tests of cognitive and executive functions were administered to the *intervention group* at baseline and 12-month follow-up. At 3-month follow-up, the patient group exhibited significantly improved dual-task speed (F = 13.93; df = 1, 16; p = 0.002) such that they demonstrated comparable performance to healthy controls, while controls remained stable from baseline to follow-up (Stablum et al., 2000). Training benefits were maintained at 12-months. There was also evidence of transfer of training effects to tests related to executive functions (i.e. Paced Auditory Serial Addition Task (PASAT) (Gronwall, 1977), Trail Making Test (Army Individual Test Battery, 1944), Backward Digit Span (Wechsler, 1981) and a variant of the Continuous Performance Task that measures inattention (Braver, Barch, & Cohen, 1999); $p \leq 0.03$) but not to other cognitive processes (e.g., story recall or phrase construction; $p > 0.05$). Preliminary evidence of generalization to daily life functioning was also suggested by a decrease in everyday cognitive problems reported by patients on the CFQ at 12-month follow-up (Stablum et al., 2000).

<u>**Conclusion:**</u> There is limited evidence (Level 2b) from one pre-post controlled group study (Stablum et al., 2000) suggesting that computerized dual-task training is more effective than no intervention at improving specific executive functions such as the ability to coordinate two actions in the subacute stage post-stroke.

CHRONIC STROKE

Of the nine studies conducted in persons with chronic stroke, two used a remedial approach for improving working memory (Vallat et al., 2005; Westerberg et al., 2007), which is a specific executive function process involving short-term maintenance and manipulation of information in simple or complex cognitive tasks (Van der Linden, Poncelet, & Majerus, 2007). Four focused on strategy training in problem-solving, planning, multi-tasking and goal management studies (Honda, 1999; Man et al., 2006; Rand et al., 2009b; Schweizer et al., 2008), while three relied on external compensatory approaches such as external cueing systems or checklists (Evans et al., 1998; Fish et al., 2008a, 2008b).

Working memory training in chronic stroke

Two studies – one fair quality RCT (Westerberg et al., 2007) and one multiple-baseline single-subject design (Vallat et al., 2005) – adopted a remedial approach for improving working memory functioning.

In the fair quality RCT, 18 persons with chronic stroke were randomly allocated to either computerized working memory training over five 40-minute intervention sessions per week for five weeks (n = 9) or to no treatment (n = 9)

(Westerberg et al., 2007). The computerized tasks involved presentations of auditory and visuo-spatial stimuli. An example of a training task was: lamps were displayed on the computer screen and participants watched the lights go on in various sequences, and then were instructed to reproduce the same sequence. At post-intervention, the training group improved significantly more than the no treatment group in all working memory and attention tests, including the Digit Span (Wechsler, 1981), Span Board (Kaplan, Fein, Morris, & Delis,1981), PASAT (Gronwall, 1977) and Ruff 2&7 Selective Attention Test (Ruff, Niemann, Allen, Farrow, & Wylie, 1992) (effect sizes=0.61 to 1.58; $p \leq 0.05$; considered to be a moderate to large treatment effect (Cohen, 1988)). The training group also reported fewer cognitive failures in daily life as measured by the CFQ (Broadbent et al., 1982) (effect size=0.80; p=0.005) (Westerberg et al., 2007). No treatment effects were found on interference control, problem-solving and declarative memory tests.

Vallat and colleagues used a multiple-baseline single-subject design (n=1) (Vallat et al., 2005). The intervention involved training of storage and processing components of verbal working memory, such as sorting a series of words in alphabetical order, over three one-hour sessions per week for six months, guided by the working memory model proposed by Baddeley (1986). After training, improvements were observed in tasks assessing working memory [i.e. forward digit span (corrected $\chi^2 = 7.1$, $p<0.01$) and in the Brown-Petersen task (Van der Linden, Coyette, & Seron, 1992) which requires the participant to recall consonant trigrams after a delay with or without an interfering task (corrected $\chi^2 = 13.4$, $p<0.001$)]. Improvement was specific to working memory tasks, as no change was observed in non-targeted tasks of verbal fluency and long-term memory. The participant also reported self-perceived improvements in a verbal communication questionnaire addressing everyday situations such as phone conversation and shopping (Darrigrand & Mazaux, 2000) ($\chi^2 = 6.2$, $p=0.01$) and on a standardized questionnaire assessing working memory functioning in daily life ($\chi^2 = 4.8$, $p<0.05$) (Vallat et al., 2005).

Conclusion: There is limited evidence (level 2a) supporting the use of working memory training compared to no intervention for the remediation of working memory in the chronic phase post-stroke. There is also preliminary indication of generalization to everyday functioning.

Strategy training in chronic stroke

Four studies – one fair quality RCT (Man et al., 2006), one single-subject study (Honda, 1999) and two pre-post studies (Rand et al., 2009b; Schweizer et al., 2008) – have focused on strategy training in the chronic phase. In the fair quality RCT (Man et al., 2006), 103 persons with acquired brain injury, including 55 individuals with stroke, were randomly allocated to one of four groups: three analogical problem-solving interventions offered in three different delivery formats over 20 weekly sessions of 45 minutes or to a no-treatment control group. Participants in the three training groups were presented with problems commonly encountered in daily life and were taught to draw analogies to solve other similar problems. The mode of treatment administration differed across the three training groups: the first participated in self-paced computer-assisted training, the second received online training through video conferencing with a therapist and the third received face-to-face therapist-led training. Significant pre to post changes in problem-solving (Category Test (Reitan & Wolfson, 1996): $p \leq 0.01$) and IADL abilities (as measured with the Lawton IADL scale (Tong & Man, 2002): $p < 0.01$) were observed in all three intervention groups but not in the control group. Between-group comparisons showed comparable improvements on these outcomes in the three training groups. However, a greater improvement in problem-solving self-efficacy was reported for the face-to-face training group as compared to the other intervention groups ($F = 6.45$; $p = 0.003$).

In the pre-post study (n=4) Rand et al. (2009b) evaluated the efficacy of virtual reality (VR) based training in a shopping task (VMall) that required multitasking, planning and problem-solving during 10 one-hour sessions over 3 weeks. From pre to post intervention, participants showed mean improvements ranging from 8% to 51% in scores on two tests assessing executive functioning in a complex shopping task performed in a real mall [i.e. Multiple Errands Test-Hospital Version (MET-HV) (Knight, Alderman, & Burgess, 2002)] and in a virtual mall [i.e. Virtual Multiple Errands Test (V-MET) (Rand, Katz, & Weiss, 2007)]. However, little or no change was noted in other IADLs as measured with the Lawton IADL Scale (Lawton, Moss, Fulcomer, & Kleban, 1982).

Using a multiple-baseline single subject design, Honda (1999) investigated the impact of a six-month intervention, including self-instructional procedures, problem solving strategies and physical exercises, in three patients with chronic stroke following ruptured ACoA aneurysm. Self-instructional procedures required the individual to verbalize a plan before and while practicing a task, with the verbalization gradually being faded out. Post intervention improvements were noted in three of the four neuropsychological tests of attention and executive function [i.e. Trail Making Test (Army Individual Test Battery, 1977), WAIS-R (Wechsler, 1981) and Tinker-Toy test (Lezak, 1981), but not Wisconsin Card Sorting Test (Berg, 1948)] and in the Good Samaritan Hospital Center for Cognitive Rehabilitation Executive Functions Behavioral Rating Scale (Sohlberg & Mateer, 1989).

The use of self-instructional strategies was also incorporated in the pre-post study by Schweizer and colleagues (2008) that assessed the efficacy of goal management training (GMT) provided during seven weekly two-hour sessions in one individual with cerebellar haemorrhage following arteriovenous malformation rupture. GMT comprises several stages in which the participant is guided to use a global meta-cognitive problem-solving strategy, including: stopping ongoing activities and thinking about task demands, refocusing on the goal of the task, splitting the task into subgoals and verifying that the desired goals have been met. This intervention also involves undertaking simulated real-world tasks and homework assignments designed to facilitate generalization of skills to everyday life. Post-intervention, “the patient made and maintained modest gains on measures of sustained attention [i.e. Sustained Attention to Response Task (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997)], planning and organization [i.e. Delis-Kaplan Executive Function System Tower Test (Delis, Kaplan, & Kramer, 2001)] that translated into significant improvement in real-life functioning” (Schweizer et al., 2008, p. 72). Specifically, evidence of functional gains in daily life was suggested by the significant other’s report on the Dysexecutive Questionnaire (Burgess, Alderman, Evans, Emslie, & Wilson, 1998) and by the participant’s successful return to work.

> **<u>Conclusion</u>:** There is limited evidence [level 2a] from four studies (Honda, 1999; Man et al., 2006; Rand et al., 2009b; Schweizer et al., 2008) suggesting that strategy training in problem solving using various formats is more effective than no intervention at improving executive functioning and, possibly, everyday functional abilities, in the chronic phase after stroke.

External compensatory approaches in chronic stroke

Three studies – including one fair quality randomized crossover trial (Fish et al., 2008a) and two single-case studies on the same patient 10 years apart (Evans et al., 1998; Fish et al., 2008b) – have evaluated the use of an external compensatory approach. The randomized crossover trial (Wilson, Emslie, Quirk, & Evans, 2001) was comprised of individuals with various aetiologies (n=143), but specific results relating to the sub-group of participants with stroke (n=36) were reported by Fish et al. (2008a). After a two-week baseline period, participants were randomly assigned to receive a paging system (NeuroPage) designed to assist with memory and planning for seven weeks (Group A: n=24 persons with stroke) or to a waiting list (Group B: n=12 persons with stroke). In the subsequent phase conditions were switched such that participants in Group B received a pager for seven weeks while those in Group A no longer had the pager. During the pager phase, participants received electronic prompts to carry out self-selected tasks such as taking medication or remembering appointments. Participants or their carers completed a daily diary, reporting whether or not each target task had been achieved. The primary outcome was the percentage of tasks successfully completed. Both groups achieved significantly more target activities during the pager phase compared to the control phase: after the first seven weeks pager Group A performed significantly better than pager-less Group B (75.1% vs. 44.8% of target tasks accomplished; $z=2.953$, $p=0.003$), but these benefits were not maintained following withdrawal of the pager (Fish et al., 2008a).

In the single-subject study with ABAB design, Evans, Emslie and Wilson (1998) investigated the efficacy of the NeuroPage cueing system combined with task-specific checklists in a woman experiencing severe executive impairments of planning, attention and initiation of intended actions seven years after a cerebrovascular accident. Clinically important improvements in all self-selected goals (i.e. medication schedule, plant watering and personal hygiene), as measured using a daily diary completed by the participant and her husband, were observed following the introduction of these external aids for three months. Ten years later, a follow-up study of this patient showed that she had ceased to use these compensatory aids and that her independence in everyday activities had decreased despite stable neuropsychological test performance (Fish et al., 2008b). Using a single-subject design with alternating treatments, the paging system and the checklist were reintroduced separately and their effects were compared for three common goals including: taking medication and reducing the time she spent getting ready for the morning and evening routine (Fish et al., 2008b). Although the checklist had a positive effect on medication adherence and evening routine ($p\leq 0.008$), the pager resulted in greater and more consistent gains in all three target functional tasks ($p\leq 0.0001$).

Conclusion: There is limited (Level 2a) evidence suggesting that the use of a paging system is more effective than no intervention to improve functional tasks that involve executive control. There is also limited evidence from one single-subject study (Level 2b) that the pager is more effective than a task-specific checklist in achieving specific functional goals (Fish et al., 2008b).

DISCUSSION

This systematic review found limited but encouraging evidence suggesting that executive function interventions may improve different aspects of executive functioning, such as working memory, dual-tasking, problem solving, goal management, multitasking and planning of everyday activities after stroke, when compared to no treatment. Interestingly, nine of the studies identified in the present review were carried out with patients in the *chronic* stage of recovery (Evans et al., 1998; Fish et al., 2008a, 2008b; Honda et al., 1999; Man et al., 2006; Rand et al., 2009b; Schweizer et al., 2008; Vallat et al., 2005; Westerberg et al., 2007), usually more than one year post-stroke. Given the importance of executive function it is disconcerting that the effectiveness of providing these interventions earlier, when the impact of treatment might potentially enhance recovery and participation in rehabilitation, has not yet been well studied.

The limited evidence provides support for both *remedial* (e.g., computer-based training of working memory and dual-tasking) and *compensatory* approaches (e.g., cognitive strategy use and paging system) in the population with executive dysfunction post-stroke. This is an important finding since it is generally suggested that remedial interventions might be more appropriate for those with more specific impairments while external compensatory aids can be used with people with more severe and persistent cognitive impairment. Stablum and colleagues (2000) hypothesized that specific retraining might facilitate and guide reorganization of the targeted executive processes with potential "cascade effects" on other executive functions. The evidence from studies using compensatory techniques also indicates that adults experiencing executive dysfunction post-stroke may learn and successfully apply compensatory strategies to reduce the daily consequences of executive function deficits. However, no studies were found that specifically investigated the use of executive function intervention *compared to conventional therapy* or an *alternative intervention*. This is an important limitation that will need to be addressed in future research in order to get a clearer understanding of the relative impact, and, advantages and disadvantages of different executive function interventions. Given the current evidence it is not possible to give clinicians specific recommendations regarding the most appropriate executive function intervention, if indeed one exists.

Most of the studies published to date also have other serious methodological flaws. A serious limitation in our knowledge regarding the effectiveness of executive function interventions post-stroke is based on the study design used. Six of the studies used a pre-post study design without a control or alternative intervention (Rand et al., 2009b; Schweizer et al., 2008) or a single-subject design (Evans et al., 1998; Fish et al., 2008b; Honda, 1999; Vallat et al., 2005). As such, the positive results that were seen in these studies might be attributed to the attention that participants received, rather than any direct value of the specific treatment provided. Also, in the study from Stablum and colleagues (2000), which used a pre-post controlled group design, participants with *subacute stroke* were compared to *healthy controls*, which does not help to answer the question of whether one type of intervention is more effective than another in those with executive function deficits post-stroke. Finally, the broad inclusion criteria in some of the studies that resulted in a heterogeneous mix of patients with various aetiologies, along with failure to describe important potential explanatory variables such as side and site of lesion (Fish et al., 2008a; Man et al., 2006; Rand et al., 2009b; Stablum et al., 2000), type of stroke (Man et al., 2006; Rand et al., 2009b), education (Evans et al., 1998; Fish et al., 2008a; Honda, 1999; Rand et al., 2009b) and handedness (Evans et al., 1998; Fish et al., 2008a, 2008b; Honda, 1999; Man et al., 2006; Rand et al., 2009b; Westerberg et al., 2007), all contribute to a body of evidence that is still relatively unclear.

Another important issue that has not been properly addressed by most studies and that will require further investigation in the population with stroke is the long-term maintenance of treatment effects. Encouragingly, two pre-post studies that specifically evaluated maintenance of treatment effects at 3- and 12-month follow-up (Stablum et al., 2000) and 4-month follow-up (Schweizer et al., 2008) reported that gains remained stable after treatment cessation. Also, the single-subject study from Fish and colleagues (2008b) reintroduced the pager and checklist strategies 10 years after the original intervention and brought the participant back to a post-intervention level of functioning.

Another important point concerns the extent to which improvements in executive function translate in to performance gains in untrained real-world functional activities. Of the 10 studies, three did not report on this outcome (Fish et al., 2008a, 2008b; Evans et al., 1998) and one found no transfer and generalization effects (Rand et al., 2009b): the other six reported some preliminary evidence of transfer and generalization to everyday functional abilities based on data from self-reported measures (Honda, 1999; Man et al., 2006; Schweizer et al., 2008; Stablum et al., 2000; Vallat et al., 2005; Westerberg et al., 2007). These findings are generally consistent with previous reviews involving other populations with acquired brain injury (Cicerone et al., 2005; Kennedy et al., 2008), that also found preliminary evidence that the strategies and skills learned during training transferred to real-world activities. Much remains to be learned about the impact of various executive function interventions on real-life functioning after stroke. Among key principles that might enhance generalization, the use of explicit strategies and their application to ecologically relevant problems and simulated real-world tasks appear promising, as indicated by the results from Man and colleagues (2006), and Schweizer and colleagues (2008). Considering that executive dysfunction, by its nature, limits a person's ability to generalize, it may be relevant to explicitly address generalization during training with patients, for example, by asking them how the tasks or strategies learned might be applied to real-life situations (Dawson et al., 2009a).

As we go forward the development of executive function interventions should also be built on well-established theories of executive function. In the present review, only four articles described the models of executive function that guided the interventions under study (Evans et al., 1998; Fish et al., 2008b; Schweizer et al., 2008; Vallat et al., 2005). As mentioned by Kennedy and colleagues (2008), "theoretically driven intervention studies would advance our understanding of executive functions, but may also advance our understanding of generalization or transfer of skill sets to untrained tasks and contexts." (Kennedy et al., 2008, p.295)

CONCLUSION

The limited evidence suggests that executive function interventions have good potential for improving aspects of executive functioning in adults with stroke. The preliminary evidence that generalization and transfer to untrained daily life activities occurs is also encouraging. Despite these positive findings, there are challenges to address in future studies. First, most of the evidence comes from studies of individuals who are in the chronic phase of stroke and yet logically it would be important to study the effects of intervention earlier on post-stroke. Also, it would be important to investigate whether a combination of approaches, involving both training in specific executive processes and compensatory strategy training that incorporates ecologically relevant tasks, could yield optimal treatment outcomes. Further down the road, as we gain a clearer understanding of the effectiveness of various interventions there will be another important challenge – that is, to then implement effective knowledge translation strategies to ensure that these relevant interventions are utilized by clinicians.

Figure 3.1: Flow Diagram of study selection

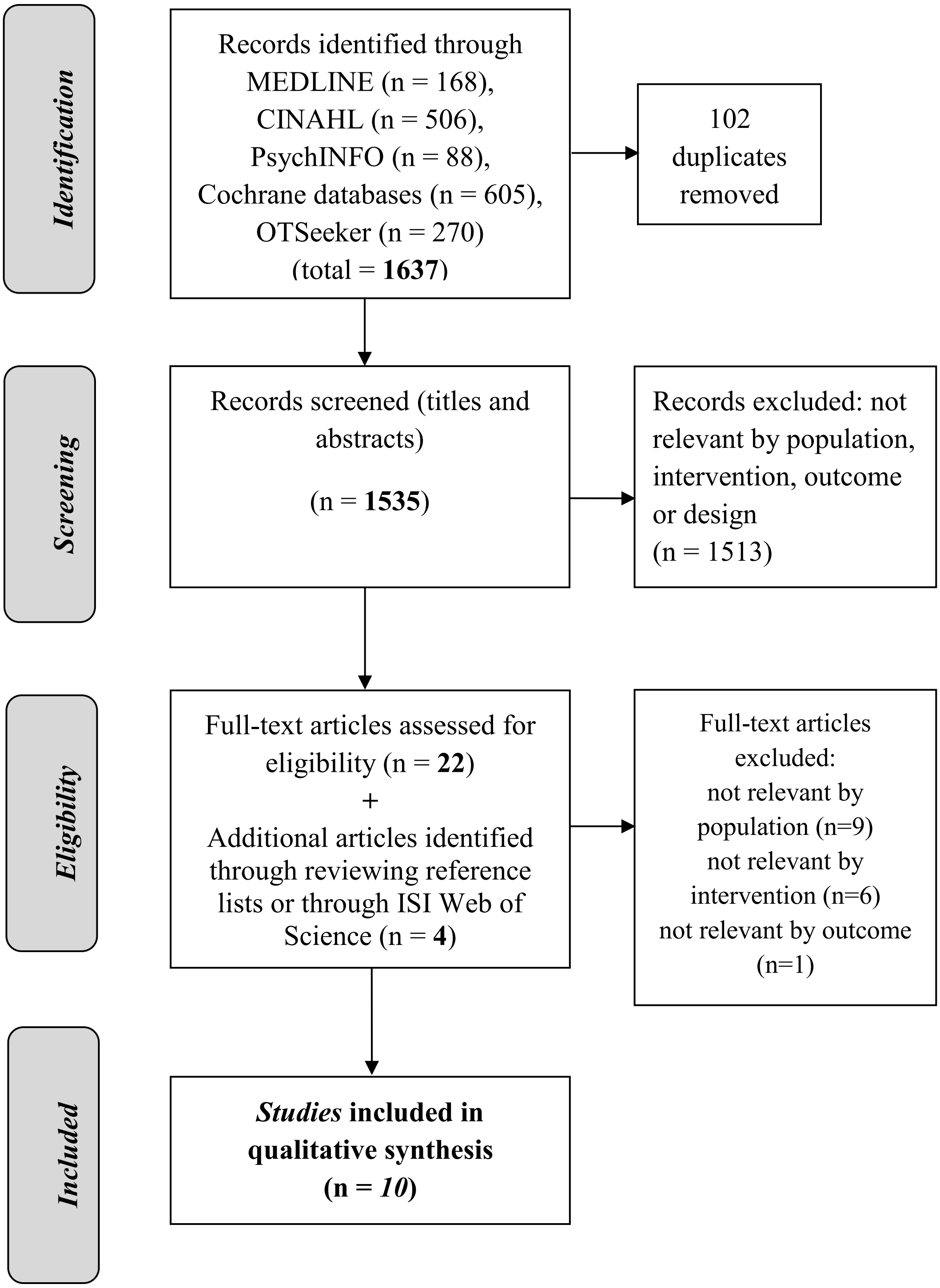


Table 3.1: Levels of evidence for research questions

Level of evidence	Description
1a (Strong)	2 or more high quality RCTs (PEDro ≥ 6) showing similar findings
1b (Moderate)	1 RCT of high quality (PEDro ≥ 6)
2a (Limited)	At least 1 fair quality RCT (PEDro = 4-5)
2b (Limited)	At least 1 poor quality RCT (PEDro < 4) or well-designed non-experimental study (non-randomized controlled trial, quasi-experimental studies, single subject series with multiple baselines, etc.)
3 (Consensus)	Agreement by an expert panel or a number of pre-post studies all with similar results
4 (Conflict)	Conflicting evidence of 2 or more equally well designed studies
5 (No evidence)	No well-designed studies; only case descriptions or cohort studies/single subject series with no multiple baseline

Table 3.2: Summary of executive function interventions in persons with stroke

Author, year PEDro score	Sample size	Study design	Intervention	Outcome	Transfer/ generalization
Subacute stage of recovery					
Stablum et al., 2000	9 (ACoA aneurysm rupture) + 9 uninjured controls	Pre-post controlled group study	IG = Computer-based dual-task training, 5 sessions (1X/week), over 5 weeks Uninjured controls = no treatment	(+) Dual-task performance improved in patients after treatment (F = 13.93; df = 1, 16; p = 0.002), but not in controls; gains maintained at 12 months (+) Transfer of training effects to other executive function tests (PASAT, Continuous Performance Task, Trail Making Test, Backward Digit Span; $p \leq 0.03$) at 12-month follow-up	(+)Decrease in patients' cognitive failures in daily life using the CFQ at 12-month follow-up
Chronic stage of recovery					
Evans et al., 1998	1 (AVM & stroke)	Single-subject study, ABAB design	Electronic cueing with a paging system over 3 months and task-specific checklist	(+) Clinically important improvements in all target tasks (medication adherence, plant watering, personal hygiene)	No report on transfer of skills
Fish et al., 2008b	1 (AVM & stroke)	Single-subject study, alternating treatments design	Electronic cueing with a paging system and task-specific checklist	(+) Significant improvement in target tasks (medication, morning and evening routine) following the use of the pager (p=10^{-8}) and the checklist ($p \leq 0.008$ for medication adherence and evening routine) compared to baseline (+) Pager more effective than checklist ($p \leq 0.0001$)	No report on transfer of skills
Fish et al., 2008a PEDro = 5	36	Randomized crossover trial	Electronic cueing with a paging system over 7 weeks *Group A: pager at T2* (n=24) *Group B: pager at T3* (n=12)	(+) Target behaviours improved when using the pager. At T2, Group A performed better than the pager-less Group B (75.1% vs 44.8% of tasks accomplished; z=2.953, p=0.003). (-) Benefits not maintained following withdrawal of the pager	No report on transfer of skills

Table 3.2 (continued): Summary of executive function interventions in persons with stroke

Author, year PEDro score	Sample size	Study design	Intervention	Outcome	Transfer/ generalization
Chronic stage of recovery (continued)					
Honda, 1999	3 (ACoA aneurysm rupture)	Single-subject study with multiple baseline	Self-instructional procedures, problem solving and physical exercises for 6 months	(+) Improvements on the Trail Making Test B and WAIS-R for the three participants; Tinker-Toy Test improved in 2/3 participants (-) No improvement in the Wisconsin Card Sorting Test	(+) Changes in a behavioural scale in 3/3 participants
Man et al., 2006 PEDro = 5	103 with ABI: 55 with stroke	RCT	Problem-solving skills training over 20 45-minute sessions + homework assignments IG 1 = computer-assisted training IG 2 = online interactive training IG 3 = face-to-face therapist-led training CG = no treatment	(+) Improvement of basic and functional problem-solving skills in quizzes in all IGs (+) Improvement of problem-solving in the *Category test* in all IGs ($p \leq 0.01$) but not the CG ($p = 0.12$) (+) Greater improvement of problem-solving *self-efficacy* in the face-to-face training group (F = 6.45; $p = 0.003$)	(+) Improvement in IADLs in all IGs ($p < 0.01$) but not CG ($p = 0.27$)
Rand et al., 2009b	4	Pre-post	Training in multitasking using a virtual reality shopping task, 10 60-minute sessions, 3 weeks	(+) Improvement ranging from 8% to 51% for all scores on the Multiple Errands Test-Hospital Version in a real mall and in a virtual mall using the Virtual Multiple Errands Test	(-) Little or no change in other IADLs
Schweizer et al., 2008	1 (cerebellar haemorrhage following AVM rupture)	Pre-post	Goal management training, 7 weekly 2-hour sessions	(+)At post-intervention: improvements in executive function tests (Sustained Attention to Response Task and Tower test) (+) Gains maintained at 4-month follow-up	(+) Executive functioning in daily life (DEX proxy version)

Table 3.2 (continued): Summary of executive function interventions in persons with stroke

Author, year PEDro score	Sample size	Study design	Intervention	Outcome	Transfer/ generalization
Chronic stage of recovery (continued)					
Vallat et al., 2005	1	Single-subject study with multiple baseline	Verbal working memory training, 3 1-hour sessions per week, 6 months	(+) Tests of working memory and attention (-) Non-targeted tasks of verbal fluency and long-term memory	(+) Questionnaire on everyday working memory functioning (+) Verbal communication questionnaire
Westerberg et al., 2007 PEDro = 5	18	RCT	IG = Home-based computerized training of working memory, 40-minute sessions, 5 days a week, 5 weeks CG = no treatment	(+) Significant differences favouring the IG on measures of working memory and attention: Span Board: ES = 0.83; $p = 0.05$ Digit Span: ES = 1.58; $p = 0.005$ PASAT: ES = 0.61; $p = 0.001$ Ruff 2&7: ES = 0.81; $p = 0.005$ (-) Stroop test, Raven's matrices and word list learning	(+) Decrease in cognitive failures in daily life using the CFQ (ES = 0.80; $p = 0.005$)

(+) = significant improvement; (-) = not significant; ABI = acquired brain injury; ACoA = anterior communicating artery; AVM = arteriovenous malformation; CFQ = Cognitive Failures Questionnaire; CG = control group; ES = effect size; DEX = Dysexecutive questionnaire; IG = intervention group; IADL = instrumental activities of daily living; PASAT: Paced Auditory Serial Addition Task; RCT = randomized controlled trial

BRIDGING MANUSCRIPT

The reviews of the two bodies of literature on executive function (EF) assessment and intervention post-stroke (in Chapters 2 and 3) allowed me to plan the pilot randomised controlled trial described in the present chapter. My systematic review of EF interventions identified different treatment approaches that were showing promise in helping persons with stroke to cope with EF deficits. The preliminary evidence on specific EF skill retraining suggested that structured, individualized and intense computerized EF training could improve targeted EF impairments (Stablum et al., 2000; Westerberg et al., 2007) but whether these interventions would impact at the activity and participation levels of functioning required further investigation. The evidence from studies on cognitive strategy training also supported the use of explicit strategies applied to ecologically relevant problems to improve some EF impairments (e.g., planning and problem-solving) and, possibly, real-world activities (Man et al., 2006; Schweizer et al., 2008). However, further research was required to compare the impact of these different intervention approaches on a variety of outcomes, including not only measures of EF impairment, but also measures of daily activities and participation in everyday life situations that are affected in persons with EF disorders. While many studies have used impairment measures to evaluate the effect of treatment on cognition/executive function, I thought it important to also incorporate ecologically valid EF assessments that reflect everyday behaviours, as described in the first manuscript (in Chapter 2).

Taking into consideration the key findings from these reviews, I designed and implemented a pilot randomized controlled trial to determine the feasibility and preliminary efficacy of two promising interventions, a strategy-training approach – the CO-OP approach which is based on the use of meta-cognitive problem-solving strategies to achieve self-selected functional goals – and a computer-based EF training program. As further described in Chapter 4, the study compared the preliminary efficacy of these interventions on a variety of outcomes covering the spectrum of impairment, activity and participation levels of assessment identified by the ICF conceptual framework. This manuscript will be submitted for publication to the *Neuropsychological Rehabilitation* journal after the oral examination of this thesis.

CHAPTER 4: *Manuscript 3*.

Comparison of two novel interventions for adults experiencing executive dysfunction post-stroke: a pilot study

From: Poulin, V., Dawson, D., Bherer, L., Lussier, M., & Korner-Bitensky, N. **Comparison of two novel interventions for adults experiencing executive dysfunction post-stroke: a pilot study**. *To be submitted to Neuropsychological Rehabilitation journal.*

Valérie Poulin, MSc, PhD candidate in Rehabilitation Science, School of Physical and Occupational Therapy, McGill University, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Montreal, Quebec.

Nicol Korner-Bitensky, PhD, Professor, School of Physical and Occupational Therapy, McGill University, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Montreal, Quebec.

Deirdre R. Dawson, PhD, Associate Professor, Department of Occupational Science & Occupational Therapy & Graduate Department of Rehabilitation Sciences University of Toronto, Senior Scientist, Rotman Research Institute, Baycrest, Member, Heart and Stroke Foundation Centre for Stroke Recovery, Toronto, Ontario.

Louis Bherer, PhD, Professor, Department of Psychology and PERFORM Centre, Concordia University, Montreal, Quebec.

Maxime Lussier, PhD candidate, Department of Psychology, University of Québec at Montreal, Montreal, Quebec.

Correspondence:

Valérie Poulin

School of Physical and Occupational Therapy, McGill University

3630 Promenade Sir-William-Osler

Montreal, Quebec, H3G 1Y5

Email: valerie.poulin2@mail.mcgill.ca

Telephone: (514) 398-5457

Fax: (514) 398-4874

Acknowledgments

This study was carried out with financial support from the Richard and Edith Strauss Canada Foundation. Valérie Poulin was also supported by a PhD fellowship award from the Fonds de recherche du Québec – Santé at the time of the study. Nicol Korner-Bitensky was supported by the Canadian Stroke Network. Louis Bherer was supported by the Canadian Research Chair program. Finally, we are especially thankful for the time and energy given to this project by our research participants and their significant others.

ABSTRACT

Rationale: Disorders in executive function (EF) are common post-stroke and play a critical role in recovery. Much still remains to be learned about the impact of various interventions used to treat executive dysfunction; especially in improving real-life functioning post-stroke.

Objective: This pilot study compared two promising interventions to improve EF and functional skills after stroke: 1) an adapted version of the Cognitive Orientation to daily Occupational Performance (CO-OP) approach, a problem-solving approach that entails guiding participants to set self-selected functional goals, develop plans, carry out their plans and verify goal attainment; and, 2) Computer-Based EF Training (Computer).

Methods: Pilot partially randomised controlled trial for persons with subacute stroke experiencing EF deficits. Participants received 16 hours of either CO-OP (n=5) or Computer training (n=4). At three time-points (baseline, post-intervention, and one month follow-up), participants' performance and satisfaction with performance on self-selected functional goals were measured using the Canadian Occupational Performance Measure. Significant others also rated participants' performance on each goal. Other outcomes included changes in EF impairment, participation in everyday life and self-efficacy.

Results: Both groups demonstrated clinically important improvements on their self-identified functional goals immediately post-intervention and at 1-month follow-up (CO-OP=63-83% of all goals improved; Computer=60-90%). The significant others' reports corroborated these findings (CO-OP=59-91% of all goals improved; Computer=53-68%). Improvements in some other outcomes were also observed, and differed by intervention.

Conclusions: Our findings provide preliminary evidence supporting the feasibility and efficacy of using both CO-OP training and Computerized EF training for select patients with executive dysfunction post-stroke.

Keywords: executive function, cognitive rehabilitation, strategy training, computerized training, stroke

INTRODUCTION

Disorders in executive function (EF) represent one of the most common sequelae of stroke, occurring in an estimated 19 to 75 percent of survivors (Lesniak, Bak, Czepiel, Seniow, & Czlonkowska, 2008; Riepe, Riss, Bittner, & Huber, 2004; Zinn, Bosworth, Hoenig, & Swartzwelder, 2007) depending on the domains measured and definition used. EF refers to "high-level cognitive functions that provide control and direction of lower-level, more automatic functions" (Stuss, 2009, p. 8) including: initiation, planning, sequencing, monitoring, problem-solving, divided attention, flexibility, working memory and inhibition (Anderson, 2008; Godefroy & Stuss, 2007; Lezak, 1989; Stuss, 2009). EF deficits affect participation in rehabilitation and recovery (Lesniak et al., 2008; Skidmore et al., 2010) with a higher risk of functional dependence (Lesniak et al., 2008), failure to return to work (Ownsworth & Shum, 2008) and poor social participation post-stroke (McDowd, Filion, Pohl, Richards, & Stiers, 2003).

Our recent systematic review on the effectiveness of EF interventions post-stroke found limited but encouraging evidence to suggest that persons with stroke can benefit from retraining specific EF skills (e.g., computerized EF skill training) and using compensatory strategies (e.g., problem-solving strategies and external cueing systems) (Poulin, Korner-Bitensky, Dawson, & Bherer 2012). To elucidate, carefully designed computerized training programs have been shown to improve specific EF processes such as dual-tasking (i.e. the ability to coordinate two actions) (Stablum, Umilta, Mogentale, Carlan, & Guerrini, 2000) and working memory (Lundqvist, Grundström, Samuelsson, & Rönnberg, 2010; Westerberg et al., 2007), with some preliminary indication of generalization to daily life tasks (Lundqvist et al., 2010; Stablum et al., 2000; Westerberg et al., 2007). Interventions focused on teaching compensatory cognitive strategies (e.g., problem-solving strategies) and using external aids (e.g., paging systems) also show promise in reducing the daily consequences of EF deficits (Poulin et al., 2012). These results come largely from studies of individuals in the chronic phase post-stroke and thus leave unanswered questions regarding effectiveness of these interventions earlier post-stroke.

Much still remains to be learned about the impact of various EF interventions on real-life functioning after stroke. Reviews of EF interventions in populations with acquired brain injury including stroke have reported preliminary evidence of transfer and generalization to everyday activities (Cicerone et al., 2005, 2011; Kennedy et al., 2008) with a key component of intervention being the use of explicit strategies applied to ecologically relevant problems (Dawson et al., 2009a; Man, Soong, Tam, & Hui-Chan, 2006; Schweizer et al., 2008). For example, transfer of skills is likely to be enhanced when therapy is provided in the person's own environment and when the chosen activities are relevant to the person (Powell, Heslin, & Greenwood, 2002). An intervention reflecting these key principles of cognitive strategy training is the «*Cognitive Orientation to daily Occupational Performance (CO-OP) approach*» (Polatajko & Mandich, 2004), which guides the individual to use a global problem-solving strategy to perform three self-identified functional tasks that they want to improve. This intervention originally developed for paediatric use in children with Developmental Coordination Disorder (DCD) was later adapted for adults with traumatic brain injury (TBI) (Dawson et al., 2009a) and stroke (McEwen et al., 2009) by two groups of researchers taking different directions. McEwen and colleagues (2009) adapted and used CO-OP as a cognitive approach to address motor performance problems in persons with chronic stroke. Findings from their two single-case studies suggested improvements in motor and functional skills, with some evidence of transfer of training to untrained skills (McEwen et al., 2009, 2010b). Dawson and colleagues (2009a) adapted and extended the key elements of the original CO-OP protocol – namely, the emphasis on training of higher-order cognitive strategies for planning and self-regulating performance and their application to meaningful, self-selected real-world activities – to specifically address everyday problems that arise from EF impairment in adults with TBI. Their initial pilot work with three adults with executive dysfunction following

TBI also indicated clinically significant improvements on both trained and untrained everyday activities. In very recent years, several other pilot studies have reported on the positive effects of CO-OP in adult populations with cognitive impairments (Dawson et al., 2013a, 2013b; Ng, Polatajko, Marziali, Hunt, & Dawson, 2013), including stroke (Skidmore et al., 2011, 2013), but none have compared CO-OP to other interventions that also target EF impairments.

This evidence suggested the directions for the current research. First, it would be important to study the effects of intervention earlier post-stroke; when the impact of treatment might potentially have a greater potential to enhance rehabilitation and recovery. As well, the benefits of direct remediation/EF skill training versus compensatory strategy training have never been studied. As such, there is little to guide clinical practice decisions on the specific relative impact and advantages of different EF interventions. Thus, the general purpose of the study presented here was to determine, prior to undertaking a larger trial, the feasibility and preliminary efficacy of two promising interventions, the CO-OP intervention and a computer-based EF training program, in persons with EF deficits in the sub-acute phase after stroke. More specifically, the first objective was to test the feasibility of participant recruitment and retention, the acceptability of assessment and intervention procedures, and the adherence to the interventions. The second objective was to compare the preliminary efficacy of CO-OP versus COMPUTER training in improving EF impairment; and, in improving performance and satisfaction with performance, in participant-chosen everyday activities immediately after the intervention and one month later. Finally, the third objective was to explore the relative efficacy of these interventions in producing transfer of training effects; specifically, improved performance, and, satisfaction with performance, in untrained participant-chosen everyday activities and in measures of instrumental activities of daily living (IADLs), social participation, self-efficacy for performing everyday activities and EF symptoms in everyday life, immediately after the intervention and one month later.

As previous work with CO-OP in adults shows evidence of improvement in everyday activities (Dawson et al., 2013a, 2013b; Ng et al., 2013; Skidmore et al., 2011, 2013), we hypothesized that participants receiving CO-OP would show greater improvement in performance and satisfaction with performance in participant-chosen everyday activities, as compared to participants receiving computer-based general EF training. As well, we hypothesized that the COMPUTER group would show more improvement than the CO-OP group on the EF impairments targeted by the computerized tasks – including working memory, inhibition, divided attention and cognitive flexibility – based on the evidence from previous studies on computer-based EF skill retraining (Lundqvist et al., 2010; Stablum et al., 2000; Westerberg et al., 2007). Finally, given the emphasis in CO-OP on training participants to generalize and transfer their learning to novel everyday life situations (Dawson et al., 2009a), we hypothesized that the CO-OP intervention would result in greater transfer of training effects – as evidenced by significantly improved performance and satisfaction with performance in untrained participant-chosen everyday activities, and in measures of IADLs, social participation, self-efficacy for performing everyday activities and EF symptoms in everyday life.

METHOD

Overview of Design

This study was a pilot single blind, stratified, multi-site partially randomized controlled trial. The first two participants received CO-OP due to practical constraints and medical conditions that may have interfered with the computerized training; the next nine participants were randomly allocated according to severity of EF impairment (see procedures for details) to receive CO-OP or computer training, with both offered with the same intensity – 16 one-hour sessions, twice weekly, for eight weeks. Each participant was assessed at baseline (T0), immediately post-intervention (T1) and one month post-intervention (T2) by a blinded evaluator using standardized measures of impairment in EF, IADLs, social participation, self-efficacy for performing everyday activities and EF symptoms in everyday life. As well, the Canadian Occupational Performance Measure (COPM) (Law et al., 2005) was used at baseline to guide the participant to identify a minimum of five individualized goals for everyday activities s/he wanted to improve upon (e.g., do the grocery shopping, prepare meals, effectively communicate in stressful interactions with children; or, resume a leisure activity such as using the internet). After identifying these goals, and again using the COPM, the participant (and when available, a significant other) rated current performance and satisfaction with performance in each goal: these ratings were repeated immediately post-intervention and one month post-intervention. In the CO-OP intervention, three of these goals were specifically trained; in the COMPUTER intervention, only general EF training was provided. The study protocol was approved by the McGill University Institutional Review Board, Montreal, Canada, as well as by the research ethics committees of individual hospitals and rehabilitations centres from which participants were recruited.

Participants

Patients with stroke were recruited from a multi-site acute care hospital and six rehabilitation centres in and around Montreal, Quebec, Canada. The following inclusion criteria were applied: diagnosis of first or recurrent stroke within the previous 12 months; evidence of EF deficits as identified using the Trail Making Test (TMT) B (Army Individual Test Battery, 1944) (1½ standard deviations (SD) below age and education matched norms (Tombaugh, 2004) *or* an indication of executive dysfunction according to the clinical observations of the treating clinician; a score $\geq$22/30 on the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975); living at home at the time of baseline assessment; proficiency in English or French; and ability to identify some day-to-day difficulties on which to base goals of treatment (i.e. self-selected goals). Potential participants were excluded if they had a history of severe psychiatric problems; severe visual problems not sufficiently corrected with corrective lenses to allow reading and computer use; important language deficits as indicated by a score of <4 on the communication items of the Functional Independence Measure (FIM), indicating the need for moderate, maximal or total assistance (Granger, Hamilton, Keith, Zielezny, & Sherwins, 1986); and/or pre-existing disabling neurological conditions including Alzheimer's disease, Multiple Sclerosis or Parkinson's disease, as noted in the medical chart.

Each patient was also asked to agree to have a significant other of their choice recruited to participate in three short interviews: at baseline; post-intervention; and, at one-month follow-up; to rate their perception of the patient's performance and satisfaction with performance, on each goal identified at baseline by the patient. The criteria for significant other inclusion were: 18 years of age or older; close friend or family member who spends time at least once a week with the participant; and, proficiency in English or French. The presence of a significant other was not an eligibility criterion for patient participation.

Procedures

Prior to initiation of the pilot trial, specifically to help refine both interventions, the research team conducted interviews with clinicians and researchers who had expertise in EF as well as the interventions of interest. These were conducted either individually or in small groups. Each interview covered topics such as eligibility criteria for participation; optimal timing and intensity; potential challenges faced when using these interventions with persons with motor and/or cognitive impairments; and, relevant changes recommended to adapt the interventions when challenges arose. Also, two workbooks (one describing the CO-OP training; the other the COMPUTER training) were prepared to guide the clinician in providing the interventions.

Screening for inclusion and stratification

Once the refined intervention protocols detailing the assessment and intervention procedures were ready, and the research therapist's training on how to provide both interventions was complete, we recruited participants. Potential participants were referred by the various clinical coordinators or treating clinicians of the participating sites; or, were identified through hospital records. The research coordinator, who was an occupational therapist with experience in stroke rehabilitation, met with the patient at his/her home to explain the study; to establish willingness to participate; and, to further screen for eligibility. The TMT B score obtained at pre-screening (or, in a few cases, at baseline assessment as noted below[2]) was used to identify EF impairment as well as to identify the stratum in which the participant was to be allocated (i.e. *mild* versus *moderate to severe* EF impairment). More specifically, stratification was based on a cut-off of $\leq$ 2 SD (i.e. mild impairment[3]) *versus* $\geq$ 2 SD (i.e. moderate to severe impairment) below age and education matched norms on TMT B (Tombaugh, 2004). The cut-off was determined based on previous work specific to IADL with individuals with mild to moderate cognitive impairments post-stroke (Mazer, Korner-Bitensky, & Sofer, 1998) and commonly accepted classifications of neuropsychological test scores (Strauss, Sherman, & Spreen, 2006).

---

[2] Note: In some cases, when the presence of executive dysfunction was already confirmed by the observations of the treating clinician who referred the participant, the TMT was not used at pre-screening. Rather, it was administered at baseline assessment – usually less than one week after pre-screening – and then again at post-intervention and one-month follow-up along with the other outcome measures (see Measures section). As well, when the TMT was administered at pre-screening, it was not administered again at baseline assessment to avoid repeated assessment over a very short time interval; it was only re-administered at post-intervention and one-month follow-up.

[3] Since the inclusion criterion mentioned previously was 1.5 SD below age and education matched norms, this means that mild EF impairment would fit within 1.5-2 SD below norms. However, it should be noted that we also included in this category participants performing in the normal range on the TMT B (<1.5 SD below norms) but showing evidence of executive dysfunction according to the clinical observations of the treating clinician.

Baseline assessment

Those who were eligible based on the initial screening, and who agreed to participate, underwent baseline assessment in their living environment. Assessment was performed by a blinded evaluator – an occupational therapist rigorously trained in the administration of all the assessment tools. The evaluator attended five two-hour training sessions that consisted of structured presentations, demonstrations, video observation, practice/simulations and feedback on the administration of the tools; and was provided with a detailed instruction manual in both French and English.

Randomization

After completion of the baseline assessment, [with the exception of the first two participants] eligible participants were randomly allocated to either the CO-OP or COMPUTER group within the stratum consisting of severity of executive dysfunction. The sequence of random assignments was generated using a random numbers table in blocks of 6; and was maintained in sealed opaque envelopes that were prepared prior to recruitment and revealed only when a participant had completed the baseline assessment.

Intervention Details

Both interventions were provided on a one-on-one basis in the participants' homes by an occupational therapist with expertise in stroke rehabilitation; both with the same planned frequency and intensity – 16 one-hour sessions, twice a week, for eight weeks. The intensity and frequency were determined based on findings from previous studies as further detailed in the next section. Participants were offered frequent breaks to prevent fatigue, particularly in the early phases of the training.

If a participant was receiving the CO-OP intervention, three of their individualized goals as determined at baseline were specifically trained; in the COMPUTER group only general EF training was provided.

CO-OP intervention

The CO-OP intervention is described as a "client-centred, performance-based, problem-solving approach that enables skill acquisition through a process of strategy use and guided discovery" (Polatajko & Mandich, 2004, p. 2). The use of a four step problem-solving strategy – where the person is to identify a specific goal, plan concrete steps to achieve that goal, carry out the plan, and check the results – forms the basis of the approach and supports the acquisition of three self-selected functional goals. In the CO-OP intervention, the therapist facilitates the individual's assessment of their performance and guides them to discover solutions to their performance problems by asking thought-provoking questions and by providing feedback, coaching, or modeling, but without explicit directed instructions on what they should do. This is in contrast to other forms of intervention where the clinician typically provides explicit information on how to perform a task.

The original CO-OP protocol developed for children with DCD included 10 one-hour sessions. We increased the number of sessions from 10 to 16 sessions lasting approximately one hour (depending on the participant's tolerance) – based on the findings from a preliminary study (Dawson et al., 2009a) suggesting that adults with cognitive impairment might benefit from additional CO-OP training sessions to address complex goals and to further support the autonomous use of the strategies in tasks of everyday life. As well, we used the adapted version of the CO-OP approach from Dawson et al. (2009a) including: changing the script introducing the problem solving strategy to make it appropriate for adults; using a personalized binder with goal sheets that the individual could use to keep track of his/her goals and plans and to record the results obtained; using additional guided discovery probes; and, placing more emphasis on training generalization and transfer of skills during the sessions.

In session #1, three of the five functional goals identified by the participant at baseline were chosen to be addressed. To select these three "trained goals" the research therapist (hereinafter referred to simply as "therapist") asked the participant to identify his or her most important goal and this goal was retained for training; the other two goals to be trained were randomly chosen from the remaining four. The participant's baseline performance in each trained goal was then determined by the therapist either through discussion and/or direct observation of task performance (depending on the goal). This process also helped the therapist identify problems/concerns with achieving the goal that could be worked on in subsequent sessions.

In CO-OP session #2, the participant was introduced to the global problem-solving strategy that is the foundation of the CO-OP method using a script and a cue card with the terms "Goal-Plan-Do-Check" written on it (Dawson et al., 2009a). The participant was then guided on how to apply the global problem-solving strategy to address the three trained goals. Depending on the participant's goals, the intervention was conducted through talking about plans and strategies for skill acquisition; through doing functional tasks in the participant's own environment and/or through homework (see Appendix 4.1 for an example of a trained goal and how it was addressed during the training sessions in the present study).

In each session, participants were encouraged to write down their plans in a personalized binder with goal sheets provided by the therapist, and to record the results obtained (i.e., whether the plan worked or not) after executing each plan and checking goal attainment (Dawson et al., 2009a). Transfer of training was also built into the sessions by eliciting discussions with the participant – at both the beginning and towards the end of each session – on how s/he had used, or could use, the problem-solving strategies in different situations (Dawson et al., 2009a). As well, in the last five sessions, the participant was encouraged to document how s/he would continue using the strategy upon completion of the training sessions (Dawson et al., 2009a).

Finally, given that another component of the CO-OP intervention is the training and involvement of the significant other to support the participant in using CO-OP techniques, if one was available, the significant other was encouraged to observe some sessions and to support the participant in the application of the strategies and the newly learned skills outside of the training sessions.

Computerized executive function training

Our overall goal in creating the COMPUTER training program was to include a variety of computerized activities with multiple EF requirements that could be used in a home-based setting with persons with varying levels of motor and cognitive / EF deficits and in both French and English language. To determine the contents/software to be used we conducted two structured reviews on software available for EF retraining (see the Stroke Engine Intervention website at http://strokengine.ca/intervention/pdf/REVIEW_OF_COMPUTER-BASED_PROGRAMS.pdf) and on the efficacy of computer-based cognitive training post-stroke (Poulin et al., 2012), and we consulted with expert researchers in computer-based EF training.

The training program was prepared in workbook format and included four tasks of the NeuroActive software involving working memory, cognitive flexibility, divided attention and inhibition (Brain Center International Inc., Quebec, QC); three divided attention tasks from the Attentional software (Le Réseau Psychotech Inc., Quebec, QC); as well as two computerized tasks designed for inhibition training (Lyrette, 2009) and dual-task training (Lussier, Gagnon, & Bherer, 2012) previously validated by two of the authors (LB and ML), for a total of nine different computer activities to be used.

These software programs all adjust the level of difficulty – for example, by reducing or increasing the number of task stimuli or the time allocated between a stimuli presentation and the user's response. Frequent individualized feedback regarding task performance is also provided on the computer screen within the software's feedback – with visual or auditory rewards for correct versus incorrect responses. Most of these computer activities also offer the advantage of reproducing typical everyday situations such as riding a bike on a busy street i.e. as in the Attentional software (Le Réseau Psychotech Inc., Quebec, QC); or, recalling and dialing a phone number in the task "Call Center" in the NeuroActive software (Brain Center International Inc., Quebec, QC). Depending on the task, the participant needs to respond either by pressing a key on the keyboard, by clicking on the mouse or by using a steering wheel and pedals.

During the first COMPUTER training session, the therapist evaluated the participant's basic computer skills and offered instructions if needed (i.e., use of the mouse and keyboard). Each training session consisted of three to four computer-based activities targeting different EF processes and involving different visual and/or auditory stimuli and response demands (see Table 4.1 for an excerpt of a typical session). Each software program was attempted once with the tasks/games first introduced at a low level of difficulty and then progressing to more difficult levels according to the participant's baseline level or as he/she improved. The participant was asked to read the instructions on the computer screen; then, the therapist further explained and demonstrated the task and the participant completed a practice trial before beginning the activity. The therapist observed the participant performing all the tasks and provided verbal encouragement. The therapist also provided verbal and/or physical assistance if the participant had difficulties understanding the instructions and/or performing a task (e.g., difficulty using the mouse in some tasks). The significant other (when available) was also invited to attend a part of some sessions.

Therapist training

The occupational therapist administering the CO-OP and the COMPUTER interventions received rigorous training. Specifically, to learn the CO-OP intervention techniques, she completed a formal CO-OP training workshop plus two days of discussion and video observation with clinicians and researchers who had used this intervention with an adult population (Dawson et al., 2009a). During the intervention phase, the CO-OP sessions were videotaped and a member of the research team experienced in the use of the CO-OP approach (DD) reviewed video recordings of the sessions to provide feedback regarding the use of CO-OP techniques.

The training for the COMPUTER intervention included three, one-hour individual training sessions plus short phone meetings with team members (LB, ML and Francis Langlois) who had designed and/or tested EF training software in older adult populations. The training sessions consisted of demonstrations and explanations on how to use the software and how to provide instructions and performance feedback to participants; and, also, recommendations to prevent mental fatigue and maintain the participant's motivation.

During the intervention phase, weekly discussions with the research team were also conducted to exchange feedback i.e. - to decide how to adjust the sessions according to specific patient circumstances (e.g., illness, stress, decrease in participant's engagement in the study intervention, participant experiencing difficulties performing some training tasks, etc.).

Measures

Screening variables

The standardized screening tools included the TMT B (Army Individual Test Battery, 1944), which is a widely used test to assess attention and EF in persons with stroke (Asimakopulos et al., 2011) and is a predictor of higher level functional outcome post-stroke (Mazer et al., 1998). The MMSE (Folstein et al., 1975) was also used to quickly screen for cognitive impairment and to assist in identifying potential participants who have sufficient cognitive ability to participate in interventions and to respond to self-report measures (Bedard et al., 2003; Folstein, Folstein, McHugh, & Fanjiang, 2001). A study from Blake, McKinney, Treece, Lee and Lincoln (2002) suggested that a cut-off of <24 out of 30 was optimum for the detection of cognitive impairment after stroke, with good specificity (88%) and moderate sensitivity (62%). Finally, the FIM (Granger et al., 1986) Communication items – Comprehension and Expression – were rated on a 7-point Likert scale from 1 (total assistance) to 7 (total independence).

Sociodemographic and clinical variables

Participant information included: age, sex, level of education, living situation and handedness. Stroke-specific information on the patient included: lesion location; time since stroke; type (hemorrhagic or ischemic); and, associated co-morbidities as determined from a medical chart review. Frequency, duration and content of other potential outpatient services received during the study intervention, such as occupational therapy or physiotherapy, and other community based activities that might potentially influence cognitive and psychosocial outcomes were also recorded weekly by the therapist providing the study intervention. As well, at each session the participant was queried about any potential negative events that had occurred since the previous session (e.g., a fall, illness, change in medication, or hospitalization) and this information was recorded.

Feasibility of Recruitment and Protocol Adherence

Rates of eligibility, recruitment, adherence to the intervention both in time and frequency, and, completion of outcome assessment sessions were recorded. The reasons for exclusion and refusal were documented. During the intervention phase, the therapist's perception of the participant's engagement in the intervention sessions was assessed using the Rehabilitation Therapy Engagement Scale (Lequerica et al., 2006) – at the end of the first and last week. The therapist also recorded detailed field notes after each session that included a description of the activities undertaken as well as any challenges encountered (e.g., participant experiencing difficulties in understanding the instructions and/or in performing the tasks, frustration with certain tasks, etc.).

As well, when administrating the outcome evaluations the blinded evaluator asked each participant to rate their satisfaction with the study interventions post-intervention and at one-month follow-up using one standard question "*How satisfied are you with the intervention you received during this study?*" scored from 0 (very dissatisfied) to 4 (very satisfied). She also administered a semi-structured interview regarding experiences with the study interventions at follow-up assessment to elicit feedback on the most preferred and disliked aspects of the treatment, the perceived benefits of the treatment as well as suggestions for modifications. Finally, after each evaluation session, the evaluator also elicited the participant's perceptions of the acceptability of the assessment procedures (e.g., duration of the sessions, order of the tests, etc.) and noted any problems/concerns that arose in administering the measurement instruments (e.g., fatigue, frustration, etc.).

Intervention outcomes

Outcomes were chosen based on their ability to assess not only change in EF impairment, but also change in the areas of activity and participation as defined by the World Health Organization (WHO)'s International Classification of Functioning, Disability and Health (ICF) (WHO, 2001). Two structured reviews of EF tools conducted by our research team (Asimakopulos et al., 2011; Poulin, Korner-Bitensky, & Dawson, 2013) and a review of outcome measures in stroke rehabilitation (Salter et al., 2012) enabled us to select measures that would have sound psychometric properties specific to a stroke population, particularly the ability to be responsive to change; that would be feasible and acceptable given the practical constraints of the study (e.g., administration time, training requirements, etc.) and that would measure the constructs of interest here including: performance and satisfaction with performance in participant-chosen goals, EF impairment, IADLs, social participation, self-efficacy for performing everyday activities and EF symptoms in everyday life. It should be noted that some measures did not have responsiveness data but had good face validity to detect change and so were included.

The Canadian Occupational Performance Measure (COPM) (Law et al., 2005) was selected as the primary outcome to detect change in performance, and satisfaction with performance, in the participant's chosen goals. The COPM is administered as a semi-structured interview through which the participant describes his/her current performance in everyday life activities; identifies activities that are difficult for him/her; and rates their importance on scale from 1 "not at all important" to 10 "extremely important". In collaboration with the interviewer, the participant is then asked to prioritize these activities and to select specific functional goals – usually five goals – s/he would like to address in the course of the intervention. Each goal is scored by the participant according to his/her current performance using a 10-point scale with 1 being "not able to do it at all" and 10 being "able to do it extremely well". Satisfaction with performance is also rated on a similar scale from 1 “not satisfied at all” to 10 “extremely satisfied”. The COPM has demonstrated good test-retest reliability in patients with stroke (Spearman’s rho correlation coefficients: 0.89 for performance scale and 0.88 for satisfaction scale) (Cup, Scholte op Reimer, Thijssen, & van Kuyk-Minis, 2003). Several studies also support the criterion concurrent validity and the construct convergent/divergent validity of the COPM (Law et al., 2005), including with patients post-stroke (Cup et al., 2003). A change score of 2 points has previously been validated as indicating a clinically important difference in a sample of 108 patients within geriatric, neurologic and orthopaedic rehabilitation (Wressle, Samuelsson, & Henriksson, 1999).

The Trail Making Test (TMT) (Army Individual Test Battery, 1944), the Color-Word Interference Test (CWIT) from the D-KEFS (Delis, Kaplan, & Kramer, 2001), the Digit Span from the Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV) (Wechsler, 2008) and a letter span task (M. Renaud & L. Bherer, personal communication, June 1, 2011) were used to measure the effect of treatment on EF impairment, more specifically, the EF processes of cognitive flexibility, divided attention, inhibition and working memory. The Trail Making Test (TMT) (Army Individual Test Battery, 1944) measures speed, attention and cognitive flexibility, which is an executive process referring to the ability to quickly shift between different actions, tasks or concepts (Anderson, 2008). This test has two parts (A and B). In part A, the participant has to 'connect-the-dots' of 25 consecutive numbers on a sheet of paper (1,2,3, etc.), which requires visual attention and speeded performance. Part B is closely related to EF, especially the processes of divided attention and cognitive flexibility, because the participant needs to alternate between numbers and letters (1, A, 2, B, etc.). Scoring was expressed in terms of the time taken to complete each part.

The Color-Word Interference Test from the D-KEFS (Delis et al., 2001) was selected as a measure of cognitive flexibility and *inhibition* – assessing the ease with which a person can stop or suppress an overlearned response in favor of a less familiar one (Strauss et al., 2006). This test includes four sub-tasks in which the person has to name color patches *(condition 1 – denomination)*, read color words in black ink *(condition 2 – reading)*, name the ink color in which color words are printed when the color and the word do not match (e.g., RED) *(condition 3 – inhibition)*, and switch back and forth between naming the dissonant ink color and reading the actual word *(condition 4 – inhibition/flexibility)*. The variable of interest here was the time taken to complete each sub-task.

Finally, the Digit Span from the WAIS-IV (Wechsler, 2008) and a letter span task (M. Renaud & L. Bherer, personal communication, June 1, 2011) were used to measure working memory, which is another executive process responsible for the temporary storage and manipulation of information (Van der Linden, Poncelet, & Majerus, 2007). The Digit Span consists of three subtasks – Digit Span Forward (DSF), Digit Span Backward (DSB) and Digit Span Sequencing (DSS) – where the participant is read a sequence of numbers and is asked to repeat the numbers in the same order as presented (DSF); in reverse order (DSB); or in ascending order (DSS). Given that the COMPUTER intervention included one training task similar to the Digit Span test, it was deemed relevant to also add a letter span task measuring other verbal working memory skills not directly trained during treatment. The letter span task (M. Renaud & L. Bherer, personal communication, June 1, 2011) followed a similar procedure as the Digit Span but with letters instead of numbers – requiring the participant to repeat a sequence of letters in the same order as presented; in reverse order; or in alphabetical order. For both tests – Digit Span and letter span – the number of correct sequences completed was recorded. With the exception of the letter span task, all of these neuropsychological EF tests have been widely used in persons with stroke (Hayes, Donnellan, & Stokes, 2011; Salter et al., 2012) and have well-established psychometric properties (Asimakopulos et al., 2011; Strauss et al., 2006). Although their responsiveness has not been formally evaluated in persons with stroke, the TMT, the CWIT and the Digit Span have been used in several RCTs

(Lundqvist et al., 2010; Westerberg et al., 2007) and single group pre-post studies (Kluding, Tseng, & Billinger, 2011; Rand, Eng, Liu-Ambrose, & Tawashy, 2010) to detect change following rehabilitation interventions post-stroke. In a single group pre-post study on the effects of a 6-month exercise and recreation program post-stroke, a moderate effect size (0.48) was reported for the change in performance on the Trail Making Test B (Rand et al., 2010). A large treatment effect was also found on the Digit Span (effect size = 1.58, $p<0.005$) in an RCT on computerized working memory training post-stroke (Westerberg et al., 2007). Similarly, significant treatment effects were reported for the CWIT (condition 4 – inhibition/flexibility) in another randomized crossover trial on computer-based working memory training with persons with stroke ($p<0.001$) (Lundqvist et al., 2010).

The Assessment of Life Habits (LIFE-H 3.1) (Fougeyrollas, Noreau, & St-Michel, 2002), which measures participation in 6 domains of daily activities (e.g., self-care and mobility) and 6 domains of social roles (e.g., interpersonal relationships and leisure) was used to explore any post-intervention transfer of training effects to social participation outcomes. The LIFE-H 3.1 is comprised of 77 items. The level of participation is evaluated on a scale from 0 to 9, by considering the degree of difficulty in carrying out each activity or role and the type of assistance required. The LIFE-H has adequate to excellent inter-rater and test-retest reliability and construct validity in a stroke population (Figueiredo, Korner-Bitensky, Rochette, & Desrosiers, 2010). Also, in a study by Rochette, Desrosiers, Bravo, St-Cyr/Tribble and Bourget (2007), the responsiveness of the LIFE-H was assessed in 35 clients with mild stroke: moderate changes in participation (effect size = 0.60) were reported from 2 weeks post-stroke to 6 months post-stroke. A change score of 0.5 point or more corresponds to a clinically important difference (Desrosiers et al., 2008).

The Self-Efficacy Scale for Performing Life Activities Post-stroke (Torkia, Gélinas, Korner-Bitensky, Rochette, & Sabiston, 2012) was used to measure self-perceived efficacy for accomplishing everyday activities. This questionnaire includes most of the items of the LIFE-H 3.1 but with the response choices eliciting information on confidence in ability to perform daily activities and social roles. Response options are presented on a visual analog scale from 0 to 10, with a higher score indicating better self-efficacy. In the present study, we only administered the items relating to the person's self-identified goals on the COPM. For example, if the participant had identified the goal – resumption of driving, we selected the corresponding item on the self-efficacy scale. This questionnaire has shown good face validity and adequate to excellent internal consistency (α=.74 to.93) in a sample of 50 individuals receiving inpatient stroke rehabilitation (Torkia et al., 2012).

The Instrumental Activities of Daily Living (IADL) Profile (Bottari, Dassa, Rainville, & Dutil, 2009a, 2009b, 2010) subtask "Obtaining information" was used to measure the impact of EF deficits on performance of an IADL task[4]. This task requires the person to use the telephone or Internet to obtain information on bus departure times. The evaluator assesses the individual's ability to plan and carry out the task and to verify attainment of the initial goal using a scale from 0 (dependent) to 4 (independence). Adequate inter-rater reliability of this task has been shown in persons with stroke (Dell'Aniello-Gauthier, 1994). The psychometric properties of the IADL Profile have also been extensively studied in persons with traumatic brain injury (Bottari et al., 2009a, 2009b, 2010), but no studies have examined its responsiveness.

The Dysexecutive questionnaire (DEX) (Wilson, Evans, Emslie, Alderman, & Burgess, 1998) was used as an additional indicator of generalization and transfer of training effects to EF in everyday life. This 20-item questionnaire elicits information on the frequency of day-to-day EF difficulties in four areas –

[4] Note: The same task is included in the ADL Profile (Dutil, Bottari, Vanier, & Gaudreault, 2005) but with a slightly different scoring scale from 0 (dependent) to 3 (independent), as described in our structured review of stroke-specific EF assessments (Poulin et al., 2013).

emotions/personality, motivation, behavior and cognition – using a five-point scale ranging from never (0) to very often (4). The maximum total score is 80. Evidence for reliability and validity of the DEX has been demonstrated in various populations with EF deficits (Bennett, Ong, & Ponsford, 2005; Odhuba, van den Broek, & Johns, 2005), including stroke (Barker, Morton, Morrison, & McGuire, 2011; Boelen, Spikman, Rietveld, & Fasotti, 2009; Chan, 2001). The responsiveness of the DEX has not been formally evaluated, but it has been used to detect change in an RCT with persons with acquired brain injury (ABI) including stroke (Spikman et al., 2010).

Sample size considerations

The originally intended sample size for this study was calculated considering the objective "to estimate the relative efficacy of CO-OP versus COMPUTER training in improving performance in participant-chosen goals", as measured using the COPM performance scale. The sample size calculation was based on preliminary data from two pilot studies – one partially randomized controlled group study estimating the effect of the CO-OP intervention versus no treatment in adults with TBI (n= 6 patients per group) (Dawson et al., personal communication in 2010 and findings published for full group in 2013) and one pilot RCT comparing the CO-OP approach (n=10) and a contemporary treatment approach with children with DCD (n=10 patients per group) (Miller, Polatajko, Missiuna, Mandich, & Macnab, 2001). Data from both studies suggested large group differences – in the order of 1 SD and greater – in COPM scores favoring the CO-OP intervention. Specifically, it was estimated that a sample of 14 participants per group would be required to detect a large effect (i.e. effect size of d = 1.22, based on preliminary data from Dawson et al. (personal communication in 2010 and findings published for full group in 2013) on the COPM performance scale with a statistical power of 80% and a 2-sided α error of 5% (Cohen, 1988; Soper, 2013), given an anticipated attrition rate of 15% (Spikman et al., 2010; Westerberg et al., 2007) (also see Table 4.2a). To accrue the required number of participants, a 12-month recruitment period was anticipated. However, the recruitment was slower than anticipated and, after 15 months of efforts using various recruitment strategies, it was decided to analyze data from the nine participants who had completed the study: five in CO-OP and four in COMPUTER group. Post-hoc power analyses indicated that this sample size only yields 30% power to detect a difference of this size (i.e. d = 1.22) with a 2-sided α error of 5%. As we became aware that we would not have enough statistical power to detect between-group differences (e.g., using a repeated-measures two-way analysis of variance), we did not perform these analyses. We elected to investigate whether there would be sufficient power to detect within-group change on the COPM performance scale following the interventions. It was estimated that a sample size of 4 would yield 80% power to detect a 2-point difference – corresponding to clinically meaningful change on the COPM scale – given a standard deviation of the differences of 1, at a two-sided significance level of 5% (Machin, Tan, & Campbell, 2009) (also see Table 4.2b). No adjustment for multiple testing of outcomes were made since in a pilot study a Type II error (i.e. concluding that the intervention is not effective when in fact it is) is of more concern than a Type I error (i.e. concluding that the intervention is effective when in fact it is not) (Rand et al., 2010). However, we are aware that this increased the chance of finding significant differences by chance alone (i.e. Type II error).

Data analyses

To evaluate the feasibility of recruitment and protocol adherence (Objective 1), we analyzed the rates of: recruitment including refusals, eligibility; adherence to the interventions and drop-outs; and, completion of assessments at the 3 time points. Descriptive analyses of the open-ended qualitative feedback from the participants regarding experiences with the study interventions and assessments; and the field notes kept by the therapist and the evaluator were used to determine the acceptability of the assessment and intervention procedures.

Descriptive statistics were used to characterize the final sample and to compare the two groups at baseline. To compare the preliminary efficacy of CO-OP versus COMPUTER training in improving the outcomes identified in objectives 2 and 3, data were analyzed at both individual and group levels. As a first step, we analyzed individual changes in scores on all outcome measures between pre (T0) and post intervention (T1), between pre (T0) and follow-up (T2) and between post intervention (T1) and follow-up (T2), and compared these scores with the established minimal clinically important difference (when available) for each measure (as described in Ries, Drake, & Marino (2010)). We compared the proportion of individuals in each group who changed/ remained stable on each outcome measure. Given that a number of methods have been proposed to define clinically important change (Crosby, Kolotkin, & Williams, 2003; Streiner & Norman, 2008) we undertook a series of steps in classifying change on each outcome. As a first step, a comprehensive literature review of every measure was undertaken to identify evidence on the responsiveness of each measure as well as the criteria for defining clinically meaningful differences. Different methods and criteria were used for determining individual change on each of the measure depending on the available psychometric evidence (see Table 4.3 for further details). For the primary outcome, COPM, a clinically significant change was indicated if there was a minimum of 2-point change on the COPM performance or satisfaction ratings (Wressle et al., 1999). We compared the proportion of goals achieved – based on a positive change of ≥ 2 points on the COPM performance and satisfaction scales (Wressle et al., 1999) – in each group using descriptive statistics. As well, for the CO-OP group, we compared the proportion of improved goals that were specifically trained versus those that were not directly trained during the study intervention using descriptive statistics. For three of the neuropsychological EF tests and for the DEX questionnaire, we used data from reliability studies to calculate Reliable Change Indices (Jacobson & Truax, 1991) for a 90% confidence interval as suggested in Strauss et al. (2006). When a measure did not have published psychometric evidence for defining clinically important change (i.e. for the Letter Span, the Self-Efficacy Scale and the IADL Profile), we examined the rating scale and the scores that could be derived in an attempt to identify a value that would be clinically meaningful (see Table 4.3 for further details).

To further explore the relative efficacy of CO-OP versus COMPUTER training (for objectives 2 and 3), effect sizes of each intervention and the ratio of CO-OP and COMPUTER effects' sizes (Figueiredo, 2009; Figueiredo et al., 2013) (i.e. effect size of CO-OP ÷ effect size of COMPUTER) were calculated for the nine outcome measures for the intervals from baseline (T0) to post-intervention (T1), from baseline (T0) to one-month follow-up (T2) and from post-intervention (T1) to one-month follow-up (T2). Effect sizes were calculated as the ratio of change score occurring between two time points to the standard deviation at baseline assessment. Small, medium and large effect sizes were labeled according to effect sizes of d=0.2, 0.5, and 0.8, respectively as per Cohen (1988). These analyses assisted in identifying the most responsive outcomes, at each point in time, and in estimating the required sample size for a RCT; and as well provided preliminary data for testing our original hypotheses regarding the relative efficacy of the CO-OP and COMPUTER interventions. To identify significant intra-group differences in the outcome measures across the three test periods (baseline, post-intervention and follow-up) Freidman Tests were used. If a significant difference was found, a Wilcoxon Test was used to further examine these differences. Analyses were performed by excluding participants who did not complete the interventions and the post-test evaluation. All analyses were carried out using SPSS System for Windows version 20 (SPSS Inc., Chicago, IL).

RESULTS

Recruitment and retention

Figure 4.1 provides details regarding enrollment, intervention allocation, follow-up, and analysis. Recruitment was undertaken in two phases: from May 2011 to September 2011 and from March 2012 to December 2012. It was estimated that a total 741 patients with a diagnosis of stroke were admitted to the participating sites during the recruitment period. This estimate was obtained by adding the number of patients with stroke admitted to each participating acute care hospital or rehabilitation center. The actual number of potential participants was likely lower because the same patient moves from hospital to rehabilitation center. A total of 58 persons with stroke were contacted and assessed for eligibility: 36% (21/58) were referred by the treating clinicians and 64% (37/58) were identified through the hospital records in one site. Among those referred, 38% (8/21) were eligible and agreed to participate; 11% (4/37) of the participants identified through hospital records were also eligible and agreed; for a total of 12 participants. The reasons for ineligibility and refusal are described in Table 4.4. It should be noted that the initial protocol for this pilot study stipulated that eligible participants had to be less than six months post-stroke. However, after two months of unsuccessful recruitment, this criterion was modified to include persons who were less than eight months post-stroke; and, was revised again later, to include those who were less than 12 months post-stroke. Of the 12 participants enrolled, one dropped out during baseline assessment because he felt stressed during the evaluation; the other 11 provided positive feedback supporting the acceptability of the assessment procedures. After completion of the baseline assessment, participants were randomly assigned to either the CO-OP or COMPUTER group. However, randomization was not possible for the first two participants who were assigned to the CO-OP intervention because of practical constraints (i.e. therapist training) and medical conditions (i.e. epilepsy) that could potentially be exacerbated by intensive computer-based training (for CO-OP#2).

Thus, a total of six participants were assigned to CO-OP intervention and five participants to COMPUTER training. One participant in each group discontinued the intervention due to negative events that occurred outside of the session times: the participant in the CO-OP group experienced a head injury after a fall; the other in the COMPUTER group had a seizure. To be cautious, we withdrew him from further intervention and reported the event to the ethics boards that had provided ethics approval for this study. All nine participants who completed the intervention also participated in the one-month follow-up.

Participants' characteristics

The characteristics of the nine participants are presented in Table 4.5. The majority were male (4 of 4 in COMPUTER group; 3 of 5 in CO-OP) and they were all living at home with their spouse. All but one (CO-OP#5) were right-handed. Both groups appeared comparable on age, education, time since stroke and scores on the MMSE and the FIM expression and communication items at pre-screening. However, participants in the CO-OP group predominantly had hemorrhagic stroke (4 of 5) while all those in the COMPUTER group had an ischemic stroke. All were receiving rehabilitation interventions during the study period (e.g., occupational therapy, speech therapy, physical therapy, etc...), except for Participant #2 in the CO-OP group who completed her rehabilitation interventions just before baseline assessment. The total number of hours of other rehabilitation interventions received during the study period ranged from 0 to 37 hours in the CO-OP group: three participants (CO-OP#2, #4 and #5) received less than 15 hours while the remaining two (CO-OP#1 and #3) received 26 and 37 hours of therapies, respectively. In the COMPUTER group, one participant (COMP#1) was participating in an intensive return to work program and received 122 hours of therapy, while the remaining participants (COMP#2, #3 and #4) received 22, 5 and 44 hours, respectively.

The participants' baseline scores on the neuropsychological measures of EF are summarized in Table 4.6. All showed evidence of executive dysfunction as indicated by borderline to extremely low scores in at least one of the EF tests. All significant others were spouses, predominantly women (75%); their mean age was 49.25 ± 11.35 years (range 33–68 years).

Adherence to the interventions

The nine participants received the full treatment - 16 sessions over an average of 10 weeks (range = 8-11 weeks for CO-OP versus 9-13 weeks for COMPUTER training). That is, while all participants missed at least one session due to illness, fatigue, holidays or other personal reasons, these were re-scheduled. The duration of sessions was similar in each group, with the CO-OP group treated an average of 57.5 ± 11.3 minutes per session and the COMPUTER group an average of 59.2 ± 5.3 minutes.

Acceptability of the interventions

At post-intervention and follow-up assessments, all participants expressed high levels of satisfaction with the interventions, except for participants "CO-OP#2" and "COMP#3" who indicated they were "*neither satisfied nor dissatisfied"*. Participant CO-OP#2 explained that she was used to setting goals and making plans as part of her daily routine and that the intervention mostly validated the strategies she was already using. Participant COMP#3 felt that the computer-based interventions were mostly focused on memory exercises and that there should be more emphasis on learning how to apply these skills to specific daily life situations. Most participants indicated that the number and duration of sessions were appropriate; but one in the COMPUTER group (COMP#4) suggested reducing the number of sessions from 16 to 12, while another one (COMP#1) expressed that he would have benefited from additional follow-up interventions.

Ratings on the Rehabilitation Therapy Engagement Scale (Lequerica et al., 2006) suggested that the participants' engagement and participation in intervention sessions (e.g., motivation, cooperation with therapists, etc.) was high in both groups (mean score = 2.9 out of 3 for both groups at the end of both the first and last weeks of intervention).

Intervention outcomes

Performance and satisfaction with performance in participant-chosen goals

The goals selected by each participant as per the COPM are summarized in Appendices 4.2a and 4.2b. At baseline each participant indicated five to eight goals they wished to work on (total = 30 goals for CO-OP; 20 for COMPUTER). Sixteen of the 30 goals identified by those in the CO-OP group were trained; the 14 remaining goals for the CO-OP group and all 20 goals for the COMPUTER group were not directly addressed during interventions.

As shown in Appendices 4.2a and 4.2b, participants identified goals that covered most of the activity and participation domains of the ICF classification (e.g., self-care, interpersonal interactions and relationships, community, social and civic life, etc.); one participant in the COMPUTER group (COMP#4) also selected two goals targeted towards improving mental functions. Initial ratings of importance of goals were comparable in both groups ($\bar{x}$ = 8.47±0.44 for CO-OP and $\bar{x}$ = 8.50±1.01 for COMPUTER); and also within the CO-OP group for trained ($\bar{x}$ = 8.80±0.96) and untrained goals ($\bar{x}$ = 8.13±0.79).

Table 4.7 shows the proportion of goals improved by $\geq$2 points on the COPM performance and satisfaction scales, as reported by each participant and significant other. In the CO-OP group, the proportions of all goals that improved to criterion at post-intervention were 63% and 83% for the participant-rated performance and satisfaction scales, respectively. The proportion of goals improved in the COMPUTER group was slightly higher for the performance scale (85%) but similar for the satisfaction scale (90%). Four of five participants in the CO-OP group maintained or improved their performance from post-intervention to follow-up; two of the four in the COMPUTER group did so – more specifically, those with *mild* EF impairment (COMP#1 and COMP#2) maintained their gains. The significant others' ratings on the COPM performance scale suggest that participants' improvements in all goals were similar for both groups at post-intervention and follow-up; while improvements in satisfaction with performance were greater for the CO-OP group at both time points.

Comparisons of self-reported improvements in performance and satisfaction with performance in trained versus untrained goals in the CO-OP group indicate that participants improved in these two parameters to a greater extent on trained goals – 81% and 94% versus 43% and 71% on untrained. These findings were also corroborated by the significant others' ratings. Also, as shown in Table 4.8, for those in the CO-OP group there were significant differences from baseline to post-intervention and from baseline to follow-up on self-reported performance and satisfaction with performance, on trained goals ($p = 0.04$); but only for satisfaction with performance on untrained goals ($p = 0.04$).

In the COMPUTER group, while none of the goals were directly trained during sessions, the majority showed clinically important improvements on the participant-rated performance and satisfaction scales at post-intervention and follow-up, as reported earlier. Within group changes on these outcomes were close-to-significant ($p = 0.07$), with corresponding large effect sizes (≥ 2.34). The proportions of untrained goals reported as improved appeared to be greater than for participants in the CO-OP group, as also indicated by the ratios of effect size of CO-OP versus COMPUTER which were lower than 1, except for the significant others' ratings on the satisfaction scale from baseline to follow-up (ratio = 2.18) (see Table 4.8).

Executive function impairment

The results shown in Tables 4.9 and 4.10 tend to suggest that participants in the CO-OP and the COMPUTER groups improved in different areas of EF impairment possibly suggesting that the interventions impacted differently. Three of four in the COMPUTER group improved on the Digit Span and on the inhibition condition of the CWIT; while, in the CO-OP group, improvements were mostly observed on the TMT B (3 of 5 participants improved at follow-up) and the Letter span-alphabetical (3 of 5 participants improved at post-intervention). Within-group differences were statistically significant for the TMT B ($p = 0.04$ at post-intervention and follow-up) and the Letter span-alphabetical in the CO-OP group ($p = 0.04$ at post-intervention); and approached significance for the TMT A ($p = 0.07$ at post-intervention and follow-up), the inhibition condition of the CWIT ($p = 0.07$ at follow-up) and the inhibition/flexibility condition of the CWIT ($p = 0.07$ at post-intervention and follow-up) in the COMPUTER group. The open-ended qualitative feedback from participants in the COMPUTER group also suggested some perceived improvement in cognitive skills following computer training, more specifically the ability to retain phone numbers (for COMP#1 and COMP#3), speed and alertness as reported by the significant other of participant COMP#4. The perceived cognitive benefits of the CO-OP intervention appeared different, with participants reporting improvements in areas of EF including initiation (CO-OP#3 and CO-OP#5), problem-solving (CO-OP#5), planning and organization (CO-OP#4).

Measures of IADLs, social participation, self-efficacy for performing everyday activities and executive function symptoms in everyday life

The results in Tables 4.9 and 4.11 may suggest some transfer of training effects to other measures of IADLs, social participation, self-efficacy for performing everyday activities and EF symptoms in everyday life (Objective 3) but, again, each intervention appeared to have a different impact on these outcomes. Three of four participants in the COMPUTER group showed clinically important improvements in the IADL profile subtask "Obtaining information", while changes in this outcome measure were less marked for the CO-OP group (ratios of effect size of CO-OP/COMPUTER = 0.07 to 0.10). Both groups showed relatively similar positive changes in social participation, as measured with the LIFE-H, at both time points. Also, the results on the DEX tend to suggest a greater efficacy of the CO-OP intervention in reducing self-reported EF symptoms in daily life at post-intervention and one-month follow-up (negative effect sizes = -0.49 and -0.81, respectively, indicating moderate to large reductions in self-reported EF symptoms in daily life) as compared to the COMPUTER intervention (positive effect sizes = 0.81 and 0.43, suggesting a mean increase in self-reported EF symptoms).[5] Positive changes in self-efficacy were also observed in both groups but, to a greater extent, in the CO-OP group. Within group analyzes showed that participants in the CO-OP group significantly improved their self-efficacy for performing everyday activities at both post-intervention (ES = 1.52; $p = 0.04$) and one-month follow-up (ES = 1.53; $p = 0.04$), as compared to baseline assessment. Positive but smaller, non-statistically significant changes were also noted in the COMPUTER group at post-intervention (ES = 0.85; $p = 0.07$) and one-month follow-up (ES = 0.38; $p = 0.27$). A further look at individual changes in the self-efficacy scores revealed that all participants in the CO-OP group improved at both post-intervention and follow-up assessments; while the proportion of participants in the COMPUTER group who changed on this outcome was lower – 3 of 4 at post-intervention, and 1 of 4 at follow-up. The qualitative feedback from participants on the perceived benefits of the CO-OP intervention also illustrates these findings:

> *"It helped to take charge of myself, to motivate me. It helped to anticipate problems for my return to work and to keep the children home by myself. "*
> – CO-OP#5

[5] *Note*: Higher scores on the DEX indicate greater self-reported EF symptoms in daily life.

> *"...the capacity to complete tasks and the satisfaction to be able to say that I did it."* – CO-OP#4

No statistically significant within group changes were found on the other three measures (i.e., LIFE-H, IADL Profile and Self-Efficacy Scale for Performing Life Activities Post-stroke) for either group.

Adverse events

Two participants did not complete all intervention sessions because of negative events that were unlikely to be related to the study intervention. The remaining nine did not experience any adverse events.

DISCUSSION

This study provides preliminary evidence for the efficacy of both the CO-OP and COMPUTER interventions in improving performance and satisfaction with performance in participant-chosen goals; and performance in measures of EF impairment. These preliminary findings add to the limited literature on EF rehabilitation post-stroke (Poulin et al., 2012) by providing further support for the use of both specific EF skill retraining and compensatory strategy training in persons experiencing executive dysfunction in the subacute phase. The findings suggest that both interventions were acceptable for training EF in this population. Indeed, we found acceptable adherence and retention rates; and, adequate levels of participant satisfaction and engagement in both interventions.

One of the main objectives of a feasibility study is to identify issues related to recruitment: recruitment rates were lower than expected even with a multi-site, multi-recruitment strategy in place. Similar recruitment struggles have been highlighted in previous studies comparing different cognitive rehabilitation approaches in other adult populations (Giles, 2010; Konsztowicz, Anton, Crane, Moafmashhadi, & Koski, 2013; Vanderploeg et al., 2008). As explained by Giles (2010), the number of clients who fit the inclusion criteria for both interventions and who are willing and available to participate is often limited. On a positive note, we were able to identify and apply some strategies that are likely to optimize recruitment in a future trial including: establishing partnerships with key personnel in each setting who are particularly interested in the study and could help in identifying potential participants; maximizing the visibility of the study (e.g., through presentations, consistent visits during staff meetings, etc.); combining a variety of targeted recruitment strategies; and closely monitoring the recruitment process to adjust our strategies as needed (Crist, Ruiz, Torres-Urquidy, Pasvogel, & Hepworth, 2013; Weierbach, Glick, Fletcher, Rowlands, & Lyder, 2010). We also modified one of our inclusion criteria – that stipulated that participants had to be less than six months post-stroke – to also include those who were less than 12 months post-stroke. It is worth noting that the definitions of the "acute", "subacute" and "chronic" phases slightly vary in the literature. While it is generally suggested that the chronic phase begins approximately 6 to 12 months post-stroke (Lindsay et al., 2010; Page & Levine, 2007), a growing body of evidence is also indicating that stroke rehabilitation is effective to promote recovery in the late post-stroke period (Korner-Bitensky, 2013). In this study, all participants were still in an active rehabilitation phase at the time of recruitment.

In the present study, both groups demonstrated clinically important improvements in performance and satisfaction with performance in their self-identified goals immediately post-intervention and at one-month follow-up. It is plausible that the changes observed in each group arose through different mechanisms: the improvements in the CO-OP group may be associated with strategies they learned; the improvements in the COMPUTER group may have arisen through training of specific EF skills (e.g., working memory, flexibility, inhibition, etc.).

The participants' and the significant others' reports provided a slightly different view of the participants' progress towards their goals. The participants' ratings tended to suggest a slightly greater improvement in goal performance in the COMPUTER group than in the CO-OP group at post-intervention, while the significant others' ratings suggested similar changes in goal performance in both groups but greater improvements in satisfaction with performance in the CO-OP group at both post-intervention and one-month follow-up. It is possible that the significant others perceived some positive effects of the CO-OP training that were not readily observed by the participants with executive dysfunction or that the participants' expectations and perceptions of their performance in everyday life activities evolved during the course of the training as they were gaining insight into their functional abilities and limitations.

There are other possible explanations for these findings – which are inconsistent with our initial hypotheses that the CO-OP intervention would have a greater impact on improving goal performance and satisfaction. First, it is worth noting that both the CO-OP and COMPUTER interventions were designed to enhance the ecological validity of the training. They were both provided in the participants' homes and they involved the accomplishment of real-world activities (in CO-OP intervention) *or* computerized tasks designed to simulate everyday life situations (e.g., driving with a steering wheel and pressing one of two pedals depending on specific signals in the COMPUTER intervention). The process of goal setting itself, whereby each participant identified individualized everyday life goals through discussion with the research evaluator, might also have positively influenced participants' motivation and engagement in the interventions and, possibly improved performance and goal attainment (Levack, Dean, Siegert, & Mcpherson, 2006; Sugavanam, Mead, Bulley, Donaghy, & van Wijck, 2013). Finally, although participants in both groups reported some specific benefits that can be attributed to the study intervention; we cannot rule out the possibility that some were attributable to the effects of other rehabilitation interventions received during the study period. Although the duration and content of other rehabilitation interventions were documented by the research therapist through weekly interviews with the participant, it was not possible to precisely estimate the extent to which each patient-specific goal OR EF impairment was addressed by these interventions. Most participants in each group also received "standard therapy" less than five hours weekly – with the exception of Participant COMP# 1 who participated in an intensive return to work program which is likely to have improved his performance in his two work-related goals and, possibly, other areas of functioning. Encouragingly, Participant COMP#1 explicitly reported that some of the skills learned during computer training were generalized and transferred to other daily activities such as playing video games with his son and some work-related tasks. This warrants further explorations to identify whether our computer-based EF intervention and those of others which show promise (Lundqvist et al., 2010; Westerberg et al., 2007; Stablum et al., 2000) indeed have therapeutic benefits in enhancing generalization and transfer of skills to everyday activities.

Surprisingly, the proportions of "untrained" goals reported as improved tended to be greater in the COMPUTER group than in the CO-OP group. It may also be that participants in the CO-OP group focused their efforts on achieving their trained goals – as suggested by clinically important improvements in performance and satisfaction with performance in nearly all trained goals – leaving less time and energy to work on the untrained goals. Another relevant question is whether there was an equivalence of complexity of goals (e.g., basic self-care activities versus IADLs, levels of physical and cognitive demands of the task, etc.) in the CO-OP and COMPUTER groups. When we analyzed and classified the participants' goals according to the activity and participation domains of the ICF (see Appendices 4.2a and 4.2b), the goals appeared similar in both groups.

Interestingly, the comparison of participants' improvements in the other outcome measures – including measures of EF impairment and measures of IADLs, social participation, self-efficacy for performing everyday activities and

EF symptoms in everyday life – tends to suggest some positive effects specific to each intervention. Specifically, the COMPUTER group showed improvements in most areas of EF targeted by the computer-based activities (i.e. working memory, inhibition, and flexibility), with the exception of one cognitive flexibility subtest – TMT B. The fact that two participants performed in the average range on the TMT B at baseline assessment might have possibly limited the likelihood of finding large treatment effects on this measure. An unanticipated finding was that the CO-OP group demonstrated moderate to large improvements in the TMT B and, also, in a working memory subtest (Letter Span Alphabetical) that was not significantly improved in the COMPUTER group. This potentially suggests that the CO-OP process – which involves the application of step-by-step problem-solving strategies and the development of alternative solutions when one's initial plan does not work – might require some working memory and cognitive flexibility skills. However, with a small sample size, these data need to be interpreted with caution.

Compared to participants in the COMPUTER group, those in the CO-OP group also appeared to demonstrate greater improvements in measures of self-efficacy and perceived EF symptoms in everyday life. These findings are consistent with those from previous pilot studies (McEwen et al., 2009, 2010b). The use of guided discovery in the CO-OP approach – whereby the therapist guides the participant to discover the strategies that will solve his/her performance problems – may contribute to the development of self-efficacy and everyday problem solving skills (Dawson et al., 2013c; Skidmore et al., 2013). McEwen (2009) also identified other key principles of the CO-OP approach that may contribute to enhancing the participants' self-efficacy.

> *"It is theorized that providing participants with greater decisional autonomy, combined with teaching them to attribute failures to a problem with their Plan, rather than personal capacity, may have lead to increased levels of self-efficacy. In addition, skill mastery is known to be an important*

contributor to self-efficacy (Mann & Eland, 2005). The acquisition and mastery of the self-selected skills post intervention likely contributed to the improved self-efficacy." (McEwen, 2009; p. 111)

Further research will be required to better decipher the components and mechanisms of action of each intervention – CO-OP and COMPUTER training – that enhance patient outcomes.

Another important point concerns the extent to which treatment effects were maintained following treatment cessation. Our findings add to the limited evidence from pilot studies on the CO-OP intervention (Dawson et al., 2009, 2013b; Ng et al., 2013) and on computerized EF training post-stroke (Lundqvist et al., 2010; Stablum et al., 2000) suggesting some maintenance of training benefits over time for both interventions (i.e., CO-OP and COMPUTER training). It is worth mentioning that in the present study a greater proportion of participants in the CO-OP group maintained their gains in goal performance and satisfaction at follow-up assessment, as compared to those in the COMPUTER group (see Table 4.8). This is consistent with a strategy training model, "where one might expect some benefit as the strategy is implemented, but increasing benefit as it becomes increasingly automated and integrated into a wider range of behaviours." (Gray, Robertson, Pentland, & Anderson, 1992, p. 113)

It is noteworthy that ten of the twelve participants initially enrolled were less than 60 years old. It may be that the CO-OP and COMPUTER interventions particularly address the needs of high functioning younger clients with stroke in whom cognitive and EF impairments can represent considerable barriers to resuming their previous community, work and family roles (Hommel, Miguel, Naegele, Gonnet, & Jaillard, 2009). As highlighted in the 2008 European guidelines for the management of stroke, "There is a lack of good quality trial evidence on rehabilitation of the younger stroke patient, especially in age relevant areas such as return to work post-event" (Quinn et al., 2009; page 105). This pilot study might represent a promising step toward the development of evidence-based cognitive interventions for this population who must regain high level EF if they are to resume activities such as driving, returning to work, childcare etc.

Finally, another clinically relevant question is whether the interventions equally benefitted all participants with stroke. The very preliminary results from the COMPUTER group tend to suggest that participants with mild EF impairment (COMP#1 and COMP#2) made larger improvements in goal performance and satisfaction and were more likely to maintain their gains at follow-up assessment than those with more severe EF problems. It might be that participants with a higher level of executive functioning used more effective strategies to improve their performance on the trained tasks (e.g., by paying attention to performance feedback and adjusting their performance accordingly) and were more likely to generalize and transfer newly learned skills from training to other everyday situations. This is consistent with previous findings from cognitive rehabilitation studies suggesting that "the presence of executive functioning deficits may moderate the response to treatment" (Cicerone et al., 2011; page 526). The results from the CO-OP group, however, did not reveal a similar trend. A larger trial would be necessary to test these hypotheses and to provide greater specificity regarding the type of patient most likely to benefit from each treatment approach.

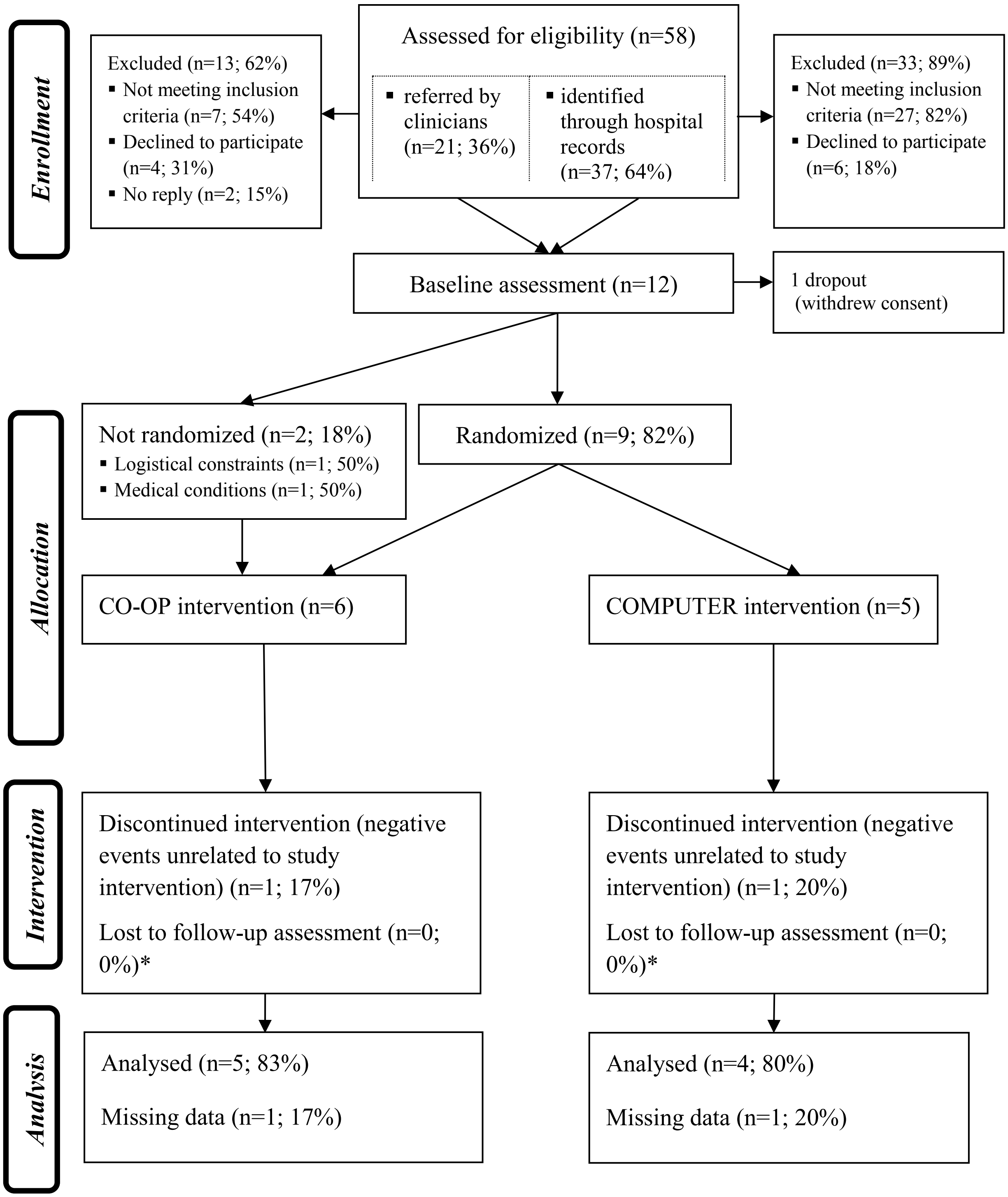
Limitations

Preliminary evidence for the feasibility of providing the CO-OP and COMPUTER interventions in persons with executive dysfunction post-stroke and the efficacy of each must be interpreted with considerable caution given the small sample size and the risk of both type I and type II errors, as explained previously. Also, the absence of a control group that received no specialized EF intervention makes it difficult to draw firm conclusions about the specific effects of the interventions. It is possible that some of the positive changes observed in the outcome measures were due to spontaneous recovery, practice effects and/or other rehabilitation interventions received during the study period. The inability to randomly assign the first two participants in the CO-OP group may also have introduced some bias, by affecting the comparability of the two groups on known and unknown confounding variables. However, a closer look at the baseline characteristics of these participants – i.e. CO-OP#1 and CO-OP#2 – did not reveal any obvious differences with the other participants.

CONCLUSIONS

In conclusion, preliminary findings from this pilot trial support the use of both interventions – CO-OP and Computerized EF training – with persons with subacute stroke experiencing EF deficits. Both treatments are feasible albeit in a select group of patients. They are both benefited by being individualized by the therapist to respect the EF level of the patient. Preliminary evidence from our quantitative and qualitative data suggests that both interventions might have a positive impact on real-world outcomes, while also offering some specific advantages and benefits. It would be important to investigate whether a combination of approaches, involving both computer training in specific EF processes and compensatory strategy training using the CO-OP approach could yield optimal treatment outcomes.

Figure 4.1: Flow Diagram



* All participants who completed the intervention also participated in the one-month follow-up.

Table 4.1: Excerpt of a typical intervention session

Tasks
1. Dual task with steering wheel and pedals (Lussier et al., 2012) ▪ Uses visual stimuli; ▪ Participant has to coordinate two motor tasks – turning a steering wheel and pressing one of two pedals depending on specific visual signals; ▪ ≈ 25-30 minutes including breaks ***OR*** Inhibition task (Lyrette, 2009) ▪ Uses visual stimuli; ▪ Participant has to press a key of the keyboard or to stop his/her action depending on specific signals; ▪ ≈ 30 minutes including breaks
2. Verbal working memory task from the NeuroActive software: Call Center ▪ Uses auditory stimuli; ▪ Participant has to recall and dial phone numbers by clicking with the mouse; ▪ ≈ 15 minutes for 2 blocks including breaks
3. Divided attention task from the Attentionnel software: Riding a bike ▪ Uses visual and auditory stimuli; ▪ Participant has to pay attention to multiple stimuli and to respond by pressing the space bar; ▪ ≈ 15 minutes for 2 blocks including breaks

Table 4.2a: Sample size required per group for comparing two independent means (i.e. between group differences) with 80% power and 2-sided α error of 5% (Cohen, 1988; Soper, 2013)

Effect size (Cohen's *d*)	**Number of participants per group**
0.50	64
0.80	26
1.00	17
1.22	12
2.00	6
2.50	4

Table 4.2b: Sample size required per group for comparing paired data (i.e. within group differences) with 80% power and 2-sided α error of 5% (Machin et al., 2008)

Effect size	**Number of participants per group**
0.5	34
0.8	15
1.0	10
2.0	4

Table 4.3: Criteria for determining individual change on the nine outcome measures

Outcome measure (possible range of scores)	**Method and references**	**Criteria for defining change**
COPM performance and satisfaction scales (1-10)	Published data on clinically important difference in a sample of 108 patients within geriatric, neurologic and orthopaedic rehabilitation (Wressle et al., 1999)	2-point change on each goal
TMT (time in seconds)	Reliable Change Index (RCI) adjusted for practice effects calculated using test-retest reliability data from a sample of 384 normal or neurologically stable adults (Dikmen, Heaton, Grant, & Temkin, 1999; also see Strauss et al. (2006))	TMT A: RCI for a 90% CI = ± 12.4 seconds + practice effects (1.0 second) TMT B: RCI for a 90% CI = ± 35.5 seconds + practice effects (3.9 seconds)
Digit span (scaled scores: 0-19)*	Age-specific RCI calculated using data from a sample of 688 healthy adults (Weschler, 2008)	RCI for a 90% CI = ± 1.7 to 2.3 points depending on the age group
CWIT (scaled scores: 0-19)*	RCI calculated using test-retest reliability data from a sample of 101 healthy adults (Delis, Kaplan, & Kramer, 2001).	RCI for a 90% CI = Denomination: ± 3.3 points Reading: ± 4.2 points Inhibition: ± 3.3 points Inhibition/flexibility: ± 3.6 points
Letter span (raw scores: 0-14)	No published data for interpreting individual change. A clinically significant difference was estimated by a 2-point change in raw scores, which usually corresponds to a change in the sequence length by one letter or more.	2-point change
LIFE-H (0-9)	Published data on clinically important change in older adults with stroke (Desrosiers et al., 2008)	0.5-point change on the mean score of all items
Self-Efficacy Scale for Performing Life Activities Post-stroke (0-10)	No published data for interpreting individual change. Clinically important difference was estimated by a change score of 10% of the scale (i.e. 1-point change); this criterion has been found to be clinically meaningful in other studies using patient-reported outcomes (Jaeschke, Singer, & Guyatt, 1989).	1-point change on the mean score of all items
IADL Profile – subtask "Obtaining information" (5-point scale from 0 (dependence) to 4 (independence))	After consultation with the test's author (C. Bottari), a clinically important difference was defined as a change in the level of assistance required for performing the task (e.g., dependence versus verbal and physical assistance).	1-point change in at least one of the operations: planning, carrying out the task or verifying attainment of the initial goal

Outcome measure (possible range of scores)	**Method and references**	**Criteria for defining change**
DEX (0-80)	RCI was calculated using internal consistency coefficients from a study with 64 persons with traumatic brain injury (Bennett, Ong, & Ponsford, 2005). A clinical severity classification of the scores of the DEX was also used for estimating clinically important change (Bodenburg & Dopslaff, 2008)	≈ 8-point difference (using both methods)

Legend: COPM = Canadian Occupational Performance Measure; TMT = Trail Making Test; CWIT = Color-Word Interference Test; LIFE-H = Assessment of Life Habits; IADL = Instrumental Activities of Daily Living; DEX = Dysexecutive Questionnaire

*****For the Digit span and the CWIT: Scaled scores (with a mean of 10 and a standard deviation of 3) were calculated using normative data reported in the tests' manuals (Delis et al., 2001; Weschler, 2008)

Table 4.4: Reasons for ineligibility and refusal according to recruitment strategy

	n
Patients referred from clinicians (n=21)	
Total not eligible	**7**
unable to identify any day-to-day difficulties s/he wants to improve	4
MMSE < 22/30	2
moving outside of the Montreal area	1
Total refused	**4**
does not think s/he needs additional interventions	3
has many other medical appointments	1
Not reachable	**2**
Patients identified through hospital records (n=37)	
Total not eligible	**27**
no cognitive/EF problems (as reported by the patient or through screening with the TMT B)	12
unable to identify any day-to-day difficulties s/he wants to improve	3
more than one year post-stroke	3
other neurological conditions	2
important language deficits	2
no English/French	2
MMSE < 22/30	1
other comorbid conditions	1
more than six months post-stroke*	1
Total refused	**6**
not interested	3
receives other health care services	1
no time; has other family responsibilities	1
does not want strangers to come to her home	1

* Early on, we attempted to recruit participants who were < 6 months post-stroke, but this was later revised to include those < 12 months.

Table 4.5: Participants' socio-demographic and stroke-related characteristics according to group

Participant	Sex	Age	Education (years)	Side and type of stroke	Time since stroke (months)	MMSE (/30)	FIM expression	FIM comprehension	Number of co-morbidities
CO-OP#1	M	50	13	right, hemorrhagic	7.5	27	7	7	3
CO-OP#2	F	39	16	right, hemorrhagic	10	30	7	7	1
CO-OP#3	F	49	11	left, hemorrhagic	3.5	27	6	6	1
CO-OP#4	M	73	17	left, hemorrhagic	4.5	28	7	7	3
CO-OP#5	M	34	14	left, ischemic	5	28	7	7	0
COMP#1	M	42	17	right, ischemic	5.5	28	7	7	1
COMP#2	M	57	16	left, ischemic	1.5	24	7	7	3
COMP#3	M	79	17	right, ischemic	11	26	6	7	7
COMP#4	M	53	14	bilateral, ischemic	7.5	28	5	7	4

Legend: COMP = computer group; F = female; FIM = Functional Independence Measure; M = male; MMSE = Mini-Mental State Examination

Table 4.6: Baseline performance on measures of executive function (EF) impairment per participant according to group

EF Measures	Baseline performance expressed as raw scores *Z-scores* or Scaled scores***								
	CO-OP group					COMPUTER group			
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**
TMT B – raw scores in seconds;	255.7	148.4	148.9	329.0	71.9	66.0	71.0	405.0	265.8
– Z-scores	*-13.3*	*-5.5*	*-5.9*	*-10.1*	*-1.7*	*-0.5*	*-0.1*	*-6.9*	*-14.0*
CWIT									
inhibition – raw scores in seconds;	52.1	56.0	40.8	91.0	57.6	71.0	94.2	76.0	134.0
– Scaled scores 0-19	*12*	*9*	*13*	*7*	*9*	*6*	*3*	*10*	*1*
inhibition/flexibility – raw scores in seconds;	72.5	86.0	95.0	194.0	67.0	80.4	76.0	136.0	145.0
– Scaled scores 0-19	*10*	*4*	*4*	*1*	*8*	*7*	*9*	*2*	*1*
Digit Span									
forward – raw scores 0-16	11	9	12	8	6	5	8	9	10
backward – raw scores 0-16	8	8	10	7	6	7	8	7	5
sequencing – raw scores 0-16	6	8	11	7	6	7	4	7	8
total – Scaled scores 0-19	*8*	*8*	*12*	*7*	*4*	*5*	*6*	*9*	*7*
Letter Span									
forward – raw score 0-14	5	10	11	9	9	6	5	8	11
backward – raw score 0-14	5	4	8	4	3	5	3	4	5
alphabetical – raw score 0-14	5	4	8	3	3	4	5	6	8

Legend: TMT B = Trail Making Test B; CWIT = Color Word Interference Test

*Z-scores were calculated using normative data from Tombaugh (2004) and were interpreted as follows: -2.0 and below = extremely low; -1.4 to -1.9 = borderline/mild impairment; -0.7 to -1.3 = low average; ± 0.6 = average; 0.7 and higher = high average, superior or very superior (based on Strauss et al., 2006)
**Scaled scores (with a mean of 10 and a standard deviation of 3) were calculated using normative data reported in the tests' manuals (Delis et al., 2001; Weschler, 2008) and were interpreted as follows: 3 and below = extremely low; 4-5 = borderline/mild impairment; 6-7 = low average; 8-12 = average; 13 and higher = high average, superior or very superior (based on Strauss et al., 2006)

Table 4.7: Proportion of goals improved by ≥2 points on the Canadian Occupational Performance Measure as per participants' and significant others' (SO) AND according to group

Ratings Outcome – *time point*	**CO-OP** Participant # 1	2	3	4	5	*All**	**COMPUTER** Participant # 1	2	3	4	*All**
PARTICIPANTS											
Performance Scale											
trained goals											
post-intervention	100	75	100	67	67	***81***	n/a	n/a	n/a	n/a	n/a
follow up	100	75	100	67	100	***88***					
untrained goals											
post-intervention	80	50	0	33	0	***43***	100	80	60	100	***85***
follow up	40	50	50	33	0	***36***	100	80	0	60	***60***
ALL GOALS											
post-intervention	88	67	60	50	40	***63***	100	80	60	100	***85***
follow up	63	67	80	50	60	***63***	100	80	0	60	***60***
Satisfaction scale											
trained goals											
post-intervention	100	75	100	100	100	***94***	n/a	n/a	n/a	n/a	n/a
follow up	100	75	100	100	100	***94***					
untrained goals											
post-intervention	60	50	50	100	100	***71***	100	80	80	100	***90***
follow up	20	100	100	100	50	***64***	100	80	60	80	***80***
ALL GOALS											
post-intervention	75	67	80	100	100	***83***	100	80	80	100	***90***
follow up	50	83	100	100	80	***80***	100	80	60	80	***80***
SIGNIFICANT OTHERS**											
Performance scale											
trained goals											
post-intervention	n/a	75	67	67	100	***77***	n/a	n/a	n/a	n/a	n/a
follow up		50	67	67	100	***69***					
untrained goals											
post-intervention	n/a	50	100	67	50	***67***	50	80	20	100	***63***
follow up		50	50	33	50	***44***	50	100	40	60	***63***
ALL GOALS											
post-intervention	n/a	67	80	67	80	***73***	50	80	20	100	***63***
follow up		50	60	50	80	***59***	50	100	40	60	***63***
Satisfaction scale											
trained goals											
post-intervention	n/a	75	67	100	100	***85***	n/a	n/a	n/a	n/a	n/a
follow up		75	100	100	100	***92***					
untrained goals											
post-intervention	n/a	50	100	100	50	***78***	75	80	40	80	***68***
follow up		100	50	100	100	***89***	75	100	0	40	***53***
ALL GOALS											
post-intervention	n/a	67	80	100	80	***82***	75	80	40	80	***68***
follow up		83	80	100	100	***91***	75	100	0	40	***53***

* Data indicate the proportion of goals improved per group – i.e., for all goals identified by the five participants in the CO-OP group and by the four in the COMPUTER group.

** The significant other (SO)'s ratings are not available (n/a) for Participant #1 in the CO-OP group.

Table 4.8: Participants' and significant others' ratings on the Canadian Occupational Performance Measure at pre, post and follow-up (FU) according to group (including effect sizes (ES) and ratios of ES) † ‡

Outcome measure (possible range of scores)	CO-OP (n = 5) Pre Mean (SD)	CO-OP Post Mean (SD) *ES Pre-Post*	CO-OP FU Mean (SD) *ES Pre-FU*	COMPUTER (n = 4) Pre Mean (SD)	COMPUTER Post Mean (SD) *ES Pre-Post*	COMPUTER FU Mean (SD) *ES Pre-FU*	Ratio of ES (CO-OP / COMPUTER) Pre-Post	Ratio of ES (CO-OP / COMPUTER) Pre-FU
PARTICIPANTS' RATINGS								
Performance (1-10)								
trained goals	3.18 (1.25)	7.77 (1.09) *3.67***	7.82 (1.51) *3.71***	n/a	n/a	n/a	n/a	n/a
untrained goals	4.19 (2.41)	6.11 (1.93) *0.80*	5.88 (1.41) *0.70*	3.25 (1.47)	7.95 (1.45) *3.19**	6.70 (2.54) *2.34*	0.25	0.30
ALL GOALS	3.64 (1.74)	7.06 (1.31) *1.96***	6.87 (1.38) *1.85***	3.25 (1.47)	7.95 (1.45) *3.19**	6.70 (2.54) *2.34*	0.61	0.79
Satisfaction (1-10)								
trained goals	3.02 (0.94)	7.77 (1.42) *5.03***	7.67 (1.65) *4.93***	n/a	n/a	n/a	n/a	n/a
untrained goals	3.35 (1.97)	6.23 (2.44) *1.47***	6.60 (1.56) *1.65***	3.25 (1.15)	7.85 (1.59) *4.01**	6.85 (2.07) *3.14**	0.37	0.53
ALL GOALS	3.20 (1.34)	7.09 (1.75) *2.90***	7.04 (1.13) *2.86***	3.25 (1.15)	7.85 (1.59) *4.01**	6.85 (2.07) *3.14**	0.72	0.91
SIGNIFICANT OTHERS' RATINGS								
Performance (1-10)								
trained goals	3.75 (0.63)	7.83 (1.45) *6.47**	7.25 (2.22) *5.55**	n/a	n/a	n/a	n/a	n/a
untrained goals	4.46 (2.42)	6.00 (2.33) *0.64**	5.33 (2.36) *0.36**	4.43 (1.46)	7.61 (0.61) *3.19**	7.08 (1.36) *1.82**	0.29	0.20
ALL GOALS	4.09 (1.44)	7.03 (1.88) *2.03**	6.43 (2.23) *1.62**	4.43 (1.46)	7.61 (0.61) *3.19**	7.08 (1.36) *1.82**	0.93	0.89
Satisfaction (1-10)								
trained goals	2.92 (0.83)	7.67 (2.23) *5.70**	7.33 (2.33) *5.30**	n/a	n/a	n/a	n/a	n/a
untrained goals	3.33 (1.83)	5.58 (2.27) *1.23**	6.83 (2.38) *1.92**	4.23 (2.16)	7.11 (1.46) *2.89*	6.13 (2.44) *0.88*	0.92	2.18
ALL GOALS	3.10 (1.13)	6.75 (2.24) *3.22**	7.11 (2.20) *3.53**	4.23 (2.16)	7.11 (1.46) *2.89*	6.13 (2.44) *0.88*	2.41	4.02

† Wilcoxon Tests: ** = significant difference from baseline, $p < 0.05$;
* = difference from baseline approaching significance, $0.05 < p < 0.10$

‡ No statistically significant within group changes were found for the interval from post-intervention to follow-up; most of the effect sizes for this time interval were small and are not reported here because of space constraints.

Table 4.9: Participants' scores on neuropsychological executive function tests at pre, post and follow-up (FU) according to group (including effect sizes (ES) and ratios of ES) † ‡

Outcome measure	**CO-OP** (n = 5)			**COMPUTER** (n = 4)			**Ratio of ES (CO-OP / COMPUTER)**	
	Pre Mean (SD)	**Post** Mean (SD) *ES Pre-Post*	**FU** Mean (SD) *ES Pre-FU*	**Pre** Mean (SD)	**Post** Mean (SD) *ES Pre-Post*	**FU** Mean (SD) *ES Pre-FU*	**Pre-Post**	**Pre-FU**
TMT¶ (raw score in seconds)								
TMT A	62.8 (33.2)	51.7 (23.0) *-0.3*	56.8 (23.6) *-0.2*	92.1 (71.3)	62.3 (36.5) *-0.4**	59.1 (39.8) *-0.5**	0.8	0.4
TMT B	190.8 (101.2)	137.4 (74.1) *-0.5***	122.8 (76.9) *-0.7***	201.9 (164.3)	205.0 (162.2) *0.0*	168.3 (146.2) *-0.2*	-28.4	3.3
CWIT¶ (raw score in seconds)								
denomination	37.8 (4.4)	33.6 (8.2) *-1.0*	30.7 (5.0) *-1.6*	45.6 (14.6)	46.0 (26.4) *0.0*	43.3 (21.0) *-0.2*	-33.7	10.4
reading	25.1 (4.3)	26.5 (5.2) *0.3*	24.4 (3.9) *-0.2*	38.5 (21.9)	33.4 (16.4) *-0.2*	35.1 (22.2) *-0.2*	-1.4	1.0
inhibition	59.5 (18.8)	63.2 (25.9) *0.2*	62.6 (20.0) *0.2*	93.8 (28.6)	77.0 (15.6) *-0.6*	67.1 (13.9) *-0.9**	-0.3	-0.2
inhibition/flexibility	102.9 (52.1)	84.0 (39.3) *-0.4*	98.4 (50.1) *-0.1*	109.4 (36.2)	86.3 (22.9) *-0.6**	87.7 (33.5) *-0.6**	0.6	0.1
Digit Span (raw score: 0-16)								
forward	9.2 (2.4)	9.8 (2.4) *0.3*	9.8 (1.3) *0.3*	8.0 (2.2)	9.0 (1.4) *0.5*	8.8 (1.5) *0.3*	0.5	0.7
backward	7.8 (1.5)	8.6 (1.9) *0.5*	8.4 (1.7) *0.4*	6.8 (1.3)	8.3 (1.7) *1.2*	8.8 (2.2) *1.6*	0.5	0.3
sequencing	7.6 (2.1)	8.4 (1.7) *0.4*	7.2 (1.6) *-0.2*	6.5 (1.7)	8.8 (1.3) *1.3*	7.0 (1.4) *0.3*	0.3	-0.7
Letter Span (raw score: 0-14)								
forward	8.8 (2.3)	8.6 (2.6) *-0.1*	8.4 (1.7) *-0.2*	7.5 (2.6)	8.0 (1.4) *0.2*	8.5 (1.3) *0.4*	-0.5	-0.5
backward	4.8 (1.9)	5.2 (2.4) *0.2*	4.6 (2.9) *-0.1*	4.3 (1.0)	5.5 (1.0) *1.3*	5.8 (2.1) *1.6*	0.2	-0.1
alphabetical	4.6 (2.1)	7.0 (2.0) *1.2***	5.6 (2.5) *0.5**	5.8 (1.7)	6.0 (2.2) *0.1*	4.8 (2.2) *-0.6*	7.9	-0.8

Legend: TMT = Trail Making Test; CWIT = Color-Word Interference Test

† Wilcoxon Tests: ** = significant difference from baseline, $p < 0.05$; * = difference from baseline approaching significance, $0.05 < p < 0.10$

‡ No statistically significant within group changes were found for the interval from post-intervention to follow-up; most of the effect sizes for this time interval were small and are not reported here because of space constraints.

¶ Negative effect size indicates improvement for TMT and CWIT.

Table 4.10: Identification of the participants who changed* versus remained stable on the secondary outcomes across all time points

Outcome measure	**CO-OP** (n = 5)															**COMPUTER** (n = 4)											
	Pre to Post Participant #					**Pre to FU** Participant #					**Post to FU** Participant #					**Pre to Post** Participant #				**Pre to FU** Participant #				**Post to FU** Participant #			
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
TMT																											
TMT A	=	+	+	=	=	-	+	+	=	=	-	=	=	=	=	=	=	+	+	=	=	+	+	=	=	=	+
TMT B	=	+	=	+	=	=	+	+	+	=	=	=	+	=	=	=	=	+	-	=	=	+	+	=	=	-	+
CWIT																											
denomination	=	+	+	=	=	=	+	=	=	=	=	=	=	=	=	=	+	=	=	=	+	=	=	=	=	=	=
reading	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=	=
inhibition	=	=	=	=	=	-	-	=	=	=	=	-	=	+	=	+	+	=	+	+	+	=	+	=	=	=	=
inhibition/flexibility	=	=	+	=	=	-	+	=	=	=	-	=	=	=	=	=	=	+	=	=	=	+	=	=	=	=	=
Digit Span	=	+	=	=	+	=	=	=	=	=	-	-	=	+	=	+	+	=	+	+	+	=	=	=	=	=	-
Letter Span																											
forward	=	-	=	=	=	+	-	=	=	=	+	=	=	=	=	=	+	=	=	=	+	=	=	=	=	=	=
backward	=	=	=	=	+	-	=	=	-	+	=	=	=	=	=	=	+	=	=	+	+	=	=	+	=	=	-
alphabetical	=	=	+	+	+	=	=	+	=	=	=	=	=	-	-	=	+	=	-	+	+	-	-	+	-	-	-
LIFE-H total score	+	=	+	=	=	+	=	+	=	+	=	=	=	=	=	+	+	=	+	+	+	=	+	=	=	=	=
Self-Efficacy Scale	+	+	+	+	+	+	+	+	+	+	=	=	=	=	=	=	+	+	+	=	=	=	+	=	=	-	=
IADL Profile – subtask Obtaining information	+	=	-	+	=	=	=	=	+	=	-	=	+	+	=	+	+	+	=	+	+	+	-	-	=	-	-
DEX	=	+	+	=	=	=	+	=	=	+	=	=	=	+	=	-	+	=	=	-	+	-	=	=	=	=	=

Legend: (+) improved; (=) stable; (-) declined; FU = follow up; TMT = Trail Making Test; CWIT = Color-Word Interference Test; LIFE-H = Assessment of Life Habits; IADL = Instrumental Activities of Daily Living; DEX = Dysexecutive Questionnaire

*Please see Table 4.3 for criteria for determining individual change on these outcome measures.

Table 4.11: Participants' scores on measures of social participation, self-efficacy, IADLs and executive function symptoms in everyday life at pre, post and follow-up (FU) according to group (including effect sizes (ES) and ratios of ES) † ‡

Outcome measure (range)	CO-OP (n = 5)			COMPUTER (n = 4)			Ratio of ES (CO-OP / COMPUTER)	
	Pre Mean (SD)	Post Mean (SD) *ES Pre-Post*	FU Mean (SD) *ES Pre-FU*	Pre Mean (SD)	Post Mean (SD) *ES Pre-Post*	FU Mean (SD) *ES Pre-FU*	Pre-Post	Pre-FU
LIFE-H total score (0-9)	7.03 (1.10)	7.65 (0.59) *0.56*	7.76 (0.50) *0.67*	5.94 (1.46)	6.92 (1.35) *0.68**	7.16 (1.25) *0.84**	0.83	0.80
Self-Efficacy Scale for Performing Life Activities Post-stroke (0-10)	6.49 (1.18)	8.29 (1.08) *1.52***	8.30 (0.94) *1.53***	7.35 (1.92)	8.98 (0.94) *0.85**	8.07 (1.22) *0.38*	1.78	4.06
IADL Profile – subtask "Obtaining information" (0-4)	2.87 (1.04)	3.13 (0.99) *0.26*	3.00 (1.00) *0.13*	2.42 (0.42)	3.50 (0.58) *2.58*	3.17 (0.79) *1.79*	0.10	0.07
DEX[¶] (0-80)	28.0 (9.8)	23.2 (13.4) *-0.49*	20.0 (10.2) *-0.81*	16.3 (4.7)	20.0 (8.9) *0,81*	18.3(9.4) *0.43*	-0.61	-1.89

Legend: LIFE-H = Assessment of Life Habits; IADL = Instrumental Activities of Daily Living; DEX = Dysexecutive Questionnaire

† Wilcoxon Tests: ** = significant difference from baseline, $p < 0.05$;
* = difference from baseline approaching significance, $0.05 < p < 0.10$

‡ No statistically significant within group changes were found for the interval from post-intervention to follow-up; most of the effect sizes for this time interval were small and are not reported here because of space constraints.

¶ Negative effect size indicates improvement for DEX.

Appendix 4.1: Excerpt of a CO-OP intervention session

One participant identified the “Goal” of learning to cook salt-free sauces. Through discussion with the therapist, the participant developed several “Plans” to move towards this goal including: searching for and selecting an easy recipe in a cookbook during the session; buying the ingredients as homework and; preparing the sauce during the next session, which he “Did”. After making the sauce, the participant and the therapist “Checked” the results and observed that the sauce tasted good but was too liquidy. Also, the participant took much more time than expected to prepare the sauce because he was poorly organized and did not systematically follow the instructions. With the therapist’s guidance, he discovered that he had forgotten to add the flour and he devised a more specific plan, which consisted of checking off each step once completed. In a subsequent session, he executed this “Plan” successfully while cooking the same sauce and the “Check” revealed that his plan worked. In the next weeks, the participant developed and applied additional plans to continue improving on this goal such as: cooking the same sauce without the therapist (as homework); and, in a session with the therapist, cooked another sauce requiring more advanced cooking skills and involving more steps.

Appendix 4.2a: Specific COPM goals (trained and untrained) and scores per participant in the CO-OP group (classified according to the International Classification of Functioning, Disability and Health (ICF)) *

Participant # • Goals	Activity and participation domain of the ICF	Performance			Satisfaction		
		Pre	Post	FU	Pre	Post	FU
CO-OP#1							
Trained goals							
• Dress independently	• self-care	1	**8**	**8**	1	**8**	**7**
• Prepare a meal independently	• domestic life	4	**8**	**8**	3	**8**	**8**
• Read more material for spiritual meetings	• learning and applying knowledge	6	**9**	**8**	6	**9**	**8**
Untrained goals							
• Improve stamina when walking	• mobility	6	7	**8**	6	6	7
• Lose weight	• self-care	4	**8**	**6**	3	**7**	**6**
• Organize a karaoke evening	• community, social & civic life	3	**6**	1	5	6	4
• Organize French lessons	• major life areas	5	**10**	6	4	**10**	5
• Improve computer skills – learn to use the internet	• learning and applying knowledge	1	**6**	1	4	**6**	3
CO-OP#2							
*Trained goals***							
• Develop strategies to decrease irritability and effectively communicate in high stress interactions with children	• interpersonal interactions and relationships	1	**7**	**7**	1	**7**	**5**
• Apply one of these strategies once weekly	• interpersonal interactions and relationships	2	**8**	**5**	2	**7**	2
• Organize and have a movie date with my husband	• community, social & civic life	1	**10**	**10**	1	**10**	**8**
• Plan, organize and complete one trip to and from the grocery store alone	• mobility	1	1	1	3	2	**5**
Untrained goals							
• Read 10 pages of my novel per week	• community, social & civic life	1	1	2	2	2	**8**
• Organize and attend a lunch with colleagues	• interpersonal interactions and relationships	1	**10**	**9**	2	**7**	**9**

*Numbers in bold indicate a clinically significant improvement of ≥ 2 points, as compared to baseline, on the Canadian Occupational Performance Measure (COPM).

** Participant CO-OP#2 was allowed to have four trained goals given that her first two goals were inter-related and were addressed together during the same training sessions.

Participant # • Goals	Activity and participation domain of the ICF	Performance			Satisfaction		
		Pre	Post	FU	Pre	Post	FU
CO-OP#3							
Trained goals							
• Pay with my debit card independently	• major life areas	1	**8**	**8**	1	**5**	**9**
• Improve efficiency of cleaning	• domestic life	3	**5**	**6**	3	**5**	**6**
• Plan and prepare weekdays dinners	• domestic life	4	**7**	**7**	4	**8**	**8**
Untrained goals							
• Read newspaper and do crossword puzzles	• community, social & civic life	3	3	3	1	**4**	**5**
• Call family members weekly	• interpersonal interactions and relationships	3	3	**7**	1	2	**5**
CO-OP#4							
Trained goals							
• Complete a woodworking project	• community, social & civic life	9	10	10	7	**10**	**10**
• Learn to cook five healthy sauces	• domestic life	1	**7**	**7**	1	**7**	**7**
• Install and use a new cognitive training software	• learning and applying knowledge	3	**9**	**9**	1	**10**	**9**
Untrained goals							
• Prepare a collection of my poems	• community, social & civic life	9	7	8	5	**7**	**8**
• Clean up my shop	• domestic life	9	8	9	2	**9**	**7**
• Improve computer skills	• learning and applying knowledge	2	**8**	**7**	3	**7**	**6**
CO-OP#5							
Trained goals							
• Resume driving	• mobility	1	**9**	**10**	1	**10**	**10**
• Take on more family responsibilities	• domestic life	4	**9**	**9**	6	**9**	**9**
• Feel in control while handling stressful situations with children	• interpersonal interactions and relationships	7	8	**10**	6	**8**	**9**
Untrained goals							
• Feel comfortable and adopt an appropriate social behavior in public places	• interpersonal interactions and relationships	8	9	9	7	**9**	**9**
• Do an exercise program to improve strength and sensation in the right side of my body	• self-care	5	5	4	5	**9**	6

Note: Numbers in bold indicate a clinically significant improvement of ≥ 2 points, as compared to baseline, on the Canadian Occupational Performance Measure (COPM).

Appendix 4.2b: Specific COPM goals and scores per participant in the COMPUTER group (classified according to the International Classification of Functioning, Disability and Health (ICF)) *

Participant # • Goals	Activity and participation domain of the ICF	Performance			Satisfaction		
		Pre	Post	FU	Pre	Post	FU
COMP#1							
• Plan and schedule a one-day visit to work site including independent transportation	• major life areas	4	**10**	**10**	3	**10**	**10**
• Review one engineering project at work	• major life areas	3	**10**	**10**	3	**10**	**9**
• Organize and attend one session with a psychologist	• self-care	2	**10**	**10**	2	**10**	**10**
• Address a stressful situation involving my son in a calm manner	• interpersonal interactions and relationships	4	**10**	**10**	4	**10**	**10**
• Jog 5 km twice weekly in preparation for a Marathon	• community, social & civic life	6	**10**	**10**	7	**10**	**10**
COMP#2							
• Plan and prepare meals	• domestic life	4	**9**	**10**	6	**10**	**8**
• Run 10 minutes without stopping	• mobility	1	**10**	**10**	1	**10**	**9**
• Complete a tennis game with my wife*	• community, social & civic life	1	1	1	1	1	1
• Complete a difficult crossword puzzle	• community, social & civic life	1	**10**	**9**	1	**10**	**9**
• Read 200 pages/week from a book	• community, social & civic life	1	**8**	**7**	2	**8**	**6**
COMP#3							
• Read the newspaper more efficiently	• community, social & civic life	6	**8**	7	6	**8**	**8**
• Walk 30 minutes with the walker indoors	• mobility	4	**6**	1	4	4	**6**
• Improve time-perception	• mental functions	3	**5**	4	3	**5**	3
• Recall content of phone conversation with my children	• mental functions	6	7	5	5	**7**	5
• Complete bilateral hand tasks in standing with no support – wash and dry my hair in the shower	• self-care	6	7	7	5	**7**	**8**
COMP#4							
• Walk 30 meters with the walker under supervision	• mobility	2	**9**	**7**	2	**8**	**5**
• Hold a 5-minute conversation with family members without having to repeat myself	• communication	5	**7**	4	3	**7**	4
• Resume driving or be placed on a waiting list for driving assessment	• mobility	1	**7**	2	1	**8**	**4**
• Wipe myself independently after going to the toilet	• self-care	1	**8**	**3**	2	**8**	**5**
• Navigate the internet	• communication	4	**7**	**7**	4	**6**	**7**

* Numbers in bold indicate a clinically significant improvement of ≥ 2 points, as compared to baseline, on the Canadian Occupational Performance Measure (COPM).

** Participation in this goal was limited by shoulder pain.

BRIDGING MANUSCRIPT

Chapter 5 addresses the last objective of my PhD agenda, specifically, the creation of a series of e-learning modules to provide the latest evidence on EF assessment and treatment post-stroke. The syntheses on EF assessment and intervention presented in Chapters 2 and 3, along with qualitative feedback on content and format of the learning materials from six expert occupational therapists, were used to guide the development of the modules. These e-learning modules became accessible online in July 2013 on an internationally known website (see the Stroke Engine website at http://strokengine.ca/intervention/index.php? page=topic&id=90 and http://strokengine.org/elearning/executivefunction/). This knowledge translation initiative was funded by the Richard and Edith Strauss Canada Foundation. As the project leader, I took the lead in all aspects of this initiative including writing the grant request, literature reviews, ethics application, conducting focus groups, data analyses and developing the content of the learning modules.

CHAPTER 5: *Manuscript 4*.
Creation of e-learning modules specific to management of executive function post-stroke

Poulin, V., Dawson, D., & Korner-Bitensky, N. (2013). **Creation of e-learning modules specific to management of executive function post-stroke**. *Published online on the Stroke Engine website at*: http://strokengine.ca/intervention/index.php? page=topic&id=90 and http://strokengine.org/elearning/executivefunction/

ABSTRACT

Rationale: Occupational therapists play an important role in the assessment and treatment of executive function (EF) disorders post-stroke; yet, we have evidence of a gap between the scientific evidence and clinical practice. Additional knowledge translation efforts are needed to enhance clinicians' awareness of evidence-based practices for the management of executive dysfunction post-stroke.

Objective: To create multi-modal web-based learning modules to provide the latest evidence on EF assessment and intervention post-stroke.

Methods: The e-learning modules were created based on our published systematic reviews on real-world EF assessments and EF interventions post-stroke (Poulin, Korner-Bitensky, Dawson, & Bherer, 2012; Poulin, Korner-Bitensky, & Dawson, 2013), and studies on the most effective knowledge translation strategies to increase clinicians' uptake of best practices. Feedback from six experts guided the development of the e-learning modules. Stroke Engine (www.strokengine.ca), an existing website that offers evidence-based information on stroke rehabilitation, was used as the host site.

Results: The e-learning modules became accessible online in July 2013 at http://strokengine.ca/intervention/index.php?page=topic&id=90 and http://strokengine.org/elearning/executivefunction; and, consist of: web-based modules with specific sections on EF assessment as well as evidence-based EF interventions; an interactive e-learning module with patient scenarios and quizzes; pocket cards summarizing EF rehabilitation best practices; and, a module for patients and families.

Conclusions: These e-learning modules address the need to enhance expertise in the management of EF disorders post-stroke.

Keywords: knowledge translation, stroke, executive function

INTRODUCTION

Clinicians providing stroke rehabilitation are increasingly encouraged to adopt evidence-based practices especially given that adherence to best practice guidelines has been shown to improve functional outcomes post-stroke (Duncan et al., 2002). However, previous studies have highlighted serious gaps between best and actual practices for various areas of stroke rehabilitation, including the detection and treatment of cognitive and EF disorders post-stroke (Korner-Bitensky, Barrett-Bernstein, Bibas, & Poulin, 2011; McClure, Salter, Foley, Mahon, & Teasell, 2012). In our 2005 Canada-wide survey determining stroke rehabilitation practices of 663 OTs (Korner-Bitensky et al., 2011), we found a low prevalence of use of specific assessments and interventions that address EF. Specifically, less than 1% of clinicians reported using standardized EF assessments. Similarly, a recent retrospective review of 123 hospital charts of patients discharged from an Ontario inpatient stroke rehabilitation facility found that, while a majority (83%) of patients were screened for cognitive impairment using generic screening tests (e.g., MoCA or MMSE), few of them were subsequently assessed with a more comprehensive cognitive assessment (McClure et al., 2012). This suggests that specific cognitive/EF impairment may have gone undetected in these patients. With respect to intervention practices, our Canada-wide survey (Korner-Bitensky et al., 2011) and a recent Australian survey (Koh, Hoffmann, Bennett, & McKenna, 2009) have shown that general cognitive interventions incorporated into training of activities of daily living, are used by approximately 50 to 80% of clinicians. However, specific interventions such as those aimed at enhancing problem-solving strategies or employing computer programs designed to retrain executive processes are seldom used (Koh et al., 2009; Korner-Bitensky et al., 2011). The extent to which clinicians incorporate specific cognitive strategies into the training of activities of daily living also remains unclear. The emerging research on EF rehabilitation post-stroke is providing evidence on the effectiveness of new interventions (Poulin et al., 2012).

To narrow the gap between current practice and evidence-based practice, it is important to implement knowledge translation (KT) strategies to ensure that relevant standardized EF assessment tools and evidence-based interventions are utilized. Knowledge translation (KT) consists in "a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically-sound application of knowledge to improve health, provide more effective health services and products and strengthen the health care system" (Canadian Institutes of Health Research, 2013). Graham and colleagues (2006) have developed a useful model – the Knowledge to Action (KTA) Model – to conceptualise the process of KT and to guide the development of effective strategies to address knowledge-practice gaps in health care (Graham et al., 2006; see Figure 5.1). This model suggests that KT involves the processes of both *knowledge creation* and *knowledge application*. As shown in Figure 5.1, the knowledge funnel represents the different phases of *knowledge creation*, from inquiry (i.e. identifying the right research questions), to the synthesis of existing evidence (e.g., systematic reviews and meta-analyzes), and to the development of tools and products that are likely to facilitate the uptake of knowledge, such as practice guidelines or decision algorithms. In contrast to the knowledge funnel, the Action Cycle illustrates the dynamic process leading to application and sustained use of knowledge in clinical practice.

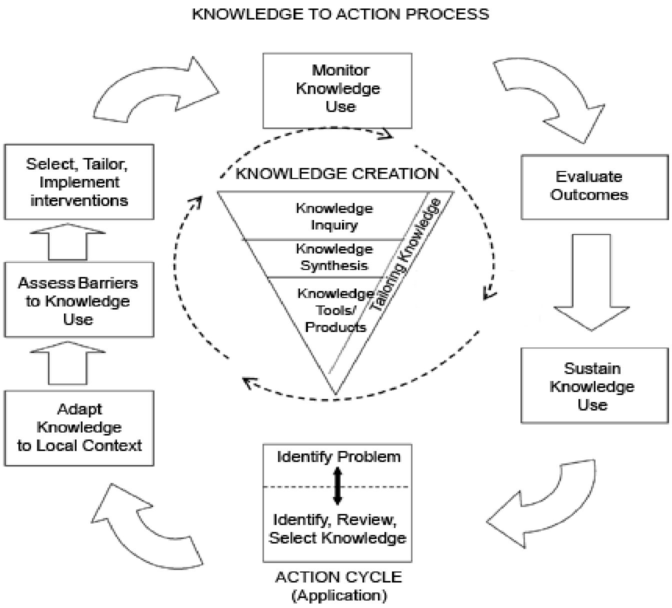


Figure 5.1: Knowledge to Action Model (Graham et al., 2006). Copyright permission has been granted.

According to the Knowledge to Action model (Graham et al., 2006), an essential step to successfully implementing evidence-based knowledge is to refine and adapt the evidence to meet the specific learning needs of users. The findings from a recent systematic review on KT strategies specific to rehabilitation clinicians also suggest that multi-modal KT interventions that meet the learning needs of different users are more effective in inciting change than uni-modal interventions, or those focused solely on health professionals (Menon, Korner-Bitensky, Kastner, McKibbon, & Straus, 2009).

The use of e-learning resources may offer several advantages for disseminating evidence-based information and facilitating uptake of knowledge by rehabilitation clinicians, as they enable clinicians to quickly access the evidence whenever they want, and they offer the possibility of combining different interactive instructional strategies (Menon, 2013).

An existing web-based KT tool that has shown promise in enhancing best practice knowledge is the Stroke Engine website (see www.strokengine.ca) (Korner-Bitensky et al., 2007a,b,c; Korner-Bitensky et al., 2008; Menon, 2013; Rochette, Korner-Bitensky, Tremblay, & Kloda, 2008). This site consolidates information on stroke rehabilitation both in lay terms for use by patients and families, and in medical terms for health professionals. A recent study using Stroke Engine as a KT intervention with occupational therapists and physical therapists providing stroke rehabilitation indicated that Stroke Engine had a positive impact on evidence-based knowledge acquisition (Menon, 2013). Based on the feedback from clinicians using the Stroke Engine website, development of learning tools that address cognitive/EF rehabilitation post-stroke is a high priority (unsolicited comments received through the "CONTACT US" link on the homepage). Also, the evidence of a gap between best and actual clinical practices related to management of executive dysfunction post-stroke (Korner-Bitensky et al., 2011) provides further support for the development of EF learning modules.

Accordingly, my global objective was to create multi-modal learning modules (including a web-based component on Stroke Engine) to provide the latest evidence on EF assessment and treatment post-stroke, in order to enhance occupational therapists' awareness of best practices for the management of executive dysfunction post-stroke.

To achieve this objective, a multi-phase study was undertaken, with specific objectives for each phase:

Phase 1:

Objective 1a: To identify and critically appraise standardized EF assessments, and interventions for persons experiencing EF problems post-stroke.

Objective 1b: To identify and critically appraise commercially available computer-based tools / videogames for EF retraining according to their purpose, client appropriateness and practicality for use in clinical practice and in home-based self-directed therapy.

Phase 2:

Objective 2: To identify occupational therapists' information needs specific to EF rehabilitation post-stroke; preferences in terms of format and content of the learning modules, as well as, barriers and facilitators expected for the use of these tools in their clinical setting, in order to tailor the learning modules to their specific needs.

Phase 3:

Objective 3: To develop the learning modules on EF assessment and intervention post-stroke and to make them web-ready.

In order to accomplish these objectives, the KTA conceptual framework by Graham et al. (2006) was used as a guiding model. Specifically, we followed the steps from "*identification, review and selection of knowledge*" to "*selection, tailoring and implementation of interventions*" in order to develop learning modules that will be adapted to the specific needs of occupational therapists providing stroke rehabilitation.

METHODS

Phase 1: Literature reviews

Review of executive function assessments and interventions post-stroke

As described in Chapters 2 and 3, a systematic review on the effectiveness of EF interventions post-stroke and a structured review of performance-based measures of EF and their stroke-specific psychometric properties were performed. It should be noted that most of the performance-based EF assessments included in Chapter 2 were *assessment tools* designed to provide a thorough assessment of the person's skills. Considering that the *detection* of cognitive impairment had been identified as a priority area for knowledge translation (Bayley et al., 2007), it was deemed relevant to also review and identify *screening tools* to detect the presence of potential cognitive/EF impairment. Information gleaned from the 2013 update of the Mood and Cognition Chapter of the Canadian Best Practice Recommendations for Stroke Care (Eskes et al., 2013a) and from another review of EF tools used in driving research conducted by our team (Asimakopulos et al., 2012) facilitated the process of identifying cognitive/EF screening tools that have sound psychometric properties specific to a stroke population.

Review of clinically useful computer-based tools/videogames with executive function components

A structured internet review was conducted to identify commercially available computer-based tools/videogames with EF components. Searches were first conducted using Google by combining the following keywords: *cognitive function, executive function, cognitive skills, cognitive training, cognitive rehabilitation, brain fitness, brain training, exercise, software and computer/computerized*. We also consulted with expert researchers in computer-based/videogame training (LB, Concordia University; and PB, McGill University) to identify additional clinically useful software.

To be considered for inclusion in this review, each computer-based tool needed to: 1) be available in English or French; 2) include at least one task targeting one or more components of executive function; and, 3) be intended for use with adults. The companies producing and distributing the software were contacted to obtain a trial version (where available). The tools were critically appraised by the principal investigator and a research assistant with the objective of identifying the *executive function components targeted* (i.e. planning, problem solving, working memory, inhibition, divided attention and switching), the *prerequisite abilities of the client required* (i.e. language, visual-perception, fine motor skills and computer skills) and the *characteristics of the cognitive training* (e.g., adjustable difficulty levels / feedback on performance). Searches were conducted on the software website to obtain information regarding the development, scientific validity and effectiveness. The names of tools were used as keywords in searching electronic databases (i.e. MEDLINE, CINAHL, PsychINFO) to further identify publications concerning their properties. Information on clinical utility (i.e. cost, ordering information, duration of the exercises and system requirements) was also collected. Information on each tool was recorded and critically appraised using a comprehensive data abstraction form specifically developed for this study as there was no published standardized form covering all the aforementioned criteria.

Phase 2: Focus groups

Design

A focus group of expert OT clinicians was conducted to identify their learning needs specific to EF rehabilitation post-stroke, their preferences in terms of format and content of the learning modules, as well as, the barriers and facilitators expected for the use of these tools in their clinical setting.

Focus group methodology was chosen as this format typically leads to insights beyond those attained through individual interviews (Morgan & Krueger, 1997). Specifically, structured focus group methodology was used including: development of questions according to a structured format, validation of content with participants during the focus group, audio-recording of content to retain salient comments, and data analyses using thematic evaluation (Fink, Kosecoff, Chassin, & Brook, 1984; Morgan & Krueger, 1997). Ethics approval was obtained by McGill's Faculty of Medicine Internal Review Board and by the CRIR Research Ethics Board.

Participants

An OT was eligible to participate if he or she had been providing OT services to adults with stroke in an acute care hospital or rehabilitation centre in Montreal or Laval within the past two years; had more than six months of clinical experience with a stroke clientele; was managing two or more adults with stroke per month; and, was proficient in English or French.

Recruitment

Eligible OTs working in adult neurology departments in acute-care hospitals, inpatient rehabilitation centres and community-based settings were identified and notified of the research project via the clinical research coordinators or the clinical administrative coordinators of the recruitment sites. Therapists interested in learning more about the study were then contacted by the principal investigator who described the purpose and verified their eligibility according to the above mentioned inclusion/exclusion criteria. Purposive sampling as well as snowball sampling were used to ensure adequate representation of the various work settings, clinical experience etc.

Question Development

Questions were developed based on the findings from: 1) our literature reviews (Poulin et al., 2012, 2013), 2) our Canadian survey of stroke rehabilitation practices of OTs (Korner-Bitensky et al., 2011); and, 3) previous focus groups (Korner-Bitensky et al., 2008; Petzold, 2011) and usability testing of Stroke Engine with stroke clinicians (Korner-Bitensky et al., 2008; Menon, Korner-Bitensky, Chignell, & Straus, 2012). The focus group was organized in two parts. In the first part, information was elicited on actual and desired assessment and intervention practices for clients with cognitive/EF deficits post-stroke. Next, questions were posed about specific learning needs regarding EF assessment tools and interventions – considering clinical context and the characteristics of their clientele. In the second part, participants were exposed to learning materials (e.g., summary table of EF screening and assessment tools, summary table of computer-based tools for EF retraining, pocket cards summarizing stroke rehabilitation best practices, etc.), as well as a previously developed e-learning module on unilateral spatial neglect (USN) (Menon, Petzold, & Korner-Bitensky, 2011; Petzold, 2011). Questions were then posed about the participants' likes/dislikes, and, preferences in terms of format and content of the learning modules. Finally, some questions were designed to elicit information regarding the facilitators and barriers to using e-learning tools.

Focus Group Procedures

The focus group last approximately 2 hours and was held at McGill University, Montreal, Quebec, Canada. Discussions were conducted in French as this was the first language of many of the participants. In-person written consent was obtained. One moderator (VP) led the focus group along with two assistants: one documented the participants' comments on a large flipchart that was viewable by all, while the other took field notes. Once participants had finished answering each question, their responses were repeated back to them to allow for comments, corrections and refinement of their replies, thus ensuring the essence of the discussion was captured.

Sample size considerations

The recommended number of participants per group for focus group discussions usually ranges from 6 to 12 (Baumgartner, Strong, & Hensley, 2002; Bernard, 1995; Johnson & Christensen, 2004; Krueger, 2000; Langford, Schoenfeld, & Izzo, 2002; Morgan, 1997; Onwuegbuzie, Dickinson, Leech, & Zoran, 2009). In the present study, the goal was to generate a variety of ideas and opinions to guide the development of e-learning modules specific to the management of post-stroke executive dysfunction that would be tailored to the needs of OTs. One focus group of a minimum of 6 clinicians was deemed sufficient to achieve this goal, especially given that three previous studies had already documented clinicians' feedback on the usability of the Stroke Engine website in general, as well as perceived barriers and facilitators to using evidence-based practice in stroke rehabilitation (Korner-Bitensky et al., 2008; Menon et al., 2012; Petzold, 2011).

Data analysis

The clinicians' sociodemographic and work-related characteristics were described using frequencies and proportions for categorical variables.

The audio-recorded discussions from the focus group, participants' comments; and the field notes from the assistant moderator, were transcribed. These data were analyzed using content-based analysis techniques (Morgan & Krueger, 1997) to identify dominant themes and key ideas for the content and format of the multi-modal learning modules. The identification and categorization of the themes was performed by the principal investigator (VP) and validated by two team members (NKB and AP). All three team members (VP, AP and NKB) were bilingual (English/French) and were able to analyze the French material and to perform forward translations from French to English. Salient comments were also abstracted to help illustrate various themes and were translated into English keeping the general meaning of the phrases.

Phase 3: Developing the learning modules

The multi-modal learning modules were created based on the 1) synthesis of review findings, 2) focus group feedback, 3) literature on effective KT strategies specific to rehabilitation (Menon et al., 2009), and 4) results of a previous KT study on unilateral spatial neglect (USN) post-stroke (Petzold et al., 2012). *Stroke Engine*, which is an existing website that offers evidence-based information on stroke rehabilitation used internationally by clinicians, students and researchers (www.strokengine.ca), was used as the host site.

The overall goal was to create web-based modules on EF assessment, as well as evidence-based EF interventions (e.g., computer-based tools for EF retraining and compensatory strategies for executive dysfunction). It was also decided to include an interactive e-learning module, consisting of clinical scenarios and quizzes, to provide clinicians with opportunities to apply this new knowledge within the context of real patients and help them develop a more practical understanding of the EF evaluation tools and interventions (Biggs, 1999). The creation of this interactive e-learning module with patient scenarios was modelled from a previously developed interactive Stroke Engine e-learning module on USN that has been pilot-tested with clinicians (Petzold et al., 2012). We used specific teaching and learning constructs and theoretical frameworks that are known to promote knowledge acquisition (Biggs, 1999; Hmelo-Silver, 2004; McKeachie & Svinicki, 2006; Miller, 1990). As recommended in the literature on problem-based learning (Hmelo-Silver, 2004; McKeachie & Svinicki, 2006), the patient scenarios developed for this study were complex enough to foster problem-solving skills and also involved the possibility of several alternative solutions in order to promote clinical reasoning. We also created a multiple-choice quizz with questions specific to the patients depicted in the vignettes. Questions were designed to reflect different levels of learning according to Bloom's Taxonomy of Learning (Bloom, Mesia, & Krathwohl, 1964). We included both generic questions that involve basic levels of learning (ex. defining executive function) as well as higher level questions that require deeper understanding and analysis, such as choosing the most appropriate assessment tool for a given patient.

Given the importance of educating individuals with stroke and their families about the consequences of executive dysfunction post-stroke and the treatment options available, we also set out to create a web-based module providing information on cognitive/EF rehabilitation in layman's terms for use by patients and families. Providing appropriate education may enable the family unit to better understand stroke-related changes in everyday executive functioning and to adopt appropriate strategies to limit the negative impact of these impairments (Oddy & Herbert, 2009).

Each web-based module was developed following a systematic step-by-step process. Draft versions were first prepared by the primary investigator (VP) with the help of two research assistants. A content expert (VP, DD or, when necessary, an external reviewer) then reviewed the module for accuracy. Prior to website posting, each module was also read by another expert in stroke rehabilitation and knowledge translation (NKB). Further details on the rigorous process undertaken in developing the *Stroke Engine* modules can be found in Korner-Bitensky et al. (2008).

RESULTS

Focus group findings

Six occupational therapists providing stroke rehabilitation in various settings (i.e. acute care hospital, in-patient or outpatient rehabilitation) and having varying levels of experience with a stroke clientele (range = 1.5 to 11 years) participated. Further details on the participants' socio-demographic and work-related characteristics are provided in Table 5.1. All clinicians were working in a neurology program, with patients with stroke representing 25% to greater than 75% of their clientele. When asked about confidence in their ability to treat patients with executive dysfunction (using a five-point scale from *not at all confident* to *extremely confident*), five reported feeling *somewhat confident* and one reported feeling *very confident*.

Participants' responses grouped into four broad categories including: (1) occupational therapists' practices related to cognition/EF, (2) challenges and facilitators for the assessment and treatment of executive dysfunction post-stroke, (3) personal learning needs and preferences in terms of content and format of an e-learning tool, and (4) barriers and facilitators to using an e-learning tool.

Occupational therapists' practices related to cognition/ executive function

The first theme echoed by all participants was around the occupational therapist's unique contribution in the functional assessment and treatment of patients with cognitive/EF impairment post-stroke: *"Our strength in occupational therapy ... the use of functional activities." "We are very good at analysing the task [...], recognising the impact [of cognitive impairments] on the person's functioning and how to compensate for these difficulties."* Another participant added: *"If I only did paper and pencil tests, I would not feel like a real OT..."*

Another theme that emerged from the discussions was around differences in the feasibility of using standardized EF measures according to work setting. To elucidate, most of the acute care clinicians indicated that they typically use generic cognitive screening tools (e.g., Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) or Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975)), as well as non-standardized functional tasks, given that currently available standardized performance-based EF tools have limited applicability and feasibility in their clinical context. Their comments suggested a gap between their actual and desired assessment practices. *"For sure, in an ideal world, I would have a standardized assessment that I could use; one that would give me an objective score…. But that is not the case in our context."* In comparison, clinicians working in rehabilitation centres reported that it was more feasible to administer standardized performance-based EF assessments such as the Behavioural Assessment of the Dysexecutive Syndrome (BADS) (Wilson et al., 1998), although the use of non-standardized assessment was also prevalent. For example, one focus group participant noted that in her site they *"test executive functions by putting the patient in a real life situation such as making a budget or grocery shopping"*.

With respect to intervention practices, participants identified some key elements of cognitive/EF rehabilitation in occupational therapy, that revolved around the importance of educating and involving family members throughout the rehabilitation process: *"In rehabilitation, a large part of the process is to educate the family […] to advise them not to do everything for the clients […] to explain to them that if their family member exhibits a particular behaviour it is perhaps because of a lack of initiative […] to reassure them but also to warn them ... because the family sometimes tends to minimise problems related to executive function."* Most of the clinicians also indicated that they explicitly address generalization and transfer of learning during their interventions, for example, by guiding clients to make links between the trained tasks and other everyday activities.

Challenges and facilitators for the assessment and treatment of executive dysfunction post-stroke

Clinicians identified challenges for the assessment and treatment of executive dysfunction post-stroke that grouped into five main themes: resources, fast discharge from acute care hospitals, complexity of EF assessment, patient factors, and, knowledge gaps. First, the lack of resources, more specifically lack of time to assess patients in the acute care setting and expensive specialized training required for the administration of some standardized tools, such as the Assessment of Motor and Process Skills (AMPS), can affect the clinician's choice of an assessment tool. Also, because of the pressure to discharge patients quickly from acute care, the clinicians reported that their role in these settings is often limited to assessment and discharge planning, with little or no time remaining for treatment. Another key theme was around the complexity of EF assessment and the nature of occupational therapy assessment: *"The tools that we use in occupational therapy are functional assessments—functional tasks and activities—they* *can't be easy to use." "These are complex tasks ... especially for executive functions."* With respect to patient factors, participants indicated that *"What renders assessment and treatment more difficult is that the patients do not simply have deficits of executive function, but also physical deficits, etc ..."* Finally, participants recognized gaps related to EF due to the fact that this area of cognitive rehabilitation was not adequately addressed during their occupational therapy university curriculum: *"We will talk about attention, and short term memory ... but for me [teaching] about executive function was very brief and very vague."* A recommended facilitator would be a timely coordinated assessment by the occupational therapist and the neuropsychologist, given their complementary roles. *"In my clinical setting, my access to neuropsychologists is not quick enough [...] In an ideal world, the neuropsychological assessment would be done at the same time as the occupational therapy assessment."*

Personal learning needs and preferences in terms of content and format of the e-learning modules

When asked about their preferences in terms of content and format of the learning modules, clinicians made several suggestions that grouped into six themes – three around content and the remaining three around format. (A detailed list of clinicians' suggestions is also presented in Table 5.2). In terms of content of the e-learning modules, the three themes identified were the need for:

(1) a comprehensive overview of EF – including neuroanatomy, definitions of EF, theoretical models of brain functioning, and functional repercussions of specific EF deficits;
(2) practical hands-on information on EF assessments and interventions, with vignettes, videos and concrete examples of remedial and compensatory EF interventions that might be used according to specific EF deficits; and,
(3) specific examples (patient vignettes) according to phase of stroke recovery.

As explained by one clinician: *"Everyone has a general idea of executive functions ... we want to know about the intervention, about the concrete and specifics ... if the client has problems with initiation, what do I do ... if there are problems with planning, what do I do?"*

Clinicians also identified three key characteristics specific to the format of the learning modules: quick and easy to use; interactive; and, sections with varying levels of explanation and complexity (e.g., quick summary versus more in-depth description for advanced learners) to meet the learning needs of various users such as novice and expert OTs, students, other health care professionals, patients and families.

Barriers and facilitators to using an e-learning tool

The main theme that emerged around facilitators to using an e-learning tool was having access to computers and internet in the work environment; while the main barriers were the lack of work time available to spend on learning new information, as well as pressure to perform and to see as many patients as possible, particularly in the acute care setting: *"We are quite lucky because we have access to computers, we have access to all these databases ... it is perhaps just time ... I mean to take the time to go consult [these databases] ... we often do this outside of regular working hours."*

Creation of the e-learning modules

The information gleaned from the focus group, combined with our review findings (Poulin et al., 2012, 2013), and, with the information from previous clinician feedback (Korner-Bitensky et al., 2008; Menon et al., 2012; Petzold, 2011), were used to create the e-learning modules.

Table 5.2 summarizes some of the clinicians' suggestions in terms of content and format of the learning modules and how these were addressed when we developed the modules.

Overview of the content of the executive function modules

The e-learning modules consist of the following components: web-based modules with specific sections on EF assessment as well as evidence-based EF interventions; an interactive e-learning module with patient scenarios; pocket cards summarizing EF rehabilitation best practices; and, a module for patients and families (see Appendices 5.1 to 5.10).

The e-learning modules can be accessed via the Stroke Engine website at http://strokengine.ca/intervention/index.php?page=topic&id=90 and http://strokengine.org/elearning/executivefunction/ (also see Appendices 5.1 to 5.10 for screenshots of the different e-learning modules). Globally, these e-learning modules include the same key features than other previously developed e-learning modules on the Stroke Engine website, but their content and format were slightly adapted according to the focus group findings.

Executive function assessment module

A short summary of 6 cognitive/EF screening tools and 16 assessment tools identified through the literature review in Phase 1 was included (see Appendix 5.6 and http://strokengine.ca/intervention/index.php?page=topic&subpage=clinician&id=90), with direct links to in-depth reviews of the tools' psychometric properties and clinical utility in the Stroke Engine Website.

Executive function intervention module

The EF intervention module summarizes the findings from our systematic review of EF interventions post-stroke (Chapter 3 of this thesis) and provides an overview of different remedial and compensatory executive function interventions (e.g., computer-based training, goal management training, external aids such as paging system and checklists, etc.) with the level of evidence of effectiveness of each. This module also includes a review of 12 computer-based programs and 3 videogames with EF components identified and critically appraised in Phase 1. Information on each computer-based program/videogame is summarized in a quick review table with links to relevant websites (see Appendix 5.7 and http://strokengine.ca/intervention/pdf/REVIEW_OF_COMPUTER-BASED_PROGRAMS.pdf).

Interactive e-learning module with patient scenarios

This module includes three clinical vignettes of patients with post-stroke executive dysfunction referred for occupational therapy assessment in an acute care, inpatient rehabilitation or community rehabilitation setting. Each vignette depicts a typical patient with a specific brain lesion – i.e., right middle cerebral artery (MCA) stroke, left MCA stroke or ruptured anterior communicating artery aneurysm – and provides information on their medical history, imaging findings, baseline and current functioning (including concrete examples of EF problems in everyday life) (see Appendices 5.8 to 5.10 for examples). The module also includes a multiple-choice quiz with interactive feedback to test clinicians' knowledge regarding best practices for the management of executive dysfunction. For each question, clinicians get immediate feedback depending on the answer they provided. Direct links to other e-learning modules that provide further information of EF assessments and interventions were also added.

Pocket cards on EF rehabilitation best practices

A printable pocket card that provides an overview of EF and assessment and treatment options was also created and posted online (see Appendices 5.4 and 5.5 and also the Stroke Engine website at: http://strokengine.ca/intervention/admin/vedios/EFPT_Pocketcard.pdf).

Patient/family module

The Patient/Family module uses a question and answer format in layman's terms to explain stroke-related changes in everyday executive functioning and relevant intervention strategies that might be used in home-based self-directed therapy (see Appendices 5.2a and 5.2b for examples).

DISCUSSION

This knowledge translation project led to the creation of a series of new e-learning modules to help close the gap between research evidence and actual practice in the management of executive dysfunction post-stroke. The feedback from the focus group allowed us to tailor the modules to the needs of occupational therapists providing stroke rehabilitation across the continuum of care (i.e. acute, in-patient rehabilitation and community rehabilitation). For example, as per clinicians' recommendations, specific patient vignettes were created for each phase of stroke recovery and concrete examples of strategies that can be used to reduce the daily consequences of various EF impairments (e.g., initiation, planning, working memory, etc.) were provided. It is important to note that all participants in the focus group were working in a neurology department – usually a specialized stroke unit – affiliated with a university and, as such, were more likely to have access to recent research evidence on stroke rehabilitation and to apply stroke best practice guidelines (Menon-Nair, Korner-Bitensky, & Ogourtsova, 2007). It is possible that clinicians working on a "general" medicine floor or rehabilitation unit would have identified slightly different learning needs and barriers/facilitators to adopting evidence-based practices specific to EF rehabilitation post-stroke.

As part of this knowledge translation initiative, we also developed an e-learning module for patients with stroke and their families. It is anticipated that this module will fill a valuable role in empowering persons with stroke and their significant others by providing them with relevant information. The need for additional information and education on the emotional and cognitive sequelae of stroke had also been identified in a previous study examining the provision of information from the perspective of patients and caregivers

(Tooth & Hoffman, 2004). As we continue to develop and further refine this module, it will be important to obtain feedback from patients and families regarding their specific needs for information on the rehabilitation of cognitive/executive functions, their perceived challenges to using various intervention strategies in home-based self-directed therapy, as well as, their preferences in terms of content and format of the learning modules.

CONCLUSIONS

Given the high prevalence and serious functional consequences of EF deficits post-stroke, concerted and assertive efforts are needed to promote best practices in the assessment and rehabilitation of these disorders. These new e-learning modules are accessible on an internationally known website (www.strokengine.ca). The next logical step will be to evaluate the benefits of using these EF e-learning modules as part of a knowledge translation intervention for enhancing clinicians' knowledge and use of best practices specific to EF rehabilitation.

Table 5.1: Clinicians' socio-demographic and work characteristics

Characteristics	N
SOCIO-DEMOGRAPHICS	
Gender (female/male)	5/1
Age (years):	
26-30	4
31-35	1
36-40	1
WORK-RELATED	
Clinical setting:	
acute care hospital	4
rehabilitation – in-patient	1
rehabilitation – outpatient	2*
Years of experience with a stroke clientele:	
1-5	4
6-10	1
11-15	1
Percentage of caseload that patients with stroke represent	
25-50%	2
50-75%	2
≥ 75%	2
Confidence in ability to treat individuals with executive dysfunction post-stroke:	
somewhat confident	5
very confident	1

*Note: One clinician was providing both in-patient and outpatient rehabilitation services.

Table 5.2: Clinicians' suggestions in terms of content and format of an e-learning tool and corresponding characteristics of our e-learning modules

Suggestions from clinicians	Corresponding characteristics of our e-learning modules
CONTENT	
Examples of compensatory strategies that can be used to improve performance of daily activities in persons with various EF problems	We included a summary table of potential external compensatory strategies that may be used according to specific EF deficits and everyday life problems
Specific examples according to phase of stroke recovery	We created an interactive e-learning module with three different vignettes of patients in the acute, subacute and chronic phase post-stroke
Sections on neuroanatomy and definitions of EF	Specific sections were added as well as a link to another website describing brain anatomy (http://thebrain.mcgill.ca/)
Videos	Links to existing videos of EF interventions were added (e.g., for Goal Management Training)
Information on clinical utility of the assessment tools and cognitive training software (e.g., cost, ordering information)	This information was included
Information for patients and families	An information module for patients and families was created
FORMAT	
Positive feedback from clinicians about the USN pocket cards	Pocket cards on EF assessment and intervention were created
Need for an interactive tool	An interactive e-learning module with vignettes and quizzes was created
Adding direct links to relevant articles	Direct access to a reference list of articles was provided
Sections with different levels of explanation/ complexity	The EF Intervention module includes a "Quick Review" section as well as more detailed explanations in the "Clinician How-to section". We also provided a short summary of EF screening and assessment tools as well as links to in-depth reviews

Appendix 5.1: Web-based executive function intervention module

Appendix 5.2a: Web-based information module for patients and their families

Appendix 5.2b: Web-based information module for patients and their families

StrokEngine

www.strokengine.ca

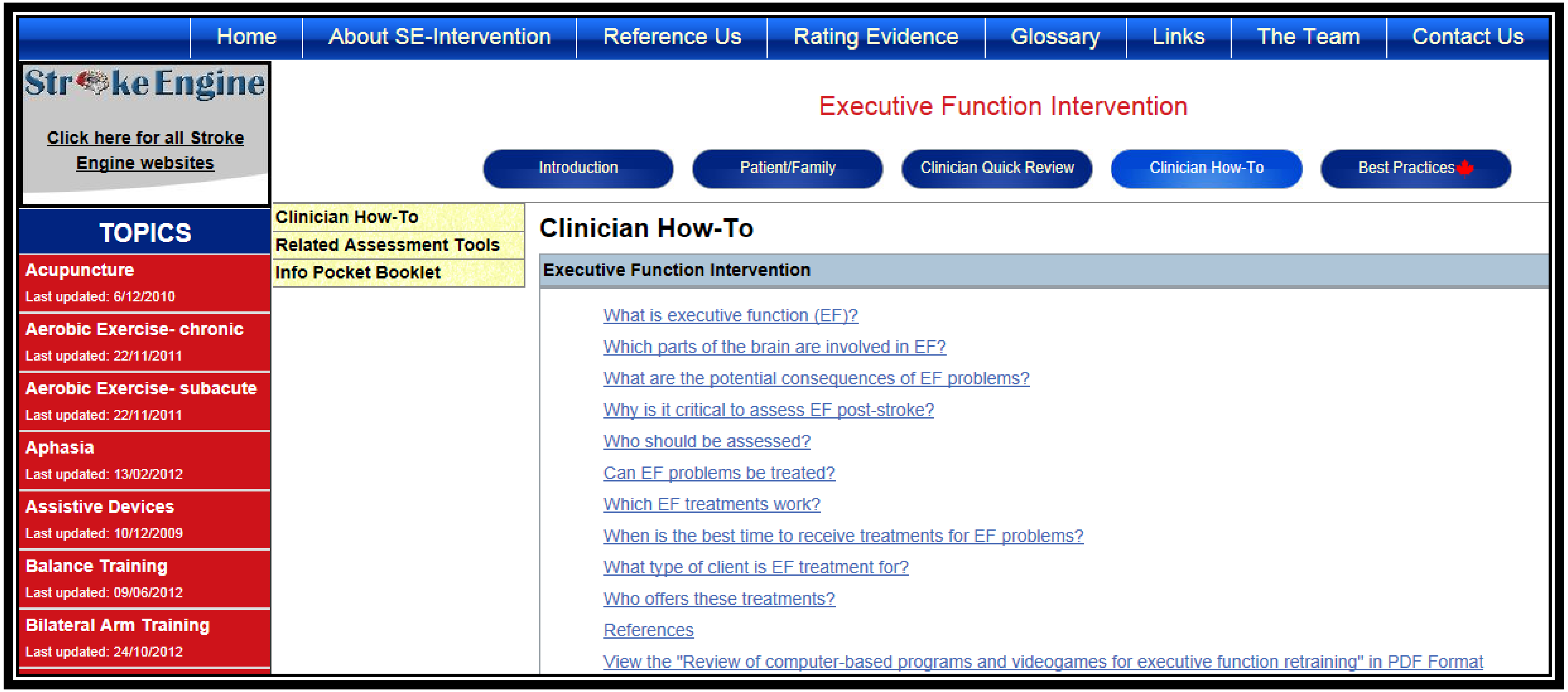
EXECUTIVE FUNCTION

Information for Patients and Families

What is Executive Function (EF)?

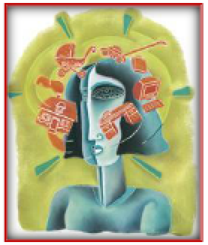
Executive functions (EF) are complex mental skills and abilities that help us to manage our attention and behaviour so we can achieve our goals.

Appendix 5.3: Web-based executive function intervention module



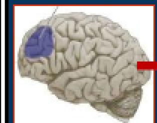
Appendix 5.4: Pocket card on executive function assessment

EXECUTIVE FUNCTION (EF) ASSESSMENT POST-STROKE



EF definition:
High-level cognitive functions responsible for initiation, planning, sequencing, and monitoring of complex goal-directed and purposeful behaviours [1]

Prevalence of post-stroke executive dysfunction: 19-75%[2]



Can a middle cerebral artery stroke lead to EF problems?
Yes, because the lateral **prefrontal cortex** is affected. [3]

Other brain lesions that may affect EF:

- Deep structures connected with frontal cortex [3]
- Posterior damage[3]
- Diffuse lesions [3]

McGill

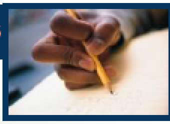
Richard and Edith Strauss Foundation

CRIR

Best practices:

- Patients should be screened for cognitive impairment (including EF) using a validated tool. [4]

Traditional screening tests



Cognitive screening test with an EF component

- Montreal Cognitive Assessment (MoCA) [5]

EF screening test

- Trail Making Test A and B [5]
- Executive Interview-25 (EXIT-25) and Quick EXIT [5]
- Frontal Assessment Battery (FAB) [5]

References:

1. Royall DR, et al. (2002). *J Neuropsychiatry Clin Neurosci, 14*(4), 377-405.
2. Poulin V, et al. (2012). *Top Stroke Rehabil, 19*(2), 158-171.
3. Stuss DT, et al. (2008). *Cognitive Neurorehabilitation: Evidence and Application* (2nd ed.) (pp. 464-486).
4. http://www.strokebestpractices.ca/index.php/cognition-mood/vascular-cognitive-impairment-and-dementia/
5. http://www.medicine.mcgill.ca/strokengine-assess/
6. Poulin V, et al. (2013). *Aust Occup Ther J, 60*, 3-19.

To obtain a copy of this pocket card, please contact us at: strokengine@gmail.com
Find the latest updates on www.strokengine.ca

Assessments that reflect real-world activities & everyday behaviors [5,6]

Tools taking less than 20 minutes

Functional assessment with an EF component

- Kettle Test [5,6]

EF-specific assessment

- Dysexecutive Questionnaire from the Behavioural Assessment of the Dysexecutive Syndrome [5]

Tools taking more than 30 minutes

Functional assessments with an EF component

- Assessment of Motor and Process Skills [5,6]
- ADL Profile [5,6]
- Functional Assessment of Verbal Reasoning and Executive Strategies [5,6]

EF-specific assessments

- Executive Function Performance Test [5,6]
- Multiple Errands Test [5,6]
- Naturalistic Action Test [5,6]
- Cooking task from Chevignard et al. (2008) [5,6]

Appendix 5.5: Pocket card on executive function intervention

EXECUTIVE FUNCTION (EF) TREATMENT POST-STROKE

Effective interventions[1, 2]	Evidence
Remedial interventions	
computerized dual-task training	Limited (2b)
computerized working memory training	Limited (2a)
verbal working memory training	Limited (2b)
Cognitive strategy training*	
analogical problem-solving training	Limited (2a)
goal management training	Limited (2b)
External compensatory approach**	
paging system	Limited (2a)
task-specific checklist	Limited (2b)

* The Cognitive Orientation to daily Occupational Performance (CO-OP) approach[3] has shown promise to improve motor and functional skills post-stroke. Further research is required to evaluate its impact on executive functioning post-stroke.

** Further research is needed to evaluate the effectiveness of new technologies (e.g. smartphone applications).

Remedial interventions

Computerized dual-task training[1]

- The tasks involve coordinating the execution of 2 responses; patients have to identify the position (right or left) of 2 letters on the computer screen, and determine whether the 2 letters are the same or different
- 1 session per week for 5 weeks

Computerized training of working memory[1]

- Computerized training for working memory; the tasks involve presentations of auditory and visuo-spatial stimuli.
- 40 to 60 minute sessions, 5 days per week, for 5 weeks

Verbal working memory training[1]

- Training of storage and processing components of verbal working memory (e.g. oral spelling and word sorting in alphabetic order)
- 60 minute sessions, 3 days per week over 6 months

References:

1. Poulin V, et al. (2012). *Top Stroke Rehabil, 19*(2), 158-171.
2. www.strokengine.ca
3. http://www.ot.utoronto.ca/coop/
4. Levine B, et al. (2011). *Front. Hum. Neurosci.* 5:9. (also see http://research.baycrest.org/gmt)

Current as of March 2013

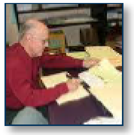
To obtain a copy of this pocket card: strokengine@gmail.com

Cognitive strategy training

Goal management training[4]

- Patients learn to stop ongoing behavior to monitor and adjust goals; this is achieved through instructional material, interactive tasks, discussion of patients' real-life deficits, and homework assignments
- weekly 2-hour sessions over 7 weeks

Analogical problem-solving training[1]



- Patients are presented with problems commonly encountered in daily life and are taught to draw analogies to solve other similar problems.
- 20 sessions of 45 minutes

External compensatory approach

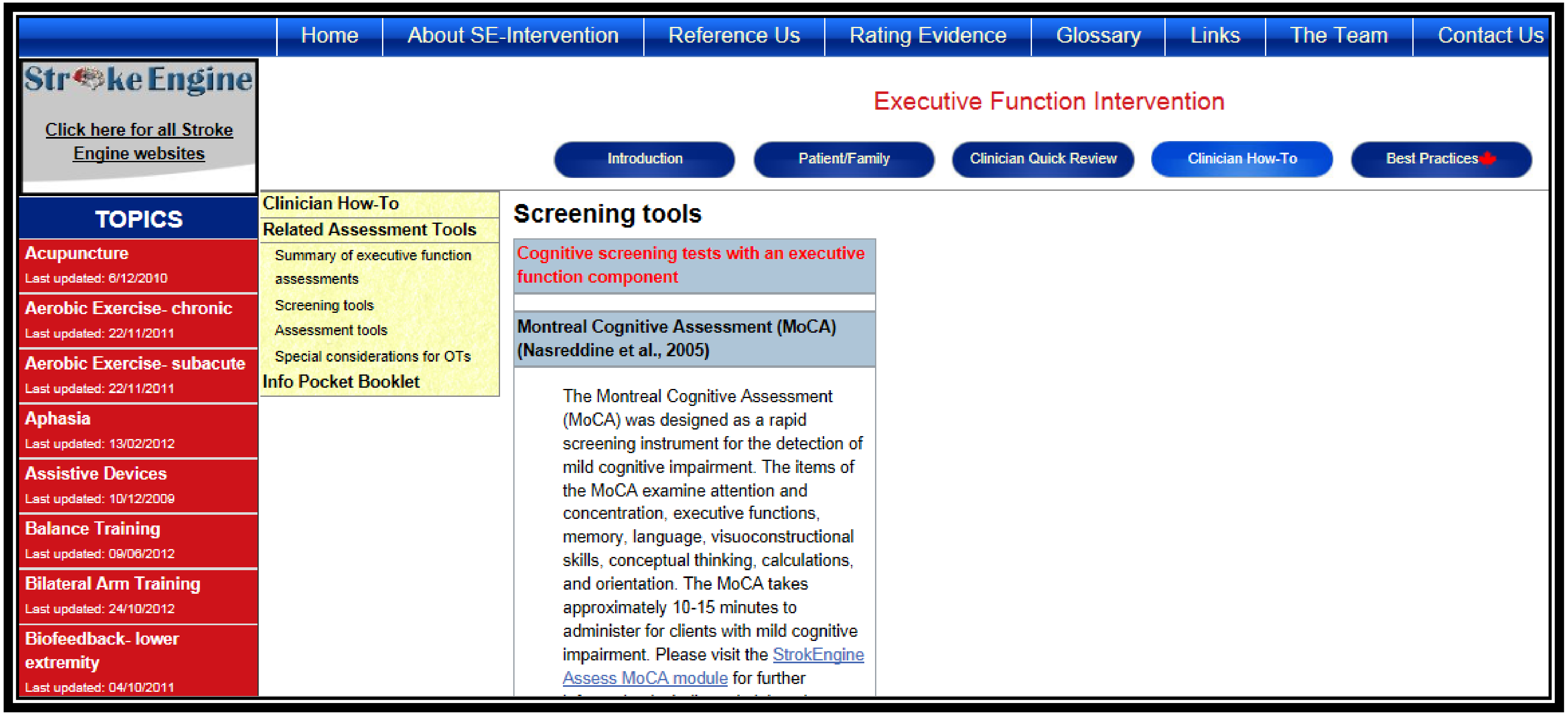
Task-specific checklist[1]

- Task-specific paper and pencil checklist: patients tick off each task once it has been done and record the total time taken to complete the task

Paging system[1,2]

- Paging system (neuropager) involving reminders sent to standard pagers to assist with memory & planning
- Duration: 7 weeks

Appendix 5.6: Web-based executive function assessment module

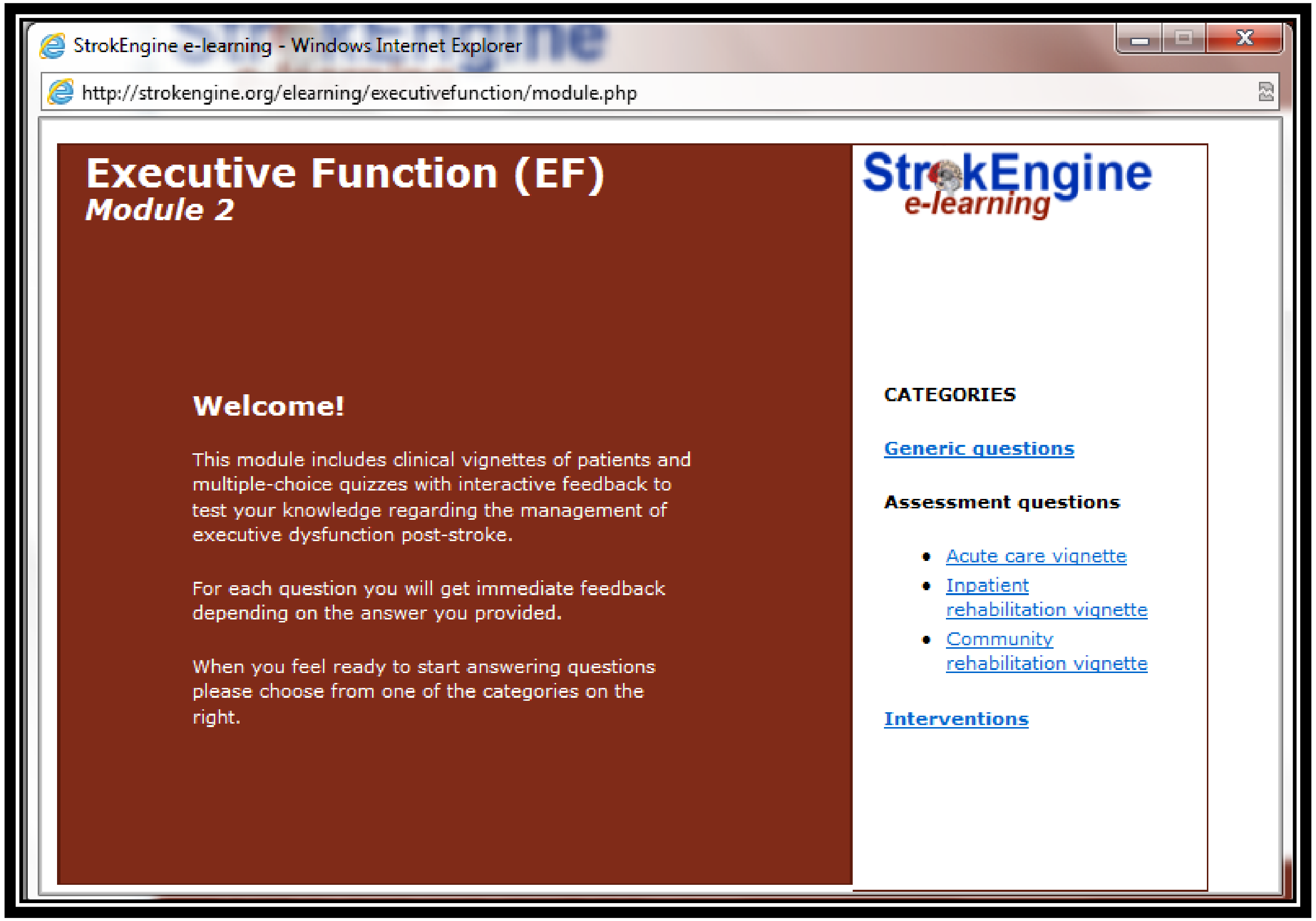


Appendix 5.7: Review of computer-based programs and videogames with executive function components

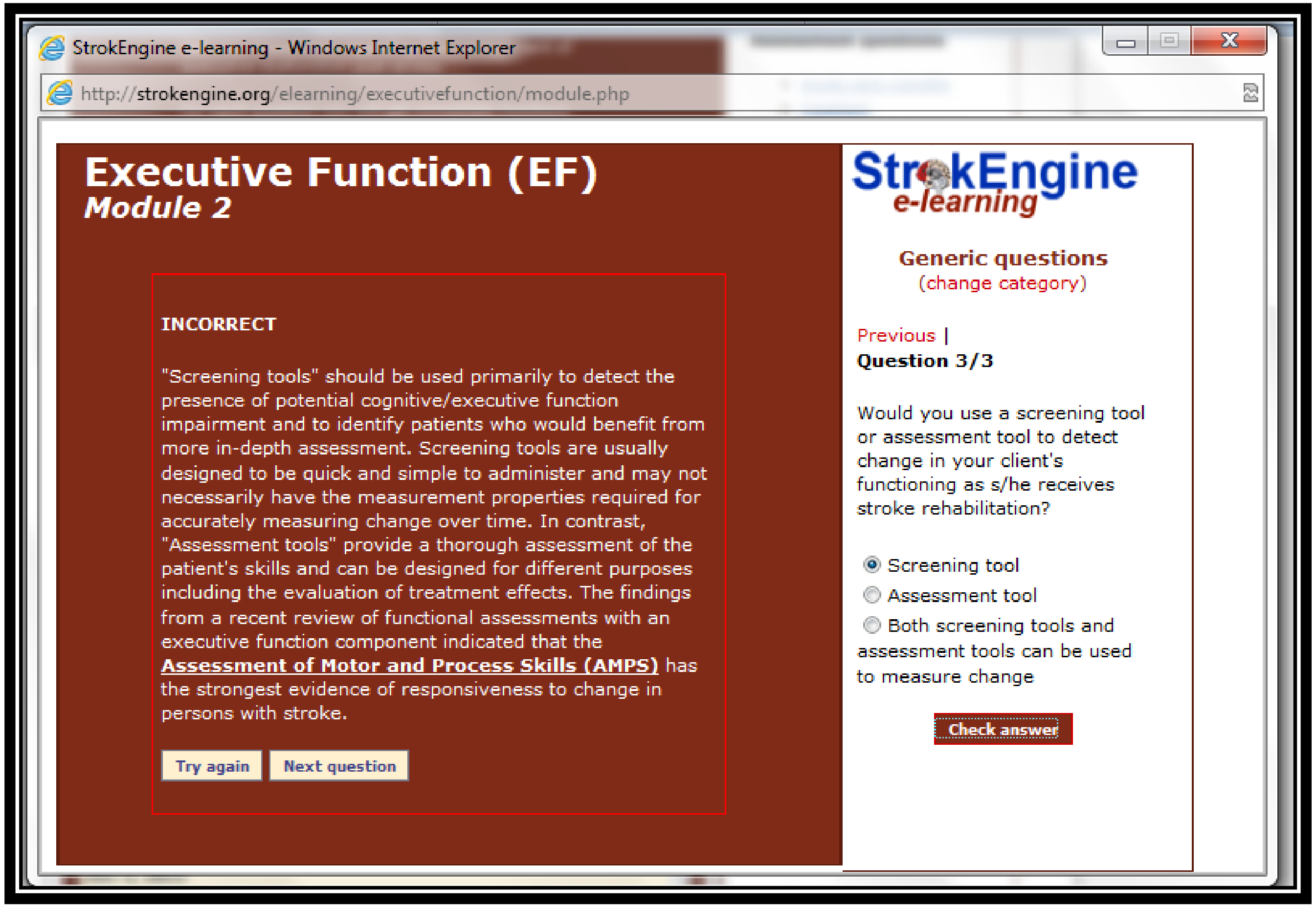
BRAIN TRAINING WEBSITES

Software	Executive function components: Planning	Problem-solving	Inhibition	Working memory	Divided attention	Flexibility	➢ Description of the software ✓ Characteristics of the cognitive training	➢ Development and scientific validity ✓ Effectiveness	Clinical utility ○ Target clientele ○ Pre-requisite abilities ○ Language ○ System requirements ○ Ordering information ○ Cost
CogniFit	X	X	X	X	X	X	➢ Includes 28 brain training games targeting different cognitive skills (e.g. planning, eye-hand coordination, visual short-term memory, working memory, naming, divided attention, shifting, inhibition, spatial perception, focus, etc...) ✓ Levels of difficulty and training tasks automatically selected by the software (based on the results of a pre-training assessment that determines the user's cognitive profile) ✓ The program automatically adjusts the training progress by monitoring the client's performance ✓ Duration of each exercise is variable (most exercises are 4 minutes each) ✓ Client's performance is recorded during each training session and presented in a graph; also each cognitive skill is recorded individually	➢ Developed and validated through neurology, cognitive science and brain research. ✓ Published studies show improvements in cognitive function in healthy older adults. Other studies in individuals with multiple sclerosis and dyslexia were also published (see http://www.cognifit.com/neuroscience). No studies on the effectiveness of CogniFit in persons with stroke were found.	**Target clientele:** Developed for healthy older adults and also adults and children with various neurological disorders, learning disabilities or attention disorders **Pre-requisite abilities:** - Using a mouse to point and click - Other pre-requisites: understanding written instructions and basic attention skills. **Language:** English, French, Spanish (and 7 other languages) **System requirements:** - Internet access **Contact information:** www.cognifit.com *Click on the following link to watch videos of the program:* http://videos.cognifit.com/

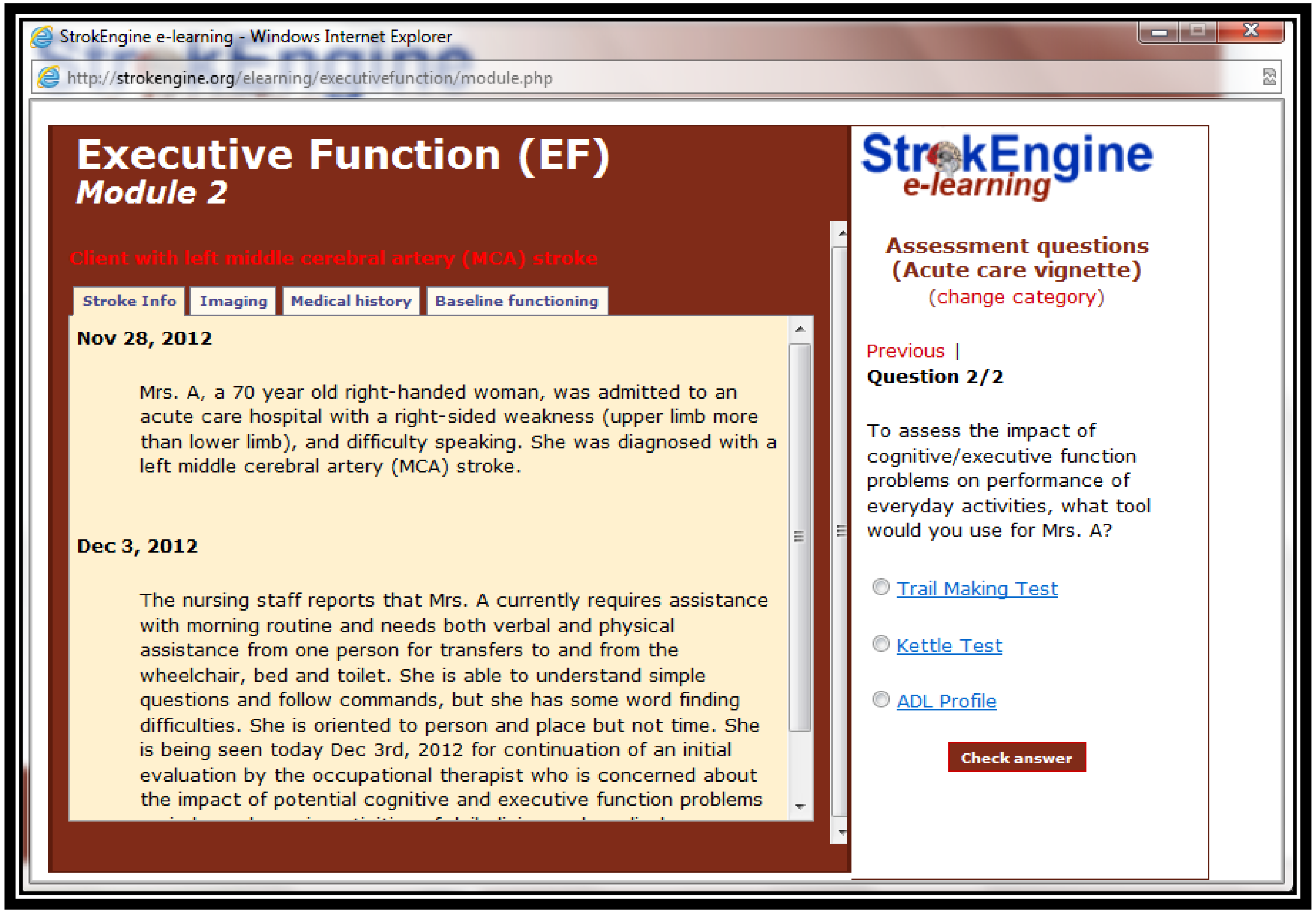
Appendix 5.8: Interactive e-learning module with patient vignettes



Appendix 5.9: Interactive e-learning module with patient vignettes



Appendix 5.10: Interactive e-learning module with patient vignettes



CHAPTER 6: Discussion and conclusions

Detection of EF impairments post-stroke and effective treatment of these disorders is critical. Studies over the past decade have provided evidence of substantial gaps in our knowledge on how to effectively manage EF impairment post-stroke (Bayley et al., 2007; Canadian Stroke Network, 2008; Korner-Bitensky, Barrett-Bernstein, Bibas, & Poulin, 2011). To address these gaps there has been growing attention and research into the management of EF impairment post-stroke. The studies conducted as part of this thesis were designed to address some of these gaps specific to EF assessment and intervention research, and to promote increased use of evidence-based practices for the management of executive dysfunction post-stroke. This chapter summarizes the main findings of this thesis as well as its overall contribution to stroke rehabilitation research and clinical practice. As well, I provide a discussion regarding the main limitations of the work, and suggestions for future endeavours related to patient management and knowledge translation to enhance EF.

Executive function assessment post-stroke (*Manuscript 1*)

The first manuscript (see Chapter 2) provides a critical review of 17 performance-based EF tools that can be used across the continuum of stroke care to evaluate the daily consequences of executive dysfunction. These are described in a *Stroke-Specific Executive Function Toolkit* according to the specific EF components assessed, their psychometric properties specific to stroke, and their clinical utility. This TOOLKIT was recently published in the Australian Occupational Therapy Journal (Poulin, Koner-Bitensky, & Dawson, 2013) and should facilitate clinicians' identification of appropriate EF tools that reflect everyday activities that are affected in patients with EF disorders. I aimed at publishing this first work in an internationally read occupational therapy journal given that in various countries, occupational therapists are the health care professionals typically involved in assessing the impact of cognitive and EF impairment on performance of daily activities (Hartman-Maeir, Katz, & Baum, 2009b; Korner-Bitensky et al., 2011;

Sansonetti & Hoffmann, 2013). Yet, the results from Canadian and Australian surveys of occupational therapists working in stroke rehabilitation (Korner-Bitensky et al., 2011; Sansonetti & Hoffmann, 2013) indicate that, while occupational therapists commonly appraise their clients' cognitive and EF abilities through observation of activities of daily living, the majority use non-standardized functional assessments. As suggested by our focus group findings (see Chapter 5), barriers to using standardized performance-based EF assessments include, among others, lack of awareness of their existence, concern that they are not feasible to administer in a timely fashion, and/or concern that the environment is not conducive to performing these assessments (e.g., limited space and equipment in the acute care setting). As well, some standardized performance-based assessments, such as the AMPS (Fisher & Bray Jones, 2010a, 2010b), require expensive specialised training. Encouragingly, our literature review of performance-based EF assessments identified several standardized tools that may be very feasible to use in a busy clinical environment given that they require no or little formal training and limited equipment, include daily life tasks that are feasible to accomplish within an hour or less, and have adequate validity and/or reliability in a stroke population. Another finding of my review was that few of the measures had been assessed for their responsiveness to patient change; findings that suggest the need for further research in this area if we are to document EF intervention effectiveness (Poulin et al., 2013). I propose several possible reasons for this gap in the psychometric evaluation of EF measures. First, given that so few intervention studies have been done on EF post-stroke, there has been little opportunity to study the responsiveness of these EF measures. Also, intervention studies often focus on the effectiveness of treatment on cognition/EF impairment and thus, impairment measures have dominated (Cicerone et al., 2011). As recommended by Sansonetti and Hoffmann (2013), "Targeted efforts to further incorporate standardised occupational performance-based methods into research, clinical practice and ongoing professional development is required to enhance occupational therapy services when working with individuals with cognitive impairment." The *Stroke-Specific Executive Function Toolkit,* along with the e-learning modules on EF assessment developed as part of this thesis should facilitate identification of appropriate performance-based EF tools for use in different clinical and research contexts. Also, it is worth mentioning that researchers from the Canadian Stroke Network are currently developing an algorithm for screening and assessment of vascular cognitive impairment (Eskes et al., 2013a) that should also support clinical decision-making and use of best practices in the assessment of EF post-stroke.

Executive function intervention post-stroke (*Manuscripts 2 and 3*)

The second manuscript of this thesis (see Chapter 3) focuses on the management of executive dysfunction and describes a systematic review on the effectiveness of EF interventions to remediate EF impairments post-stroke and/or to improve functional tasks compromised by these impairments. This review found limited but encouraging evidence from ten studies – one including participants in the subacute stage and nine including participants in the chronic stage – suggesting that persons with stroke may possibly benefit from both bottom-up and top-down rehabilitation approaches. Three studies on specific EF skill training (e.g., computerized EF training) and seven studies on learning compensatory strategies (e.g., problem-solving strategies and external cueing systems) for improving different aspects of executive functioning such as working memory, dual tasking, problem-solving, goal management and planning of everyday activities reported positive benefits for survivors of stroke. This systematic review has been published in Topics in Stroke Rehabilitation (Poulin, Korner-Bitensky, Dawson, & Bherer, 2012) and a structured abstract has also been written for this review to be included in the Database of Abstracts of Reviews of Effects (DARE) (see http://www.crd.york.ac.uk/CRDWeb/ShowRecord.asp?AccessionNumber=12012019409&UserID=0#.UoDwFKN3v4g). Since this thesis work began, other systematic reviews related to treatment of executive dysfunction after acquired brain injury have also been published (Chung, Pollock, Campbell, Durward, & Hagen, 2013; Cicerone et al., 2011; Kennedy et al., 2008; Rohling, Faust, Beverly, & Demakis, 2009; Zoccolotti et al., 2011), but none of these specifically focus on stroke. Most also found some evidence to support the use of problem-solving or meta-cognitive training (Cicerone et al., 2011; Kennedy et al., 2008; Zoccolotti et al., 2011), as well as external aids (e.g., paging systems) to manage executive dysfunction after acquired brain injury (Cicerone et al., 2011; Zoccolotti et al., 2011). Cicerone and colleagues (2011) also concluded that the use of computer-based interventions for attention and working memory training may be considered as a practice option, as long as there is some involvement and guidance from a therapist. However, Chung and colleagues (2013) reported insufficient availability of high-quality evidence to recommend any specific EF rehabilitation intervention. Differing conclusions between their meta-analyses and other systematic reviews that suggest more positive results might possibly be explained in terms of methodological differences. To elucidate, Chung and colleagues excluded non-randomised and non-controlled studies, as well as studies that did not have full outcome data available for a meta-analysis, while these studies were usually included in the other reviews. Given the limited number of studies that focus specifically on EF interventions post stroke, I also decided to include non-controlled and single-case studies in my systematic review. Although the methodological limitations of these studies (e.g., absence of control group, small sample size, etc.) reduce the possibility of drawing strong conclusions about the effectiveness of interventions, their findings are still relevant to "elucidate innovative and potentially effective treatments" (Cicerone et al., 2011, page 520) and to form hypotheses for future studies (Levine et al., 2008). The evidence from my systematic review adds support to a growing body of literature suggesting that EF interventions have good potential for improving aspects of executive functioning in those with acquired brain injury, including stroke. A unique contribution of my review is to provide a synthesis of the evidence specific to the different stages of stroke recovery, along with recommendations to guide future research in EF rehabilitation post-stroke. Given that the effects of cognitive rehabilitation have been found to be moderated by the type of brain injury (e.g., traumatic brain injury versus stroke), (Rohling et al., 2009), it is important to determine the effectiveness of EF interventions specific to those with stroke.

My review of the literature on EF intervention post-stroke also allowed me to plan the intervention study described in this thesis. The review findings indicated that interventions involving direct EF skill retraining, strategy training, or external compensatory approaches, were more effective than no intervention at improving EF and, possibly, functioning in everyday activities. However, the review also identified a need for additional RCTs that compare the efficacy and advantages of these different treatment approaches. The preliminary evidence on direct remediation/EF skill retraining suggested that structured, individualized and intense computerized EF training could improve targeted EF impairments (Westerberg et al., 2007; Stablum, Umilta, Mogentale, Carlan, & Guerrini, 2000) but whether these interventions would impact at the activity and participation levels of functioning required further investigation. With respect to strategy training, the use of explicit strategies applied to ecologically relevant problems was also showing promise to achieve improvements in some EF impairments (e.g., planning and problem-solving) and, possibly, real-world activities (Man, Soong, Tam, & Hui-Chan , 2006; Schweizer et al., 2008), which was consistent with other recommendations supporting the use of "formal problem-solving strategies and their application to everyday situations and functional activities during postacute rehabilitation after TBI" (Cicerone et al., 2011, p. 523). A third point of interest was that most of the evidence was from studies in the chronic stage of recovery: I thought it important to investigate the effects of EF interventions earlier post-stroke – when the impact of treatment might have a greater potential to enhance recovery.

Taking into consideration the body of evidence on intervention effectiveness available at the time and the research gaps identified in my systematic review, I designed and conducted the pilot RCT to determine the feasibility and preliminary efficacy of two promising interventions, a strategy-training approach – the CO-OP approach which is based on the use of meta-cognitive problem-solving strategies to achieve self-selected functional goals – and a computer-based EF training program for use in a home-based setting with persons with EF deficits in the sub-acute phase after stroke (see Manuscript 3 in Chapter 4). One of the strengths of this study was that the relative impact of each intervention on a variety of outcomes, including measures of EF impairment but also patient-centred outcome measures, such as the Canadian Occupational Performance Measure (COPM) and the Self-Efficacy Scale for Performing Life Activities Post-Stroke, which reflect improvements in personally relevant areas of daily life functioning was explored. Findings from this study supported the feasibility, acceptability and preliminary efficacy of using both CO-OP training and computerized EF training in this population. An interesting finding was that both interventions showed promise for improving EF impairment and performance and satisfaction with performance in participant-chosen everyday activities, while also offering some distinct benefits. The COMPUTER group showed larger gains than the CO-OP group in some areas of EF impairment that were specifically targeted by the computerized tasks (e.g., inhibition). The CO-OP group demonstrated greater improvements in a measure of self-efficacy for performing everyday activities and in EF in everyday life as measured with the DEX questionnaire. These results suggest that the changes observed in each group possibly arose through different mechanisms. The improvements in the CO-OP group may be associated with strategies they learned combined with the use of guided discovery that potentially contributed to enhancing self-efficacy and everyday problem solving and cognitive skills. The improvements in the COMPUTER group may have arisen through training of specific EF skills (e.g., working memory, flexibility, inhibition, etc.). These results have implications for clinical practice and future research on EF rehabilitation post-stroke and raise the hypothesis that a combination of EF interventions, involving both training of specific EF processes and strategy training that incorporates ecologically relevant tasks, will yield optimal treatment outcomes. Our findings, however, must be interpreted with caution given the study limitations, including the small sample size and the risk of both type I and type II errors, failure to randomize the first two participants and the absence of a control group that received no specialized EF intervention. Logically, the next step would be to build on these findings and lessons learned from this pilot study to implement a large multi-site RCT that compares the impact of CO-OP training, Computerized EF training and a combination of both interventions in persons experiencing executive dysfunction post-stroke. It is worth mentioning, however, that two ongoing RCTs that were initiated recently; one from Dawson and colleagues (2013c) and the other from Eskes, Mayo, McGrath and Butler (2013b) should also enhance our understanding of the effect of different cognitive rehabilitation interventions involving cognitive strategy training (Dawson et al., 2013c; Eskes et al., 2013b) and specific cognitive/EF skill training using computerized tasks (Eskes et al., 2013b). The evidence from the traumatic brain injury literature also provides support for the use of comprehensive-holistic cognitive rehabilitation that combines different intervention strategies addressing an individual's cognitive, emotional, interpersonal and functional skills (Cicerone et al., 2011). As suggested by Cicerone et al. (2011), "Studies of comprehensive-holistic cognitive rehabilitation provide the best evidence for improvements in health-related outcomes, such as social participation and quality of life." (Cicerone et al., 2011, page 527). This might be a promising area for future research in stroke rehabilitation. Future research should also examine characteristics of individuals who benefit the most from specific intervention approaches, as well as patient characteristics (e.g., age, lesion location, severity of cognitive and language impairments) that affect effectiveness of interventions.

Another important area for future research concerns the clinical feasibility of the CO-OP and the COMPUTER interventions – in terms of the time, resources and training required for their implementation. In my pilot RCT, the interventions consisted of 16 one-hour individual sessions, twice a week, for eight weeks, provided in the participant's home setting by a trained occupational therapist. The frequency and duration of the study interventions were relatively similar to those of other outpatient rehabilitation interventions received by our participants, which suggests that this level of treatment intensity might be feasible, particularly in an outpatient rehabilitation setting. However, the delivery of interventions in the client's home setting would probably require some reorganization of the rehabilitation services to allow clinicians to travel into the community on a more regular basis. The use of information technologies (e.g., internet or telephone-based approaches) to provide some or all of the training sessions at a distance should also be explored to make these interventions more widely available, in a time and cost-efficient way. Encouragingly, the pilot RCT from Westerberg et al.

(2007) supported the feasibility and efficacy of a home-based computerized working memory training program coupled with distance access to clinician guidance via telephone. Recent pilot work in three adults with TBI also suggested that it might be feasible to administer the CO-OP training through an Internet-based videoconferencing format (Ng, Polatajko, Marziali, Hunt, & Dawson, 2013), but additional research is still required in this area. The feasibility of implementing these interventions in a small group format in outpatient rehabilitation settings or within external community groups also deserves further research attention. "In addition to the time and cost benefits, it is becoming clear that group interventions also offer peer and social support for stroke survivors" (Schouten, Murray, & Boshoff, 2011, p. 208). There is also promising evidence from the TBI literature to support the use of group-based interventions for improving executive and problem-solving deficits (Cicerone et al., 2011; Rath, Simon, Langenbahn, Sherr, & Diller, 2003).

In terms of therapist requirements to provide the CO-OP and the COMPUTER training, there are some prerequisite skills specific to each intervention. Therapists administering the computer training program should have the necessary skills for selecting and grading computerized tasks according to the person's specific EF level and deficits. To learn the CO-OP techniques, it is also recommended that therapists receive formal training and have a client-centred philosophy, skills in activity analysis, effective communication skills and a sufficient understanding of learning principles (Polatajko and Mandich, 2004). A combination of various learning strategies may be helpful to learn this approach – such as participation in a training workshop, consultation of written manuals detailing the key CO-OP techniques and principles, video observation, therapist's self-analysis / self-reflection using a diary, as well as feedback and exchange with other therapists experienced in the use of this approach. The use of web-based interactive technologies (e.g., discussion forums, virtual communities of practice) might also be a promising avenue to further support clinicians in the implementation of this novel intervention.

Translating the evidence into clinical practice (*Manuscript 4*)

Another important goal of my doctoral work was to enhance knowledge translation in the area of EF. Specifically, the thesis led to the creation of a series of web-based learning modules on EF assessment and intervention, as well as user-friendly pocket cards designed to summarize EF rehabilitation best-practices for clinicians. We suggest that clinicians may want to use these modules in conjunction with the patient vignettes and the interactive self-assessment quizzes that we have also prepared.

As suggested in the Knowledge to Action (KTA) Model (Graham et al., 2006), the development of learning tools that synthesize knowledge in user-friendly formats and that are tailored to the stakeholders' needs may potentially facilitate the uptake of knowledge. It will be important in future research to determine whether these learning modules and tools indeed have positive benefits in enhancing clinicians' knowledge of evidence-based EF assessments and interventions post-stroke. To further enhance learning and knowledge use, these modules might also be used in conjunction with other KT strategies (Menon, 2013), such as workshops on EF assessment and intervention, local opinion leader, journal club and/or other existing web-based resources (e.g., virtual communities of practice and discussion forums for health professionals working in stroke rehabilitation; also see David, Poissant, & Rochette, 2012). For example, the local champion on cognition and stroke or the clinicians who do journal club at lunchtime could access the EF modules and use them as learning materials. Indeed, the evidence on the effectiveness of KT strategies specific to rehabilitation clinicians supports the use of multimodal active educational methods to facilitate implementation of new assessments and/or interventions into clinical practice (Menon, Korner-Bitensky, Kastner, McKibbon, & Straus, 2009). It has also been suggested that clinicians' motivation and readiness to change their habitual practices are important factors influencing the uptake of best practices (Rochette, Korner-Bitensky, & Thomas, 2009). Future research might also explore how to best address these important personal factors as part of a web-based KT intervention.

As part of the current KT project, we also developed a web-based information module for persons with stroke and their families that explains the consequences of executive dysfunction and the treatment options available. Such information is important to enable individuals with stroke and their families to better understand stroke-related changes in everyday executive functioning and to empower them to participate in the "decision-making [process] regarding the interventions that are effective and in which they would be willing to participate" (Rochette, Korner-Bitensky, Tremblay, & Kloda, 2008, p. 1511). This is also consistent with the new stroke best practice guidelines stressing the importance of active involvement and education of persons with stroke and their families throughout the rehabilitation process (Lindsay et al., 2010, 2013). As we continue to develop and further refine this module, it will be important to obtain feedback from individuals with stroke and their family members regarding their specific needs for information on the rehabilitation of cognitive/executive functions, their perceived challenges to using various intervention strategies in home-based self-directed therapy, as well as, their preferences in terms of content and format of the learning modules.

Conclusion

This doctoral work was initiated in response to important research and practice gaps in the area of cognitive/EF rehabilitation post-stroke (Bayley et al., 2007; Canadian Stroke Network, 2008; Korner-Bitensky et al., 2011). Findings from my systematic literature reviews and my research projects represent a step in the right direction to enhance our knowledge about how to assess and treat executive dysfunction post-stroke; and, to promote evidence-based practices in the management of these disorders. The active involvement of clinicians, persons with stroke and their families will continue to be important as we design and implement future research and KT initiatives in order to generate useful evidence that reflects their needs and priorities.

REFERENCES

Alderman, N., Burgess, P. W., Knight, C., & Henman, C. (2003). Ecological validity of a simplified version of the multiple errands shopping test. *J Int Neuropsychol Soc, 9*(1), 31-44.

Anderson, P. J. (2008). Towards a developmental model of executive function. In V. Anderson, R. Jacobs, & P. Anderson (Eds.), *Executive functions and the frontal lobes: A life span perspective* (pp. 3–21). New York, NY: Taylor & Francis.

Anderson, V., Jacobs, R., & Anderson, P. (2008). *Executive functions and the frontal lobes: A lifespan perspective*. New York, NY: Taylor & Francis.

Andresen, E. M. (2000). Criteria for assessing the tools of disability outcomes research. *Arch Phys Med Rehabil, 81*(12 Suppl 2), S15-20.

Ardila, A. (2008). On the evolutionary origins of executive functions. *Brain Cogn, 68*(1), 92-99. doi: 10.1016/j.bandc.2008.03.003

Army Individual Test Battery. (1944). *Manual of Directions and Scoring.* Washington, DC: War Department, Adjutant General's Office.

Asimakopulos, J., Boychuck, Z., Sondergaard, D., Poulin, V., Menard, I., & Korner-Bitensky, N. (2012). Assessing executive function in relation to fitness to drive: a review of tools and their ability to predict safe driving. *Aust Occup Ther J, 59*(6), 402-427. doi: 10.1111/j.1440-1630.2011.00963.x

Baddeley, A. D. (1986). *Working memory*. New York, NY: Oxford University Press.

Baguena, N., Thomas-Anterion, C., Sciessere, K., Truche, A., Extier, C., Guyot, E., & Paris, N. (2006). [Ecologic evaluation in the cognitive assessment of brain injury patients: generation and execution of script]. *Ann Readapt Med Phys, 49*(5), 234-241. doi: 10.1016/j.annrmp.2006.02.007

Bamdad, M. J., Ryan, L. M., & Warden, D. L. (2003). Functional assessment of executive abilities following traumatic brain injury. *Brain Inj, 17*(12), 1011-1020.

Barker, L. A., Morton, N., Morrison, T. G., & McGuire, B. E. (2011). Inter-rater reliability of the Dysexecutive Questionnaire (DEX): comparative data from non-clinician respondents-all raters are not equal. *Brain Inj, 25*(10), 997-1004. doi: 10.3109/02699052.2011.59704

Basak, C., Boot, W. R., Voss, M. W., & Kramer, A. F. (2008). Can training in a real-time strategy video game attenuate cognitive decline in older adults? *Psychol Aging, 23*(4), 765-777. doi: 10.1037/a0013494

Bates, B., Choi, J. Y., Duncan, P. W., Glasberg, J. J., Graham, G. D., Katz, R. C., . . . Zorowitz, R. (2005). Veterans Affairs/Department of Defense Clinical Practice Guideline for the Management of Adult Stroke Rehabilitation Care: executive summary. *Stroke, 36*(9), 2049-2056. doi: 10.1161/01.STR.0000180432.73724.AD

Baum, C. M., Connor, L. T., Morrison, T., Hahn, M., Dromerick, A. W., & Edwards, D. F. (2008). Reliability, validity, and clinical utility of the Executive Function Performance Test: a measure of executive function in a sample of people with stroke. *Am J Occup Ther, 62*(4), 446-455.

Baum, C. M., Morrison, T., Hahn, M., & Edwards, D. F. (2003). *Test manual: Executive Function Performance Test.* St. Louis, MO: Washington University.

Baumgartner, T. A., Strong, C. H., & Hensley, L. D. (2002). *Conducting and reading research in health and human performance* (3rd ed.). New York: McGraw-Hill.

Bayley, M. T., Hurdowar, A., Teasell, R., Wood-Dauphinee, S., Korner-Bitensky, N., Richards, C. L., . . . Jutai, J. W. (2007). Priorities for stroke rehabilitation and research: results of a 2003 Canadian Stroke Network consensus conference. *Arch Phys Med Rehabil, 88*(4), 526-528. doi: 10.1016/j.apmr.2007.01.005

Bedard, M., Molloy, D. W., Squire, L., Minthorn-Biggs, M-B., Dubois, S., Lever, J. A., & O'Donnell, M. (2003). Validity of self-reports in dementia research: The Geriatric Depression Scale. *Clin Gerontol, 26*, 155-163.

Bennett, P. C., Ong, B., & Ponsford, J. (2005). Measuring executive dysfunction in an acute rehabilitation setting: using the dysexecutive questionnaire (DEX). *J Int Neuropsychol Soc, 11*(4), 376-385.

Berg, E. A. (1948). A simple objective technique for measuring flexibility in thinking. *J Gen Psychol, 39*, 15-22. doi: 10.1080/00221309.1948.9918159

Bernard, H. R. (1995). *Research methods in anthropology: Qualitative and quantitative approaches*. Walnut Creek, CA: AltaMira.

Bernspang, B., & Fisher, A. G. (1995). Differences between persons with right or left cerebral vascular accident on the Assessment of Motor and Process Skills. *Arch Phys Med Rehabil, 76*(12), 1144-1151.

Bherer, L., Kramer, A. F., Peterson, M. S., Colcombe, S., Erickson, K., & Becic, E. (2005). Training effects on dual-task performance: are there age-related differences in plasticity of attentional control? *Psychol Aging, 20*(4), 695-709. doi: 10.1037/0882-7974.20.4.695

Bherer, L., Kramer, A. F., Peterson, M. S., Colcombe, S., Erickson, K., & Becic, E. (2008). Transfer effects in task-set cost and dual-task cost after dual-task training in older and younger adults: further evidence for cognitive plasticity in attentional control in late adulthood. *Exp Aging Res, 34*(3), 188-219. doi: 10.1080/03610730802070068

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development, 18*(1), 57-75.

Bjorkdahl, A., Nilsson, A. L., Grimby, G., & Sunnerhagen, K. S. (2006). Does a short period of rehabilitation in the home setting facilitate functioning after stroke? A randomized controlled trial. *Clin Rehabil, 20*(12), 1038-1049. doi: 10.1177/0269215506071230

Blake, H., McKinney, M., Treece, K., Lee, E., & Lincoln, N. B. (2002). An evaluation of screening measures for cognitive impairment after stroke. *Age Ageing, 31*(6), 451-456.

Bloom, B. S., Mesia, B. B., & Krathwohl, D. R. (1964*). Taxonomy of Educational Objectives (two vols: The Affective Domain & The Cognitive Domain).* New York, NY: David McKay.

Bodenburg, S., & Dopslaff, N. (2008). The Dysexecutive Questionnaire Advanced: Item and rest score characteristics, 4-factor solution, and severity classification. *J Nerv Ment Dis, 196*(1), 75–78.

Boelen, D. H., Spikman, J. M., Rietveld, A. C., & Fasotti, L. (2009). Executive dysfunction in chronic brain-injured patients: assessment in outpatient rehabilitation. *Neuropsychol Rehabil, 19*(5), 625-644. doi: 10.1080/09602010802613853

Bottari, C., Dassa, C., Rainville, C., & Dutil, E. (2009a). The criterion-related validity of the IADL Profile with measures of executive functions, indices of trauma severity and sociodemographic characteristics. *Brain Inj, 23*(4), 322-335. doi: 10.1080/02699050902788436

Bottari, C., Dassa, C., Rainville, C., & Dutil, E. (2009b). The factorial validity and internal consistency of the Instrumental Activities of Daily Living Profile in individuals with a traumatic brain injury. *Neuropsychol Rehabil, 19*(2), 177-207. doi: 10.1080/09602010802188435

Bottari, C., & Dawson, D. R. (2011). Executive functions and real world performance: How good are we at distinguishing people with acquired brain injury from healthy controls? *Occup Ther J Res*, *31*(1-Supplement), S61-68.

Bottari, C. L., Dassa, C., Rainville, C. M., & Dutil, E. (2010). The IADL profile: development, content validity, intra- and interrater agreement. *Can J Occup Ther, 77*(2), 90-100.

Braver, T. S., Barch, D. M., & Cohen, J. D. (1999). Cognition and control in schizophrenia: a computational model of dopamine and prefrontal function. *Biol Psychiatry, 46*(3), 312-328.

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The Cognitive Failures Questionnaire (CFQ) and its correlates. *Br J Clin Psychol, 21 (Pt 1)*, 1-16.

Burgess, P. W., Alderman, N., Evans, J., Emslie, H., & Wilson, B. A. (1998). The ecological validity of tests of executive function. *J Int Neuropsychol Soc, 4*(6), 547-558.

Burgess, P. W., Alderman, N., Forbes, C., Costello, A., Coates, L. M., Dawson, D. R., . . . Channon, S. (2006). The case for the development and use of "ecologically valid" measures of executive function in experimental and clinical neuropsychology. *J Int Neuropsychol Soc, 12*(2), 194-209. doi: 10.1017/S1355617706060310

Canadian Institutes of Health Research. (2013). *Knowledge Translation.* Ottawa, Government of Canada. Retrieved from http://www.cihr-irsc.gc.ca/e/46977.html

Canadian Stroke Network. (2008). Research proposals sought into cognitive impairment. *Brainwaves*, Issue 77. Retrieved from http://www.canadianstrokenetwork.ca/wp content/uploads/2010/07/brainwavesJuly2008_EN.pdf

Cederfeldt, M., Widell, Y., Elgmark Andersson, E., Dahlin-Ivanoff, S., & Gosman-Hedström, G. (2011) Concurrent validity of the Executive Function Performance Test in people with mild stroke. *Br J Occup Ther, 74*(9), 443-449.

Chan, R. C. (2001). Dysexecutive symptoms among a non-clinical sample: A study with the use of the Dysexecutive Questionnaire. *Br J Psychol, 92 Part 3*, 551-565.

Chan, R. C., Shum, D., Toulopoulou, T., & Chen, E. Y. (2008). Assessment of executive functions: review of instruments and identification of critical issues. *Arch Clin Neuropsychol, 23*(2), 201-216. doi: 10.1016/j.acn.2007.08.010

Chaytor, N., & Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: a review of the literature on everyday cognitive skills. *Neuropsychol Rev, 13*(4), 181-197.

Chevignard, M., Pillon, B., Pradat-Diehl, P., Taillefer, C., Rousseau, S., Le Bras, C., & Dubois, B. (2000). An ecological approach to planning dysfunction: script execution. *Cortex, 36*(5), 649-669.

Chevignard, M. P., Taillefer, C., Picq, C., Poncet, F., Noulhiane, M., & Pradat-Diehl, P. (2008). Ecological assessment of the dysexecutive syndrome using execution of a cooking task. *Neuropsychol Rehabil, 18*(4), 461-485. doi: 10.1080/09602010701643472

Chung, C. S., Pollock, A., Campbell, T., Durward, B. R., & Hagen, S. (2010). Cognitive rehabilitation for executive dysfunction in patients with stroke or other adult non-progressive acquired brain damage. *Cochrane Database Syst Rev, 3*, CD008391.

Chung, C. S., Pollock, A., Campbell, T., Durward, B. R., & Hagen, S. (2013). Cognitive rehabilitation for executive dysfunction in adults with stroke or other adult non-progressive acquired brain damage. *Cochrane Database Syst Rev, 4*, CD008391. doi: 10.1002/14651858.CD008391.pub2

Cicerone, K. D., Dahlberg, C., Kalmar, K., Langenbahn, D. M., Malec, J. F., Bergquist, T. F., . . . Morse, P. A. (2000). Evidence-based cognitive rehabilitation: recommendations for clinical practice. *Arch Phys Med Rehabil, 81*(12), 1596-1615. doi: 10.1053/apmr.2000.19240

Cicerone, K. D., Dahlberg, C., Malec, J. F., Langenbahn, D. M., Felicetti, T., Kneipp, S., . . . Catanese, J. (2005). Evidence-based cognitive rehabilitation: updated review of the literature from 1998 through 2002. *Arch Phys Med Rehabil, 86*(8), 1681-1692. doi: 10.1016/j.apmr.2005.03.024

Cicerone, K. D., Langenbahn, D. M., Braden, C., Malec, J. F., Kalmar, K., Fraas, M., . . . Ashman, T. (2011). Evidence-based cognitive rehabilitation: updated review of the literature from 2003 through 2008. *Arch Phys Med Rehabil, 92*(4), 519-530. doi: 10.1016/j.apmr.2010.11.015

Cicerone, K., Levin, H., Malec, J., Stuss, D., & Whyte, J. (2006). Cognitive rehabilitation interventions for executive function: moving from bench to bedside in patients with traumatic brain injury. *J Cogn Neurosci, 18*(7), 1212-1222. doi: 10.1162/jocn.2006.18.7.1212

Cochrane central register of controlled trials (CENTRAL) in the Cochrane Collaboration, Cochrane Library. (2011). Retrieved from http://www.cochranelibrary.com.

Cochrane database of systematic review in the Cochrane Collaboration, Cochrane Library. (2011). Retrieved from http://www.cochranelibrary.com.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Crist, J. D., Ruiz, M. R., Torres-Urquidy, O. H., Pasvogel, A., & Hepworth, J. T. (2013). Recruiting hospitalized Mexican American elder adults and caregivers: challenges and strategies. *Res Gerontol Nurs, 6*(1), 22-28. doi: 10.3928/19404921-20121205-01

Crosby, R. D., Kolotkin, R. L., & Williams, G. R. (2003). Defining clinically meaningful change in health-related quality of life. *J Clin Epidemiol, 56*(5), 395-407.

Cup, E. H., Scholte op Reimer, W. J., Thijssen, M. C., & van Kuyk-Minis, M. A. (2003). Reliability and validity of the Canadian Occupational Performance Measure in stroke patients. *Clin Rehabil, 17*(4), 402-409.

Curran, M. (2004). Scaffolded training facilitates learning of naturalistic actions after stroke. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 64*(8-B), 4074.

Dahlin, E., Nyberg, L., Backman, L., & Neely, A. S. (2008). Plasticity of executive functioning in young and older adults: immediate training gains, transfer, and long-term maintenance. *Psychol Aging, 23*(4), 720-730. doi: 10.1037/a0014296

Darrigrand, B., & Mazaux, J. (2000). *Echelle de communication verbale de bordeaux*. Isbergues: Ortho Edition.

David, I., Poissant, L., & Rochette, A. (2012). Clinicians' expectations of Web 2.0 as a mechanism for knowledge transfer of stroke best practices. *J Med Internet Res, 14*(5), e121. doi: 10.2196/jmir.2016

Davidson, D. J., Zacks, R. T., & Williams, C. C. (2003). Stroop interference, practice, and aging. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn, 10*(2), 85-98. doi: 10.1076/anec.10.2.85.14463

Dawson, D. R., Anderson, N. D., Binns, M. A., Bottari, C., Damianakis, T., Hunt, A., . . . Zwarenstein, M. (2013c). Managing executive dysfunction following acquired brain injury and stroke using an ecologically valid rehabilitation approach: a study protocol for a randomized, controlled trial. *Trials, 14*(1), 306. doi: 10.1186/1745-6215-14-306

Dawson, D. R., Anderson, N. D., Burgess, P., Cooper, E., Krpan, K. M., & Stuss, D. T. (2009b). Further development of the Multiple Errands Test: standardized scoring, reliability, and ecological validity for the Baycrest version. *Arch Phys Med Rehabil, 90*(11 Suppl), S41-51. doi: 10.1016/j.apmr.2009.07.012

Dawson, D. R., Binns, M. A., Hunt, A., Lemsky, C., & Polatajko, H. J. (2013a). Occupation-based strategy training for adults with traumatic brain injury: a pilot study. *Arch Phys Med Rehabil, 94*(10), 1959-1963. doi: 10.1016/j.apmr.2013.05.021

Dawson, D. R., Gaya, A., Hunt, A., Levine, B., Lemsky, C., & Polatajko, H. J. (2009a). Using the cognitive orientation to occupational performance

(CO-OP) with adults with executive dysfunction following traumatic brain injury. *Can J Occup Ther, 76*(2), 115-127.

Dawson, D., Richardson, J., Troyer, A., Binns, M., Clark, A., Polatajko, H., . . . Bar, Y. (2013b). An occupation-based strategy training approach to managing age-related executive changes: a pilot randomized controlled trial. *Clin Rehabil*. doi: 10.1177/0269215513492541

de Bruin, A. F., Diederiks, J. P., de Witte, L. P., Stevens, F. C., & Philipsen, H. (1997). Assessing the responsiveness of a functional status measure: the Sickness Impact Profile versus the SIP68. *J Clin Epidemiol, 50*(5), 529-540.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System.* San Antonio, TX: The Psychological Corporation.

Dell'Aniello-Gauthier, M. (1994). *Étude métrologique du mini-profil, instrument de mesure du statut fonctionnel des personnes âgées victimes d'un accident vasculaire cérébral*. (Unpublished master's thesis). Université de Sherbrooke, Sherbrooke, Canada.

DeLuca, J., & Locker, R. (1996). Cognitive rehabilitation following anterior communicating artery aneurysm bleeding: a case report. *Disabil Rehabil, 18*(5), 265-272.

Desmond, D. W., Erkinjuntti, T., Sano, M., Cummings, J. L., Bowler, J. V., Pasquier, F., . . . Hachinski, V. C. (1999). The cognitive syndrome of vascular dementia: implications for clinical trials. *Alzheimer Dis Assoc Disord, 13 Suppl 3*, S21-29.

Desrosiers, J., Demers, L., Robichaud, L., Vincent, C., Belleville, S., & Ska, B. (2008). Short-term changes in and predictors of participation of older adults after stroke following acute care or rehabilitation. *Neurorehabil Neural Repair, 22*(3), 288-297. doi: 10.1177/1545968307307116

Dickerson, A., Reistetter, T., & Trujullo, L. (2010). Using an IADL Assessment to Identify Older Adults Who Need a Behind-the-Wheel Driving Evaluation. *J Appl Gerontol, 29*, 494–506.

Diehl, M., Marsiske, M., Horgas, A. L., Rosenberg, A., Saczynski, J. S., & Willis, S. L. (2005). The Revised Observed Tasks of Daily Living: A Performance-Based Assessment of Everyday Problem Solving in Older

Adults. *J Appl Gerontol, 24*(3), 211-230. doi: 10.1177/0733464804273772

Dikmen, S. S., Heaton, R. K., Grant, I., & Temkin, N. R. (1999). Test-retest reliability and practice effects of expanded Halstead-Reitan Neuropsychological Test Battery. *J Int Neuropsychol Soc, 5*(4), 346-356.

Dirette, D. K., Hinojosa, J., & Carnevale, G. J. (1999). Comparison of remedial and compensatory interventions for adults with acquired brain injuries. *J Head Trauma Rehabil, 14*(6), 595-601.

Doble, S. E., Fisk, J. D., Lewis, N., & Rockwood, K. (1999). Test-retest reliability of the Assessment of Motor and Process Skills (AMPS) in elderly adults. *Occup Ther J Res, 19*, 203-215.

Duchek, J. (1991). Cognitive Dimensions of Performance. In C. Christiansen & C. M. Baum (Eds.), *Occupational therapy: Overcoming human performance deficits* (pp. 285-304). Thorofare, NJ: SLACK Incorporated.

Duncan, P. W., Horner, R. D., Reker, D. M., Samsa, G. P., Hoenig, H., Hamilton, B., . . . Dudley, T. K. (2002). Adherence to postacute rehabilitation guidelines is associated with functional recovery in stroke. *Stroke, 33*(1), 167-177.

Duncan, P. W., Zorowitz, R., Bates, B., Choi, J. Y., Glasberg, J. J., Graham, G. D., . . . Reker, D. (2005). Management of Adult Stroke Rehabilitation Care: a clinical practice guideline. *Stroke, 36*(9), e100-143. doi: 10.1161/01.STR.0000180861.54180.FF

Dutil, E., Bottari, C., Vanier, M., & Gaudreault, C. (2005). *ADL Profile: Description of the instrument* (4th ed.). Montreal: Les Éditions Émersion.

Eskes, G., Mayo, N., McGrath, P., & Butler, B. (2013b). *Stroke Help: Turning SMART Goals into smart actions: Evaluating 'Stroke Help' distance interventions to improve cognitive performance post-stroke*. Retrieved from http://crfh.ca/index.php/research-programs/current-research/stroke/

Eskes, G., Salter, K., on behalf of the Mood and Cognition in Stroke Writing Group and the Evidence-Based Review in Stroke Rehabilitation Team. (2013a). Chapter 7: Mood and Cognition in Stroke. In M. P. Lindsay, G. Gubitz, M. Bayley, & S. Phillips (Eds.) on behalf of the Canadian Stroke

Best Practices and Standards Advisory Committee. *Canadian Best Practice Recommendations for Stroke Care.* Ottawa, Canada: Canadian Stroke Network.

Evans, J. J. (2009). Rehabilitation of executive functioning: an overview. In M. Oddy & A. Worthington (Eds.), *The rehabilitation of executive disorders: a guide to theory and practice* (pp. 59-73). New York, NY: Oxford University Press.

Evans, J. J., Emslie, H., & Wilson, B. A. (1998). External cueing systems in the rehabilitation of executive impairments of action. *J Int Neuropsychol Soc, 4*(4), 399-408.

Evans, J. J., Greenfield, E., Wilson, B. A., & Bateman, A. (2009). Walking and talking therapy: improving cognitive-motor dual-tasking in neurological illness. *J Int Neuropsychol Soc, 15*(1), 112-120. doi: 10.1017/S1355617708090152

Fasotti, L., Kovacs, F., Eling, P. A. T. M., Brouwer, W. H. (2000). Time pressure management as a compensatory strategy training after closed head injury. *Neuropsychol Rehabil, 10*, 47-65.

Figueiredo, S. (2009). *Nordic walking: A new training for frail elderly.* (Order No. MR66106, McGill University (Canada)). *ProQuest Dissertations and Theses,*139. Retrieved from http://search.proquest.com/docview/807440133?accountid=12339. (807440133).

Figueiredo, S., Finch, L., Mai, J., Ahmed, S., Huang, A., & Mayo, N. E. (2013). Nordic walking for geriatric rehabilitation: a randomized pilot trial. *Disabil Rehabil, 35*(12), 968-975. doi: 10.3109/09638288.2012.717580

Figueiredo, S., Korner-Bitensky, N., Rochette, A., & Desrosiers, J. (2010). Use of the LIFE-H in stroke rehabilitation: A structured review of its psychometric properties. *Disabil Rehabil*, *32*(9), 705-712. doi: 10.3109/09638280903295458.

Fink, A., Kosecoff, J., Chassin, M., & Brook, R. H. (1984). Consensus methods: characteristics and guidelines for use. *Am J Public Health, 74*(9), 979-983.

Fish, J., Evans, J. J., Nimmo, M., Martin, E., Kersel, D., Bateman, A., . . . Manly, T. (2007). Rehabilitation of executive dysfunction following brain injury: "content-free" cueing improves everyday prospective memory performance. *Neuropsychologia, 45*(6), 1318-1330. doi: 10.1016/j.neuropsychologia.2006.09.015

Fish, J., Manly, T., Emslie, H., Evans, J. J., & Wilson, B. A. (2008a). Compensatory strategies for acquired disorders of memory and planning: differential effects of a paging system for patients with brain injury of traumatic versus cerebrovascular aetiology. *J Neurol Neurosurg Psychiatry, 79*(8), 930-935. doi: 10.1136/jnnp.2007.125203

Fish, J., Manly, T., & Wilson, B. A. (2008b). Long-term compensatory treatment of organizational deficits in a patient with bilateral frontal lobe damage. *J Int Neuropsychol Soc, 14*(1), 154-163. doi: 10.1017/S1355617708080120

Fisher, A. G., & Bray Jones, K. (2010a). *Assessment of Motor and Process Skills. Vol. 1: Development, Standardization, and Administration Manual* (7th ed.). Fort Collins, CO: Three Star Press.

Fisher, A. G., & Bray Jones, K. (2010b). *Assessment of Motor and Process Skills. Vol. 2: User Manual* (7th ed.). Fort Collins, CO: Three Star Press.

Foley, N. C., Teasell, R. W., Bhogal, S. K., & Speechley, M. R. (2003). Stroke Rehabilitation Evidence-Based Review: methodology. *Top Stroke Rehabil, 10*(1), 1-7.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res, 12*(3), 189-198.

Folstein, M. F., Folstein, S. E., McHugh, P. R., & Fanjiang, G. (2001). *Mini Mental State Examination User's Guide*. Odessa, FL: Psychological Assessment Resources.

Fong, K. N., & Howie, D. R. (2009). Effects of an explicit problem-solving skills training program using a metacomponential approach for outpatients with acquired brain injury. *Am J Occup Ther, 63*(5), 525-534.

Fougeyrollas, P., Noreau, L., & St-Michel, G. (2002). *Life Habits measure – Shortened version (LIFE-H 3.1)*. Québec, Canada: CQCIDIH

Fuster, J. M. (2002). Frontal lobe and cognitive development. *J Neurocytol, 31*(3-5), 373-385.

Gervais, N. (1995). *Étude de validité de trait du Profil des AVQ. Instrument de mesure portant sur les activités de la vie quotidienne* (Unpublished master's thesis). Université de Montréal, Montréal, Canada.

Giles, G. M. (2010). Cognitive versus functional approaches to rehabilitation after traumatic brain injury: commentary on a randomized controlled trial. *Am J Occup Ther, 64*(1), 182-185.

Godefroy, O., & Stuss, D. T. (2007). Dysexecutive syndromes. In O. Godefroy & J. Bogousslavsky (Eds.), *The behavioral and cognitive neurology of stroke* (pp. 369-406). Cambridge: Cambridge University Press.

Goverover, Y. (2004). Categorization, deductive reasoning, and self-awareness: association with everyday competence in persons with acute brain injury. *J Clin Exp Neuropsychol, 26*(6), 737-749. doi: 10.1080/13803390490509321

Goverover, Y., & Hinojosa, J. (2002). Categorization and deductive reasoning: predictors of instrumental activities of daily living performance in adults with brain injury. *Am J Occup Ther, 56*(5), 509-516.

Goverover, Y., & Josman, N. (2004). Everyday problem solving among four groups of individuals with cognitive impairments: Examination of the discriminant validity of the Observed Tasks of Daily Living – Revised. *OTJR: Occupation, Participation and Health, 24*(3), 103-112.

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: time for a map? *J Contin Educ Health Prof, 26*(1), 13-24. doi: 10.1002/chp.47

Granger, C. V., Hamilton, B. B., Keith, R. A., Zielezny, M., & Sherwins, F. S. (1986). Advance in functional assessment for medical rehabilitation. *Top Geriatr Rehabil, 1*, 59-74.

Gray, J.M., Robertson, I., Pentland, B., & Anderson, S. (1992). Microcomputerbased attentional retraining after brain damage: a randomized group controlled trial. *Neuropsychol Rehabil, 2*, 97-115.

Grieve, J. L., & Gnanasekaran, L. (2008). *Neuropsychology for occupational therapists: cognition in occupational performance* (3rd ed.). Oxford, UK: Blackwell Publishing.

Gronwall, D. M. (1977). Paced auditory serial-addition task: a measure of recovery from concussion. *Percept Mot Skills, 44*(2), 367-373.

Guyatt, G. R., & Rennie, D. (2002). *Users' guides to the medical literature: A manual for evidence-based clinical practice*. Chicago, IL: AMA Press.

Hachinski, V., Iadecola, C., Petersen, R. C., Breteler, M. M., Nyenhuis, D. L., Black, S. E., . . . Leblanc, G. G. (2006). National Institute of Neurological Disorders and Stroke-Canadian Stroke Network vascular cognitive impairment harmonization standards. *Stroke, 37*(9), 2220-2241. doi: 10.1161/01.STR.0000237236.88823.47

Happaney, K., Zelazo, P. D., & Stuss, D. T. (2004). Development of orbitofrontal function: current themes and future directions. *Brain Cogn, 55*(1), 1-10. doi: 10.1016/j.bandc.2004.01.001

Hartman-Maeir, A., Armon, N., & Katz, N. (2005). *The Kettle Test: A cognitive functional screening test*. Unpublished protocol. Helene University, Jerusalem, Israel. Retrieved from http://www.rehabmeasures.org/Lists/RehabMeasures/DispForm.aspx?ID=939

Hartman-Maeir, A., Harel, H., & Katz, N. (2009a). Kettle test--a brief measure of cognitive functional performance. Reliability and valdity in stroke rehabilitation. *Am J Occup Ther, 63*(5), 592-599.

Hartman-Maeir, A., Katz, N., & Baum, C. M. (2009b). Cognitive Functional Evaluation (CFE) Process for Individuals with Suspected Cognitive Disabilities. *Occup Ther Health Care, 23*(1), 1-23. doi: 10.1080/07380570802455516

Hayes, S., Donnellan, C., & Stokes, E. (2011). The measurement and impairment of executive function after stroke and concepts for physiotherapy. *Physical Therapy Reviews, 16*, 178-190.

Heart and Stroke Foundation of Canada. (2012). *What is a stroke?* Retrieved from http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3483935/k.736A/Stroke__What_is_Stroke.htm

Heart and Stroke Foundation of Canada. (2013). *Statistics – Stroke.* Retrieved from http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3483991/k.34A8/Statistics.htm

Hershkovitz, A., & Brill, S. (2007). The association between patients' cognitive status and rehabilitation outcome in a geriatric day hospital. *Disabil Rehabil, 29*(4), 333-337. doi: 10.1080/09638280600787096

Heruti, R. J., Lusky, A., Dankner, R., Ring, H., Dolgopiat, M., Barell, V., . . . Adunsky, A. (2002). Rehabilitation outcome of elderly patients after a first stroke: effect of cognitive status at admission on the functional outcome. *Arch Phys Med Rehabil, 83*(6), 742-749.

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educ Psychol Rev, 16*(3), 235-266.

Hochstenbach, J., Mulder, T., van Limbeek, J., Donders, R., & Schoonderwaldt, H. (1998). Cognitive decline following stroke: a comprehensive study of cognitive decline following stroke. *J Clin Exp Neuropsychol, 20*(4), 503-517. doi: 10.1076/jcen.20.4.503.1471

Hommel, M., Miguel, S. T., Naegele, B., Gonnet, N., & Jaillard, A. (2009). Cognitive determinants of social functioning after a first ever mild to moderate stroke at vocational age. *J Neurol Neurosurg Psychiatry, 80*(8), 876-880. doi: 10.1136/jnnp.2008.169672

Honda, T. (1999). Rehabilitation of executive function impairments after stroke. *Top Stroke Rehabil, 6*(1), 15-22.

Intercollegiate Stroke Working Party. (2004). *National Clinical Guidelines for Stroke* (2nd ed.). Suffolk: The Lavenham Press Ltd.

Isaki, E., & Turkstra, L. (2000). Communication abilities and work re-entry following traumatic brain injury. *Brain Inj, 14*(5), 441-453.

ISI Web of Knowledge. (2011). *ISI Web of Science.* Retrieved from http://apps.isiknowledge.com.

Jacobson, N. S., & Truax, P. (1991). Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. *J Consult Clin Psychol, 59*(1), 12-19.

Jaeschke, R., Singer, J., & Guyatt, G. H. (1989). Measurement of health status. Ascertaining the minimal clinically important difference. *Control Clin Trials, 10*(4), 407-415.

Johansson, B., Norrving, B., & Lindgren, A. (2000). Increased stroke incidence in Lund-Orup, Sweden, between 1983 to 1985 and 1993 to 1995. *Stroke, 31*(2), 481-486.

Johnson, R. B., & Christensen, L. B. (2004). *Educational research: Quantitative, qualitative, and mixed approaches*. Boston: Allyn and Bacon.

Josman, N., Hof, E., Klinger, E., Marie, R. M., Goldenberg, K., Weiss, P. L., & Kizony, R. (2006). Performance within a virtual supermarket and its relationship to executive functions in poststroke patients. *Proceedings of International Workshop on Virtual Rehabilitation*, New York, 106-109.

Josman, N., Klinger, E., & Kizony, R. (2008). Performance within the Virtual Action Planning Supermarket (VAP-S): An executive function profile of three different populations suffering from deficits in the central nervous system. *Proceedings of the 7th International Conference on Disability, Virtual Reality and Associated Technologies*, Maia & Porto, Portugal, 33-38.

Kang, Y. J., Ku, J., Han, K., Kim, S. I., Yu, T. W., Lee, J. H., & Park, C. I. (2008). Development and clinical trial of virtual reality-based cognitive assessment in people with stroke: preliminary study. *Cyberpsychol Behav, 11*(3), 329-339. doi: 10.1089/cpb.2007.0116

Kaplan, E., Fein, D., Morris, R., & Delis, D. (1981). *WAIS-R as a neuropsychological instrument.* New York, NY: The Psychological Corporation.

Kennedy, M. R., Coelho, C., Turkstra, L., Ylvisaker, M., Moore Sohlberg, M., Yorkston, K., . . . Kan, P. F. (2008). Intervention for executive functions after traumatic brain injury: a systematic review, meta-analysis and clinical recommendations. *Neuropsychol Rehabil, 18*(3), 257-299. doi: 10.1080/09602010701748644

Kizony, R., & Katz, N. (2002). Relationships between cognitive abilities and the process scale and skills of the assessment of motor and process skills (AMPS) in patients with stroke. *Occup Ther J Res, 22*(2), 82-92.

Klinger, E., Chemin, I., Lebreton, S., & Marié, R. M. (2004). A virtual supermarket to assess cognitive planning. *Cyberpsychol Behav, 7*, 292–293.

Klinger, E., Chemin, I., Lebreton, S., & Marie, R. M. (2006). Virtual action planning in Parkinson's disease: a control study. *Cyberpsychol Behav, 9*(3), 342-347. doi: 10.1089/cpb.2006.9.342

Kluding, P. M., Tseng, B. Y., & Billinger, S. A. (2011). Exercise and executive function in individuals with chronic stroke: a pilot study. *J Neurol Phys Ther, 35*(1), 11-17. doi: 10.1097/NPT.0b013e318208ee6c

Knight, C., Alderman, N., & Burgess, P. W. (2002). Development of a simplified version of the multiple errands test for use in hospital settings. *Neuropsychol Rehabil, 12*(3), 231-256.

Koh, C. L., Hoffmann, T., Bennett, S., & McKenna, K. (2009). Management of patients with cognitive impairment after stroke: a survey of Australian occupational therapists. *Aust Occup Ther J, 56*(5), 324-331. doi: 10.1111/j.1440-1630.2008.00764.x

Konsztowicz, S., Anton, J., Crane, J., Moafmashhadi, P., & Koski, L. (2013). A pilot study of training and compensation interventions for mild cognitive impairment. *Dement Geriatr Cogn Dis Extra, 3*(1), 192-201. doi: 10.1159/000350026

Korner-Bitensky, N. (2013). When does stroke rehabilitation end? *Int J Stroke, 8*(1), 8-10. doi: 10.1111/j.1747-4949.2012.00963.x

Korner-Bitensky, N., Barrett-Bernstein, S., Bibas, G., & Poulin, V. (2011). National survey of Canadian occupational therapists' assessment and treatment of cognitive impairment post-stroke. *Aust Occup Ther J, 58*(4), 241-250. doi: 10.1111/j.1440-1630.2011.00943.x

Korner-Bitensky, N., Roy, M. A., Teasell, R., Kloda, L., Storr, C., Asseraf-Pasin, L., & Menon, A. (2008). Creation and pilot testing of StrokEngine: a stroke rehabilitation intervention website for clinicians and families. *J Rehabil Med, 40*(5), 329-333. doi: 10.2340/16501977-0177

Korner-Bitensky, N., Teasell, R., Bayley, M., Wood-Dauphinee, S., Richards, C., Barreca, S.,… Donnini, D. (2007b). Stroke Engine-Intervention. Montreal: Stroke Engine. Retrieved from www.strokengine.ca

Korner-Bitensky, N., Teasell, R., Richards, C., Malouin, F., Desrosiers, J., Wood-Dauphinee, S., … Salter, K. (2007c). Stroke Engine-Assess. Montreal: Stroke Engine. Retrieved from www.strokengine.ca

Korner-Bitensky, N., Teasell, R., Wood-Dauphinee, S., Foley, N., Jutai, J., Salter, K., . . . Kloda, L. (2007a). Introducing Stroke Engine: The stroke rehabilitation intervention website for clinicians, patients and families. *OT Now*, *9*, 10-12.

Kramer, A. F., Larish, J. F., & Strayer, D. L. (1995). Training for attentional control in dual task settings: A comparison of young and old adults. *J Exp Psychol-Appl, 1*, 50-76.

Kramer, A. F., Larish, J. F., Weber, D. L., & Bardell, L. (1999). Training for executive control: Task coordination strategies and aging. In D. Gopher & A. Koriat (Eds.), *Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application* (pp. 617-652). Cambridge, MA: MIT Press.

Krueger, R. A. (2000). *Focus groups: A practical guide for applied research* (3rd ed.). Thousand Oaks, CA: Sage.

Ku, J., Lee, J. H., Han, K., Kim, S. I., Kang, Y. J., & Park, E. S. (2009). Validity and reliability of cognitive assessment using virtual environment technology in patients with stroke. *Am J Phys Med Rehabil, 88*(9), 702-710. doi: 10.1097/PHM.0b013e3181aa427d

Lamberts, K. F., Evans, J. J., & Spikman, J. M. (2010). A real-life, ecologically valid test of executive functioning: the executive secretarial task. *J Clin Exp Neuropsychol, 32*(1), 56-65. doi: 10.1080/13803390902806550

Langford, B. E., Schoenfeld, G., & Izzo, G. (2002). Nominal grouping sessions vs. focus groups. *Qual Market Res Int J*, *5*, 58–70.

Law, M., Baptiste, S., Carswell, A., McColl, M. A., Polatajko, H., & Pollock, N. (2005). *Canadian Occupational Performance Measure* (4th ed.). Toronto, ON: CAOT.

Lawton, M. P., Moss, M., Fulcomer, M., & Kleban, M. H. (1982). A research and service oriented multilevel assessment instrument. *J Gerontol, 37*(1), 91-99.

Lequerica, A. H., Rapport, L. J., Whitman, R. D., Millis, S. R., Vangel, S. J., Hanks, R. A., & Axelrod, B. N. (2006). Psychometric Properties of the Rehabilitation Therapy Engagement Scale When Used Among

Individuals With Acquired Brain Injury. *Rehabil Psychol, 51*(4), 331-337.

Lesniak, M., Bak, T., Czepiel, W., Seniow, J., & Czlonkowska, A. (2008). Frequency and prognostic value of cognitive disorders in stroke patients. *Dement Geriatr Cogn Disord, 26*(4), 356-363. doi: 10.1159/000162262

Levack, W. M., Dean, S. G., Siegert, R. J., & McPherson, K. M. (2006). Purposes and mechanisms of goal planning in rehabilitation: the need for a critical distinction. *Disabil Rehabil, 28*(12), 741-749. doi: 10.1080/09638280500265961

Levine, B., Robertson, I. H., Clare, L., Carter, G., Hong, J., Wilson, B. A., . . . Stuss, D. T. (2000). Rehabilitation of executive functioning: an experimental-clinical validation of goal management training. *J Int Neuropsychol Soc, 6*(3), 299-312.

Levine, B., Turner, G. R., & Stuss, D. T. (2008). Rehabilitation of frontal lobe functions. In D. T. Stuss, G. Winocur, & I. H. Robertson (Eds.), *Cognitive Neurorehabilitation: Evidence and Application* (2nd ed.). (pp. 464-486). United Kingdom: Cambridge University Press.

Lewis, M. W., Babbage, D. R., & Leathem, J. M. (2011). Assessing executive performance during cognitive rehabilitation. *Neuropsychol Rehabil, 21*(2), 145-163. doi: 10.1080/09602011.2010.543867

Lezak, M. (1989). *Assessment of the behavioral consequences of head trauma*. New York, NY: Alan Liss Inc.

Lezak, M. D. (1981). Tinker-toy Test. In M. D. Lezak (ed). *Neuropsychological Assessment*. (3rd ed.). (pp. 660-665). New York, NY: Oxford University Press.

Lincoln, N. B., Majid, M. J., & Weyman, N. (2000). Cognitive rehabilitation for attention deficits following stroke. *Cochrane Database Syst Rev*(4), CD002842. doi: 10.1002/14651858.CD002842

Lindsay, P., Bayley, M., Hellings, C., Hill, M., Woodbury, E., & Phillips, S. (2008) Canadian best practice recommendations for stroke care (updated 2008). *CMAJ, 179*, S1-S25.

Lindsay, M. P., Gubitz, G., Bayley, M., Hill, M. D., Davies-Schinkel, C., Singh, S., & Phillips, S. (2010). *Canadian Best Practice Recommendations for Stroke Care (Update 2010)*. On behalf of the

Canadian Stroke Strategy Best Practices and Standards Writing Group. Ottawa, Canada: Canadian Stroke Network.

Lindsay, M. P., Gubitz, G., Bayley, M., & Phillips, S. (Eds.) on behalf of the Canadian Stroke Best Practices and Standards Advisory Committee. (2013). *Canadian Best Practice Recommendations for Stroke Care.* Ottawa, Canada: Canadian Stroke Network.

Lo Priore, C., Castelnuovo, G., Liccione, D., & Liccione, D. (2003). Experience with V-STORE: considerations on presence in virtual environments for effective neuropsychological rehabilitation of executive functions. *Cyberpsychol Behav, 6*(3), 281-287. doi: 10.1089/109493103322011579

Looi, J. C., & Sachdev, P. S. (1999). Differentiation of vascular dementia from AD on neuropsychological tests. *Neurology, 53*, 670-678.

Lundqvist, A., Grundström, K., Samuelsson, K., Rönnberg, J. (2010). Computerized training of working memory in a group of patients suffering from acquired brain injury. *Brain Injury, 24*(10), 1173-83. doi: 10.3109/02699052.2010.498007.

Luria, A. R. (1966). *Higher cortical functions in man*. New York, NY: Basic Books.

Lussier, M., Gagnon, C., & Bherer, L. (2012). An investigation of response and stimulus modality transfer effects after dual-task training in younger and older. *Front Hum Neurosci, 6*, 129. doi: 10.3389/fnhum.2012.00129

Lyrette, J. (2009). *Les bienfaits de l'entraînement attentionnel chez les personnes âgées: examen des effets de transfert aux tests neuropsychologiques* (Doctoral dissertation). Retrieved from http://www.archipel.uqam.ca/2580/

MacDonald, S., & Johnson, C. J. (2005). Assessment of subtle cognitive-communication deficits following acquired brain injury: A normative study of the Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES). *Brain Inj, 19*(11), 895-902.

Machin, D., Tan, S. B., & Campbell, M. J. (2009). *Sample Size Tables for Clinical Studies* (3rd Ed.). Hoboken, NJ: BMJ Books.

Maeir, A., Krauss, S., & Katz, N. (2011). Ecological validity of the Multiple Errands Test (MET) on discharge from neurorehabilitation hospital. *OTJR: Occupation, Participation and Health, 31*(Suppl 1), S38-S46.

Man, D. W., Soong, W. Y., Tam, S. F., & Hui-Chan, C. W. (2006). A randomized clinical trial study on the effectiveness of a tele-analogy-based problem-solving programme for people with acquired brain injury (ABI). *NeuroRehabilitation, 21*(3), 205-217.

Mann, D. D., & Eland, D. C. (2005). Self-efficacy in mastery learning to apply a therapeutic psychomotor skill. *Percept Mot Skills, 100*(1), 77-84.

Marom, B., Jarus, T., & Josman, N. (2006). The relationship between the Assessment of Motor and Process Skills (AMPS) and the Large Cognitive Level (LACL) test in clients with stroke. *Phys Occup Ther Geriatr, 24*(4), 33-50.

Mazer, B. L., Korner-Bitensky, N. A., & Sofer, S. (1998). Predicting ability to drive after stroke. *Arch Phys Med Rehabil, 79*(7), 743-750.

McClure, J. A., Salter, K., Foley, N., Mahon, H., & Teasell, R. (2012). Adherence to Canadian Best Practice Recommendations for Stroke Care: vascular cognitive impairment screening and assessment practices in an Ontario inpatient stroke rehabilitation facility. *Top Stroke Rehabil, 19*(2), 141-148. doi: 10.1310/tsr1902-141

McDowd, J. M., Filion, D. L., Pohl, P. S., Richards, L. G., & Stiers, W. (2003). Attentional abilities and functional outcomes following stroke. *J Gerontol B Psychol Sci Soc Sci, 58*(1), P45-53.

McDowell, I., & Newell, C. (1996). *Measuring Health. A Guide to Rating Scales and Questionnaires*. New York: Oxford University Press.

McEwen, S. E. (2009). *Using the cognitive orientation to daily occupational performance (CO-OP) treatment approach with adults with stroke: Efficacy and adaptations.* (Order No. NR72395, University of Toronto (Canada)). *ProQuest Dissertations and Theses,* 207. Retrieved from http://search.proquest.com/docview/870045924?accountid=12339. (870045924).

McEwen, S. E., Polatajko, H. J., Davis, J. A., Huijbregts, M., & Ryan, J. D. (2010a). 'There's a real plan here, and I am responsible for that plan': participant experiences with a novel cognitive-based treatment approach for adults living with chronic stroke. *Disabil Rehabil, 32*(7), 540-550. doi: 10.3109/09638280903180189

McEwen, S. E., Polatajko, H. J., Huijbregts, M. P., & Ryan, J. D. (2010b). Inter-task transfer of meaningful, functional skills following a cognitive-based treatment: Results of three multiple baseline design experiments in adults with chronic stroke. *Neuropsychol Rehabil, 20*(4), 541-561. doi: 10.1080/09602011003638194

McEwen, S. E., Polatajko, H. J., Huijbregts, M. P., & Ryan, J. D. (2009). Exploring a cognitive-based treatment approach to improve motor-based skill performance in chronic stroke: Results of three single case experiments. *Brain Inj, 23*(13-14), 1041-1053. doi: 10.3109/02699050903421107

McKeachie, W. J., & Svinicki, M. (2006). *Teaching tips: strategies, research, and theory for college and university teachers* (12th ed.). Boston, MA: Houghton Mifflin.

Menon, A. (2013). *Benefits of an E-learning Intervention for Implementing Stroke Rehabilitation Best Practices* (Unpublished doctoral dissertation). University of Toronto, Toronto, Canada.

Menon, A., Korner-Bitensky, N., Chignell, M., & Straus, S. (2012). Usability testing of two e-learning resources: methods to maximize potential for clinician use. *J Rehabil Med, 44*(4), 338-345. doi: 10.2340/16501977-0952

Menon, A., Korner-Bitensky, N., Kastner, M., McKibbon, K. A., & Straus, S. (2009). Strategies for rehabilitation professionals to move evidence-based knowledge into practice: a systematic review. *J Rehabil Med, 41*(13), 1024-1032. doi: 10.2340/16501977-0451

Menon, A., Petzold, A., & Korner-Bitensky, N. (2011). *Unilateral Spatial Neglect*. Retrieved from Stroke Engine website: http://strokengine.ca/intervention/index.php?page=topic&id=32

Menon-Nair, A., Korner-Bitensky, N., & Ogourtsova, T. (2007). Occupational therapists' identification, assessment, and treatment of unilateral spatial neglect during stroke rehabilitation in Canada. *Stroke, 38*(9), 2556-2562. doi: 10.1161/STROKEAHA.107.484857

Mercier, L., Audet, T., Hébert, R., Rochette, A., & Dubois, M. (2001). Impact of motor, cognitive, and perceptual disorders on ability to perform activities of daily living after stroke. *Stroke, 32*, 2602-2608.

Miller, G. E. (1990). The assessment of clinical skills/competence/performance. *Acad Med, 65*(9 Suppl), S63-67.

Miller, L. T., Polatajko, H. J., Missiuna, C., Mandich, A. D., & Macnab, J. J. (2001). A pilot trial of a cognitive treatment for children with developmental coordination disorder. *Hum Mov Sci, 20*(1-2), 183-210.

Miotto, E. C., Evans, J. J., de Lucia, M. C., & Scaff, M. (2009). Rehabilitation of executive dysfunction: a controlled trial of an attention and problem solving treatment group. *Neuropsychol Rehabil, 19*(4), 517-540. doi: 10.1080/09602010802332108

Morgan, D. L. (1997). *Focus groups as qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Morgan, D. L., & Krueger, R. A. (1997). *The focus group kit*. London: Sage.

Nasreddine, Z. S., Phillips, N. A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc, 53*(4), 695-699. doi: 10.1111/j.1532-5415.2005.53221.x

National Institute of Neurological Disorders and Stroke. (2004). What You Need to Know About Stroke. Bethesda, MD. Retrieved from http://stroke.nih.gov/documents/NIH_NINDS_KnowStrokeAABroch.pdf

National Stroke Foundation. (2010). *Clinical Guidelines for Stroke Management 2010*. Melbourne, Australia. Retrieved from http://www.nhmrc.gov.au /_files_nhmrc/file/publications/synopses/cp126.pdf.

Neistadt, M. E. (1992). The Rabideau kitchen evaluation – revised: An assessment of meal preparation skill. *Occup Ther J Res, 12*, 242-253.

Neistadt, M. E. (1994). A meal preparation treatment protocol for adults with brain injury. *Am J Occup Ther, 48*(5), 431-438.

Ng, E. M., Polatajko, H. J., Marziali, E., Hunt, A., & Dawson, D. R. (2013). Telerehabilitation for addressing executive dysfunction after traumatic brain injury. *Brain Inj, 27*(5), 548-564. doi: 10.3109/02699052.2013.766927

Novakovic-Agopian, T., Chen, A. J., Rome, S., Abrams, G., Castelli, H., Rossi, A., . . . D'Esposito, M. (2011). Rehabilitation of executive functioning with training in attention regulation applied to individually defined goals: a pilot study bridging theory, assessment, and treatment. *J Head Trauma Rehabil, 26*(5), 325-338. doi: 10.1097/HTR.0b013e3181f1ead2

Nys, G. M., van Zandvoort, M. J., de Kort, P. L., Jansen, B. P., de Haan, E. H., & Kappelle, L. J. (2007). Cognitive disorders in acute stroke: prevalence and clinical determinants. *Cerebrovasc Dis, 23*(5-6), 408-416. doi: 10.1159/000101464

O'Brien, J. T., Erkinjuntti, T., Reisberg, B., Roman, G., Sawada, T., Pantoni, L., . . . DeKosky, S. T. (2003). Vascular cognitive impairment. *Lancet Neurol, 2*(2), 89-98.

Oddy, M., & Herbert, C. (2009). The family and executive disorders. In M. Oddy & A. Worthington (Eds.), *The rehabilitation of executive disorders: a guide to theory and practice* (pp. 327-339). New York, NY: Oxford University Press.

Odhuba, R. A., van den Broek, M. D., & Johns, L. C. (2005). Ecological validity of measures of executive functioning. *Br J Clin Psychol, 44*(Pt 2), 269-278. doi: 10.1348/014466505X29431

Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A Qualitative Framework for Collecting and Analyzing Data in Focus Group Research. *International Journal of Qualitative Methods, 8*(3), 1-21. Retrieved from http://connection.ebscohost.com/c/articles/51827937/qualitative-framework-collecting-analyzing-data-focus-group-research

Ownsworth, T., & Shum, D. (2008). Relationship between executive functions and productivity outcomes following stroke. *Disabil Rehabil, 30*(7), 531-540. doi: 10.1080/09638280701355694

Page, S. J., & Levine, P. (2007). Modified constraint-induced therapy in patients with chronic stroke exhibiting minimal movement ability in the affected arm. *Phys Ther, 87*(7), 872-878. doi: 10.2522/ptj.20060202

Patel, M. D., Coshall, C., Rudd, A. G., & Wolfe, C. D. (2002). Cognitive impairment after stroke: clinical determinants and its associations with long-term stroke outcomes. *J Am Geriatr Soc, 50*(4), 700-706.

Petzold, A. (2011). *Increasing knowledge of best practices in occupational therapists treating post-stroke unilateral spatial neglect.* (Order No. MR74968, McGill University (Canada)). *ProQuest Dissertations and Theses*, 115. Retrieved from http://search.proquest.com/docview/876017848?accountid=12339. (876017848).

Petzold, A., Korner-Bitensky, N., Salbach, N. M., Ahmed, S., Menon, A., & Ogourtsova, T. (2012). Increasing knowledge of best practices for occupational therapists treating post-stroke unilateral spatial neglect: results of a knowledge-translation intervention study. *J Rehabil Med, 44*(2), 118-124. doi: 10.2340/16501977-0910

Physiotherapy Evidence Database. (2011). *PEDro scale*. Retrieved from http://www.pedro.org.au/english/downloads/pedro-scale/.

Pohjasvaara, T., Leskela, M., Vataja, R., Kalska, H., Ylikoski, R., Hietanen, M., . . . Erkinjuntti, T. (2002). Post-stroke depression, executive dysfunction and functional outcome. *Eur J Neurol, 9*(3), 269-275.

Polatajko, H. J., & Mandich, A. (2004). *Enabling Occupation in Children: The Cognitive Orientation to daily Occupational Performance (CO-OP) Approach*. Ottawa, Ontario: CAOT Publications.

Ponsford, J. (2004). Rehabilitation following traumatic brain injury and cerebrovascular accident. In J. Ponsford (Ed.), *Cognitive and behavioral rehabilitation: from neurobiology to clinical practice* (pp. 299-342). New York, NY: The Guilford Press.

Ponsford, J. (2008). Rehabilitation of attention following traumatic brain injury. In D. T. Stuss, G. Winocur, & I. H. Robertson (Eds.), *Cognitive Neurorehabilitation: Evidence and Application* (2nd ed., pp. 507-521). United Kingdom: Cambridge University Press.

Poulin, V., & Desrosiers, J. (2008). Participation after stroke: comparing proxies' and patients' perceptions. *J Rehabil Med, 40*(1), 28-35. doi: 10.2340/16501977-0115

Poulin, V., & Desrosiers, J. (2009). Reliability of the LIFE-H satisfaction scale and relationship between participation and satisfaction of older adults with disabilities. *Disabil Rehabil, 31*(16), 1311-1317. doi: 10.1080/09638280802572957

Poulin, V., Korner-Bitensky, N., & Dawson, D. R. (2013). Stroke-specific executive function assessment: a literature review of performance-based tools. *Aust Occup Ther J, 60*(1), 3-19. doi: 10.1111/1440-1630.12024

Poulin, V., Korner-Bitensky, N., Dawson, D. R., & Bherer, L. (2012). Efficacy of executive function interventions after stroke: a systematic review. *Top Stroke Rehabil, 19*(2), 158-171. doi: 10.1310/tsr1902-158

Powell, J., Heslin, J., & Greenwood, R. (2002). Community based rehabilitation after severe traumatic brain injury: a randomised controlled trial. *J Neurol Neurosurg Psychiatry, 72*(2), 193-202.

Public Health Agency of Canada. (2009). *Tracking Heart Disease and Stroke in Canada.* Retrieved from http://www.phac-aspc.gc.ca/publicat/2009/cvd avc/pdf/cvd-avs-2009-eng.pdf

Public Health Agency of Canada. (2011). *Tracking Heart Disease and Stroke in Canada – Stroke Highlights 2011*. Retrieved from http://www.phac aspc.gc.ca/cd-mc/cvd-mcv/sh-fs-2011/index-eng.php

Quinn, T. J., Paolucci, S., Sunnerhagen, K. S., Sivenius, J., Walker, M. F., Toni, D., . . . Committee, E. S. O. W. (2009). Evidence-based stroke r-ehabilitation: an expanded guidance document from the european stroke organisation (ESO) guidelines for management of ischaemic stroke and transient ischaemic attack 2008. *J Rehabil Med, 41*(2), 99-111. doi: 10.2340/16501977-0301

Rand, D., Basha-Abu Rukan, S., Weiss, P. L., & Katz, N. (2009a). Validation of the Virtual MET as an assessment tool for executive functions. *Neuropsychol Rehabil, 19*(4), 583-602. doi: 10.1080/09602010802469074

Rand, D., Eng, J. J., Liu-Ambrose, T., & Tawashy, A. E. (2010). Feasibility of a 6-month exercise and recreation program to improve executive functioning and memory in individuals with chronic stroke. *Neurorehabil Neural Repair, 24*(8), 722-729. doi: 10.1177/1545968310368684

Rand, D., Katz, N., & Weiss, P. L. (2007). Evaluation of virtual shopping in the VMall: comparison of post-stroke participants to healthy control groups. *Disabil Rehabil, 29*(22), 1710-1719. doi: 10.1080/09638280601107450

Rand, D., Weiss, P. L., & Katz, N. (2009b). Training multitasking in a virtual supermarket: a novel intervention after stroke. *Am J Occup Ther, 63*(5), 535-542. y

Raspelli, S., Carelli, F., Morganti, F., Albani, G., Pignatti, R., Mauro, A., …Riva, G. (2009). A neuro VR-based version of the multiple errands test for the assessment of executive functions: A possible approach. *Journal of CyberTherapy and Rehabilitation, 2*(4), 299-313.

Rasquin, S. M., Lodder, J., Ponds, R. W., Winkens, I., Jolles, J., & Verhey, F. R. (2004b). Cognitive functioning after stroke: a one-year follow-up study. *Dement Geriatr Cogn Disord, 18*(2), 138-144. doi: 10.1159/000079193

Rasquin, S. M., Verhey, F. R., van Oostenbrugge, R. J., Lousberg, R., & Lodder, J. (2004a). Demographic and CT scan features related to cognitive impairment in the first year after stroke. *J Neurol Neurosurg Psychiatry, 75*(11), 1562-1567. doi: 10.1136/jnnp.2003.024190

Rath, J. F., Simon, D., Langenbahn, D. M., Sherr, R. L., & Diller, L. (2003). Group treatment of problem-solving deficits in outpatients with traumatic brain injury: A randomised outcome study. *Neuropsychol Rehabil, 13* (4), 461-488.

Reitan, R. M., & Wolfson, D. (1996). Theoretical, methodological and validated bases of the Halstead-Reitan neuropsychological test battery. In I. Grant & K. M. Adams (Eds.), *Neuropsychological Assessment of Neuropsychological Disorders* (pp. 3-42). New York, NY: Oxford University Press.

Rexroth, P., Fisher, A. G., Merritt, B. K., & Gliner, J. (2005). ADL differences in individuals with unilateral hemispheric stroke. *Can J Occup Ther, 72*(4), 212-221.

Riepe, M. W., Riss, S., Bittner, D., & Huber, R. (2004). Screening for cognitive impairment in patients with acute stroke. *Dement Geriatr Cogn Disord, 17*(1-2), 49-53. doi: 10.1159/000074082

Ries, J. D., Drake, J. M., & Marino, C. (2010). A small-group functional balance intervention for individuals with Alzheimer disease: a pilot study. *J Neurol Phys Ther, 34*(1), 3-10. doi: 10.1097/NPT.0b013e3181d00f2e

Robertson, I. H., & Fitzpatrick, S. M. (2008). The future of cognitive neurorehabilitation. In D. T. Stuss, G. Winocur, & I. H. Robertson (Eds.), *Cognitive Neurorehabilitation: Evidence and Application* (2nd ed., pp. 565-74). United Kingdom: Cambridge University Press.

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). 'Oops!': performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia, 35*(6), 747-758.

Rochette, A., Desrosiers, J., Bravo, G., St-Cyr-Tribble, D., & Bourget, A. (2007). Changes in participation after a mild stroke: quantitative and qualitative perspectives. *Top Stroke Rehabil, 14*(3), 59-68. doi: 10.1310/tsr1403-59

Rochette, A., Korner-Bitensky, N., & Thomas, A. (2009). Changing clinicians' habits: is this the hidden challenge to increasing best practices? *Disabil Rehabil, 31*(21), 1790-1794. doi: 10.1080/09638280902803773

Rochette, A., Korner-Bitensky, N., Tremblay, V., & Kloda, L. (2008). Stroke rehabilitation information for clients and families: assessing the quality of the StrokEngine-Family website. *Disabil Rehabil, 30*(19), 1506-1512.

Rohling, M. L., Faust, M. E., Beverly, B., & Demakis, G. (2009). Effectiveness of cognitive rehabilitation following acquired brain injury: a meta-analytic re-examination of Cicerone et al.'s (2000, 2005) systematic reviews. *Neuropsychology, 23*(1), 20-39. doi: 10.1037/a0013659

Roman, G. C. (2003). Vascular dementia: distinguishing characteristics, treatment, and prevention. *J Am Geriatr Soc, 51*(5 Suppl Dementia), S296-304. doi: 10.1046/j.1532-5415.5155.x

Ruff, R. M., Niemann, H., Allen, C. C., Farrow, C. E., & Wylie, T. (1992). The Ruff 2 and 7 Selective Attention Test: a neuropsychological application. *Percept Mot Skills, 75*(3 Pt 2), 1311-1319.

Sackett, D. L., Straus S. E., Richardson, W. S., Rosenberg, W., & Haynes, R. B. (2000). *Evidence-based medicine: how to practice and teach EBM* (2nd ed.). Edinburgh & New York: Churchill Livingstone.

Salter, K., Jutai, J. W., Teasell, R., Foley, N. C., Bitensky, J., & Bayley, M. (2005). Issues for selection of outcome measures in stroke rehabilitation: ICF activity. *Disabil Rehabil, 27*(6), 315-340. doi: 10.1080/09638280400008545

Salter, K., Jutai, J., Zettler, L., Moses, M., McClure, A., Foley, N., & Teasell, R. (2012). *Module 21 Outcome Measures in Stroke rehabilitation. The Evidence-Based Review of Stroke Rehabilitation (EBRSR) 15th ed*. Retrieved from http://www.ebrsr.com/uploads/Chapter-21-outcome-assessment-SREBR-15_1.pdf

Salter, K., Teasell, R., Bitensky, J., Foley, N., Bhogal, S. K., Mahon, H., & McClure, J. A. (2012). *Module 12 Cognitive Disorders and Apraxia*. *The Evidence-Based Review of Stroke Rehabilitation (EBRSR)*. Retrieved from http://www.ebrsr.com/uploads/Cognitive-Disorders-and-Apraxia-SREBR-15-(2).pdf

Sansonetti, D., & Hoffmann, T. (2013). Cognitive assessment across the continuum of care: the importance of occupational performance-based assessment for individuals post-stroke and traumatic brain injury. *Aust Occup Ther J, 60*(5), 334-342. doi: 10.1111/1440-1630.12069

Schouten, L., Murray, C., Boshoff, K., Sherman, K., & Patterson, S. (2011). Overcoming the long-term effects of stroke: qualitative perceptions of involvement in a group rehabilitation programme... ...includes commentary by Sherman K and Patterson S. *International Journal of Therapy & Rehabilitation, 18*(4), 198-208.

Schwartz, M. F., Segal, M., Veramonti, T., Ferraro, M., & Buxbaum, L. J. (2002). The Naturalistic Action Test: A standardised assessment for everyday action impairment, *Neuropsychol Rehabil, 12*(4), 311-339.

Schweizer, T. A., Levine, B., Rewilak, D., O'Connor, C., Turner, G., Alexander, M. P., . . . Stuss, D. T. (2008). Rehabilitation of executive functioning after focal damage to the cerebellum. *Neurorehabil Neural Repair, 22*(1), 72-77. doi: 10.1177/1545968307305303

Shallice, T., & Burgess, P. W. (2001). Deficits in strategy application following frontal lobe damage in man. *Brain, 114*, 727-741.

Skidmore, E. R., Dawson, D. R., Whyte, E. M., Butters, M. A., Dew, M. A., Grattan, E. S., . . . Holm, M. B. (2013). Developing complex interventions: lessons learned from a pilot study examining strategy training in acute stroke rehabilitation. *Clin Rehabil*. doi: 10.1177/0269215513502799

Skidmore, E. R., Holm, M. B., Whyte, E. M., Dew, M. A., Dawson, D., & Becker, J. T. (2011). The feasibility of meta-cognitive strategy training in acute inpatient stroke rehabilitation: case report. *Neuropsychol Rehabil, 21*(2), 208-223. doi: 10.1080/09602011.2011.552559

Skidmore, E. R., Whyte, E. M., Holm, M. B., Becker, J. T., Butters, M. A., Dew, M. A., . . . Lenze, E. J. (2010). Cognitive and affective predictors of rehabilitation participation after stroke. *Arch Phys Med Rehabil, 91*(2), 203-207. doi: 10.1016/j.apmr.2009.10.026

Smart, A. (2006). A multi-dimensional model of clinical utility. *Int J Qual Health Care, 18*(5), 377-382. doi: 10.1093/intqhc/mzl034

Soderback, I. (1988). The effectiveness of training intellectual functions in adults with acquired brain damage. An evaluation of occupational therapy methods. *Scand J Rehabil Med, 20*(2), 47-56.

Sohlberg, M. M., & Mateer, C. A. (1989). Good Samaritan Hospital Center for Cognitive Rehabilitation Executive Functions Behavioral Rating Scale. In M. M. Sohlberg & C. A. Mateer (Eds.), *Introduction to Cognitive Rehabilitation* (pp. 257-259). New York, NY: The Guilford Press.

Soong, W., Tam, S. F., Man, W. K., & Hui-Chan, C. (2005). A pilot study on the effectiveness of tele-analogy-based problem-solving training for people with brain injuries. *Int J Rehabil Res, 28*(4), 341-347.

Soper, D. S. (2013). A-priori Sample Size Calculator for Student t-Tests [Software]. Retrieved from http://www.danielsoper.com/statcalc

Spikman, J. M., Boelen, D. H., Lamberts, K. F., Brouwer, W. H., & Fasotti, L. (2010). Effects of a multifaceted treatment program for executive dysfunction after acquired brain injury on indications of executive functioning in daily life. *J Int Neuropsychol Soc, 16*(1), 118-129. doi: 10.1017/S1355617709991020

Srikanth, V. K., Thrift, A. G., Saling, M. M., Anderson, J. F., Dewey, H. M., Macdonell, R. A., & Donnan, G. A. (2003). Increased risk of cognitive impairment 3 months after mild to moderate first-ever stroke: a Community-Based Prospective Study of Nonaphasic English-Speaking Survivors. *Stroke, 34*(5), 1136-1143. doi: 10.1161/01.STR.0000069161.35736.39

Stablum, F., Umilta, C., Mogentale, C., Carlan, M., & Guerrini, C. (2000). Rehabilitation of executive deficits in closed head injury and anterior communicating artery aneurysm patients. *Psychol Res, 63*(3-4), 265-278.

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A Compendium of neuropsychological tests: Administration, norms, and commentary* (3rd ed.). New York, NY: Oxford University Press.

Streiner, D. L., & Norman, G. R. (2008). *Health Measurement Scales: a practical guide to their development and use* (4th ed.). New York, NY: Oxford University Press Inc.

Sturm, W., & Willmes, K. (1991). Efficacy of a reaction training on various attentional and cognitive functions in stroke patients. *Neuropsychol Rehabil, 1*, 259-280.

Stuss, D. T. (2009). Rehabilitation of frontal lobe dysfunction: a working framework. In M. Oddy & A. Worthington (Eds.), *The rehabilitation of executive disorders: a guide to theory and practice* (pp. 3-17). New York, NY: Oxford University Press.

Stuss, D. T., Alexander, M. P., Floden, D., Binns, M. A., Levine, B., McIntosh, A. R., …Hevenor, S. J. (2002). Fractionation and localization of distinct frontal lobe processes: Evidence from focal lesions in humans. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 392-407). New York, NY: Oxford University Press.

Sugavanam, T., Mead, G., Bulley, C., Donaghy, M., & van Wijck, F. (2013). The effects and experiences of goal setting in stroke rehabilitation - a systematic review. *Disabil Rehabil, 35*(3), 177-190. doi: 10.3109/09638288.2012.690501

Tatemichi, T. K., Desmond, D. W., Stern, Y., Paik, M., Sano, M., & Bagiella, E. (1994). Cognitive impairment after stroke: frequency, patterns, and relationship to functional abilities. *J Neurol Neurosurg Psychiatry, 57*(2), 202-207.

Tellier, M., & Rochette, A. (2009). Falling through the cracks: a literature review to understand the reality of mild stroke survivors. *Top Stroke Rehabil, 16*(6), 454-462. doi: 10.1310/tsr1606-454

Tham, K., Ginsburg, E., Fisher, A. G., & Tegner, R. (2001). Training to improve awareness of disabilities in clients with unilateral neglect. *Am J Occup Ther, 55*(1), 46-54.

Toglia, J. P., Golisz, K. M., & Goverover, Y. (2009). Evaluation and Intervention for Cognitive Perceptual Impairments. In E. B. Crepeau, E. S. Cohn, & B. A. B. Schell (Eds.), *Willard and Spackman's occupational therapy* (11th ed., pp. 739-76). Philadelphia: Lippincott, Williams & Wilkins.

Tombaugh, T. N. (2004). Trail Making Test A and B: normative data stratified by age and education. *Arch Clin Neuropsychol, 19*(2), 203-214. doi: 10.1016/S0887-6177(03)00039-8

Tong, A. Y. C., & Man, D. W. K. (2002). The Validation of the Hong Kong Chinese Version of the Lawton Instrumental Activities of Daily Living Scale for Institutionalized Elderly Persons. *Occup Ther J Res, 22*, 132-142.

Tooth, L., & Hoffmann, T. (2004). Patient perceptions of the quality of information provided in a hospital stroke rehabilitation unit. *Br J Occ Ther, 67*, 111-117.

Torkia, C., Gélinas, I., Korner-Bitensky, N., Rochette, A., & Sabiston, C. (2012). Self-efficacy scale for performing life activities post-stroke: preliminary testing. Poster session presented at the Canadian Stroke Congress, September 29 - October 2, 2012, Calgary, *e27.* Abstract retrieved from http://www.strokecongress.ca/2012/wp-content/uploads/2012/10/STRAbstract_cover.pdf

Vallat, C., Azouvi, P., Hardisson, H., Meffert, R., Tessier, C., & Pradat-Diehl, P. (2005). Rehabilitation of verbal working memory after left hemisphere stroke. *Brain Inj, 19*(13), 1157-1164. doi: 10.1080/02699050500110595

Van der Linden, M., Coyette, F., & Seron, X. (1992) Selective impairment of the “central executive” component of working memory: A single case study. *Cogn Neuropsychol , 9*, 301-326.

Van der Linden, M., Poncelet, M., & Majerus, S. (2007). Working memory dysfunctions in stroke patients. In O. Godefroy & J. Bogousslavsky (Eds.), *The Behavioral and Cognitive Neurology of Stroke* (pp. 431-443). Cambridge, UK: Cambridge University Press.

Vanderploeg, R. D., Schwab, K., Walker, W. C., Fraser, J. A., Sigford, B. J., Date, E. S., . . . Veterans Brain Injury Center Study, G. (2008). Rehabilitation of traumatic brain injury in active duty military personnel and veterans: Defense and Veterans Brain Injury Center randomized controlled trial of two rehabilitation approaches. *Arch Phys Med Rehabil, 89*(12), 2227-2238. doi: 10.1016/j.apmr.2008.06.015

Waehrens, E. E., & Fisher, A. G. (2007). Improving quality of ADL performance after rehabilitation among people with acquired brain injury. *Scand J Occup Ther, 14*(4), 250-257. doi: 10.1080/11038120601182974

Wechsler, D. (1981). *WAIS-R manual*. New York: The Psychological Corporation.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale—Fourth Edition: Canadian*. Toronto, ON: Pearson Canada Assessment Inc.

Weierbach, F. M., Glick, D. F., Fletcher, K., Rowlands, A., & Lyder, C. H. (2010). Nursing research and participant recruitment: organizational challenges and strategies. *J Nurs Adm, 40*(1), 43-48. doi: 10.1097/NNA.0b013e3181c97afb

Wells, G. A., Shea, B., O’Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2011). *The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis*. Retrieved from http://www.ohri.ca/programs/ clinical_epidemiology/oxford.asp.

Westerberg, H., Jacobaeus, H., Hirvikoski, T., Clevberger, P., Ostensson, M. L., Bartfai, A., & Klingberg, T. (2007). Computerized working memory training after stroke--a pilot study. *Brain Inj, 21*(1), 21-29. doi: 10.1080/02699050601148726

Wilson, A. (2009). Evidence for the effectiveness of neuropsychological rehabilitation. In B. A. Wilson, F. Gracey, J. J. Evans, & A. Bateman (Eds.), *Neuropsychological Rehabilitation: theory, models, therapy and outcome* (pp. 22-36). Cambridge: Cambridge University Press.

Wilson, B. A., Alderman, N., Burgess, P., Emslie, H., & Evans, J. J. (1996). *Behavioral Assessment of the Dysexecutive Syndrome*. Bury St. Edmunds, England: Thames Valley Test Company.

Wilson, B. A., Emslie, H. C., Quirk, K., & Evans, J. J. (2001). Reducing everyday memory and planning problems by means of a paging system: a randomised control crossover study. *J Neurol Neurosurg Psychiatry, 70*(4), 477-482.

Wilson, B. A., Evans, J. J., Emslie, H., Alderman, N., & Burgess, P. (1998). The development of an ecologically valid test for assessing patients with dysexecutive syndrome. *Neuropsychol Rehabil, 8*(3), 213-228.

Winkens, I., Van Heugten, C. M., Wade, D. T., Habets Winkens, I., Van Heugten, C. M., Wade, D. T., … Fasotti, L. (2009). Efficacy of time pressure management in stroke patients with slowed information processing: a randomized controlled trial. *Arch Phys Med Rehabil, 90*(10), 1672-1679. doi: 10.1016/j.apmr.2009.04.016

Wolf, T. J., Baum, C., & Conner, L. T. (2009). Changing face of stroke: implications for occupational therapy practice. *Am J Occup Ther, 63*(5), 621-625.

Wolf, T. J., Morrison, T., & Matheson, L. (2008). Initial development of a work-related assessment of dysexecutive syndrome: the Complex Task Performance Assessment. *Work, 31*(2), 221-228.

Wolf, T. J., Stift, S., Connor, L. T., Baum, C., & Cognitive Rehabilitation Research Group. (2010). Feasibility of using the EFPT to detect executive function deficits at the acute stage of stroke. *Work, 36*(4), 405-412. doi: 10.3233/WOR-2010-1045

World Health Organization. (2001). *International Classification of Functioning, Disability and Health*. Geneva: WHO.

Wressle, E., Samuelsson, K., & Henriksson, C. (1999). Responsiveness of the Swedish Version of the Canadian Occupational Performance Measure. *Scand J Occup Ther, 6*, 84-89.

Wright, R. W., Brand, R. A., Dunn, W., & Spindler, K. P. (2007). How to write a systematic review. *Clin Orthop Relat Res, 455*, 23-29. doi: 10.1097/BLO.0b013e31802c9098

Yantz, C. L., Johnson-Greene, D., Higginson, C., & Emmerson, L. (2010). Functional cooking skills and neuropsychological functioning in patients with stroke: an ecological validity study. *Neuropsychol Rehabil, 20*(5), 725-738. doi: 10.1080/09602011003765690

Yip, B. C., & Man, D. W. (2009). Virtual reality (VR)-based community living skills training for people with acquired brain injury: A pilot study. *Brain Inj, 23*(13-14), 1017-1026. doi: 10.3109/02699050903379412

Yoo, E. Y., Jung, M. Y., Park, H. S., Kim, J. R., & Jeon, H. S. (2009). Group constraint-induced movement therapy: Motor and functional outcomes in individuals with stroke. *Can J Occup Ther, 76*(5), 335-341.

Zinn, S., Bosworth, H. B., Hoenig, H. M., & Swartzwelder, H. S. (2007). Executive function deficits in acute stroke. *Arch Phys Med Rehabil, 88*(2), 173-180. doi: 10.1016/j.apmr.2006.11.015

Zoccolotti, P., Cantagallo, A., De Luca, M., Guariglia, C., Serino, A., & Trojano, L. (2011). Selective and integrated rehabilitation programs for disturbances of visual/spatial attention and executive function after brain damage: a neuropsychological evidence-based review. *Eur J Phys Rehabil Med, 47*(1), 123-147.