Training cognitive skills: How mental exercises and culture influence attention

Claire M. Champigny

Department of Psychiatry

McGill University, Montréal

December 2014

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Master of Science

© Claire Champigny, 2014

Table of Contents

General Introduction

The present thesis contains two original manuscripts representing the scope of my Master's research. Over the past two years, my work has revolved around the multifaceted concept of *attention*. Reflecting its versatile nature, my research spans mental and cultural influences on attention.

The first manuscript, an experimental piece, centers on a specific portion of my involvement in a project entitled "Attention Training in Health and Disease." This research study aims to elucidate the potential merits and shortcomings of attention training in children, as reflected by cognitive and behavioural effects. Measures include neuropsychological assessments to track cognitive progress as well as behavioural scales to index varying aspects of control processes, such as those associated with hyperactivity. Several graduate students in the laboratory have led the project since its conception in 2007 and have steadily improved its scientific merit. Upon my arrival as the new head of the experimental protocol, I included additional neuropsychological measures for a stronger focus on cognitive improvement. With the advice of Dr. Marilyn Jones-Gotman, I incorporated measures of concentration, verbal fluency, and working memory into the protocol. I have decided to focus this section of the thesis on results concerning the measures of cognitive skills I added, to reflect my original contribution to this study.

The second manuscript in this thesis consists of a narrative review documenting the limits of the tools that scientists use to measure the influence of culture on altered states of attention. One such state comprises hypnotic response. Hypnosis refers to an atypical state of attention revolving around attentive-receptive concentration; in line with the notion of mental training, findings show that cultural influences – which act similarly to a type of attention training – modify responsiveness to hypnotic experiences. Cross-cultural differences in hypnotic response serve as an interesting lens to elucidate relevant factors to research on attention. My manuscript focuses on the caveats associated with translations of current research instruments that often disregard the impact of socio-cultural parameters and historical subtexts. This latter manuscript is currently under consideration for publication in the peer-reviewed journal *Transcultural Psychiatry*.

Contribution of authors

Manuscript 1: *Attention training for children: Cognitive improvements in healthy and impulsive populations*

Claire Champigny: Leading and organizing the research effort, data collection and analysis, interpretation of results, and writing of manuscript.

Amir Raz: Corresponding author, supervising the research process, commenting on the manuscript and providing guidance.

Manuscript 2: *Transcultural factors in hypnotizability scales: Limits and future prospects*

Claire Champigny: Primary author, writing the manuscript.

Amir Raz: Corresponding author, supervising the research process, editing and commenting on the manuscript and providing direction and guidance.

Abstract

Attention, a multifaceted cognitive skill, is malleable in the face of both exogenous and endogenous factors. From explicit brain training exercises to subconscious sociocultural influences, environmental factors have the power to modify individual attentional control. In turn, a solid grasp of attentional resources can manifest itself in a variety of ways, from improved performance on cognitive tasks and behavioural regulation to successful hypnotic induction. In the former case, neuroscientists have shown that exercises targeting the development and practice of attentional skills have the potential to enhance other cognitive functions, such as working memory and inhibition of responses, as well as increase behavioural and emotional regulation. In relation to the latter case, transcultural psychiatrists have reported that cultural practices inducing altered states of consciousness, such as sweat lodges and chanting, may also exercise attention and thus shape response to hypnotic suggestions. The following experimental study delves into the claims of brain training as a form of cognitive enhancement and rehabilitation tool for children, while the subsequent narrative review examines the methodologies used in studies comparing cross-cultural response to hypnotic experiences.

Keywords: *attention, brain training, hypnosis, transcultural psychiatry*

Résumé

L'attention, faculté cognitive à facettes multiples, peut être modifiée par des facteurs exogènes et endogènes. De l'entraînement explicite du cerveau aux influences socioculturelles subconscientes, les facteurs environnementaux détiennent le pouvoir de changer le contrôle de l'attention. À son tour, une gestion solide de ces capacités attentionnelles peut se manifester sous plusieurs formes, entre autres l'amélioration de la performance dans des tâches cognitives, la régulation comportementale, et l'induction hypnotique. Dans le premier cas, des neuroscientifiques ont démontré que des exercices visant le développement et la pratique de compétences attentionnelles ont le potentiel d'améliorer d'autres fonctions cognitives – la mémoire de travail et l'inhibition de réponses, par exemple – ainsi que la régulation comportementale et émotionnelle. Dans le cas de l'hypnose, des psychiatres ont rapporté que des pratiques culturelles déclenchant des états altérés de conscience, comme les huttes de sudation ou les chants rituels, peuvent aussi exercer l'attention et donc augmenter la réaction aux suggestions hypnotiques. L'étude expérimentale présentée ici explore les assertions de l'entraînement du cerveau en tant qu'outil pour l'amélioration et la réhabilitation cognitives chez les enfants. La revue qui suit examine les méthodologies utilisées par les chercheurs visant à comparer les expériences hypnotiques à travers différentes cultures.

Mots-clés: *attention, entraînement du cerveau, hypnose, psychiatrie transculturelle*

Acknowledgements

First and foremost, I would like to thank my supervisor, Dr. Amir Raz. From the moment I joined the lab in my undergraduate years to my graduation day for my master's degree, you've continually supported me and taught me to grow as a researcher, a clinician, and a critical scientist. You've challenged me and taught me to stand on my feet. Thank you for your patience, your trust, and your guidance.

Thank you to the members of the Raz Lab for the heart-warming experience, atmosphere, assistance and advice. Special thanks to those who have so generously offered their time and effort to me. Rebecca – on top of your valuable editorial suggestions, you've helped me figure out so many random issues, from formatting to EndNote to "why isn't this working?" I love knowing I can always go to you with the most indiscriminate technical problems. Mathieu, I am forever indebted to you! Thank you for reading, commenting, re-reading and re-commenting on countless manuscripts, and for your vital help with data analysis. Jenilee, you were a big help in coordinating and carrying out the Attention Training project, and I am confident the program will continue to grow in your hands. Sheida, I treasure your friendly guidance, your advice, and your continued support for this project. Daniella, thank you for your kind assistance in data analysis and your warm conviviality. To my enthusiastic and dedicated attention trainers – Liana, Nadine, Jennifer, Nancy, Clemence, Irmak, Anna, Raveena, Rémi, and Daphné – you make a great team of coaches. It was a pleasure working with you. And of course, thank you to my office colleagues, Rebecca, Jenilee, and Liana, without whom my time in Child Psych would not have been as jovial and productive.

Finally, to my amazing family, to Patrick, and to my supportive friends and cheerleaders: your encouragement means the world to me. Thank you for patiently listening in times of stress and for celebrating with me in times of success.

I dedicate this thesis to my beloved parents. Je vous aime de tout mon cœur.

Manuscript 1: Experimental study

Attention training for children: Cognitive improvements in healthy and impulsive populations

Claire M. Champigny [a] & Amir Raz [a,b,c]

[a] Department of Psychiatry, McGill University

[b] Departments of Neurology & Neurosurgery, McGill University

[c] Institute for Community and Family Psychiatry of the Jewish General Hospital

Address for correspondence:

Institute for Community and Family Psychiatry

4333 Côte Ste Catherine

Montréal, QC H3T 1E4

Canada

E-mail address: amir.raz@mcgill.ca

Telephone: 514-340-8210

Abstract

In line with the historically recent and enthralling concept of neuroplasticity, computerized brain training characterizes the zeitgeist of North American society. Fascinating the general public and rapidly forming a billion-dollar industry, brain training programs attract significant attention from the neuroscientific community. Researchers have begun investigating their potential to enhance cognitive skills and regulate behaviour, and have increasingly focused on training the attention systems as a means of decreasing symptoms in children diagnosed with impulse-control disorders. Despite the initial excitement regarding the promise of brain training, myriad psychological studies have pointed to contradictory and inconclusive benefits, pertaining in particular to the transfer effects of the exercises. In an effort to aid in elucidating the genuine advantages of attention training, our team examined the effects of a four-week computerized attention training program on three interlaced cognitive skills: executive attention, working memory, and verbal fluency. We recruited healthy children as well as pediatric patients suffering from an impulse-control disorder. Preliminary results intimate improvement in executive attention and verbal fluency capacities for healthy children. Our diagnosed case studies, however, failed to demonstrate consistent or significant results, preventing us from formulating conclusive remarks for pathological populations. Further continuation of this project will shed more light on the limits and benefits of attention training for children.

Keywords: *attention training, neuroplasticity, impulse-control disorder, executive attention, working memory, verbal fluency.*

Introduction

Accompanying the thriving concept of neuroplasticity, the burgeoning field of brain training captivates neuroscientists, clinicians, and laypeople alike. Although the benefits and limits of such training remain poorly understood, a plethora of commercial companies have already developed computerized programs with the promise to enhance or rehabilitate diverse cognitive skills in a vast range of populations (Rabipour & Raz, 2012). Attention training has received particular notice in the scientific community, leading to a variety of studies examining the potential of such programs to regulate behaviour and emotion and to improve related cognitive skills (e.g., Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). In fact, neurocognitive scientists have begun assessing brain training programs as a non-pharmacological alternative for individuals such as children with impulse-control disorders (Rabipour & Raz, 2012).

The present study examines the benefits and limits of a four-week computerized attention training program on several interrelated cognitive skills: executive attention, working memory and verbal fluency. We focus our investigation on healthy children as well as children diagnosed with an impulse-control disorder. The manuscript begins with recapitulating the neurobiology and history of neuroplasticity before delving into the role of neuroplasticity in brain training. Next, we cover the development of attention training as a specific form of cognitive training. We then introduce the three cognitive skills whose improvement we will investigate – executive attention, working memory, and verbal fluency – as well as their perceived capacity for modification based on past research. We introduce our methodology, including participants, measures, conditions and training program. Finally, we analyze our results, consider the limitations of the study design and administration, and discuss potential implications.

Neuroplasticity

Attention training, which our experimental study investigates, relies on the principles of neuroplasticity. In order to fully comprehend the extent of the known benefits, limits, and controversies surrounding attention training, it is necessary to understand the role of neuroplasticity in such training. In the following section, we expound on the basic neural mechanisms by which neuroplasticity functions and review its history, notably its slow, difficult development as a legitimate scientific fact.

Definition & Neurobiology

A fairly recent concept, *neuroplasticity* refers to the dynamic adaptation of neural pathways and synapses to changes resulting from behaviour, thought, emotions, injuries and environmental influences (Pascual-Leone et al., 2011). The human brain therefore possesses the inherent capacity to change its very structure in response to various activities, gradually perfecting its circuits to better suit the task at hand. Sufficient exposure to exogenous factors can reorganize the anatomy of the brain and enhance neural connections. One of the fundamental mechanisms of neuroplasticity relies on the neurological process of synaptic pruning, wherein the overall number of synapses decreases to give way to the more efficient synaptic configurations (Doidge, 2007). Efficient connections typically form when two neighbouring neurons produce an impulse simultaneously, which causes their cortical maps to merge and allows them to fire concurrently from then on. Hebb's law summarizes this concept as "neurons that fire together, wire together" (Hebb, 1949). Naturally, neuroplasticity can also render our brains more vulnerable to negative outside influences; once a particular plastic change settles in the brain, it can prevent other changes from occurring. Just as it engenders growth and reorganization, neuroplasticity also produces and maintains stubborn habits and disorders (Doidge, 2007). Only after the discovery of neuroplasticity – and consequently, the official rebuttal of the theory of the brain as a hard-wired circuit – could scientists even begin to consider the potential of modifying the brain with training.

History

> The common wisdom was that after childhood the brain changed only when it began the long process of decline; that when brain cells failed to develop properly, or were injured, or died, they could not be replaced. … Scientists who wondered if the healthy brain might be improved or preserved through activity or mental exercise were told not to waste their time. A neurological nihilism – a sense that treatment for many brain problems was ineffective or even unwarranted – had taken hold, and it spread through our culture, even stunting our overall view of human nature. (Doidge, 2007, pp. xvii-xviii)

It wasn't until the late 20th century that the scientific community began to acknowledge the existence and power of neuroplasticity throughout human life. The notion of a fixed nervous system, as well as the idea that new neurons stopped developing after birth, was rooted firmly in the popular scientific opinion until recently (O'Rourke, 2007; Rosenzweig, 1996). However, evidence has long suggested the possibility to alter neural connections beyond childhood. As early as the late 18th century, Michele Vincenzo Malacarne compared the dissected brains of animals who had either received excessive training or none at all, and discovered substantially larger cerebellums in the trained animals (Malacarne, 1793). Yet, his contemporaries largely neglected his findings (Rosenzweig, 1996). A century later, William James first applied the concept of plasticity to behaviour; like Malacarne, his neuroscientific colleagues rejected his idea as well (James, 1890). Thirty years later, Karl Lashley performed the first experiments demonstrating changes in neural pathways in the brains of rhesus monkeys in response to repeated exposure to the same stimuli (Lashley, 1923). He also introduced and coined the principle of *equipotentiality*: that healthy parts of the brain may take on the role of damaged portions when necessary. Still, neuroscientists resisted and refused to budge. In 1959, the father of eminent neuroscientist Paul Bach-Y-Rita suffered a stroke that left half of his face and body paralyzed and unable to speak. Like all neuroscientists at the time, Bach-Y-Rita believed that brain damaged patients could not recover and mourned his father's loss of function. His brother, George Bach-Y-Rita, took on the responsibility of helping his father recuperate. Unaware of the current rehabilitation research and unencumbered by pessimistic theories, he applied a fresh approach to his father's condition.

> I decided that instead of teaching my father to walk, I was going to teach him first to crawl. … We played games on the floor, with me rolling marbles, and him having to catch them. Or we'd throw coins on the floor, and he'd have to try and pick them up with his weak right hand. Everything we tried involved turning normal life experiences into exercises. (Doidge, 2007, p. 21)

Over time, the father learned to walk and talk, eventually returning to his previous life of teaching and hiking. Doctors attributed this unprecedented recovery to uncommonly light damage from the stroke rather than to the innovative rehabilitation method. However, an autopsy following the death of the father seven years later revealed a lesion so extensive – the brain stem and primary motor cortex were irreparably destroyed – that only a major reorganization of the brain in response to motor training could explain the functional recovery. Although this remarkable discovery failed to gain attention in the scientific literature, it prompted Paul Bach-Y-Rita to further investigate neuroplasticity.

In the 1960s, the certainty in the neuroscientific façade began to crack as evidence accumulated. Paul Bach-Y-Rita led the movement with the creation of a new device that allowed congenitally blind people to see based on the premise of neuroplasticity (Bach-y-Rita, 1967). In line with the notion of sensory substitution – if one sense is damaged, other senses will take over its function – Bach-y-Rita trained the skin and touch receptors of his patients to act like a retina. Patients sat in a chair covered in 400 electrical stimulators pressing against their skin, and a large camera behind the chair scanned the area in front of the patients. The camera sent electrical signals of the image to the stimulators, which functioned like pixels: vibrating for the dark parts of the scene and holding still for the brighter shades. The brain's capacity to adapt supported the notion of neuroplasticity, which brought Bach-y-Rita to famously claim, "We see with our brains, not with our eyes" (Doidge, 2007, p. 15). This time, the scientific community could not ignore the budding evidence for neuroplasticity, and more researchers delved into the issue.

In 1970, David Hubel and Torsten Wiesel studied cortical remapping in kittens. They sewed one eye shut and recorded the cortical brain maps. Results showed that the portion of the brain associated with the shut eye was not idle, as they had hypothesized; instead, it processed visual information from the open eye, seemingly to avoid wasting 'cortical real estate' (Hubel & Wiesel, 1970). These findings supported the possibility of brain plasticity in infancy, during what developmental scientists label the *critical period*, a phase in the (generally early) life span during which an organism has heightened sensitivity to exogenous stimuli (Siegler, 2006).

Michael Merzenich was the first to argue that neuroplasticity could occur beyond the critical period. He micromapped a monkey's hand map in the brain, amputated the middle finger, and waited several months before micromapping the monkey's hand map again. Close examination showed that the brain map for the amputated finger had disappeared, and the maps for the adjacent fingers had grown into the space that originally covered the middle finger. These results demonstrated the dynamic nature of brain maps and the flexibility of brain resources according to the principle of use it or lose it. Moreover, Merzenich claimed that humans can increase the brain's capacity to learn, and that the brain constantly adapts itself. He colourfully described the brain as "not an inanimate vessel that we fill; rather it is more like a living creature with an appetite, one that can grow and change itself with proper nourishment and exercise" (Doidge, 2007, p. 47).

Scientific literature on the subject of neuroplasticity has substantially increased over the past twenty years (Figure 1). In line with the rising popularity of neuroplasticity, the alluring concept of brain training has captured the zeitgeist of North American society, promising rehabilitation for the ill and a competitive edge for the healthy.

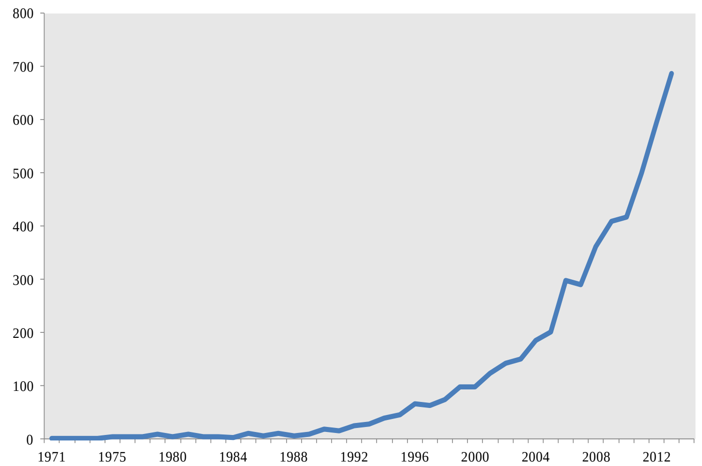


Figure 1. Scopus publication profile for "neuroplasticity OR 'brain plasticity'" for "all fields" (article and review) since 1971.

Brain Training

Subsequent to the neurobiology and history of neuroplasticity, we now focus on the concept of brain training. Before specifically examining research in attention training, it is essential to understand the general development of brain training, including potential benefits as well as doubts and controversies surrounding its efficacy. We recapitulate these points in the following section.

Definition & History

Brain training broadly refers to repeated practice of an activity to enhance a specific set of cognitive skills or general cognitive ability and appears to induce changes at the behavioural, functional, and neuronal levels over a specific timeframe (Rabipour & Raz, 2012). Similar to neuroplasticity, researchers have long debated the legitimacy of brain training, although even today, further evidence is necessary before reaching a consensus.

Publications reporting instances of neuroplasticity as a result of brain training have significantly increased in the past twenty years. Studies in the 1990s have shown that motor and perceptual training in monkeys leads to enhanced performance in motor and perceptual tasks, with parallel adjustments in synaptic connectivity in the associated cortical areas (Nudo, Milliken, Jenkins, & Merzenich, 1996; Recanzone, Merzenich, Jenkins, Grajski, & Dinse, 1992). A particularly revolutionizing article appeared in 1997, when Eleanor Maguire documented a redistribution and enlargement of grey matter in the right hippocampus of London taxi drivers as compared to controls, prompting her to associate that brain area with storage of spatial memories (Maguire, Frackowiak, & Frith, 1997). Moreover, Maguire uncovered a strong positive correlation between the success and the length of training and a larger hippocampus; like a muscle, the brain grew in direct response to practice. Further research uncovered enlarged motor, auditory, and visuo-spatial regions in musicians (Gaser & Schlaug, 2003), as well as greater development of neural regions related to the programming of motor tasks in professional typists (Cannonieri, Bonilha, Fernandes, Cendes, & Li, 2007). Another study revealed that the effects of brain training occur even more rapidly than previously expected; brain scans belonging to medical students during an examination period demonstrated a significant increase in grey matter in the posterior and lateral parietal cortex over the course of only several months (Draganski et al., 2006). Such results prompted researchers to posit an association between the concentrated acquisition of a large amount of information and a particular pattern of structural grey matter changes (Draganski et al., 2006). In line with these findings, the same researchers also uncovered structural changes in grey matter in the brains of participants who learned to juggle over the course of three months (Draganski et al., 2004). A follow-up study examining more specifically the temporal parameters of the effects of juggling revealed increases in grey matter volume following as little as one week of training (Driemeyer, Boyke, Gaser, Buchel, & May, 2008). The mounting research depicting brain changes in response to practice confidently promotes brain training as a plausible model for cognitive improvement; however, controversy and doubts surround its efficacy, especially pertaining to transferability.

Doubts

As brain training rises in popularity, escalating skepticism challenges its efficacy for various cognitive abilities (e.g., Ghorayshi, 2014; Owen et al., 2010; Turley-Ames & Whitfield, 2003). In fact, in October 2014, the Stanford Center of Longevity released an open letter signed by 73 neuroscientists from around the world stating that companies selling cognitive exercises make “exaggerated and misleading claims” that lack scientific evidence. While programs may improve performance on a specific subset of skills, these benefits may not transfer to other domains. Researchers can only reasonably expect the effects of cognitive training to transfer to functions that rely on the same neural networks; for example, they do not anticipate effects from touch and sensory exercises to transfer to language modalities (Olesen, Westerberg, &

Klingberg, 2004). Conversely, training that targets higher association cortices might extend to more general effects; for instance, neural changes in the intraparietal-prefrontal network will likely improve performance on working memory and attentional tasks (Klingberg, 2010). Some scientists disagree with such claims of transferability in brain training, and have attempted to disprove them. In collaboration with the British Broadcasting Corporation (BBC) Laboratory in the UK, researchers recruited over 11,000 healthy subjects to participate in a large-scale project to test the brain training theory (Owen et al., 2010). For six weeks, participants regularly trained online using cognitive exercises targeting reasoning, memory, attention, planning, and visuospatial skills. The team presented the results in *Nature* and on the BBC television program "Bang Goes the Theory," stunning fellow scientists and the general public with the allegation that although brain training improves performance on the trained tasks, it fails to benefit general cognitive ability (Owen et al., 2010). The study drew international attention not only for its results, but also for its notable flaws. For instance, participants only played an average of four hours over the course of the six weeks; the sessions may have been too short and dispersed to cause changes in cognitive skills (Katsnelson, 2010). In addition, the games in use were designed to target an older population of adults over 60 years of age, who would have a lower mean starting score and higher variability in performance, thus leaving more room for improvement. "You may have more of an ability to see an effect if you're not trying to create a supernormal effect in a healthy person," explains neurologist Peter Snyder (as cited in Katsnelson, 2010). In line with the controversy over the efficacy of such programs, further research has pointed to inconclusive transfer effects, with meta-analyses calculating few benefits and condemning the practice (Melby-Lervag & Hulme, 2013; Papp, Walsh, & Snyder, 2009), while others affirm the potential of brain training (e.g., Berry et al., 2010; Rueda, Posner, & Rothbart, 2005). These caveats demonstrate the need for further investigation to better understand the benefits and current limits of brain training.

Attention Training

In the following section, we concentrate on a model of attention networks set forth by psychologist Michael Posner. His theory led to a wave of brain training research that targets the attention systems as a means of decreasing impulsivity. We end with examining the potential of these techniques as treatment for children with impulse-control disorders.

Attention Networks

Attention encompasses distinct neural processes that mature independently at different stages of life, starting in childhood (Posner & Rothbart, 2007). Stepping away from traditional theories of attention as a unitary system, Michael Posner suggested that attention spans three independent yet strongly connected networks: alerting, orienting, and executive attention (Posner & Petersen, 1990; Posner & Rothbart, 2007). Many studies and cognitive tests support the existence of these three distinct attentional networks; one such test is the Attention Network Test, wherein subjects must quickly respond to congruent, incongruent and neutral cues on a computer screen while keeping their attention fixated on a center target (Fan, McCandliss, Sommer, Raz, & Posner, 2002; Rueda, Fan, et al., 2004). Although significantly interwoven, Posner's three networks control different aspects of attention (Raz & Buhle, 2006). The alerting network regulates sustained attention and alertness in preparation for an impending stimulus, while the orienting network controls scanning, or the ability to select specific information from an array of sensory stimuli (Raz & Buhle, 2006). Neuroimaging studies have shown activity in

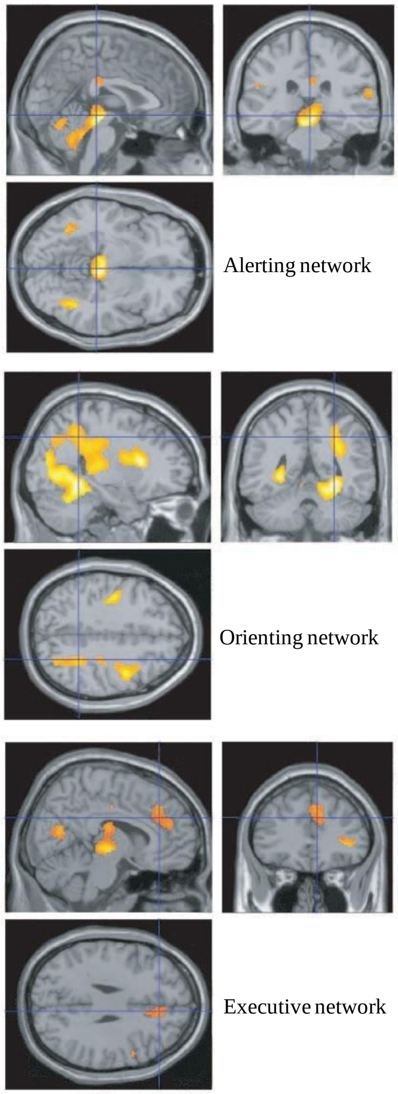


Figure 2. Functional activation of attention networks during ANT.

Source: Raz & Buhle, 2007, from REF. 85 © (2004) Wiley InterScience.

the frontal and parietal regions of the right hemisphere when individuals achieve and maintain an alert state (Robertson & Garavan, 2004). Conversely, the orienting network draws upon several areas for specific roles: the temporoparietal junction and superior temporal lobe regulate disengagement from a particular stimulus (Friedrich, Egly, Rafal, & Beck, 1998; Karnath, Ferber, & Himmelbach, 2001), the superior parietal lobe participates in voluntary, covert shifts of attention (Corbetta, Kincade, Ollinger, McAvoy, & Shulman, 2000), and the superior colliculus and frontal eye fields mediate overt eye movements for attentional shifts (Corbetta, 1998) (Figure 2). The alerting and orienting networks constitute the more primitive aspects of attention. The executive network, on the other hand, mediates higher-order functions and pertains the most to brain training. Executive attention contributes to emotional and behavioural self-regulation, defined as the abilities to regulate our thoughts and actions (Raz & Buhle, 2006; Rueda, Posner, et al., 2005). Neuroimaging studies have identified the anterior cingulate cortex (ACC) and the dorsolateral prefrontal cortex (DLPFC) as important nodes in the executive network, although their specific roles relating to resolving versus monitoring response conflicts remain unclear. Preliminary findings show that the ACC may target the resolution of response conflict while the DLPFC may support heteromodal conflict resolution (Liu, Banich, Jacobson, & Tanabe, 2004; Milham et al., 2001; van Veen & Carter, 2005). The early development of executive attention, commencing at four years of age, appears to have strong potential for environmental modification such as brain training (Rueda, Fan, et al., 2004; Rueda, Posner, Rothbart, & Davis-Stober, 2004; Rueda, Rothbart, et al., 2005).

Impulse-Control Disorders

Neuroscientific research has increasingly focused on training the attention systems as a means of improving behavioural self-control, prompting scientists to explore these techniques as non-pharmaceutical treatment alternatives for children with impulse-control disorders (ICDs) (Rabipour & Raz, 2012). ICDs comprise psychiatric disorders often diagnosed in childhood and characterized by excessive impulsivity, or the failure to resist a temptation or urge, which causes problems in emotional and behavioural regulation (American Psychiatric Association, 2013). Renowned examples of ICDs include Attention-Deficit/Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder (ODD). The former constitutes a neurodevelopmental disorder characterized by impairments in attentional control as well as hyperactive, impulsive behaviours. Clinical studies estimate an ADHD prevalence rate of approximately 6-7% in individuals under 18 years of age, while ODD has an estimated lifetime prevalence of 10.2% (Dickstein, 2010). An ODD diagnosis requires symptoms such as active disrespect of authority, frequent loss of temper, and feelings of anger, resent and/or spite (American Psychiatric Association, 2013). While ADHD symptoms typically attenuate into adulthood (Kooij et al., 2010), a lack of treatment for ODD engenders a 50% chance of Conduct Disorder (CD) development (Lahey, Loeber, Quay, Frick, & Grimm, 1992). CD includes a similar but more severe set of symptoms compared to ODD, ranging from aggression and violence towards people and animals to violation of laws, most commonly in the form of theft and destruction of property (American

Psychiatric Association, 2013). Disruptive Mood Dysregulation Disorder (DMDD) constitutes another childhood ICD. Children suffering from DMDD exhibit severe and recurrent temper outbursts frequently – three times a week on average – and display a persistently irritable or angry mood (American Psychiatric Association, 2013).

ICDs can cause serious impairments in academic performance and social functioning (e.g., Klingberg et al., 2005), many of which persist into adulthood (Biederman, Mick, & Faraone, 2000; Rasmussen & Gillberg, 2000). The reason for such effects relates to a chief component of ICDs: deficits in executive functioning, including working memory and behavioural regulation such as response inhibition (Barkley, 2006; Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Hervey, Epstein, & Curry, 2004; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). In fact, psychiatrist Russell Barkley established a notorious model for ADHD as a disorder primarily centering around deficits in self-regulation and executive functioning (Barkley, 2012). He defines self-regulation as the means by which an individual manages themselves in order to attain their goals, involving three processes: i) an action directed at themselves so as to ii) result in a change in behaviour in order to iii) alter the likelihood of a future consequence or attainment of a goal (Barkley, 2012). For example, if an individual walks into a coffee shop and wants to resist ordering a pastry, they may perform certain actions to assist in self-regulation, such as averting their eyes from the pastries, walking to a different section of the shop, mentally self-motivating themselves to resist the dessert, and so on. These processes draw upon a variety of executive functioning skills, such as self-awareness (when realizing you face a dilemma), inhibition (when restraining your urge to order the pastry), and executive attention (when re-directing your attention away from the temptation). As such, disorders such as ADHD and other

ICDs reflect impairments in self-regulation and executive functioning processes that, in turn, strongly rely on other cognitive skills such as executive attention.

A Solution for Impulse-Control Disorders

Parents of children with an ICD often desperately search for treatment and encounter a difficult conundrum when faced with the typical intervention: medication. Recent meta-analyses support the claim that pharmacological interventions for ICDs improve children's learning skills and academic performance (Prasad et al., 2013); however, stimulant medications also engender adverse side effects (Smith, Barkley, & Shapiro, 2006) and their benefits usually disappear after discontinuation (Beck, Hanson, Puffenberger, Benninger, & Benninger, 2010). Consequently, parents and professionals may hesitate to give these pills to pediatric patients (Rabipour & Raz, 2012). Computerized attention training programs offer a new treatment option, as they seem to significantly benefit children with attentional difficulties. Several studies have revealed improvements in attentive abilities and academic skills (Kerns, Eso, & Thomson, 1999) as well as a decrease in ADHD symptomatology (Rabiner, Murray, Skinner, & Malone, 2010; Shalev, Tsal, & Mevorach, 2007) after participation in an attention training program. Given the high prevalence of ICDs in children and their impact on academic success, the scientific community has focused considerable effort into finding additional treatments to alleviate symptoms, either as an adjunct to medication or as an alternative (Rabipour & Raz, 2012).

Executive Attention, Working Memory, and Verbal Fluency

Having funneled down from neuroplasticity to brain training to attention training and ICDs, we now delve into the three cognitive skills that we examined in our study. Scientific research has repeatedly shown that the multi-layered processes involved in executive attention (EA), working memory (WM), and verbal fluency (VF) intimately interlace with each other and are all prone to benefits from attention training programs. In the following section, we cover the role of each cognitive skill in ICDs as well as current research on their potential for modification through training.

Executive Attention

Definition

Executive attention (EA) affords the ability to select relevant information and ignore irrelevant stimuli (Astle & Scerif, 2009). Many researchers believe that this ability reflects domain-general processing that influences the subsequent acquisition of other cognitive skills (Scerif, 2010). Moreover, studies have shown that EA skills predict the effectiveness of working memory capacity (McVay & Kane, 2009; Robinson-Riegler, 2011).

EA begins development in early childhood, around four years of age. Due to an underdeveloped frontal cortex, infants have virtually no capacity to concentrate; they cannot choose which stimuli to pay attention to and which to ignore (Bell & Wolfe, 2007; Colombo, 2001). The phenomenon of *sticky fixation,* whereby babies are incapable of disengaging their attention from a particularly salient target, illustrates this concept (Hood & Atkinson, 1993). Although infants may sometimes exercise a limited portion of their attention, they cannot utilize EA specifically (Colombo & Cheatham, 2006; Johnson, 1995). As the frontal lobes mature, children's capacity to concentrate increases (Astle & Scerif, 2009).

Role in Impulse-Control Disorders

Children suffering from an ICD demonstrate impairments in EA as evidenced by their symptoms pertaining to impulsivity and lack of self-regulation (Dovis, Van der Oord, Wiers, & Prins, 2013). A meta-analysis of 83 studies revealed that individuals with ADHD showed significant deficits on all executive functioning measures, notably EA and response inhibition (Willcutt et al., 2005). Failure to control urges often stems from a lack of cognitive and behavioral inhibition, or the suppression of unwanted thoughts or actions (Nigg, 2000). Such inhibitions partially serve to protect attentional resources from taxing distractions (Nigg, 2000). Self-regulation requires the same attentional resources to achieve a stable maintenance of behaviour or thoughts in the face of distracting stimuli or impulses (Wenzel, Kubiak, & Conner, 2014). Studies show that children often show similar rates of behavioural and attentional control, suggesting a link between both skills, and that infant fixation duration, which is mediated by attention, predicts those rates (Papageorgiou et al., 2014; Rose, Feldman, Jankowski, & Van Rossem, 2012). Behavioural data indicates that children demonstrating strong EA skills, as evidenced by time and patient effort exerted on conflict tasks such as the Stroop task, score high on measures of self control (Rothbart, Sheese, Rueda, & Posner, 2011). Additionally, research suggests that effortful control correlates negatively with impulsivity and other childhood externalizing behavioural problems such as hyperactivity and aggression (Berdan, Keane, & Calkins, 2008; Gusdorf, Karreman, van Aken, Dekovic, & van Tuijl, 2011). In line with these findings, children suffering from attentional difficulties – in this case, ADHD – scored significantly lower than healthy children on measures of effortful control (Samyn, Roeyers, & Bijttebier, 2011). Neuroimaging studies suggest that children suffering from an ICD may exhibit impaired EA abilities due to a slower development of their frontal lobe (Shaw et al., 2006).

Finally, genes that modulate the dopaminergic system strongly influence executive attention and appear to associate with ICDs as well, pointing to a possible dopaminergic deficiency in children with an ICD (Fan, Fossella, Sommer, Wu, & Posner, 2003; Fossella et al., 2002).

Training Executive Attention

The early development in EA appears to have strong potential for brain training (Rueda, Fan, et al., 2004; Rueda, Posner, et al., 2004; Rueda, Rothbart, et al., 2005). Recent data indicate that attention training can positively influence brain activity, cognition and behaviour in children as young as four years of age (Rueda, Posner, et al., 2005). In 2005, researchers created an attention training program for children that targets Posner's three attentional networks, with a focus on the executive network (Rueda, Rothbart, et al., 2005). They trained participants for five days, after which results showed significant improvements in a variety of measures, notably executive attention, nonverbal reasoning, fluid thinking, and temperament (Rueda, Rothbart, et al., 2005). In addition, electrophysiological recordings demonstrated maturation of neural activation patterns associated with the executive attention network to more adult-like signals. Training programs that target attention have proven to produce measurable structural and functional changes in the brain (Diamond & Lee, 2011; Rabiner et al., 2010; Rabipour & Raz, 2012; Rueda, Posner, et al., 2005; Thorell, Lindqvist, Bergman Nutley, Bohlin, & Klingberg, 2009).

An increasing body of evidence indicates that certain genes may modulate EA, which would explain contradictory results in scientific studies investigating the links between brain training and attention (Posner & Patoine, 2009). Overall, research suggests that EA skills show malleability and potential for improvement although conflicting results illustrate a lack of scientific understanding of the exact processes involved.

In our study, we measure EA skills using the D2 Test of Attention. We provide further information about this instrument in the Methodology section.

Working Memory

Definition

Working memory (WM) refers to the active retention, maintenance, manipulation, and retrieval of information over a brief period of time (Baddeley, 2000; Klingberg, 2010; Unsworth, Redick, Heitz, Broadway, & Engle, 2009). Neurophysiological studies have found an association between maintenance of information in WM and elevated and sustained neural firing in drawn-upon brain areas such as the dorsolateral prefrontal cortex (Funahashi, Bruce, & Goldman-Rakic, 1989).

Numerous academic tasks rely heavily on WM skills, from the complex overarching skills involved in learning and reasoning to the more specific skills implicated in arithmetic problem solving, reading comprehension, remembering instructions, and text generation (Conway, Kane, & Engle, 2003; Daneman & Carpenter, 1980; Kellogg, 2001; Klingberg, 2010; Nigg, 2006; Passolunghi & Siegel, 2001; Swanson & Berninger, 1996). Individual differences in complex span tasks – tasks that require simultaneous storing and processing information – closely relate to children's abilities in reading (S. E. Gathercole & Pickering, 2000; Swanson & Sachse-Lee, 2001) and mathematics (Geary, Hoard, Byrd-Craven, & De Soto, 2004), and effectively predict later academic achievement (S. E. Gathercole & Pickering, 2000). Further research has confirmed that differences in general intellectual abilities do not cause these associations (Cain, Oakhill, & Lemmon, 2004; S. E. Gathercole, Alloway, Willis, & Adams, 2006).

Role in Impulse-Control Disorders

Children suffering from ICDs often demonstrate deficiencies in cognitive abilities pertaining to executive functioning, a broad construct that includes processes such as WM, attention, planning, and behavioural regulation (Barkley, 2006). WM deficits are closely related to impaired inhibitory (Davidson, Amso, Anderson, & Diamond, 2006) and attentional functions (Chacko et al., 2014; Klingberg, 2010). In fact, researchers have so often found WM deficits in ADHD populations that many consider those impairments part of the crux of the disorder (Castellanos & Tannock, 2002; Dowson et al., 2004; Karatekin & Asarnow, 1998; Kempton et al., 1999; Kuntsi, Oosterlaan, & Stevenson, 2001; Martinussen et al., 2005; Rapport, Chung, Shore, & Isaacs, 2001).

The two most plausible neurobiological explanations for the correlation between WM and ICD symptoms relate to the frontostriatal brain regions and the dopaminergic system. Research suggests that WM functions strongly depend on frontostriatal brain regions (Bunge, Ochsner, Desmond, Glover, & Gabrieli, 2001; Fletcher & Henson, 2001; Kondo et al., 2004; Lewis, Dove, Robbins, Barker, & Owen, 2004) and the cerebellum (Gottwald, Mihajlovic, Wilde, & Mehdorn, 2003; Lalonde & Strazielle, 2003). Converging data from neuroimaging and neuropsychological studies indicates that children diagnosed with an ICD exhibit dynsfunctions in those brain regions, which would potentially explain the link between WM and symptoms pertaining to impulsivity and attention (Castellanos & Tannock, 2002; Durston, 2003; Giedd, Blumenthal, Molloy, & Castellanos, 2001). Moreover, clinical studies have found that catecholamines – specifically the dopaminergic and noradrenergic systems – modulate WM processes (Arnsten, 2001; Bedard, Martinussen, Ickowicz, & Tannock, 2004; Goldman-Rakic, Castner, Svensson, Siever, & Williams, 2004; Mattay et al., 2000). In accordance with these findings, children diagnosed with an ICD typically suffer from a catecholamine dysregulation, specifically within the dopaminergic system (Biederman & Faraone, 2002; Levy & Swanson, 2001; Maher, Marazita, Ferrell, & Vanyukov, 2002; Misener et al., 2004). In summary, diagnosed children seem to exhibit WM deficits due to a dysfunction in frontostriatocerebellar brain circuits and/or a catecholamine dysregulation.

Impairments in WM have also been associated with patterns of academic achievement similar to those of children with an ICD (Chacko et al., 2014; Gathercole, 2000; S. E. Gathercole, Brown, & Pickering, 2003; Swanson, Jerman, & Zheng, 2008). In such cases, WM limitations may be directly at fault for constraining academic progress, rather than behavioural symptoms such as inattention or hyperactivity (Rapport, Scanlan, & Denney, 1999).

Training Working Memory

Until recently, few scientists believed WM to be a cognitive skill capable of improvement through training. Only 40 years ago, researchers reported a series of studies attempting to improve short-term memory in subjects suffering from learning disabilities (Butterfield & Wambold, 1973). Although their approach led to some performance improvements, there was no evidence of transfer to non-trained WM tasks, to other cognitive tasks, or to everyday performance. These findings provided support for the static view of WM formulated by George Miller (1994). WM, unlike many other cognitive skills, seemed to remain impervious to environment and experience (Campbell, Dollaghan, Needleman, & Janosky, 1997).

Subsequent research, however, suggests that WM training can indeed improve performance via transfer effects, with neuronal changes to illustrate it. For instance, several studies have found WM training effects localized in the prefrontal and parietal cortices as well as in the basal ganglia (Dahlin, Neely, Larsson, Backman, & Nyberg, 2008; Olesen et al., 2004). Training effects in the frontoparietal network might provide the basis for transfer between WM tasks and controlled attention (Klingberg, 2010). Moreover, several studies have reported transfer effects in children after training, in both WM skills and in other cognitive skills (Table 1).

Table 1. Examples of studies examining the benefits of WM training on cognition.

Researchers	Population Age	Population condition	Transfer to WM	Transfer to other cognitive skills
Thorell et al., 2009	4-5 years old	Healthy	✓	✓
Swanson et al., 2008	5-8 years old	Healthy	✓	✓
Klingberg et al., 2005	7-12 years old	ADHD	✓	✓
Klingberg, Forssberg, & Westerberg, 2002	7-15 years old	ADHD	✓	✓
Holmes et al., 2010	8-11 years old	ADHD	✓	

Studies have also found that WM training in children with ADHD led to a significant decrease in the number of inattentive symptoms, indicating a possible overlap in neural mechanisms underlying the control of attention and those responsible for WM (Klingberg et al., 2005; Mezzacappa, 2010). The training-induced improvements observed in academic settings underline the relevance of WM training for academic success (Holmes, Gathercole, & Dunning, 2009).

On the other hand, several meta-analyses have failed to uncover WM training effects; results showed improvement in scores on trained WM tasks, but there was no transfer to other non-trained tasks (e.g., Melby-Lervag & Hulme, 2013; Turley-Ames & Whitfield, 2003). Such findings, paired with twin studies claiming that WM capacity appears to be highly heritable (Kremen et al., 2007), attract considerable attention to the debate regarding the validity of training-induced plasticity in the WM neural network (Klingberg, 2010).

In our study, we measure WM skills using the Backwards Digit Span and the Buschke Selective Reminding Task. We provide further information about these neuropsychological tools in the Methodology section.

Verbal Fluency

Definition

Verbal fluency (VF) refers to an individual's ability to generate words spontaneously, usually within a restricted category (Lezak, Howieson, Bigler, & Tranel, 2012). A neuropsychological task assessing VF requires subjects to retrieve associated words from long term memory storage (Lezak, 1995; Thurstone & Thurstone, 1938). Neuropsychologists divide VF into two categories: *semantic fluency*, in which the subject must name words pertaining to a given category, and *phonological fluency*, in which the subject must generate words beginning with a given letter (Benton, 1968; Hurks et al., 2004; Newcombe, 1969). Fluent speaking calls for control over motor abilities involving speech muscles, linguistic abilities for the formulation and planning of speech, and socioemotional abilities to aid in execution under emotional or communicative stress (Bosshardt, 2006).

Functional magnetic resonance imaging (fMRI) studies have isolated the neural correlates of VF and have uncovered extensive activation in a distributed set of regions: the left frontal cortex corresponding to Broca's area, the inferior and dorsolateral prefrontal cortex, the premotor cortex, and the cerebellum (Abrahams et al., 2003; Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Cabeza & Nyberg, 2000; Henry & Crawford, 2004; Indefrey & Levelt, 2000; Marien, Engelborghs, Fabbro, & De Deyn, 2001; McGraw, Mathews, Wang, & Phillips, 2001; Schlosser et al., 1998).

Role in Impulse-Control Disorders

Evidence with regards to the relationship between ICDs and performance on VF tasks remain uncertain (Hurks et al., 2004). VF skills rely on attention capacity and executive functioning (Monsch et al., 1994; Nejati, Pouretemad, & Bahrami, 2013; Rosser & Hodges, 1994), which are aspects of cognition frequently impaired in populations with ICDs (Barkley, 1998). In fact, clinical and epidemiological studies found high rates of comorbidity between stuttering and ICDs (Alm & Risberg, 2007; Biederman et al., 1993). Individuals with ADHD tend to perform significantly worse than healthy controls on both semantic and phonological VF tasks (Grodzinsky & Barkley, 1999; Grodzinsky & Diamond, 1992; Klorman et al., 1999; Koziol & Stout, 1992; Loge, Staton, & Beatty, 1990; Pineda, Ardila, & Rosselli, 1999; Schuerholz, Singer, & Denckla, 1998).

Other studies uncovered a deficit in subjects with ADHD on phonological fluency tests, but analogous performance on semantic fluency tests as compared to a healthy control group (Hurks et al., 2004). Researchers speculate that a phonological fluency task presents a greater challenge to individuals suffering from ICDs because it places a higher demand on their weak executive functioning skills (Barkley, 2006; Martinussen et al., 2005).

Finally, other studies failed to uncover any differences in performance between healthy and diagnosed subjects (Barkley, Grodzinsky, & DuPaul, 1992; Fischer, Barkley, Edelbrock, & Smallish, 1990; Grodzinsky & Diamond, 1992; Kusche, Cook, & Greenberg, 1993; Loge et al., 1990; Pineda et al., 1999; Reader, Harris, Schuerholz, & Denckla, 1994; Weyandt & Willis, 1994). The first neuroimaging study on VF and subjects with an ICD even claimed that diagnosed subjects performed significantly *better* on semantic tasks than their control counterparts did; examination using functional near-infrared spectroscopy (fNRIS) illustrated diminished brain activation in ADHD subjects during completion of the task (Schecklmann et al., 2008). Findings suggest that the ADHD subjects may have found the task less challenging than controls did, and therefore needed to exert less cognitive effort, although the exact reasons for this difference remain unknown.

Training Verbal Fluency

Attention training can reduce VF difficulties, as demonstrated with stuttering subjects (Nejati et al., 2013). Stuttering, the most common verbal fluency disorder, refers to an inability to speak smoothly under self-imposed or external demands, such as time limits or complex sentence formulation (Starkweather, 2002). Attention training, which practices response inhibition and impulse control, seems to decrease stuttering, often characterized as a lack of inhibitory and attentional control (Nejati et al., 2013). Studies have also established a link between greater emotional reactivity and stuttering; as such, improving a child's emotional control may aid in rehabilitation (Karrass et al., 2006). Training executive attention may enhance

VF with strategies that concern shifting attention from emotionally arousing stimuli to safe stimuli in order to calmly focus on language production (Izard, Stark, Trentacosta, & Schultz, 2008). Overall, preliminary studies show that training seems to positively affect verbal fluency skills, especially in the case of stuttering.

In our study, we measure VF capacity using the Controlled Oral Word Association Test. We provide further information about this instrument in the Methodology section.

Intertwinement

Executive attention (EA), working memory (WM), and verbal fluency (VF) neurologically and functionally intertwine with each other. For example, EA relies on prefrontal and parietal regions that largely overlap with activation during WM tasks (Corbetta & Shulman, 2002). Such an overlap is consistent with the fact that WM tasks necessitate solid control of attention (D'Esposito, 2007; Jarrold & Towse, 2006; McNab & Klingberg, 2008; Vogel, McCollough, & Machizawa, 2005). The shared mechanisms of sustained neural activity and multi-modal frontoparietal network point toward an intimate link between EA and WM, as illustrated by neuroimaging studies (D'Esposito, 2007; Klingberg, 2010). Additionally, studies have reported a high correlation between VF and attention capacity as well as executive functioning (Barkley, 1998; Monsch et al., 1994; Nejati et al., 2013; Rosser & Hodges, 1994). For example, children who suffer from stuttering typically show attentional difficulties, such as high distractibility and problems in shifting their attention from one task to another (Karrass et al., 2006; Monfrais-Pfauwadel & Lacombe, 2002; Schwenk, Conture, & Walden, 2007). Studies have also pointed to an association between VF issues – again, in the case of stuttering – and WM (Bajaj, 2007). Hand in hand, issues pertaining to EA and WM impair children with stuttering (Anderson, Wagovich, & Hall, 2006; Bakhtiar, Abad, & Panahi, 2007; Hakim & Ratner, 2004). In addition, deficits in verbal working memory – e.g., forgetting a new phone number – correlate with language acquisition weaknesses such as difficulties with vocabulary and word decoding (Baddeley, Gathercole, & Papagno, 1998; Swanson & Howell, 2001). While some researchers believe that the same neurodevelopmental impairments underlie attention, memory and language weaknesses and others assert that deficits in one area may simply contribute to deficits in the other (Redmond, 2005), most scientists agree that EA (Guion & Pederson, 2007) and WM (Baddeley, 2003) play an important role in language processing.

Overall, scientific research has repeatedly shown that the cognitive processes involved in EA, WM, and VF intimately interlace with each other. In the present study, we examined improvements on measures of these three cognitive skills in children following a four-week attention training program comprising cognitive exercises and a motivational component.

Methodology

Participants

Participants include 27 children ranging from 5-9 years of age. We recruited participants from a school in Montreal (N = 24), a child psychiatry program (N = 2), and via parents who reached out to our laboratory (N = 1). We divided subjects into two groups that we will analyze separately: “Case 1” and “Case 2.” Case 1 comprises healthy children (N = 25) made up of 11 girls and 14 boys between 5 and 9 years of age (Figure 3).

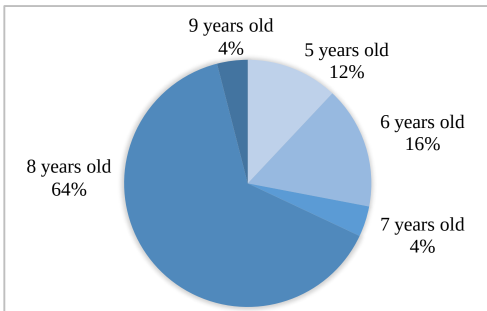


Figure 3. Age frequency of healthy participants (Case 1).

Case 2 includes case studies of children diagnosed with an ICD (N = 2). Luke and Amanda[1] were referred to us by child psychiatrists from the Jewish General Hospital of Montreal (JGH) based on specific criteria (Table 2).

Table 2. Inclusion and exclusion criteria for eligibility of diagnosed subjects.

Inclusion criteria	Exclusion criteria
o 4 to 11 years of age. o Diagnosis of impulse-control disorder (e.g., Attention Deficit/Hyperactivity Disorder (ADHD), Disruptive Mood Dysregulation Disorder (DMDD), Oppositional Defiant Disorder (ODD))	o Diagnosis of Autism Spectrum Disorder. o Diagnosis of Epilepsy. o Diagnosis of Tourette's syndrome. o Diagnosis of Mental Retardation. o Currently on psychotic or stimulant medication. o Legally blind or deaf.

Attention Training Program

In accordance with the findings that attention training programs can cause significant structural and functional changes in the brain and that computerized cognitive exercises constitute one of the most popular forms of brain training (Rabipour & Raz, 2012), our research team has decided to use an adaptation of "Teach-the-Brain." This computerized program, developed and tested by Michael Posner's team, includes cognitive exercises presented as games that target attentional networks in children (Rueda, Rothbart, et al., 2005). Our program differs from many other brain training courses in that it employs implicit training; improvement is based solely on repetition and feedback, in contrast to explicit training, which uses a variety of meta-cognitive strategies to consciously train specific abilities (Klingberg, 2010).

Each exercise in the program attempts to achieve a specific type of training by tapping various executive control skills. For example, certain challenges work alerting attention by

[1] Names have been changed to protect anonymity.

requiring participants to anticipate stimuli. In the "Catch that thief!" game, a duck swims underwater across a pond in a straight line and the children must calculate where the duck will emerge. Other games train working memory skills; "Save the painting" requires participants to remember multiple attributes on cartoon portraits in order to later pick it out of an array. Some games exercise inhibitory control. In "Undercover spy," children must withhold clicking on a stack of hay until it moves, indicating a wolf hiding underneath. As the levels increase, the hay takes longer to move and shifts ever so slightly, thus requiring close attention and impulse control. To ensure appropriately paced advancement, children progress to higher levels after several consistently successful trials.

Participants received a total of ten 30-minute brain training sessions, at a rate of three times a week, at their school. Each participant had a coach, or *attention trainer*, who picked them up from class and led them to their session. All ten attention trainers were undergraduate students studying psychology in Montreal with a strong background in child care. Their role in this program included setting up the computer and exercises for each session; providing guidance and encouragement to participants; explaining instructions and offering clues when necessary; providing tangible motivation in the form of certificates and small prizes; and aiding in the transfer of a participant's skills and learning techniques from the games to the classroom and at home. To measure cognitive progress, we conducted pre-assessments two weeks prior to the first session, post-assessments two weeks after the last session, and long term assessments about six weeks after the last session (Figure 4). Overall

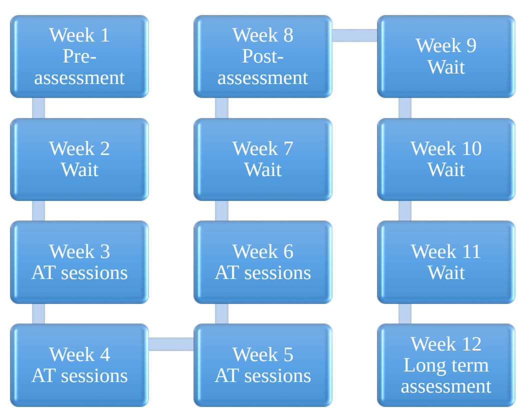


Figure 4. Attention Training program procedure.

session duration lasted approximately four weeks, concluding an entire round's length – including assessments and brain training sessions – at about twelve weeks. Although we explained to parents that we would conduct three separate assessments with their children, we intentionally withheld specific information about the assessment procedures. For example, we did not tell parents what type of tests we would conduct nor that we would use the same tests for all three assessments. The participants were given less information than their parents; they were only aware that we would conduct a pre-assessment. As such, we hoped to minimize potential practice effects that can arise due to expectation; for instance, a child that knows she will be tested on the same material again may deliberately or subconsciously mentally prepare herself and thus increase her score.

Measures

Because attention relates strongly to working memory and verbal fluency, we decided to investigate the effects of our brain training program on participants' skills pertaining to those three cognitive aspects. We used the D2 Test of Attention[2] to measure executive attention, the Backwards Digit Span and the children's Buschke Selective Reminding Test to examine working memory, and the children's Controlled Oral Word Association Test to study verbal fluency.

Executive Attention: D2 Test of Attention

The D2 Test of Attention (D2), also known as the Concentration Endurance Test, assesses selective and sustained attention as well as visual scanning ability (Brickenkamp & Zillmer, 1998). It measures speed, rule compliance and quality of performance in response to the

[2] Earlier leaders of this project used the child Attention Network Test to measure attentional capacities but encountered a ceiling effect. We therefore decided to replace the child Attention Network Test with the D2 Test of Attention.

manual discrimination of similar visual stimuli. In the form of a paper and pencil task, the D2 requires subjects to cancel out specific target characters interspersed with nontarget characters in 14 successive timed trials. The visual similarity between the target and nontarget characters causes a high competition for executive attention and therefore requires complex attentional processing (Bates & Lemay, 2004). Prior to standardization, a score represents the number of targets a participant crosses off, minus errors (i.e., crossing out the wrong character or failing to cross off a target character). Hence, a high score indicates a greater capacity to focus and work efficiently. Subjects who score in the lowest percentiles tend to have difficulty concentrating, including warding off distractions (Zillmer & Kennedy, 1999). See Appendix A.

Working Memory: Backwards Digit Span

The Backwards Digit Span (BDS), a subtest of the Weschler Intelligence Scale for Children, 4th Edition (WISC-IV), requires subjects to repeat increasingly longer digit sequences in reverse order (Wechsler, 2003). There are two trials per length of span, which increases variability. For example, for the 3-digit span, a child is asked to repeat in reverse order a group of three digits (first trial) and then another group of three digits (second trial). High scores indicate longer sequences of successfully repeated numbers. We standardized scores with the age-appropriate tables provided in the WISC-IV. As opposed to simply demanding short term auditory memory, the BDS requires the additional processing demands of working memory and mental flexibility to reverse the digit sequence (Connors, Carr, & Willis, 1998; Groth-Marnat, Gallgher, Hale, & Kaplan, 2000; Hebben & Milberg, 2002; Ramsay & Reynolds, 1995). The mental manipulation of information draws upon executive functioning skills (Denckla, 1994). Researchers have argued that BDS scores can yield information about a child’s attention processes and prove useful in diagnostic and treatment determination (Hale, Hoeppner, & Fiorello, 2002). See Appendix B.

Working Memory: Children's Buschke Selective Reminding Test

The Buschke Selective Reminding Test (BSRT) measures verbal working memory and learning in the form of a cued, list-learning task (Buschke & Fuld, 1974). Steven Morgan (1982) developed alternate forms of the neuropsychological test for application with children. The procedure involves reading a list of eight animals and subsequently asking the child to recall as many of them as possible, in any order. The examiner then cues the subject by repeating the words he or she failed to recall. The subject is then asked to recall all the words again, including those that were previously forgotten and cued. The test continues over the course of six trials, or until the subject recalls all words for two consecutive trials. Each assessment uses the same version of the test, thus comprising the same eight animals to recall for reliability purposes. Researchers found that not only did memorizing the list of words draw upon working memory resources, but the mental manipulation required does as well (Strauss, Sherman, & Spreen, 2006). The children's BSRT does not appear to include a standardization process for scores; hence, an individual's total score comprises the sum of all successfully recalled words for each trial. A higher number therefore indicates better recall. See Appendix C.

Verbal Fluency: Children's Controlled Oral Word Association Test

The children's Controlled Oral Word Association Test (COWAT) comprises three subtests to capture both the semantic and phonological aspects of verbal fluency. Individuals must spontaneously generate words in response to a category cue (e.g., animals) within 60 seconds. Such a task requires the use of executive processing skills because it involves a controlled search for words; the child must activate information (animals) while controlling the repetition of exemplars as well as inhibiting words that do not belong in the category and variations of an already generated word (e.g., dog and doggy and puppy). See Appendix D.

Three subtests form the children's COWAT, and we will analyze each separately. The first two subtests, "Animals" and "Food," measure semantic fluency, and the third subtest, "Words starting with the sound 'Sh'," assesses phonological fluency. We used the same subtests for each assessment for item reliability and to ensure that change in performance is not attributable to one test version proving easier than another. While the adult version asks participants to generate words beginning with specific letters (F, A, and S), which requires basic spelling skills, the children's version asks for words beginning with a sound ("Sh"). Studies indicate that generating words according to a category may prove easier than based on an initial letter or sound because the brain organizes language semantically rather than phonologically (Collins & Loftus, 1988; Hurks et al., 2004; Jescheniak & Levelt, 1994; Mercer, 1976). In line with these findings, normative data show that scores on the first two subtests remain consistently higher than scores on the phonological subtest (Strauss et al., 2006). As a non-commercial test, the children's COWAT does not appear to include standardization tables for raw scores. As such, an individual's total score conveys the number of correct generated words for all subtests (i.e., excluding repetitions, variations, and incorrect categories).

Conditions

Our original protocol stated that we would randomly assign children from Case 1 to one of three groups: the Intervention group, the Placebo-Control group, or the Waitlist-Control group. Children in both the Intervention and the Placebo-Control groups would have received ten sessions with a coach (Table 3). Children in the Placebo-Control group, contrary to those in the Intervention Group, would not have played the brain training games. Their pseudo-training would have consisted of watching science-related videos. Their attention trainer would ask questions about the videos and provide the same encouragement, certificates and small prizes as the children in the Intervention group received. As such, we would have created a condition that allowed us to disentangle the effects of the motivation component – the coaches – and the direct effects of the cognitive exercises. In the Waitlist-Control group, participants would have received the same assessments at similar intervals, with an eight week break between pre- and post-evaluations, but would not have had any sessions. This condition would illustrate how much progress children can exhibit due to external factors unrelated to our program, such as classes or natural development.

Table 3. Conditions for participants in Attention Training program.

Intervention	Placebo-Control	Waitlist-Control
○ Pre, post, and long term assessments. ○ 10 attention training sessions. ○ Behavioural motivation (coach).	○ Pre, post, and long term assessments. ○ 10 video sessions. ○ Behavioural motivation (coach).	○ Pre, post, and long term assessments. ○ 0 sessions.

Following discussions with the faculty of the participating school, we unexpectedly had to modify our methodology. Due to the novel and disruptive nature of our program – children would miss class briefly to conduct their brain training sessions – the administration accepted to partake in our study on the condition that we place all children in the Intervention group. They felt uncomfortable with a methodology that would split the children into a group that benefits and two groups that may not. Not only did they fear the children themselves would be upset upon realizing that their friends played computer games while they were in the control condition, but they also worried that parents would disagree with our methods. In order to keep our collaboration with this otherwise compliant school, we felt it necessary to eliminate the control groups temporarily. After analyzing preliminary data, we established connections with other schools who agreed to split future participants into treatment, placebo and control groups. Our team is currently working with new students in those schools and gathering data to compare conditions. As a result, the present manuscript reports preliminary data from the past year that encompasses children placed in the Intervention group only.

Results

Case 1: Healthy Children

Case 1 includes all healthy participants in the intervention group. Analyses examine differences in scores between the pre-assessment, post-assessment, and long term assessment, as well as potential gender influences. We hypothesize that children's scores would increase on all measures after receiving attention training sessions. We also predict that girls and boys will improve similarly; in other words, we do not expect gender effects or interactions. While all kids were eligible for the BSRT and the COWAT (N = 25), several were too young for the D2 and the BDS, thus reducing the total number of test takers (N = 18).

Executive Attention: D2 Test of Attention (D2)

We conducted a mixed within between subjects ANOVA to compare scores on the D2 across pre-, post- and long term assessments and across genders. See Table 4 for means and standard deviations. There was a significant effect for Time, Wilks' Lambda = .085, F (2,14) = 75.324, (p<.001), multivariate partial eta squared = .915. Subjects improved their scores on the D2.

Table 4. Means and standard deviations of D2 scores.

Time	Gender	Mean	SD
Pre	Female (N=9)	95.4	10.9
	Male (N=8)	98.8	4.6
	Total (N=17[3])	97.0	8.5
Post	Female	107.7	11.1
	Male	111.5	7.6
	Total	109.5	9.5
Long term	Female	110.2	11.4
	Male	112.8	6.7
	Total	111.4	9.3

We performed pair-wise comparisons and controlled for multiple comparisons using the Bonferroni correction. Results showed a significant effect between the pre- and post-assessments (p<.001) as well as between the pre- and long term assessments (p<.001). There was a non-significant difference between the post- and long term assessments (p=.730). See Table 5 for results.

Table 5. Pair-wise comparisons of D2 scores by Time.

Time	Time	Standard Error	Significance	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Pre	Post	1.141	<.001*	-15.561	-9.412
Pre	Long Term	1.497	<.001*	-18.422	-10.356
Post	Long Term	1.567	.730	-6.123	2.317

[3] Due to an error in assessment administration that invalidated one subject's scores, we analyzed the scores of 17 rather than 18 participants on the D2.

Within the mixed within between subjects ANOVA, we also investigated the relationship between Time (as measured by scores at pre-, post-, and long term assessments) and Gender (male and female). Gender was non-significant, F (1,15) = .592, (p = .454), partial eta squared = .038. The interaction between time and gender was also non-significant, Wilks' Lambda = .988, F (2,14) = .083, (p = .921), multivariate partial eta squared = .012. Results demonstrate no relationship or interaction between gender and performance on the D2 (Figure 5).

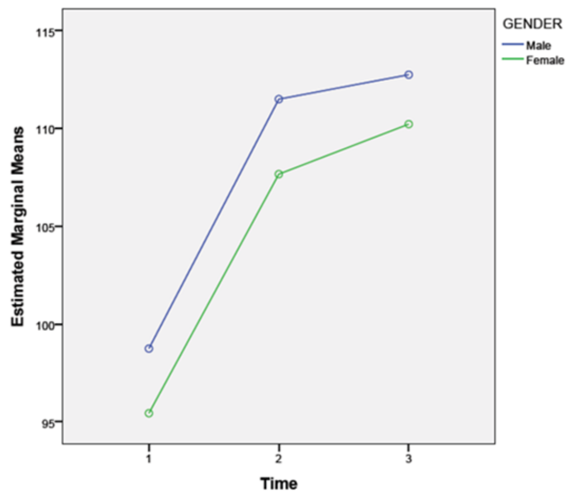


Figure 5. Estimated marginal means of Time by Gender on the D2.

Working Memory: Backwards Digit Span (BDS)

We conducted a mixed within between subjects ANOVA to compare scores on the BDS across pre-, post- and long term assessments and across genders. The means and standard deviations are presented in Table 6. We found a close but non-significant effect for time, Wilks' Lambda = .699, F (2,15) = 3.223, (p= .068), multivariate partial eta squared = .301. Participants' scores failed to increase on the BDS.

Table 6. Means and standard deviations of BDS scores.

Time	Gender	Mean	SD
Pre	Female (N=9)	11.4	2.2
	Male (N=9)	11.3	2.8
	Total (N=18)	11.4	2.5
Post	Female	13.2	3.9
	Male	12.7	2.3
	Total	12.9	3.1
Long Term	Female	13.7	3.5
	Male	13.2	3.5
	Total	13.4	3.4

Within the mixed within between subjects ANOVA, we also investigated the relationship between Time and Gender. Gender was non-significant, F (1,16) = .103, (p=.753), multivariate partial eta squared = .006. The interaction between time and gender was also non-significant, Wilks' Lambda = .995, F (2,15) = .039, (p=.962), multivariate partial eta squared = .005. Results fail to indicate a relationship or an interaction between gender and performance on the BDS (Figure 6).

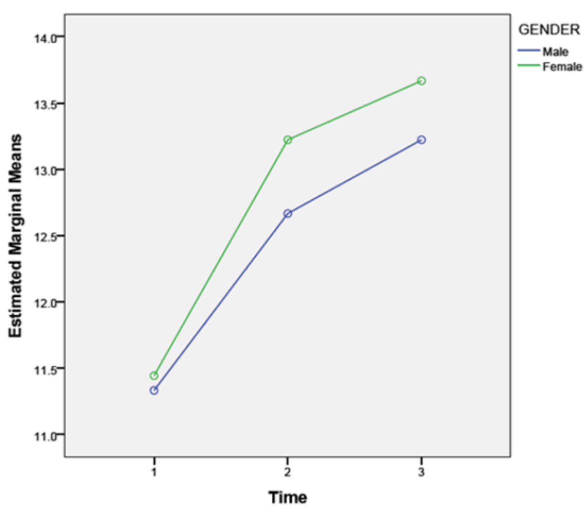


Figure 6. Estimated marginal means of Time by Gender on the BDS.

Working Memory: Buschke Selective Reminding Task (BSRT)

We conducted a mixed within between subjects ANOVA to compare scores on the BSRT across pre-, post- and long term assessments and across genders. See Table 7 for means and standard deviations. We found a non-significant effect for time, Wilks' Lambda = .875, F (2,22) = 1.577, (p=.229), multivariate partial eta squared = .125. Subjects' scores did not augment on this measure at all.

Table 7. Means and standard deviations of BSRT scores.

Time	Gender	Mean	SD
Pre	Female (N=11)	40.5	3.9
	Male (N=14)	39.4	4.6
	Total (N=25)	39.8	4.2
Post	Female	41.6	4.6
	Male	40.5	4.3
	Total	41.0	4.4
Long Term	Female	41.9	3.8
	Male	40.9	4.3
	Total	41.4	4.0

As for the relationship between Time and Gender, we found that Gender was non-significant, F (1, 23) = .557, (p = .463), partial eta squared = .024. The interaction between time and gender was also non-significant, Wilks' Lamba = 1, F (2,22) = .005, (p = .995), partial eta squared < .001. Results indicate no relationship or interaction between gender and performance on the BSRT (Figure 7).

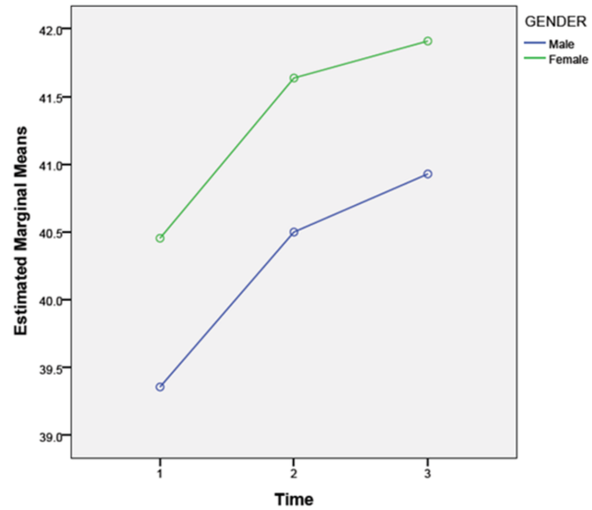


Figure 7. Estimated marginal means of Time by Gender on the BSRT.

Verbal Fluency: Controlled Oral Word Association Test (COWAT)

Finally, we also conducted a mixed within between subjects ANOVA to compare scores on the COWAT across assessments and across genders. See Table 8 for means and standard deviations. We discovered a significant effect for time, Wilks' Lambda = .397, F (2,22) = 16.736, (p<.001), multivariate partial eta squared = .603. Participants' performance on the COWAT improved overall.

Table 8. Means and standard deviations of COWAT scores.

Time	Gender	Mean	SD
Pre	Female (N=11)	26.6	4.9
	Male (N=14)	26.4	9.9
	Total (N=25)	26.5	7.9
Post	Female	30.5	5.3
	Male	30.7	12.3
	Total	30.6	9.7
Long Term	Female	31.8	6.3
	Male	33.1	12.3
	Total	32.6	10.0

We performed pair-wise comparisons and controlled for multiple comparisons using the Bonferroni correction. Results showed a significant effect between pre- and post-assessments (p=.005) and between pre- and long term assessments (p<.001). There was a non-significant effect between post- and long term assessments (p=.488). See Table 9 for results.

Table 9. Pair-wise comparisons of COWAT scores by Time.

Time	Time	Standard Error	Significance	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Pre	Post	1.135	.005*	-6.983	-1.120
Pre	Long Term	1.071	<.001*	-8.714	-3.182
Post	Long Term	1.315	.488	-5.291	1.499

As for the relationship between Time and Gender, our calculations showed that Gender was non-significant, F (1,23) = 0.17, (p = .898), partial eta squared = .001. The interaction between Time and Gender was also non-significant, Wilks' Lamba = .978, F (2,22) = .245, (p = .785), partial eta squared = .022. Results show no relationship or interaction between gender and performance on the COWAT (Figure 8).

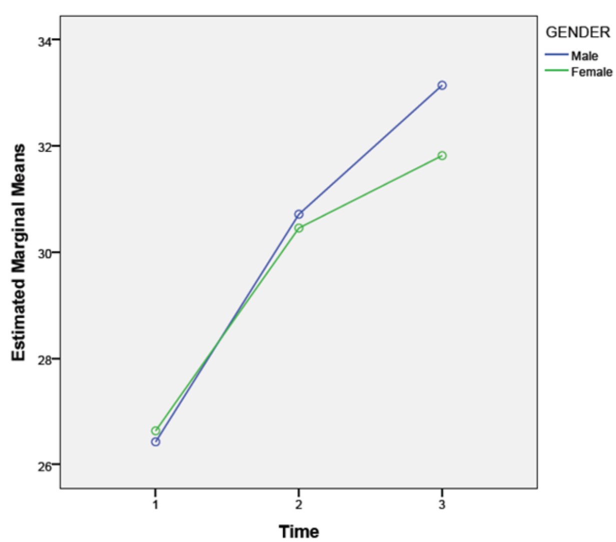


Figure 8. Estimated marginal means of Time by Gender on the COWAT.

We examined the subscores on the COWAT separately as well. The first two subscores reflect Semantic Fluency (Animals and Food) while the third subscore measures Phonological Fluency (Words starting with the sound "Sh"). Table 10 indicates the means and standard deviations for all three subscores.

Table 10. Means, standard deviations and norms of COWAT scores (N=25).

Subtest	Time	Mean	SD	Norms (means ages 6-9)
Animals	Pre	11.9	3.5	
	Post	14.6	4.3	10.74 – 13.76
	Long Term	14.4	3.7	
Food	Pre	10.9	4.4	
	Post	11.6	4.7	9.74 – 14.05
	Long Term	13.2	5.4	
Words starting with the sound "Sh"	Pre	3.7	1.8	
	Post	4.4	2.5	4.24 – 5.95
	Long Term	5.0	2.8	

We conducted a mixed within between subjects ANOVAs on all three subtests to compare scores on the pre-, post- and long term assessments. We found a significant effect for Time in both semantic subtests, indicating improvement in scores pertaining to semantic fluency, but a non-significant – albeit close – effect of Time on phonological fluency. See Table 11 for results.

Table 11. Mixed within between subjects ANOVA results for COWAT scores.

Subtest	Wilks' Lambda	F value	Significance	Partial Eta Squared
Animals	.524	F (2,22) = 10.000	p=.001*	.476
Food	.713	F (2,22) = 4.425	p=.024*	.287
"Sh"	.766	F (2,22) = 3.368	p=.053	.234

We therefore performed pair-wise comparisons for the Animals and Food subtests and controlled for multiple comparisons using the Bonferroni correction. For the Animals subtest, results showed a significant effect between pre- and post-assessments (p = .003) and between pre- and long term assessments (p = .003). There was a non-significant effect between post- and long term assessments (p = 1.000). For the Food subtest, results only showed a significant effect between pre- and long term assessments (p = .018). There were non-significant effects between pre- and post-assessments (p = 1.000) and between post- and long term assessments (p = .291). See Tables 12 and 13 for results.

Table 12. Pair-wise comparisons of scores on Animals subtest of COWAT by Time.

Time	Time	Standard Error	Significance	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Pre	Post	.726	.003*	-4.655	-.904
Pre	Long Term	.668	.003*	-4.232	-.781
Post	Long Term	.782	1.000	-1.747	2.292

Table 13. Pair-wise comparisons on Food subtest of COWAT by Time.

Time	Time	Standard Error	Significance	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Pre	Post	.790	1.000	-2.691	1.386
Pre	Long Term	.712	.018*	-4.001	-.324
Post	Long Term	.873	.291	-3.764	.744

In line with our previous findings, our calculations showed that Gender was non-significant in all three subtests. In the Animals subtest, F (1,23) = 0.206, (p = .654), partial eta squared = .009. In the Food subtest, F (1,23) = 0.020, (p = .889), partial eta squared = .001. In the “Sh” subtest, $F (1,23) = 0.035$, ($p = .853$), partial eta squared = .002. As expected, the interaction between Time and Gender was also non-significant in all three subtests. In the Animals subtest, Wilks’ Lamba = .980, $F (2,22) = .245$, ($p = .801$), partial eta squared = .020. In the Food subtest, Wilks’ Lamba = .921, $F (2,22) = .943$, ($p = .405$), partial eta squared = .079. In the “Sh” subtest, Wilks’ Lamba = .993, $F (2,22) = .080$, ($p = .923$), partial eta squared = .007. In conclusion, results show no relationship or interaction between gender and performance on all three subtests of the COWAT.

Finally, we observed an unexpected rise in error rates across Time. Participants committed in average 0.8 errors in the pre-assessment, 1.16 in the post-assessment, and 1.28 in the long term assessment. See Figure 9 for details.

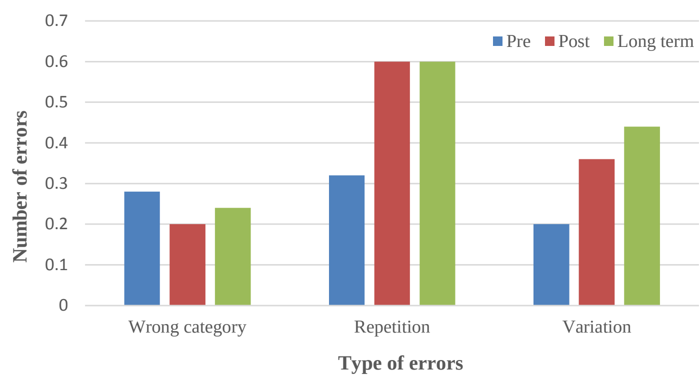


Figure 9. Average number of errors on the COWAT, per type, across pre-, post- and long term assessments.

Discussion

Subjects in Case 1 significantly improved in measures of executive attention and verbal fluency. In the case of executive attention, substantial results appeared in both post- and long term assessments and exhibited similar strength, suggesting that the training effects remained stable and did not decline for at least six weeks after the cognitive exercises ended. As for verbal fluency, as was the case with executive attention, we uncovered progress between pre- and post-assessments as well as pre- and long term assessments. Subjects seem to have improved those skills and experienced durable training effects. Closer examination revealed that the means for the semantic subscores stand considerably higher than the means for the phonological subscore, in accordance with the finding that individuals perform better when asked to generate words within a specific category than beginning with a letter or sound (Schecklmann et al., 2008). Subjects considerably improved on verbal fluency and similar scores on the post- and long term assessments indicate that the training effects lasted sturdily after the end of the attention training program. The subtests concerning semantic fluency boasted more significant progress than the phonological fluency subtest, for which scores improved but not significantly, which suggests that cognitive training may improve the former more readily than it improves the latter, or that semantic fluency is the more malleable subtype, or both. The performance of participants unexpectedly worsened in terms of errors, which potentially suggests that improvement in verbal fluency may occur partially due to more lax behaviours towards preventing mistakes.

Conversely, subjects failed to show a general improvement on the BDS and BSRT tests for working memory. Although the means slightly increase on both tasks between each assessment, the difference in scores failed to reach significance. One possible explanation relates to the fact that successful exercising of working memory may require more time to consolidate the effects of training. Furthermore, perhaps the children's age affected their lack of improvement on these tasks; younger or older children may show more noteworthy progress.

Finally, our analyses rules out an interaction effect between gender and performance, indicating that gender does not have an effect on the benefits of attention training in this particular program. In summary, preliminary results indicate that our program benefits healthy children's skills pertaining to executive attention and verbal fluency, but not working memory abilities.

Case 2: Case Studies

We recruited Luke and Amanda (names have been changed), both diagnosed with an impulse-control disorder, from the Jewish General Hospital's Child Psychiatry behavioural program. The reason why only two children were eligible for our study pertains to the exclusion criteria of medication. We do not accept participants currently on stimulant medication to avoid confounding variables in our experiment. Our protocol states that participating children diagnosed with an impulse-control disorder must not take stimulant medication during their time in our program. Because the child's health takes priority over our study, we asked participating psychiatrists to notify us if they prescribed medication to our subjects during the course of our study. In such a case, we would consequently exclude the child's data from our analyses. Luke and Amanda comprised the only subjects that did not take any stimulant medication during our study. Their psychiatrists prescribed stimulants shortly after our post-assessments, thus rendering the children ineligible for long term assessments. As a result, both Luke and Amanda underwent a pre- and post-assessment but neither received a long term assessment.

Luke: Introduction

We met with our first patient, Luke, when he was 5 years and 9 months old. At that point, he had attended the JGH Child Psychiatry behavioural program for five months. Luke's psychiatrist diagnosed him with Oppositional Defiant Disorder (ODD), characterized by a pattern of angry and/or defiant behaviour, as well as potential vindictiveness (American Psychiatric Association, 2013). He especially suffers from impulsivity and low self-esteem, and exhibits a tendency towards violence. Luke lives with his parents in Montreal and speaks English at home and at his school. He enjoys martial arts and plays video games.

During his pre-assessment, Luke acted shy and spoke little. He enjoyed completing the neuropsychological tasks and listened to directions well. We met with Luke two months later for his post-assessment. His shyness had decreased compared to the first meeting; he felt comfortable enough to candidly speak to the assessor. He claimed that he enjoyed the attention training games as well as his coach's guidance. He remained calm and quiet.

Due to his young age, Luke was ineligible for the D2 Test of Attention (D2) as well as the Backwards Digit Span (BDS). As such, we analyzed his results on the Buschke Selective Reminding Test (BSRT) and the Controlled Oral Word Association Test (COWAT).

Luke: Results on the BSRT

Luke's scores on the BSRT remained relatively stable and within the norm (Table 14). Healthy children his age recall an average of 5.3 words per trial, with a standard deviation of 1.2. Luke's average recall per trial grew from 5.17 in his pre-assessment to 6 in his post-assessment, showing a slight improvement in performance from average to half a standard deviation above the mean.

Table 14. Luke's scores on the BSRT.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total
Pre	4	6	4	6	6	5	31
Post	3	5	6	7	8	7	36

Luke: Results on the COWAT

See Table 15 for Luke's scores on the three COWAT subtests, on the pre- and post assessments, as compared to normative data for healthy children his age. During his pre-assessment, Luke scored almost 2 SDs below the norm in the Animals category but approximately 1 SD above the norm in the Food category. In his post-assessment, however, he performed within average range. His scores on the phonological fluency subtest stably remained on the low end in both assessments, placing him over 2 SDs lower than the average for his age.

Table 15. Luke's scores on the COWAT as compared to normative data.

	Animals	Food	"Sh"	Total
Pre-assessment	6	13	0	19
Post-assessment	10	9	1	20
Norms	10.7 (SD 2.4)	9.7 (SD 3.3)	4.2 (SD 1.6)	24.7

Source: (Strauss et al., 2006)

Because children with impulse-control disorders suffer from a deficit in response inhibition (Schecklmann et al., 2008), we expected to find a higher number of errors (i.e., repetitions, variations, and words not pertaining to the category) in the diagnosed subjects compared to the healthy population prior to training. Due to the lack of normative data for children's errors on the COWAT, we compared Luke's performance to that of the healthy participants of this study. As anticipated, Luke committed more errors on average than our healthy population; although subjects in Case 1 scored an average of 1.1 total errors during their pre-assessment, Luke made a total of 8 errors (Table 16). In his post-assessment, however, his mistakes significantly decreased to a total of 2.

Table 16. Luke's errors on the COWAT as compared to subjects in Case 1.

	Repetitions	Not in category	Variations	Total
Mean in Case 1: pre	0.6	0.3	0.3	1.1
Luke: pre	0.0	8.0	0.0	8.0
Luke: post	2.0	0.0	0.0	2.0

Luke: Discussion

Results imply that our program has failed to train Luke's verbal fluency skills and \working memory. Luke's working memory capacity remained stable and within the norm, though we noticed a slight increase over time. His results on the verbal fluency assessment illustrate an inconsistent performance in the semantic fluency subtests and a poor performance on the phonological subtest. We conjecture that failure to focus, failure to comply, or an unusual mental state during the pre-assessment may have generated the incoherent results on the semantic fluency test and error rates. Luke committed a significant amount of unusual errors in the COWAT during his pre-assessment; he named eight words belonging to an entirely different category than the one he was asked to think about. It seems he could not contain the words emerging in his mind, thus supporting the notion that children with impulse-control disorders exhibit impairments in response inhibition (Schecklmann et al., 2008). Although his error rate declined in his post-assessment, it is difficult to judge whether this decline was meaningful or whether his pre-assessment performance did not accurately represent his abilities. Finally, his scores reflect a genuine deficiency in phonological fluency. Our brain training program does not seem to have aided Luke to employ a stronger set of cognitive skills, as reflected by his sometimes inconsistent, sometimes stably low performances on neuropsychological assessments.

Amanda: Introduction

Our second patient, Amanda, was 7 years and 3 months old when we met with her to conduct her pre-assessment. She had joined the JGH Child Psychiatry behavioural program fewer than two months prior to our meeting. Her psychiatrist had tentatively diagnosed her with Disruptive Mood Dysregulation Disorder (DMDD), characterized by a persistent angry mood as well as severe and recurrent temper outbursts (American Psychiatric Association, 2013). Amanda showed symptoms of anxiety and perfectionism that resulted in melt-downs when things did not go her way. She exhibited social awkwardness, as illustrated by a lack of eye contact and consistent hiding behind her hair. A couple of months later, her psychiatrist began to contemplate a diagnosis of Generalized Anxiety Disorder (GAD) as well. Symptoms of GAD include excessive, uncontrollable, and often irrational worry that interferes with daily functioning (American Psychiatric Association, 2013). Like Luke, Amanda lives with her parents in Montreal, only speaks English, and sometimes plays video games.

Very shy, Amanda did not look me in the eye during the entire pre-assessment; instead, she looked at the table or her hands. She showed hyperactive and anxious symptoms, such as fidgeting in her seat and playing with her hair constantly. She often replied “I don’t know” to questions. When prompted to take an educated guess, however, she usually gave the correct answer. This behaviour led me to believe that she lacked self-esteem or originally did not want to comply, or both. When she felt that she answered incorrectly, she became frustrated and at the brink of crying. In order to minimize her irritation, I had to constantly encourage and congratulate her for her effort.

Amanda was 7 years and 6 months old when I met with her for her post-assessment. We established eye contact briefly at the beginning of the session, and in a few words, she spoke to me about her day. Amanda ventured far more guesses compared to the pre-assessment, and did so without my asking. This may be due to a decreased need to defy me or due to increased confidence. Her frustration and hyperactivity tremendously decreased; she was slightly fidgety but seldom played with her hands or hair. Short breaks allowed her to remain focused and positive, rather than inattentive and irritated. Her voice was stronger and she did not demonstrate any need to cry. In short, Amanda was noticeably more self-assured.

Due to her age at the time of the assessments, Amanda was ineligible for the D2 Test of Attention (D2). As such, we will analyze her results on the Backwards Digit Span (BDS), the Buschke Selective Reminding Test (BSRT), and the Controlled Oral Word Association Test (COWAT).

Amanda: Results on the BDS

Amanda performed equally on the BDS during the pre- and post-assessments. She attained a total score of 12 both times, as well as a Longest Backwards Digit Span (LBDS) of 3 both times. According to norms, Amanda's LBDS places her in the 48^{th} percentile, with 76% of children scoring a 3 or higher (Wechsler, 2003).

Amanda: Results on the BSRT

Amanda's scores on the BSRT considerably increased between both assessments, with her total score more than doubling (Table 17). Normative data for healthy children her age report an average of 6.1 words per trial, with a standard deviation of 1.1. Although her subpar performance on the pre-assessment earned her a mere average of 2.2 per trial, Amanda escalated to a 5.7 average per trial at her post-assessment, carrying her to a healthy norm.

Table 17. Amanda's scores on the BSRT.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total
Pre	3.0	4.0	5.0	1.0	0.0	0.0	13.0
Post	5.0	4.0	6.0	6.0	6.0	7.0	34.0

Amanda: Results on the COWAT

See Table 18 for Amanda's scores on the three COWAT subtests, on the pre- and post-assessments, as compared to normative data for healthy children her age. Amanda's performance on the semantic subtests noticeably improved between the pre- and post- assessments. While she initially began with Animals and Food scores placing her 3 SDs and 4 SDs below the average respectively, she rose in the direction of a healthy performance with scores about 2.5 SDs and 1 SD below the norm respectively. Amanda's scores on the phonological subtest, however, remained null both times, showing no improvement at all.

Table 18. Amanda's scores on the COWAT as compared to normative data.

	Animals	Food	"Sh"	Total
Pre-assessment	3.0	1.0	0.0	4.0
Post-assessment	5.0	9.0	0.0	14.0
Norms	12.4 (SD 2.9)	11.9 (SD 2.7)	5.5 (SD 1.6)	29.8

Source: (Strauss et al., 2006)

We were also interested in the kinds of errors – repetition, out of category, variation – that Amanda made when completing the COWAT; however, she made none in both her pre- and post-assessments.

Amanda: Discussion

Amanda's cognitive progress lacks uniformity. In terms of her working memory skills, her contradictory performances on the BDS compared to the BSRT render it difficult to unearth potential progress. Her scores on the BDS failed to increase over time, while her scores on the BSRT did so considerably. As such, we cannot formulate a confident conclusion regarding whether or not our brain training program developed her working memory capacity. As for her verbal fluency skills, although results imply that our exercises successfully improved Amanda's semantic fluency skills, we conjecture that her pre-assessment scores were so low that perhaps the improvement was due to a lack of enthusiasm or a particularly irritable mood the first time we met with her. A recurring null score on the "Sh" subtest of the COWAT indicates that our program failed to expand her extremely weak phonological fluency skills. Overall, it seems Amanda gained few advantages from participating in our brain training program. We speculate that, because our cognitive exercises target impulse-control symptoms, Amanda possibly did not benefit if the root of her psychiatric difficulties lies in anxiety rather than impulsivity.

Discussion

Conclusion

The present study examined the effects of attention training on two pediatric populations: healthy (Case 1) and diagnosed with an impulse-control disorder (Case 2). Subjects in Case 1 significantly improved on measures of executive attention and verbal fluency after completing the ten sessions of our attention training program; however, they failed to show progress in measures of working memory. The subtests concerning semantic fluency, as opposed to phonological fluency, boasted significant progress, suggesting that training may develop semantic fluency more readily than phonological fluency and/or that semantic fluency is the more plastic subtype. Improvements in executive attention and semantic verbal fluency endured for at least six weeks after the end of the program, indicating solid and durable progress. In terms of working memory, analyses revealed little to no progress, perhaps due to the fact that successful exercising of these skills requires additional, longer, or more condensed sessions to consolidate the training effects. Future studies should implement a more intense program to better investigate cognitive skills that require more time to show effects, such as working memory.

Subjects in Case 2 showed quite different cognitive improvements. Luke, diagnosed with Oppositional Defiant Disorder and suffering from violent impulses and low self-esteem, failed to show general improvement in both his working memory and his verbal fluency skills. Amanda, on the other hand, showed some improvement in semantic fluency, although her performance remained below average, and more solid progress in working memory, jumping from an extremely low score to a performance comparable to her healthy peers. Neither child improved on measures of phonological fluency. Overall, it seems the program barely benefitted Amanda and Luke. Perhaps Amanda's debilitating anxiety overshadowed her impulsive problems, thus disabling her from receiving the benefits of a program that aims to assuage symptoms pertaining to attention and behavioural regulation specifically. Although our exercises explicitly target the range of psychiatric impairments that Luke suffers from, his lack of progress may conceivably stem from the short duration and low intensity of our program. Again, further research delving into the matter should implement a more intense set of sessions.

Overall, results from this preliminary study suggest that attention training may develop the executive attention and verbal fluency skills of healthy children but it fails to show consistent results with children suffering from an impulse-control disorder. Further research should investigate the more nuanced effects of breadth, length and density of training sessions on cognitive improvements, examine age as a potential mediator of progress, and include a variety of control groups to differentiate the direct effects of attention training from placebo-like effects such as motivation.

Limitations

The limitations of the present study hinder confident, generalizable, and precise conclusions. The first, most severe defect pertains to the lack of control groups. Without the Placebo-Control group and Waitlist-Control group described in our original protocol, we lack the data to disentangle the effects of our program from placebo effects, from practice effects, and from the normal improvements that accompany a child's development. Moreover, improvements on neuropsychological measures may occur as a result of motivational factors; the active interest, monitoring, and vivid encouragement that our attention trainers provide subjects with may cause cognitive improvements more so than the attention training (Green & Bavelier, 2008). The Placebo-Control group would elucidate such effects because it includes the motivational component of the program while excluding the cognitive training. The Waitlist-Control group, in which subjects are entirely left out of the program, would shed light on whether the simple participation in our program, including skipping class, receiving prizes, and obtaining the attention and care of an attention trainer, may cause cognitive improvement. The act of providing treatment – even a sham treatment – can induce seemingly unrelated progress and decrease psychiatric symptoms simply because the subject feels cared for (Kermen, Hickner, Brody, &

Hasham, 2010; Tilburt, Emanuel, Kaptchuk, Curlin, & Miller, 2008). Our new, current implementation of both control groups will clarify which effects were specific to our program.

The small amount, short length and relatively dispersed concentration of attention training sessions constitute a severe second limitation. As mentioned previously, perhaps we would have uncovered more significant effects if we had implemented more than ten sessions, if each session lasted longer than thirty minutes, and if we conducted sessions more closely together than three times per week. We had based our protocol on previous studies with the aim of minimally disrupting the class schedules and academic lives of our participants (Rueda, Rothbart, et al., 2005).

A third limitation pertains to the fact that our sample prevented meaningful age comparisons between healthy subjects. We recruited those subjects in a school (with the exception of the child whose parents contacted us separately), in which we worked with two grades only. As a result, our healthy participants were either approximately 5 to 9 years old. Not only were we lacking a spread out equal age range, but our modest sample size also prevented further age-related analyses.

Fourth, our assessments give way to potential practice effects. For example, participants can remember the three subtests of the COWAT – Animals, Food, and Words starting with the sound “Sh” – and build up their mental repertoire in order to increase their score, deliberately or subconsciously. We considered this issue and opted nevertheless to use the same test versions for each assessment for three reasons. We primarily wanted to ensure solid item reliability; different versions of a neuropsychological test sometimes cannot be compared to each other due to inevitable variation in difficulty. The tests we used either had one version only (e.g., the BDS) or had several versions whose difficulty levels did not match (e.g., the children's BSRT). We had also established certain procedures to minimize the risk of practice effects. For instance, we did not inform participants that they would receive several assessments, let alone the same tests and same versions. Last, we simply aimed to conform to previous research literature for scientific consistency and validity.

Finally, our low number of case studies renders results ungeneralizable. Two unique individuals cannot reasonably represent the large scope of children diagnosed with an impulse-control disorder. The team continuing this research study should prioritize recruitment of more psychiatric subjects.

Implications and Future Directions

The implications of our findings essentially revolve around healthy children, due to the inconsistent results in our pathological case studies. Sustainable and generalizeable effects may arise from a large number of condensed attention training sessions over the course of a longer time period; in line with these parameters, it may prove beneficial to incorporate attention training courses in academic settings (Rabipour & Raz, 2012). In fact, several elementary schools in Canada have already integrated self-regulation programs in their curriculum to enhance the attentional skills of their students (e.g., Wells, 2013). Further research will have to follow these developments to determine the specific forms of training and frequency necessary to trigger cognitive and behavioural improvement.

Acknowledgements

We would like to thank Sheida Rabipour for her kind guidance, lab members Jenilee-Sarah Napoleon and Liana Corber for their participation with assessments, Mathieu Landry and Daniella Karidi for their assistance with data analysis, and the undergraduate students that comprised our team of attention trainers. Dr. Raz acknowledges the support of the Canada Research Chair program, the Canadian Institutes of Health Research, and the Natural Sciences and Engineering Research Council of Canada.

References

Abrahams, S., Goldstein, L. H., Simmons, A., Brammer, M. J., Williams, S. C., Giampietro, V. P., . . . Leigh, P. N. (2003). Functional magnetic resonance imaging of verbal fluency and confrontation naming using compressed image acquisition to permit overt responses. *Hum Brain Mapp, 20*(1), 29-40. doi: 10.1002/hbm.10126

Alm, P. A., & Risberg, J. (2007). Stuttering in adults: the acoustic startle response, temperamental traits, and biological factors. *J Commun Disord, 40*(1), 1-41. doi: 10.1016/j.jcomdis.2006.04.001

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). Washington, D.C.: American Psychiatric Association.

Anderson, J. D., Wagovich, S. A., & Hall, N. E. (2006). Nonword repetition skills in young children who do and do not stutter. *J Fluency Disord, 31*(3), 177-199. doi: 10.1016/j.jfludis.2006.05.001

Arnsten, A. F. T. (2001). Dopaminergic and noradrenergic influences on cognitive functions mediated by prefrontal cortex. *Stimulant drugs and ADHD: Basic and clinical neuroscience.*, 185-208.

Astle, D. E., & Scerif, G. (2009). Using developmental cognitive neuroscience to study behavioral and attentional control. *Dev Psychobiol, 51*(2), 107-118. doi: 10.1002/dev.20350

Bach-y-Rita, P. (1967). Sensory plasticity. Applications to a vision substitution system. *Acta Neurol Scand, 43*(4), 417-426.

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends Cogn Sci, 4*(11), 417-423.

Baddeley, A. (2003). Working memory: looking back and looking forward. *Nat Rev Neurosci, 4*(10), 829-839. doi: 10.1038/nrn1201

Baddeley, A., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105*(1), 158-173.

Bajaj, A. (2007). Working memory involvement in stuttering: exploring the evidence and research implications. *J Fluency Disord, 32*(3), 218-238. doi: 10.1016/j.jfludis.2007.03.002

Bakhtiar, M., Abad, A. D., & Panahi, M. S. (2007). Nonword repetition ability of children who do and do not stutter and covert repair hypothesis. *Indian J Med Sci, 61*(8), 462-470.

Baldo, J. V., Shimamura, A. P., Delis, D. C., Kramer, J., & Kaplan, E. (2001). Verbal and design fluency in patients with frontal lobe lesions. *J Int Neuropsychol Soc, 7*(5), 586-596.

Barkley, R. A. (1998). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (2 ed.).

Barkley, R. A. (2006). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (3 ed.). New York: Guilford.

Barkley, R. A. (2012). *Executive Functioning and Self-Regulation: Extended Phenotype, Synthesis, and Clinical Implications*. New York: Guilford Publications.

Barkley, R. A., Grodzinsky, G. M., & DuPaul, G. J. (1992). Frontal lobe functions in attention deficit disorder with and without hyperactivity: A review and research report. *Journal of Abnormal Child Psychology, 20*(2), 163-188.

Bates, M. E., & Lemay, E. P., Jr. (2004). The d2 Test of attention: construct validity and extensions in scoring techniques. *J Int Neuropsychol Soc, 10*(3), 392-400. doi: 10.1017/S135561770410307X

Beck, S. J., Hanson, C. A., Puffenberger, S. S., Benninger, K. L., & Benninger, W. B. (2010). A controlled trial of working memory training for children and adolescents with ADHD. *J Clin Child Adolesc Psychol, 39*(6), 825-836. doi: 10.1080/15374416.2010.517162

Bedard, A. C., Martinussen, R., Ickowicz, A., & Tannock, R. (2004). Methylphenidate improves visual-spatial memory in children with attention-deficit/hyperactivity disorder. *J Am Acad Child Adolesc Psychiatry, 43*(3), 260-268. doi: 10.1097/00004583-200403000-00006

Bell, M. A., & Wolfe, C. D. (2007). Changes in brain functioning from infancy to early childhood: evidence from EEG power and coherence working memory tasks. *Dev Neuropsychol, 31*(1), 21-38. doi: 10.1080/87565640709336885

Benton, A. L. (1968). Differential behavioural effects in frontal lobe disease. *Neuropsychologia, 6*, 53-60.

Berdan, L. E., Keane, S. P., & Calkins, S. D. (2008). Temperament and externalizing behavior: social preference and perceived acceptance as protective factors. *Dev Psychol, 44*(4), 957-968. doi: 10.1037/0012-1649.44.4.957

Berry, A. S., Zanto, T. P., Clapp, W. C., Hardy, J. L., Delahunt, P. B., Mahncke, H. W., & Gazzaley, A. (2010). The influence of perceptual training on working memory in older adults. *PLoS One, 5*(7), e11537. doi: 10.1371/journal.pone.0011537

Biederman, J., & Faraone, S. V. (2002). Current concepts on the neurobiology of Attention-Deficit/Hyperactivity Disorder. *J Atten Disord, 6 Suppl 1*, S7-16.

Biederman, J., Faraone, S. V., Spencer, T., Wilens, T., Norman, D., Lapey, K. A., . . . Doyle, A. (1993). Patterns of psychiatric comorbidity, cognition, and psychosocial functioning in adults with attention deficit hyperactivity disorder. *Am J Psychiatry, 150*(12), 1792-1798.

Biederman, J., Mick, E., & Faraone, S. V. (2000). Age-dependent decline of symptoms of attention deficit hyperactivity disorder: impact of remission definition and symptom type. *Am J Psychiatry, 157*(5), 816-818.

Boonstra, A. M., Oosterlaan, J., Sergeant, J. A., & Buitelaar, J. K. (2005). Executive functioning in adult ADHD: a meta-analytic review. *Psychol Med, 35*(8), 1097-1108.

Bosshardt, H. G. (2006). Cognitive processing load as a determinant of stuttering: summary of a research programme. *Clin Linguist Phon, 20*(5), 371-385. doi: 10.1080/02699200500074321

Brickenkamp, R., & Zillmer, E. (1998). *D2 Test of Attention*. Germany: Hogrefe Publishing.

Bunge, S. A., Ochsner, K. N., Desmond, J. E., Glover, G. H., & Gabrieli, J. D. (2001). Prefrontal regions involved in keeping information in and out of mind. *Brain, 124*(Pt 10), 2074-2086.

Buschke, H., & Fuld, P. A. (1974). Evaluating storage, retention, and retrieval in disordered memory and learning. *Neurology, 24*(11), 1019-1025.

Butterfield, E. C., & Wambold, C. (1973). On the theory and practice of improving short-term memory. *Am J Ment Defic, 77*(5), 654-659.

Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *J Cogn Neurosci, 12*(1), 1-47.

Cain, K., Oakhill, J., & Lemmon, K. (2004). Individual Differences in the Inference of Word Meanings From Context: The Influence of Reading Comprehension, Vocabulary Knowledge, and Memory Capacity. *Journal of Educational Psychology, 96*(4), 671-681.

Campbell, T., Dollaghan, C., Needleman, H., & Janosky, J. (1997). Reducing bias in language assessment: Processing-dependent measures. *Journal of Speech Hearing Research, 40*(3), 519-525.

Cannonieri, G. C., Bonilha, L., Fernandes, P. T., Cendes, F., & Li, L. M. (2007). Practice and perfect: length of training and structural brain changes in experienced typists. *Neuroreport, 18*(10), 1063-1066. doi: 10.1097/WNR.0b013e3281a030e5

Castellanos, F. X., & Tannock, R. (2002). Neuroscience of attention-deficit/hyperactivity disorder: the search for endophenotypes. *Nat Rev Neurosci, 3*(8), 617-628. doi: 10.1038/nrn896

Chacko, A., Bedard, A. C., Marks, D. J., Feirsen, N., Uderman, J. Z., Chimiklis, A., . . . Ramon, M. (2014). A randomized clinical trial of Cogmed Working Memory Training in school-age children with ADHD: a replication in a diverse sample using a control condition. *J Child Psychol Psychiatry, 55*(3), 247-255. doi: 10.1111/jcpp.12146

Collins, A. M., & Loftus, E. F. (1988). A spreading-activation theory of semantic processing. *Readings in cognitive science: A perspective from psychology and artificial intelligence.*, 126-136.

Colombo, J. (2001). The development of visual attention in infancy. *Annu Rev Psychol, 52*, 337-367. doi: 10.1146/annurev.psych.52.1.337

Colombo, J., & Cheatham, C. L. (2006). The emergence and basis of endogenous attention in infancy and early childhood. *Adv Child Dev Behav, 34*, 283-322.

Connors, F. A., Carr, M. D., & Willis, S. (1998). Is the phonological loop responsible for intelligence related differences in forward digit span? *American Journal of Mental Retardation, 103*, 1-11.

Conway, A. R., Kane, M. J., & Engle, R. W. (2003). Working memory capacity and its relation to general intelligence. *Trends Cogn Sci, 7*(12), 547-552.

Corbetta, M. (1998). Frontoparietal cortical networks for directing attention and the eye to visual locations: identical, independent, or overlapping neural systems? *Proc Natl Acad Sci U S A, 95*(3), 831-838.

Corbetta, M., Kincade, J. M., Ollinger, J. M., McAvoy, M. P., & Shulman, G. L. (2000). Voluntary orienting is dissociated from target detection in human posterior parietal cortex. *Nat Neurosci, 3*(3), 292-297. doi: 10.1038/73009

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nat Rev Neurosci, 3*(3), 201-215. doi: 10.1038/nrn755

D'Esposito, M. (2007). From cognitive to neural models of working memory. *Philos Trans R Soc Lond B Biol Sci, 362*(1481), 761-772. doi: 10.1098/rstb.2007.2086

Dahlin, E., Neely, A. S., Larsson, A., Backman, L., & Nyberg, L. (2008). Transfer of learning after updating training mediated by the striatum. *Science, 320*(5882), 1510-1512. doi: 10.1126/science.1155466

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*(4), 450-466. doi: http://dx.doi.org/10.1016/S0022-5371(80)90312-6

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia, 44*(11), 2037-2078. doi: 10.1016/j.neuropsychologia.2006.02.006

Denckla, M. B. (1994). Measurement of executive function. In G. R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities* (pp. 117-142). Baltimore, MD: Brookes.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-964. doi: 10.1126/science.1204529

Dickstein, D. P. (2010). Oppositional defiant disorder. *J Am Acad Child Adolesc Psychiatry, 49*(5), 435-436.

Doidge, N. (2007). *The brain that changes itself*. New York, NY: Viking.

Dovis, S., Van der Oord, S., Wiers, R. W., & Prins, P. J. (2013). What part of working memory is not working in ADHD? Short-term memory, the central executive and effects of reinforcement. *J Abnorm Child Psychol, 41*(6), 901-917. doi: 10.1007/s10802-013-9729-9

Dowson, J. H., McLean, A., Bazanis, E., Toone, B., Young, S., Robbins, T. W., & Sahakian, B. J. (2004). Impaired spatial working memory in adults with attention-deficit/hyperactivity disorder: comparisons with performance in adults with borderline personality disorder and in control subjects. *Acta Psychiatr Scand, 110*(1), 45-54. doi: 10.1111/j.1600-0447.2004.00292.x

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature, 427*(6972), 311-312. doi: 10.1038/427311a

Draganski, B., Gaser, C., Kempermann, G., Kuhn, H. G., Winkler, J., Buchel, C., & May, A. (2006). Temporal and spatial dynamics of brain structure changes during extensive learning. *J Neurosci, 26*(23), 6314-6317. doi: 10.1523/JNEUROSCI.4628-05.2006

Driemeyer, J., Boyke, J., Gaser, C., Buchel, C., & May, A. (2008). Changes in gray matter induced by learning--revisited. *PLoS One, 3*(7), e2669. doi: 10.1371/journal.pone.0002669

Durston, S. (2003). A Review of the Biological Bases of ADHD: What Have We Learned From Imaging Studies? *Mental retardation and developmental disabilities research reviews, 9*(3), 184-195.

Fan, J., Fossella, J., Sommer, T., Wu, Y., & Posner, M. I. (2003). Mapping the genetic variation of executive attention onto brain activity. *Proc Natl Acad Sci U S A, 100*(12), 7406-7411. doi: 10.1073/pnas.0732088100

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *J Cogn Neurosci, 14*(3), 340-347. doi: 10.1162/089892902317361886

Fischer, M., Barkley, R. A., Edelbrock, C. S., & Smallish, L. (1990). The adolescent outcome of hyperactive children diagnosed by research criteria: II. Academic, attentional, and neuropsychological status. *J Consult Clin Psychol, 58*(5), 580-588.

Fletcher, P. C., & Henson, R. N. (2001). Frontal lobes and human memory: insights from functional neuroimaging. *Brain, 124*(Pt 5), 849-881.

Fossella, J., Sommer, T., Fan, J., Wu, Y., Swanson, J. M., Pfaff, D. W., & Posner, M. I. (2002). Assessing the molecular genetics of attention networks. *BMC Neurosci, 3*, 14.

Friedrich, F. J., Egly, R., Rafal, R. D., & Beck, D. (1998). Spatial attention deficits in humans: a comparison of superior parietal and temporal-parietal junction lesions. *Neuropsychology, 12*(2), 193-207.

Funahashi, S., Bruce, C. J., & Goldman-Rakic, P. S. (1989). Mnemonic coding of visual space in the monkey's dorsolateral prefrontal cortex. *J Neurophysiol, 61*(2), 331-349.

Gaser, C., & Schlaug, G. (2003). Brain structures differ between musicians and non-musicians. *J Neurosci, 23*(27), 9240-9245.

Gathercole. (2000). Assessment of working memory in six- and seven-year-old children. *Journal of Educational Psychology, 92*(2), 377-390.

Gathercole, S. E., Alloway, T. P., Willis, C., & Adams, A. M. (2006). Working memory in children with reading disabilities. *J Exp Child Psychol, 93*(3), 265-281. doi: 10.1016/j.jecp.2005.08.003

Gathercole, S. E., Brown, L., & Pickering, S. J. (2003). Working memory assessments at school entry as longitudinal predictors of National Curriculum attainment levels. *Educational and Child Psychology, 20*(3), 109-122.

Gathercole, S. E., & Pickering, S. J. (2000). Assessment of working memory in six- and seven-year-old children. *Journal of Educational Psychology, 92*(2), 377-390.

Geary, D. C., Hoard, M. K., Byrd-Craven, J., & De Soto, M. C. (2004). Strategy choices in simple and complex addition: Contributions of working memory and counting knowledge for children with mathematical disability. *Journal of Experimental Child Psychology, 88*(2), 121-151.

Ghorayshi, A. (2014). Brain games exploit anxieties about memory loss for profit – scientists. *The Guardian*. http://www.theguardian.com/science/2014/oct/23/brain-games-memory-loss-open-letter

Giedd, J. N., Blumenthal, J., Molloy, E., & Castellanos, F. X. (2001). Brain imaging of attention deficit/hyperactivity disorder. *Ann N Y Acad Sci, 931*, 33-49.

Goldman-Rakic, P. S., Castner, S. A., Svensson, T. H., Siever, L. J., & Williams, G. V. (2004). Targeting the dopamine D1 receptor in schizophrenia: insights for cognitive dysfunction. *Psychopharmacology (Berl), 174*(1), 3-16. doi: 10.1007/s00213-004-1793-y

Gottwald, B., Mihajlovic, Z., Wilde, B., & Mehdorn, H. M. (2003). Does the cerebellum contribute to specific aspects of attention? *Neuropsychologia, 41*(11), 1452-1460.

Green, C. S., & Bavelier, D. (2008). Exercising your brain: a review of human brain plasticity and training-induced learning. *Psychol Aging, 23*(4), 692-701. doi: 10.1037/a0014345

Grodzinsky, G. M., & Barkley, R. A. (1999). Predictive power of frontal lobe tests in the diagnosis of attention deficit hyperactivity disorder. *Clin Neuropsychol, 13*(1), 12-21. doi: 10.1076/clin.13.1.12.1983

Grodzinsky, G. M., & Diamond, R. (1992). Frontal lobe functioning in boys with attention-deficit hyperactivity disorder. *Developmental Neuropsychology, 8*(4), 427-445.

Groth-Marnat, G., Gallgher, R. E., Hale, J. B., & Kaplan, E. (2000). The Wechsler intelligence scales. In G. Groth-Marnat (Ed.), *Neurosychological assessment in clinical practice* (pp. 129-194). New York: Wiley.

Guion, S. G., & Pederson, E. (2007). Investigating the role of attention of phonetic learning. In O.-S. Bohn & M. J. Munro (Eds.), *Language experience in second language speech learning: In honor of James Emil Flege* (pp. 57-77). Amsterdam: John Benjamins.

Gusdorf, L. M., Karreman, A., van Aken, M. A., Dekovic, M., & van Tuijl, C. (2011). The structure of effortful control in preschoolers and its relation to externalizing problems. *Br J Dev Psychol, 29*(Pt 3), 612-634. doi: 10.1348/026151010X526542

Hakim, H. B., & Ratner, N. B. (2004). Nonword repetition abilities of children who stutter: an exploratory study. *J Fluency Disord, 29*(3), 179-199. doi: 10.1016/j.jfludis.2004.06.001

Hale, J. B., Hoeppner, J.-A. B., & Fiorello, C. A. (2002). Analyzing digit span components for assessment of attention processes. *Journal of Psychoeducational Assessment, 20*(2), 128-143.

Hebb, D. (1949). *The Organization of Behavior*. New York: Wiley & Sons.

Hebben, N., & Milberg, W. (2002). Essentials of Test Selection, Administration, and Scoring *Essentials of Neuropsychological Assessment*. New York: John Wiley & Sons, Inc.

Henry, J. D., & Crawford, J. R. (2004). A meta-analytic review of verbal fluency performance following focal cortical lesions. *Neuropsychology, 18*(2), 284-295. doi: 10.1037/0894-4105.18.2.284

Hervey, A. S., Epstein, J. N., & Curry, J. F. (2004). Neuropsychology of adults with attention-deficit/hyperactivity disorder: a meta-analytic review. *Neuropsychology, 18*(3), 485-503. doi: 10.1037/0894-4105.18.3.485

Holmes, J., Gathercole, S. E., & Dunning, D. L. (2009). Adaptive training leads to sustained enhancement of poor working memory in children. *Dev Sci, 12*(4), F9-15. doi: 10.1111/j.1467-7687.2009.00848.x

Holmes, J., Gathercole, S. E., Place, M., Dunning, D. L., Hilton, K. A., & Elliott, J. G. (2010). Working memory deficits can be overcome: Impacts of training and medication on working memory in children with ADHD. *Applied Cognitive Psychology, 24*(6), 827-836.

Hood, B. M., & Atkinson, J. (1993). Disengaging visual-attention in the infant and adult. *Infant Behavior & Development, 16*(4), 405-422.

Hubel, D. H., & Wiesel, T. N. (1970). The period of susceptibility to the physiological effects of unilateral eye closure in kittens. *J Physiol, 206*(2), 419-436.

Hurks, P. P. M., Hendriksen, J. G. M., Vles, J. S. H., Kalff, A. C., Feron, F. J. M., Kroes, M., . . . Jolles, J. (2004). Verbal fluency over time as a measure of automatic and controlled processing in children with ADHD. *Brain and Cognition, 55*(3), 535-544.

Indefrey, P., & Levelt, W. J. M. (2000). *The New Cognitive Neuroscience* (2 ed.). Cambridge, M.A.: MIT Press.

Izard, C., Stark, K., Trentacosta, C., & Schultz, D. (2008). Beyond Emotion Regulation: Emotion Utilization and Adaptive Functioning. *Child Dev Perspect, 2*(3), 156-163. doi: 10.1111/j.1750-8606.2008.00058.x

James, W. (1890). *The Principles of Psychology*.

Jarrold, C., & Towse, J. N. (2006). Individual differences in working memory. *Neuroscience, 139*(1), 39-50. doi: 10.1016/j.neuroscience.2005.07.002

Jescheniak, J. D., & Levelt, W. J. M. (1994). Word frequency effects in speech production: Retrieval of syntactic information and of phonological form. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*(4), 824-843.

Johnson, M. H. (1995). The inhibition of automatic saccades in early infancy. *Dev Psychobiol, 28*(5), 281-291. doi: 10.1002/dev.420280504

Karatekin, C., & Asarnow, R. F. (1998). Working memory in childhood-onset schizophrenia and attention-deficit/hyperactivity disorder. *Psychiatry Res, 80*(2), 165-176.

Karnath, H. O., Ferber, S., & Himmelbach, M. (2001). Spatial awareness is a function of the temporal not the posterior parietal lobe. *Nature, 411*(6840), 950-953. doi: 10.1038/35082075

Karrass, J., Walden, T. A., Conture, E. G., Graham, C. G., Arnold, H. S., Hartfield, K. N., & Schwenk, K. A. (2006). Relation of emotional reactivity and regulation to childhood stuttering. *J Commun Disord, 39*(6), 402-423. doi: 10.1016/j.jcomdis.2005.12.004

Katsnelson, A. (2010). No gain from brain training. *Nature*.

Kellogg, R. T. (2001). Competition for working memory among writing processes. *Am J Psychol, 114*(2), 175-191.

Kempton, S., Vance, A., Maruff, P., Luk, E., Costin, J., & Pantelis, C. (1999). Executive function and attention deficit hyperactivity disorder: stimulant medication and better executive function performance in children. *Psychol Med, 29*(3), 527-538.

Kermen, R., Hickner, J., Brody, H., & Hasham, I. (2010). Family physicians believe the placebo effect is therapeutic but often use real drugs as placebos. *Fam Med, 42*(9), 636-642.

Kerns, K. A., Eso, K., & Thomson, J. (1999). Investigation of a direct intervention for improving attention in young children with ADHD. *Developmental Neuropsychology, 16*(2), 273-295.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends Cogn Sci, 14*(7), 317-324. doi: 10.1016/j.tics.2010.05.002

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlstrom, K., . . . Westerberg, H. (2005). Computerized training of working memory in children with ADHD--a randomized, controlled trial. *J Am Acad Child Adolesc Psychiatry, 44*(2), 177-186. doi: 10.1097/00004583-200502000-00010

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *J Clin Exp Neuropsychol, 24*(6), 781-791. doi: 10.1076/jcen.24.6.781.8395

Klorman, R., Hazel-Fernandez, L. A., Shaywitz, S. E., Fletcher, J. M., Marchione, K. E., Holahan, J. M., . . . Shaywitz, B. A. (1999). Executive functioning deficits in attention-deficit/hyperactivity disorder are independent of oppositional defiant or reading disorder. *J Am Acad Child Adolesc Psychiatry, 38*(9), 1148-1155. doi: 10.1097/00004583-199909000-00020

Kondo, H., Morishita, M., Osaka, N., Osaka, M., Fukuyama, H., & Shibasaki, H. (2004). Functional roles of the cingulo-frontal network in performance on working memory. *Neuroimage, 21*(1), 2-14.

Kooij, S. J., Bejerot, S., Blackwell, A., Caci, H., Casas-Brugue, M., Carpentier, P. J., . . . Asherson, P. (2010). European consensus statement on diagnosis and treatment of adult ADHD: The European Network Adult ADHD. *BMC Psychiatry, 10*, 67. doi: 10.1186/1471-244X-10-67

Koziol, L. F., & Stout, C. E. (1992). Use of a verbal fluency measure in understanding and evaluation ADHD as an executive function disorder. *Perceptual and Motor Skills, 75*(3 Pt. 2), 1187-1192.

Kremen, W. S., Jacobsen, K. C., Xian, H., Eisen, S. A., Eaves, L. J., Tsuang, M. T., & Lyons, M. J. (2007). Genetics of verbal working memory processes: a twin study of middle-aged men. *Neuropsychology, 21*(5), 569-580. doi: 10.1037/0894-4105.21.5.569

Kuntsi, J., Oosterlaan, J., & Stevenson, J. (2001). Psychological mechanisms in hyperactivity: I. Response inhibition deficit, working memory impairment, delay aversion, or something else? *J Child Psychol Psychiatry, 42*(2), 199-210.

Kusche, C. A., Cook, E. T., & Greenberg, M. T. (1993). Neuropsychological and cognitive functioning in children with anxiety, externalizing, and comorbid psychopathology. *J Clin Child Psychol, 22*(2), 172-195.

Lahey, B. B., Loeber, R., Quay, H. C., Frick, P. J., & Grimm, J. (1992). Oppositional defiant and conduct disorders: issues to be resolved for DSM-IV. *J Am Acad Child Adolesc Psychiatry, 31*(3), 539-546. doi: 10.1097/00004583-199205000-00023

Lalonde, R., & Strazielle, C. (2003). The effects of cerebellar damage on maze learning in animals. *Cerebellum, 2*(4), 300-309. doi: 10.1080/14734220310017456

Lashley, K. (1923). The behavioristic interpretation of consciousness. *Psychol Bull, 30*, 237–272, 329–353.

Levy, F., & Swanson, J. M. (2001). Timing, space and ADHD: the dopamine theory revisited. *Aust N Z J Psychiatry, 35*(4), 504-511.

Lewis, S. J., Dove, A., Robbins, T. W., Barker, R. A., & Owen, A. M. (2004). Striatal contributions to working memory: a functional magnetic resonance imaging study in humans. *Eur J Neurosci, 19*(3), 755-760.

Lezak, M. D. (1995). *Neuropsychological Assessment* (3 ed.). New York: Oxford University Press.

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). Neuropsychological assessment (5th ed.). *Neuropsychological assessment (5th ed.).*

Liu, X., Banich, M. T., Jacobson, B. L., & Tanabe, J. L. (2004). Common and distinct neural substrates of attentional control in an integrated Simon and spatial Stroop task as assessed by event-related fMRI. *Neuroimage, 22*(3), 1097-1106. doi: 10.1016/j.neuroimage.2004.02.033

Loge, D. V., Staton, R. D., & Beatty, W. W. (1990). Performance of children with ADHD on tests sensitive to frontal lobe dysfunction. *J Am Acad Child Adolesc Psychiatry, 29*(4), 540-545. doi: 10.1097/00004583-199007000-00006

Maguire, E. A., Frackowiak, R. S., & Frith, C. D. (1997). Recalling routes around london: activation of the right hippocampus in taxi drivers. *J Neurosci, 17*(18), 7103-7110.

Maher, B. S., Marazita, M. L., Ferrell, R. E., & Vanyukov, M. M. (2002). Dopamine system genes and attention deficit hyperactivity disorder: a meta-analysis. *Psychiatr Genet, 12*(4), 207-215.

Malacarne, M. V. M. (1793). *Discorsi accademici*.

Marien, P., Engelborghs, S., Fabbro, F., & De Deyn, P. P. (2001). The lateralized linguistic cerebellum: a review and a new hypothesis. *Brain Lang, 79*(3), 580-600. doi: 10.1006/brln.2001.2569

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. *J Am Acad Child Adolesc Psychiatry, 44*(4), 377-384. doi: 10.1097/01.chi.0000153228.72591.73

Mattay, V. S., Callicott, J. H., Bertolino, A., Heaton, I., Frank, J. A., Coppola, R., . . . Weinberger, D. R. (2000). Effects of dextroamphetamine on cognitive performance and cortical activation. *Neuroimage, 12*(3), 268-275. doi: 10.1006/nimg.2000.0610

McGraw, P., Mathews, V. P., Wang, Y., & Phillips, M. D. (2001). Approach to functional magnetic resonance imaging of language based on models of language organization. *Neuroimaging Clin N Am, 11*(2), 343-353, x.

McNab, F., & Klingberg, T. (2008). Prefrontal cortex and basal ganglia control access to working memory. *Nat Neurosci, 11*(1), 103-107. doi: 10.1038/nn2024

McVay, J. C., & Kane, M. J. (2009). Conducting the train of thought: working memory capacity, goal neglect, and mind wandering in an executive-control task. *J Exp Psychol Learn Mem Cogn, 35*(1), 196-204. doi: 10.1037/a0014104

Melby-Lervag, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Dev Psychol, 49*(2), 270-291. doi: 10.1037/a0028228

Mercer, N. M. (1976). Frequency and availability in the encoding of spontaneous speech. *Lang Speech, 19*(2), 129-143.

Mezzacappa. (2010). Working memory training for children with attention problems or hyperactivity: A school-based pilot study. *School Mental Health, 2*(4), 202-208.

Milham, M. P., Banich, M. T., Webb, A., Barad, V., Cohen, N. J., Wszalek, T., & Kramer, A. F. (2001). The relative involvement of anterior cingulate and prefrontal cortex in attentional control depends on nature of conflict. *Brain Res Cogn Brain Res, 12*(3), 467-473.

Miller, G. A. (1994). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 101*(2), 343-352.

Misener, V. L., Luca, P., Azeke, O., Crosbie, J., Waldman, I., Tannock, R., . . . Barr, C. L. (2004). Linkage of the dopamine receptor D1 gene to attention-deficit/hyperactivity disorder. *Mol Psychiatry, 9*(5), 500-509. doi: 10.1038/sj.mp.4001440

Monfrais-Pfauwadel, M. C., & Lacombe, I. (2002). Attention deficits in the school aged stuttering child: constituent trait or comorbidity. *Rev Laryngol Otol Rhinol (Bord), 123*(5), 291-295.

Monsch, A. U., Bondi, M. W., Butters, N., Paulsen, J. S., Salmon, D. P., Brugger, P., & Swenson, M. R. (1994). A comparison of category and letter fluency in Alzheimer's disease and Huntington's disease. *Neuropsychology, 8*(1), 25-30.

Morgan, S. F. (1982). Measuring long-term memory storage and retrieval in children. *J Clin Neuropsychol, 4*(1), 77-85.

Nejati, V., Pouretemad, H. R., & Bahrami, H. (2013). Attention training in rehabilitation of children with developmental stuttering. *NeuroRehabilitation, 32*(2), 297-303. doi: 10.3233/NRE-130847

Newcombe, F. (1969). *Missle Wounds of the Brain: A Study of Psychological Deficits*. London: Oxford University Press.

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: views from cognitive and personality psychology and a working inhibition taxonomy. *Psychol Bull, 126*(2), 220-246.

Nigg, J. T. (2006). *What causes ADHD? Understanding what goes wrong and why*. New York: Guilford Press.

Nudo, R. J., Milliken, G. W., Jenkins, W. M., & Merzenich, M. M. (1996). Use-dependent alterations of movement representations in primary motor cortex of adult squirrel monkeys. *J Neurosci, 16*(2), 785-807.

O'Rourke, M. (2007). Train Your Brain. *Slate: Brains! Special Issue*.

Olesen, P. J., Westerberg, H., & Klingberg, T. (2004). Increased prefrontal and parietal brain activity after training of working memory. *Nat Neurosci, 7*(1), 75-79. doi: 10.1038/nn1165

Owen, A. M., Hampshire, A., Grahn, J. A., Stenton, R., Dajani, S., Burns, A. S., . . . Ballard, C. G. (2010). Putting brain training to the test. *Nature, 465*(7299), 775-778. doi: 10.1038/nature09042

Papageorgiou, K. A., Smith, T. J., Wu, R., Johnson, M. H., Kirkham, N. Z., & Ronald, A. (2014). Individual Differences in Infant Fixation Duration Relate to Attention and Behavioral Control in Childhood. *Psychol Sci, 25*(7), 1371-1379. doi: 10.1177/0956797614531295

Papp, K. V., Walsh, S. J., & Snyder, P. J. (2009). Immediate and delayed effects of cognitive interventions in healthy elderly: a review of current literature and future directions. *Alzheimers Dement, 5*(1), 50-60. doi: 10.1016/j.jalz.2008.10.008

Pascual-Leone, A., Freitas, C., Oberman, L., Horvath, J. C., Halko, M., Eldaief, M., . . . Rotenberg, A. (2011). Characterizing brain cortical plasticity and network dynamics across the age-span in health and disease with TMS-EEG and TMS-fMRI. *Brain Topogr, 24*(3-4), 302-315. doi: 10.1007/s10548-011-0196-8

Passolunghi, M. C., & Siegel, L. S. (2001). Short-term memory, working memory, and inhibitory control in children with difficulties in arithmetic problem solving. *J Exp Child Psychol, 80*(1), 44-57. doi: 10.1006/jecp.2000.2626

Pineda, D., Ardila, A., & Rosselli, M. (1999). Neuropsychological and behavioral assessment of ADHD in seven- to twelve-year-old children: a discriminant analysis. *J Learn Disabil, 32*(2), 159-173.

Posner, M. I., & Patoine, B. (2009). How arts training improves attention and cognition. *Cerebrum*.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annu Rev Neurosci, 13*, 25-42. doi: 10.1146/annurev.ne.13.030190.000325

Posner, M. I., & Rothbart, M. K. (2007). *Educating the human brain* (1 ed.). Washington, DC: American Psychological Association.

Prasad, V., Brogan, E., Mulvaney, C., Grainge, M., Stanton, W., & Sayal, K. (2013). How effective are drug treatments for children with ADHD at improving on-task behaviour and academic achievement in the school classroom? A systematic review and meta-analysis. *Eur Child Adolesc Psychiatry, 22*(4), 203-216. doi: 10.1007/s00787-012-0346-x

Rabiner, D. L., Murray, D. W., Skinner, A. T., & Malone, P. S. (2010). A randomized trial of two promising computer-based interventions for students with attention difficulties. *J Abnorm Child Psychol, 38*(1), 131-142. doi: 10.1007/s10802-009-9353-x

Rabipour, S., & Raz, A. (2012). Training the brain: fact and fad in cognitive and behavioral remediation. *Brain Cogn, 79*(2), 159-179. doi: 10.1016/j.bandc.2012.02.006

Ramsay, M. C., & Reynolds, C. R. (1995). Separate digits tests: a brief history, a literature review, and a reexamination of the factor structure of the Test of Memory and Learning (TOMAL). *Neuropsychol Rev, 5*(3), 151-171.

Rapport, M. D., Chung, K. M., Shore, G., & Isaacs, P. (2001). A conceptual model of child psychopathology: implications for understanding attention deficit hyperactivity disorder and treatment efficacy. *J Clin Child Psychol, 30*(1), 48-58. doi: 10.1207/S15374424JCCP3001_6

Rapport, M. D., Scanlan, S. W., & Denney, C. B. (1999). Attention-deficit/hyperactivity disorder and scholastic achievement: a model of dual developmental pathways. *J Child Psychol Psychiatry, 40*(8), 1169-1183.

Rasmussen, P., & Gillberg, C. (2000). Natural outcome of ADHD with developmental coordination disorder at age 22 years: A controlled, longitudinal, community-based study. *J Am Acad Child Adolesc Psychiatry, 39*(11), 1424-1431.

Raz, A., & Buhle, J. (2006). Typologies of attentional networks. *Nat Rev Neurosci, 7*(5), 367-379. doi: 10.1038/nrn1903

Reader, M. J., Harris, E. L., Schuerholz, L. J., & Denckla, M. B. (1994). Attention deficit hyperactivity disorder and executive dysfunction. *Developmental Neuropsychology, 10*(4), 493-512.

Recanzone, G. H., Merzenich, M. M., Jenkins, W. M., Grajski, K. A., & Dinse, H. R. (1992). Topographic reorganization of the hand representation in cortical area 3b owl monkeys trained in a frequency-discrimination task. *J Neurophysiol, 67*(5), 1031-1056.

Redmond, S. M. (2005). Differentiating SLI from ADHD using children's sentence recall and production of past tense morphology. *Clin Linguist Phon, 19*(2), 109-127.

Robertson, I. H., & Garavan, H. (2004). Vigilant attention. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences III* (pp. 631-639). Cambridge, MA: MIT Press.

Robinson-Riegler, B. (2011). *Cognitive psychology: Applying the science of the mind*. Boston, MA: Pearson Education Inc.

Rose, S. A., Feldman, J. F., Jankowski, J. J., & Van Rossem, R. (2012). Information Processing from Infancy to 11 Years: Continuities and Prediction of IQ. *Intelligence, 40*(5), 445-457. doi: 10.1016/j.intell.2012.05.007

Rosenzweig, M. R. (1996). Aspects of the search for neural mechanisms of memory. *Annu Rev Psychol, 47*, 1-32. doi: 10.1146/annurev.psych.47.1.1

Rosser, A., & Hodges, J. R. (1994). Initial letter and semantic category fluency in Alzheimer's disease, Huntington's disease, and progressive supranuclear palsy. *J Neurol Neurosurg Psychiatry, 57*(11), 1389-1394.

Rothbart, M. K., Sheese, B. E., Rueda, M. R., & Posner, M. I. (2011). Developing Mechanisms of Self-Regulation in Early Life. *Emot Rev, 3*(2), 207-213. doi: 10.1177/1754073910387943

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia, 42*(8), 1029-1040. doi: 10.1016/j.neuropsychologia.2003.12.012

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: contributions to the emergence of self-regulation. *Dev Neuropsychol, 28*(2), 573-594. doi: 10.1207/s15326942dn2802_2

Rueda, M. R., Posner, M. I., Rothbart, M. K., & Davis-Stober, C. P. (2004). Development of the time course for processing conflict: an event-related potentials study with 4 year olds and adults. *BMC Neurosci, 5,* 39. doi: 10.1186/1471-2202-5-39

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). Training, maturation, and genetic influences on the development of executive attention. *Proc Natl Acad Sci U S A, 102*(41), 14931-14936. doi: 10.1073/pnas.0506897102

Samyn, V., Roeyers, H., & Bijttebier, P. (2011). Effortful control in typically developing boys and in boys with ADHD or autism spectrum disorder. *Res Dev Disabil, 32*(2), 483-490. doi: 10.1016/j.ridd.2010.12.038

Scerif, G. (2010). Attention trajectories, mechanisms and outcomes: at the interface between developing cognition and environment. *Dev Sci, 13*(6), 805-812. doi: 10.1111/j.1467-7687.2010.01013.x

Schecklmann, M., Ehlis, A.-C., Plichta, M. M., Romanos, J., Heine, M., Boreatti-Hummer, A., . . . Fallgatter, A. J. (2008). Diminished prefrontal oxygenation with normal and above-average verbal fluency performance in adult ADHD. *Journal of Psychiatric Research, 43*(2), 98-106.

Schlosser, R., Hutchinson, M., Joseffer, S., Rusinek, H., Saarimaki, A., Stevenson, J., . . . Brodie, J. D. (1998). Functional magnetic resonance imaging of human brain activity in a verbal fluency task. *J Neurol Neurosurg Psychiatry, 64*(4), 492-498.

Schuerholz, L. J., Singer, H. S., & Denckla, M. B. (1998). Gender study of neuropsychological and neuromotor function in children with Tourette Syndrome with and without attention-deficit hyperactivity disorder. *Journal of Child Neurology, 13*(6), 277-282.

Schwenk, K. A., Conture, E. G., & Walden, T. A. (2007). Reaction to background stimulation of preschool children who do and do not stutter. *J Commun Disord, 40*(2), 129-141. doi: 10.1016/j.jcomdis.2006.06.003

Shalev, L., Tsal, Y., & Mevorach, C. (2007). Computerized progressive attentional training (CPAT) program: effective direct intervention for children with ADHD. *Child Neuropsychol, 13*(4), 382-388. doi: 10.1080/09297040600770787

Shaw, P., Lerch, J., Greenstein, D., Sharp, W., Clasen, L., Evans, A., . . . Rapoport, J. (2006). Longitudinal mapping of cortical thickness and clinical outcome in children and adolescents with attention-deficit/hyperactivity disorder. *Arch Gen Psychiatry, 63*(5), 540-549. doi: 10.1001/archpsyc.63.5.540

Siegler, R. (2006). *How Children Develop, Exploring Child Develop Student Media Tool Kit & Scientific American Reader to Accompany How Children Develop*. New York: Worth Publishers.

Smith, B. H., Barkley, R. A., & Shapiro, C. J. (2006). Attention-deficit/hyperactivity disorder. In E. J. Mach & R. A. Barkley (Eds.), *Treatment of childhood disorders* (pp. 65-136). New York: Guilford.

Starkweather, C. W. (2002). The epigenesis of stuttering. *J Fluency Disord, 27*(4), 269-287; quiz 287-268.

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary* (3 ed.). New York, NY: Oxford University Press.

Swanson, H. L., & Berninger, V. W. (1996). Individual differences in children's working memory and writing skill. *J Exp Child Psychol, 63*(2), 358-385. doi: 10.1006/jecp.1996.0054

Swanson, H. L., & Howell, M. (2001). Working memory, short-term memory, and speech rate as predictors of children's reading performance at different ages. *Journal of Educational Psychology*, *93*(4), 720-734.

Swanson, H. L., Jerman, O., & Zheng, X. (2008). Growth in working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology, 100*(2), 343-379.

Swanson, H. L., & Sachse-Lee, C. (2001). Mathematical problem solving and working memory in children with learning disabilities: Both executive and phonological processes are important. *Journal of Experimental Child Psychology*, *79*(3), 294-321.

Thorell, L. B., Lindqvist, S., Bergman Nutley, S., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Dev Sci, 12*(1), 106-113. doi: 10.1111/j.1467-7687.2008.00745.x

Thurstone, L. L., & Thurstone, T. G. (1938). *Primary Mental Abilities*. Chicago, IL: University of Chicago Press.

Tilburt, J. C., Emanuel, E. J., Kaptchuk, T. J., Curlin, F. A., & Miller, F. G. (2008). Prescribing "placebo treatments": results of national survey of US internists and rheumatologists. *BMJ, 337*, a1938. doi: 10.1136/bmj.a1938

Turley-Ames, K. J., & Whitfield, M. M. (2003). Strategy training and working memory task performance. *Journal of Memory and Language, 49*(4), 446-468.

Unsworth, N., Redick, T. S., Heitz, R. P., Broadway, J. M., & Engle, R. W. (2009). Complex working memory span tasks and higher-order cognition: a latent-variable analysis of the relationship between processing and storage. *Memory, 17*(6), 635-654. doi: 10.1080/09658210902998047

van Veen, V., & Carter, C. S. (2005). Separating semantic conflict and response conflict in the Stroop task: a functional MRI study. *Neuroimage, 27*(3), 497-504. doi: 10.1016/j.neuroimage.2005.04.042

Vogel, E. K., McCollough, A. W., & Machizawa, M. G. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature, 438*(7067), 500-503. doi: 10.1038/nature04171

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children* (4 ed.). San Antonio, TX: The Psychological Corporation.

Wells, K. (2013). Self-regulation technique helps students focus in class. *CBC News*. Retrieved from CBC News website: http://www.cbc.ca/news/canada/self-regulation-technique-helps-students-focus-in-class-1.2440688

Wenzel, M., Kubiak, T., & Conner, T. S. (2014). Positive affect and self-control: attention to self-control demands mediates the influence of positive affect on consecutive self-control. *Cogn Emot, 28*(4), 747-755. doi: 10.1080/02699931.2013.851069

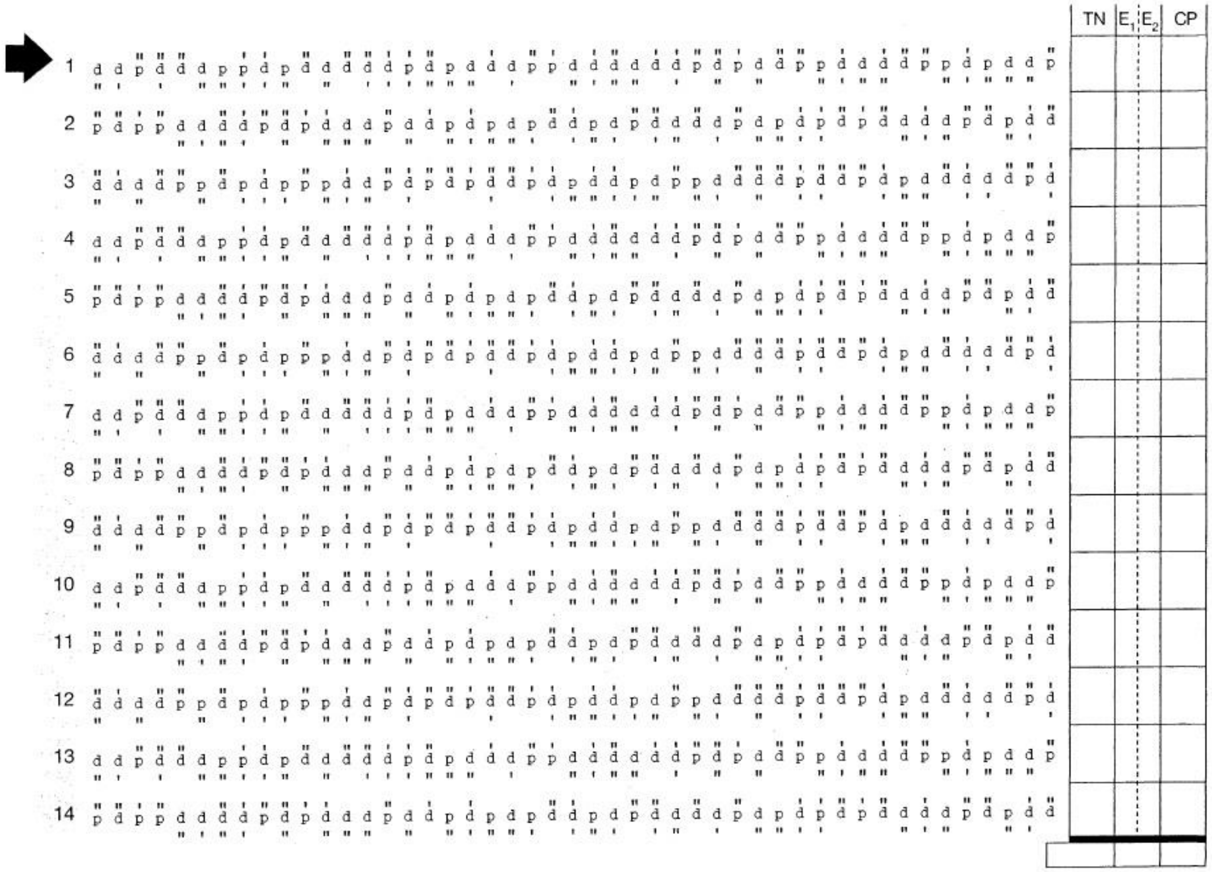
Weyandt, L. L., & Willis, W. G. (1994). Executive functions in school-aged children: Potential efficacy of tasks in discriminating clinical groups. *Developmental Neuropsychology, 10*(1), 27-38. doi: 10.1080/87565649409540564

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biol Psychiatry, 57*(11), 1336-1346. doi: 10.1016/j.biopsych.2005.02.006

Zillmer, E. A., & Kennedy, C. H. (1999). *Preliminary United States norms for the d2 Test of Attention.* Paper presented at the 19th Annual Meeting of the National Academy of Neuropsychology, San Antonio, TX.

Appendix A

The D2 Test of Attention



Appendix B

The Backwards Digit Span

Item	Trial		Score	
1.	Trial 1	2-1	0	1
	Trial 2	1-3	0	1
2.	Trial 1	3-5	0	1
	Trial 2	6-4	0	1
3.	Trial 1	5-7-4	0	1
	Trial 2	2-5-9	0	1
4.	Trial 1	7-2-9-6	0	1
	Trial 2	8-4-9-3	0	1
5.	Trial 1	4-1-3-5-7	0	1
	Trial 2	9-7-8-5-2	0	1
6.	Trial 1	1-6-5-2-9-8	0	1
	Trial 2	3-6-7-1-9-4	0	1
7.	Trial 1	8-5-9-2-3-4-6	0	1
	Trial 2	4-5-7-9-2-8-1	0	1
8.	Trial 1	6-9-1-7-3-2-5-8	0	1
	Trial 2	3-1-7-9-5-4-8-2	0	1
Total Score				
Longest Backwards Digit Span (LBDS)				

Appendix C

The Buschke Selective Reminding Test

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Trial 6**
Dog	Dog	Dog	Dog	Dog	Dog	Dog
Horse	Horse	Horse	Horse	Horse	Horse	Horse
Turtle	Turtle	Turtle	Turtle	Turtle	Turtle	Turtle
Lion	Lion	Lion	Lion	Lion	Lion	Lion
Squirrel	Squirrel	Squirrel	Squirrel	Squirrel	Squirrel	Squirrel
Bear	Bear	Bear	Bear	Bear	Bear	Bear
Elephant	Elephant	Elephant	Elephant	Elephant	Elephant	Elephant
Rabbit	Rabbit	Rabbit	Rabbit	Rabbit	Rabbit	Rabbit
Recall per Trial						
Total Recall	**(Number recalled over all 8 trials)**					

Appendix D

The Controlled Oral Word Association Test

Category	Words	Score
Animals		
Food		
Words starting with the sound "Sh"		
Total Score		

Connecting Text

Research findings suggest that cultural practices may influence responsiveness to hypnotic experience by modulating attention in a way similar to brain training exercises (e.g., Kirsch, Wickless, & Moffitt, 1999; Lynn & Green, 2011). Hypnosis refers to an atypical state of attention revolving around attentive-receptive concentration (Raz & Buhle, 2006) and some researchers even view hypnosis as a kind of “attention contract” in which the subject surrenders cognitive control to the hypnotist (MacLeod, 2011). The overlap between hypnosis and attention supports the notion that the manipulation of attentional skills can alter cognitive processes that, in turn, affect hypnotic response. For example, parents who spend time playing imaginative “pretend” games with a child seem to enhance their proficiency in using fantasy-based techniques and exhibit higher rates of hypnotizability as a result (Morgan & Hilgard, 1973; Raz, 2012). As such, aptitude for imaginative involvement appears to contribute to hypnotic ability and illustrates the potential for various cultural practices to influence hypnotizability through the modulation of attention.

In response to discoveries that sociocultural forces mold the ability to control attention and imagine a suggested experience (Bourguignon & Evascu, 1977; Krippner, 2000), transcultural researchers have begun to investigate the specific differences in hypnotic response across societies. The following manuscript documents the limitations of typical translation procedures that psychiatrists use for these cross-cultural studies.

References

Bourguignon, E., & Evascu, T. (1977). Altered states of consciousness within a general evolutionary perspective: a holocultural analysis. *Behavior Science Research, 12*, 199-216.

Kirsch, I., Wickless, C., & Moffitt, K. H. (1999). Expectancy and suggestibility: are the effects of environmental enhancement due to detection? *Int J Clin Exp Hypn, 47*(1), 40-45. doi: 10.1080/00207149908410021

Krippner, S. (2000). Cross-Cultural Perspectives on Transpersonal Hypnosis. In E. Leskowitz (Ed.), *Transpersonal Hypnosis: Gateway to Body, Mind, and Spirit* (pp. 141-162). Boca Raton, Florida: CRC Press LLC.

Lynn, S. J., & Green, J. P. (2011). The sociocognitive and dissociation theories of hypnosis: toward a rapprochement. *Int J Clin Exp Hypn, 59*(3), 277-293. doi: 10.1080/00207144.2011.570652

MacLeod, C. M. (2011). Hypnosis and the control of attention: where to from here? *Conscious Cogn, 20*(2), 321-324. doi: 10.1016/j.concog.2009.10.007

Morgan, A. H., & Hilgard, E. R. (1973). Age differences in susceptibility to hypnosis. *International Journal of Clinical and Experimental Hypnosis, 21*(2), 78-85.

Raz, A. (2012). Hypnosis as a lens to the development of attention. *Conscious Cogn, 21*(3), 1595-1598. doi: 10.1016/j.concog.2012.05.011

Raz, A., & Buhle, J. (2006). Typologies of attentional networks. *Nat Rev Neurosci, 7*(5), 367-379. doi: 10.1038/nrn1903

Manuscript 2: Narrative review

Transcultural factors in hypnotizability scales: Limits and prospects

Claire M. Champigny [a] & Amir Raz [a,b,c]

[a] Department of Psychiatry, McGill University

[b] Departments of Neurology & Neurosurgery, McGill University

[c] Institute for Community and Family Psychiatry of the Jewish General Hospital

Address for correspondence:

Institute for Community and Family Psychiatry

4333 Côte Ste Catherine

Montréal, QC H3T 1E4

Canada

E-mail address: amir.raz@mcgill.ca

Telephone: 514-340-8210

Abstract

Hypnotic suggestibility – loosely termed hypnotizability – is difficult to assess across cultures. Investigators often use translated research instruments to guide their inquiry in disparate geographic locations. Present-day hypnosis researchers rely heavily on two primary scales that are more than half a century old: the Stanford Hypnotic Susceptibility Scale: Form C (SHSS:C) and the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A). Scholars typically translate these scales to measure hypnotizability transculturally. This approach, however, operates under the specious assumption that the concept of hypnotizability is largely monolithic or universal across cultures. Alas whereas translations likely conserve the linguistic content, they may arguably imply different cultural meanings and historical subtexts. Whereas social scientists acknowledge the importance of qualitative and phenomenological accounts in the study of altered consciousness, including suggestibility, researchers interested in hypnotizability rarely consider the impact of findings from anthropology and ethnography. Clinicians and scholars stand to benefit from incorporating the insights of anthropologists and transcultural psychiatrists in the overarching investigation of a concept as nuanced as hypnotizability.

Keywords: hypnotizability, hypnosis, transcultural psychiatry, ethnography, translation.

Introduction

Hypnotizability

The topic spanning susceptibility to suggestion, compliance with instructions, and adherence to orders, has fascinated behavioral scientists for centuries (Baker, 1990; Brown & Fromm, 1986; Halligan & Oakley, 2014; Hull, 1993; Kihlstrom, 2013; Raz, 2007; Wagstaff, 1981). Albeit patently important for any culture, the scientific measurement and quantification of such parameters is often elusive and tenuous (Woody & Barnier, 2008). One way to study this topic is through the lens of hypnotizability, a concept that has steadily harnessed scientific attention over the past century (Figure 1).

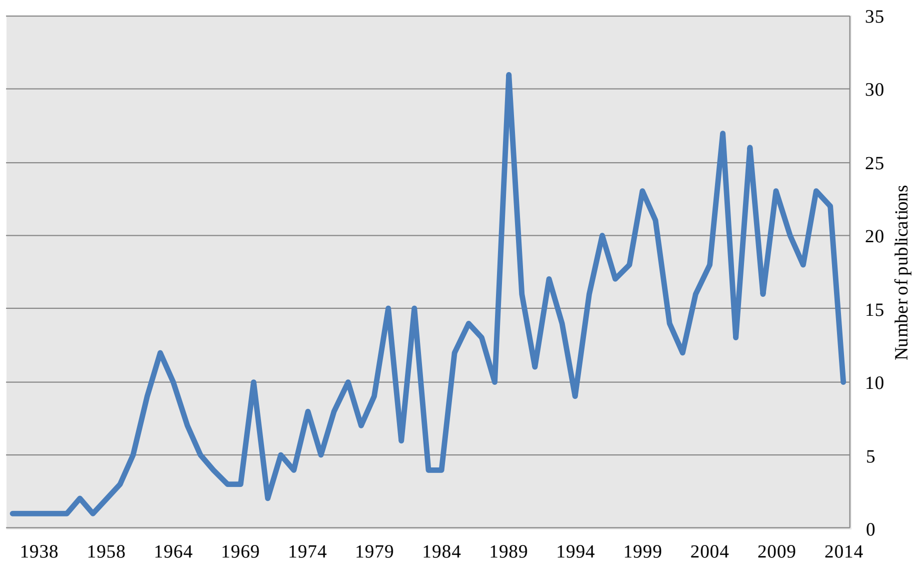


Figure 1. Scopus publication profile for "hypnotizability" for "all fields" (article and review) since 1930.

A phenomenon involving attentive receptive concentration, hypnosis refers to a change in baseline mental activity and suggestibility through a top-down process (Raz, 2011; Raz & Buhle, 2006). A top-down approach involves an active perception in the absence of direct sensory input, which comes about chiefly via expectation. Such a process contrasts with bottom-up approaches, which involve an absence of higher level direction in sensory processing (Beiderman, Glass & Stacy, 1973). Whereas individuals likely experience hypnosis differently, they typically report an increase in absorption, focused attention, and reduction in spontaneous thoughts (Oakley & Halligan, 2009). A hypnotic induction generates changes in the experience of self and the environment (Raz, Shapiro, Fan, & Posner, 2002). Such occurrences may lead to short-term benefits, such as reduced tension, and long-term benefits – in contexts commonly labeled *hypnotherapy* – including pain relief. While practitioners have used hypnosis for centuries, investigators have recently heralded hypnosis as an empirical vehicle for gaining control over deeply-ingrained psychological processes (Raz, 2011). For example, recent cognitive accounts demonstrate that hypnosis can disrupt word recognition (e.g., Lifshitz, Aubert-Bonn, Fischer, Kashem, & Raz, 2012), generate or alter the symptomology of neuropsychological conditions (e.g., Barabasz & Barabasz, 2008; Cohen-Kadosh, Henik, Catena, Walsh, & Fuentes, 2009; Halligan & Oakley, 2013; Kihlstrom, 2013; Oakley & Halligan, 2009, 2013; Raz, 2004; Terhune, Cardeña & Lindgren, 2010), and override even highly automatic multimodal sensory integration (e.g., Déry, Campbell, Lifshitz, & Raz, 2014). Research suggests that distinct patterns of brain activations attributable to hypnosis affect cognitive processing (Egner, Jamieson & Gruzelier, 2005; Fingelkurts, Fingelkurts, Kallio, & Revonsuo, 2007; Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002). In addition, hypnosis efficiently and inexpensively aids the symptoms of many debilitating disorders (e.g., acute and chronic health conditions (Graci & Hardie, 2007; Pinnell & Covino, 2000) and chronic pain (Elkins, Jensen, & Patterson, 2007)). Individual variability, however, characterizes hypnotic responding and often goes by the appellation hypnotizability (Laurence, Beaulieu-Prévost, & Du Chéné, 2008). The present paper centers on this susceptibility to hypnotic suggestion and common flaws associated with its measurement and assessment transculturally.

Measuring Hypnotizability

"Most of those [researchers and practitioners] who have shaped the history of hypnosis not only recognize the major importance of these individual differences in responsivity to suggestions, but also attempted to document them" (Dixon & Laurence, 1992). The disposition towards a hypnotic response, *hypnotizability*, provides a starting point from which to quantify hypnotic phenomena under standard conditions. In order to measure such phenomena, and in accordance with traditional scientific models, researchers devised scales that assign numbers to the varying manifestations of hypnotizability (Woody & Barnier, 2008). Rigorous hypnosis research requires formal measuring instruments that would yield relevant information to domains such as diagnostic accuracy and treatment efficacy (Council, 1999). The availability of psychometrically valid instruments allows researchers to communicate in clear and quantifiable ways, facilitate independent replication, and set a clear standard for exploration (Woody & Barnier, 2008).

> … There are many other purposes for such measures. Now that hypnosis is being used widely in medical practice, as in dentistry, obstetrics, surgery, and psychotherapy, it is desirable to know whether or not the hypnotic method is appropriate for a given subject. We do not now know, for example, how much susceptibility is all that is necessary for some psychotherapeutic uses of hypnosis. Having a standardized scale will help to make our knowledge more precise. (Hilgard, Weitzenhoffer, Landes, & Moore, 1961, pp. 1-2)

While some hypnosis researchers disagree on the nuances of the term *hypnotizability* (Council, 1999; Kirsch, 2014; Kirsch et al., 2011), for the purpose of this paper we prefer to sideline this important terminological debate and focus on the aforementioned definition of hypnotizability as susceptibility to hypnotic suggestion. Most scientists have reached a consensus regarding certain features of hypnotizability traits. Despite some disagreements (Fassler, Lynn, Knox, 2008), scientists generally agree that hypnotizability is a stable trait, perhaps more so than IQ (Hilgard, 1965; Nash & Barnier, 2008). Some findings even propose that highly hypnotizable individuals display distinct brain morphology (Horton, Crawford, Harrington, & Downs, 2004) and neural activity (Hoeft et al., 2012; cf Blinderman, 2014) that enable deep absorption in their experiences (Roche & McConkey, 1990) and inhibition of unwanted stimuli (Nash & Benham, 2005).

Researchers typically categorize the hypnotizability levels of their participants by measuring responses to various suggestions. In the 18th and 19th centuries, hypnotizability scales consisted of subjective ratings of the depth of experience of participants based on the professional judgment of clinicians, as opposed to standardized procedures (Orne & O'Connell, 1967). Nowadays, administration of hypnotizability scales begins with a hypnotic induction followed by suggestions. These suggestions comprise motor or cognitive effects and aim to either produce an effect (positive suggestion) or inhibit a response (negative suggestion). For example, a positive motor suggestion may ask participants to feel their arm levitating, while a negative motor suggestion may ask them to feel an inability to bend their arm; a positive cognitive suggestion may encourage participants to experience a visual hallucination, while a negative cognitive suggestion may encourage them to suppress their hearing. Participants pass or fail test items based on overt behavioral criteria.

Hypnotizability Scales

Researchers in the United States independently developed and tested two hypnotizability scales, which when used together form the current gold standard for assessing hypnotizability in research. Psychologists André Weitzenhoffer and Ernest Hilgard came up with the Stanford Hypnotic Susceptibility Scale: Form C (SHSS:C) in 1959, whereas psychologists Ronald Shor and Emily Orne designed the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A) in 1962. On the one hand, the SHSS:C evaluates individual subjects on twelve hypnotic suggestions. Throughout the hypnotic procedure, the hypnotist takes notes to (in)validate subject responses. The SHSS:C displays particularly impressive test-retest reliability over 10 (r = .64), 15 (r = .82), and 25 years (r = .71) (Piccione, Hilgard & Zimbardo, 1989). Researchers consider the SHSS:C a reliable and robust measure of individual responsiveness. On the other hand, The HGSHS:A tests multiple subjects simultaneously using twelve hypnotic suggestions and a self-scoring questionnaire that subjects complete immediately following their hypnotic experience. This scale provides a method for quickly identifying high and low hypnotizable individuals within a large sample, although it rates individuals with lower sensitivity than does the SHSS:C. Several experts, most notably Weitzenhoffer himself (1974, 1978, 1980), have expressed their concerns regarding the confusion between suggestions and instructions, as well as the clinical impracticality (50-90 minutes) of the SHSS:C. Despite the development of a plethora of other scales (see Table 1 in Appendix A), the SHSS:C and the HGSGS:A prevail, especially when used in concert, as the most functional and psychometrically sound hypnotizability scales to date (Barber, 1965**;** Hilgard, 1965; Sheehan & McConkey, 1982; Spanos & Chaves, 1991).

The Role of Culture

Social cognitive theories of hypnosis assert that response expectancy, which culture largely mediates, plays a preeminent role in shaping response to hypnotic suggestions (Barber, Spanos & Chaves 1974; Kirsch & Lynn, 1995; Kirsch, Silva, Comey, & Reed, 1995; Kirsch, Wickless, & Moffitt, 1999; Lynn & Green, 2011; Page, Handley, & Green, 1997; Sheehan & Perry, 1977). In general terms, *culture* refers to the beliefs, customs, arts, etc., of a particular society or group of people. Historical and social forces within a culture mold the ability to imagine a suggested experience, which further depends on an interaction between neurocognitive predispositions and socio-cultural beliefs about altered states of consciousness (Bourguignon & Evascu, 1977; Krippner, 2000). For example, labeling an induction procedure as *hypnosis* rather than *relaxation* increases participant response to subsequent suggestions (Oakley & Gandhi, 2005). Certain cultural activities may induce specific altered states of consciousness, such as the use of psychoactive plants, fasting, thirsting, self-mutilation, sweat lodges, sleeplessness, incessant dancing, bleeding, meditation, chanting, or drumming (Furst, 1977). These activities resemble hypnotic practices in the sense that altered cognition and personal beliefs co-determine the desired experience (Furst, 1977). Such practices prevail globally; approximately 89% of 488 studied societies socially approve and promote altered states of consciousness (Bourguignon & Evascu, 1977). Due to the nature of hypnosis as a top-down process, this social encouragement primes certain populations for hypnotic phenomena by ingraining in them a sense of familiarity with such mental experiences. By promoting altered states of consciousness, populations may shape their own mental capacities and render themselves more hypnotizable (Furst, 1977). A substantial reason why researchers in transcultural psychiatry endorse the comparison of hypnotizability across societies stems from the aforementioned finding that expectancy and culture can affect hypnotic responsiveness.

Lost in Translation

Translating quantitative instruments – such as hypnosis scales – constitutes an essential element of any transcultural study (Kleinman, 1987). A frequent error, however, posits that a concept – in this case, hypnotizability – is universal, and therefore measurable with the same test items across cultures by translating the original language into the language of the target population (Jones & Kay, 1992). Such an ethnocentric error demonstrates that Western psychiatrists often fail to assess their own sociocultural background, despite the fact this consideration would have optimized analyses of the culture under study (Stanghellini & Ciglia, 2013). Although translation procedures aim for rigor and linguistic accuracy, they tend to focus on translating words/phrases and often miss the complex subtleties of cultural interpretations concerning higher order abstractions and concepts (e.g., Bravo, Canino, Rubio-Stipec, & Woodbury, 1991; Ketzer & Crescenzi, 2002). The semiotics of biology and medicine tend to neglect the fact that perceptual, cognitive, interpersonal, and social processes mediate the verbal explanations of bodily processes in an individual (Kirmayer, 2005). For example, cultural explanations for certain somatic feelings set up expectations that influence the ways in which individuals attend to their mind-body continuum (Kirmayer & Sartorius, 2007). Based on the methodology used to translate hypnotizability scales, it seems psychiatric researchers often assume that the *description* of embodied experience correctly and objectively reflects that experience. As a result, researchers often resort to a quick and simple translation when they should instead re-work the test items to convey the appropriate concepts pertaining to each culture (Kleinman, 1987).

Translation Procedures

Researchers have an array of options at their disposal for the translation of a scientific tool. In *back translation*, one of the most common translation procedures, one interpreter translates the first half of the instrument from the source language to the target language, while a second interpreter performs the same task on the second half of the instrument (Brislin, 1970; Chapman & Carter, 1979). They then switch positions and translate each text back to the source language, enabling a comparison of the two English versions of the instrument. After discussing the content of the items with the investigator, the interpreters repeat the back translation until they deem both versions equivalent. Despite its meticulousness, back translation ensures only literal accuracy (Allen & Walsh, 2000) and exhibits weak conceptual equivalence (Larkin, Dierckx de Casterlé & Schotsmans, 2007). Coined by Brislin (1993), *conceptual equivalence* addresses the translation of not only words, but also their embedded meaning and intent. This notion emphasizes the importance for a measured construct to uphold the appropriate meaning between the languages under study (Brislin, 1993; Hunt & Bhopal, 2004).

When translation procedures fail to maintain conceptual equivalence in research materials – such as hypnotizability scales – participants will likely understand the translated scale differently than they would have understood the original scale. A recent examination of the pass rates for the posthypnotic amnesia item in the HGSHS:A across ten countries has exposed its poor reliability, as illustrated by highly fluctuating rates (Figure 2) (Freedman, 2012).

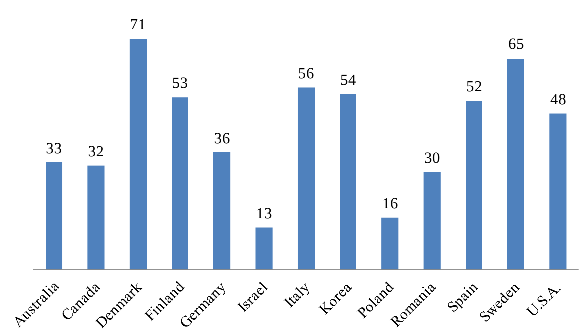


Figure 2. Percentage of pass rate for amnesia item of HGSHS:A as found by Freedman (2012).

For this suggestion, the hypnotist instructs participants to forget what has happened during the session until the onset of a specific cue. As soon as the hypnotic experience ends, they list "all the things that happened since you began looking at the target" in their response booklet. Participants who report fewer than four hypnotic suggestions have successfully passed the posthypnotic amnesia item. Researchers have attributed the unexpected variations in pass rates to translational and cultural differences (Freedman, 2012). For instance, they conjectured that the strangely high passing rate (53%) in a Finnish population may have arisen due to a lack of conceptual equivalence (Kallio & Ihamuotila, 1999). They believed that "the wording [in the Finnish scale] … may lead to a somewhat different meaning when translated. In Finnish the verb *happen* (*tapahtua*) has a passive connotation (more like *occur*) and a better translation might have been the more active *tehdä* which is equal to *do*" (Kallio & Ihamuotila, 1999, p. 230). Due to the passive nature of the translated instructions, Finnish participants reported their subjective experience rather than listing the suggestions they remembered. Researchers consequently scored such participants as highly amnesic. Similar results arose when translating and testing the HGSHS:A in a Swedish population; researchers calculated a 65% passing rate (Bergman, Trenter & Kallio, 2003). They blamed the implausible outcome to translation problems as well, positing that subjects misinterpreted the suggestion as "referring to changes in the content of consciousness as a result of suggestions delivered during the induction procedure. In the English original, the verb *happen* is used in the response booklet. However, it might be better to use the verb *do* in the translated versions" (p. 354, Bergman, Trenter & Kallio, 2003). The next section explores how researchers cannot perform valid comparisons and reach legitimate conclusions without conceptual equivalence (Flaherty et al., 1988; Hunt & Bhopal, 2003).

Conceptual Differences

Dissimilarities in thinking that stem from unique sociocultural factors cause conceptual differences in languages, wherein linguistically similar words do not reflect the same construct in each language. In the case of Post-Traumatic Stress Disorder (PTSD), for example, both leading diagnostic manuals used in North American psychiatry – the Diagnostic and Statistical Manual (DSM-5) and the International Statistical Classification of Diseases and Related Health Problems (ICD-10) – put an emphasis on the perceived threats to life and bodily integrity in their diagnoses. Some medical anthropologists argue that such an approach ignores a crucial point; "What is highly variable is what constitutes a threat and how that changes from one society to another, and within societies, depending upon the experiences of people" (Allan Young, personal communication, September 26, 2013). Many of the classical instruments for measuring stress inputs in terms of life changes, such as the Social Readjustment Rating Scale (SRRS) (Holmes & Rahe, 1967), overlook conceptual differences within societies (A. Young, personal communication, September 26, 2013).

> "What was represented in the instruments that had been developed by the stress researchers was a translation of culturally normative ideas. … They weren't applicable within … American society. … Much of the research was done in New York City and one of the highest stressful life events was being convicted of a crime and being sentenced to some kind of incarceration, it could be brief, but incarceration and conviction. For middle class Americans, this certainly was true. ... On the other hand, research included poor black Americans and poor Hispanic, mainly at that time, Puerto Rican Americans for whom incarceration was a less extraordinary event than it was for middle class white people. So there was … a gross difference between them." (A. Young, recorded personal communication, September 26, 2013).

Similar cultural examples apply to the field of hypnotizability. For example, in Japan, researchers found that, compared to the English version, a direct translation of hypnotizability scales into Japanese resulted in significantly fewer words, thus considerably shortening the length of the induction procedure (Y. Fukui, personal communication by Eli Sheiner, September 9, 2012). Because Japanese, compared to North American, culture presents hypnosis more as a holistic experience, it became difficult for Japanese researchers to optimally measure hypnotizability using scales with such specific dimensions of hypnotic response. They agreed upon the necessary establishment of new, more culturally appropriate scales to compare hypnotic experiences in Japanese and American populations. A second example pertains to researchers who encountered validity problems when using a translation of the Diagnostic Interview Schedule (DIS) in Peru (Gaviria et al., 1984). The substance abuse section of the DIS failed to reflect Peruvian culture; many of the substances listed were unavailable in Peru, while coca paste, a major drug in the country, did not appear in the scale. Consequently, researchers drew on faulty DIS scores for their calculations, resulting in inaccurate rates of Peruvian substance abuse. They encountered similar issues when translating the DIS into Hopi, a Native American language (Manson, Shore & Bwosi, 1985). For example, one DIS item combines the concepts of guilt, shame, and sinfulness. Western populations often experience these feelings collectively; however, the Hopi strongly discriminate among all three concepts. They indicated that the DIS necessitated three separate questions to correctly assess such a fusion of feelings in their population. The fact that certain items might not relate to the same normative concept in two cultures constituted another key problem. Auditory hallucinations, for instance, are culturally consonant among Native Americans; the DIS, however, does not take into account this alternative cultural norm and incorrectly assesses it as a pathological symptom. Carlo Steirlin describes a similar diagnostic error in the case of a resident evaluating an aboriginal hunter from Northern Quebec. The patient presented with symptoms such as withdrawal, poor sleep, and loss of appetite, due to a preoccupation with the spirit of an animal he killed. He reported feeling "an estrangement of the spiritual connection between himself and the fallen animal at the moment of the kill … which deeply disturbed him" (Steirlin, as cited in Guzder & Rousseau, 2013, p. 355). The resident diagnosed the patient with delusional disorder and prescribed a neuroleptic medication for treatment, thereby ignoring cultural explanatory models. In conclusion, in order to realize a meaningful translation of scales that acknowledges cultural significance, researchers must consider the diversity of unique meanings embedded in languages:

> "The referents of symbols - i.e., their meaning - are aspects of a culture or a life world, not objects outside of language through which language obtains meaning. 'Heart discomfort' for Iranians is not the equivalent of 'heart palpitations' for Americans; it does not mean the same thing (Good, 1977). It is a symbol which condenses a distinctive set of meanings, a culture specific semantic network…" (Good & Del Vecchio Good, 1986)

Without taking into consideration the effects of these sets of meanings, scales that follow Western biomedical standards cause misdiagnoses of cultural differences. Results intimate that populations respond more or less strongly to hypnosis when, in actuality, they may understand the questions in the scales, or the entire Western concept of hypnosis, differently. To decrease such erroneous findings, researchers should allocate resources towards a comprehensive translation of local idioms and subtle linguistic complexities, and subsequently modify the original scales. Although this template may seem like a straightforward solution, researchers rarely follow it (Kleinman, 1987; McHugh & Slavney, 1986) and instead, often opt to use an *asymmetrical* translation procedure.

Asymmetrical Translation

Campbell and Werner (1970) define two categories of translations: symmetrical and asymmetrical. Symmetrical translation emphasizes the meaning, familiarity, and coloquialness of each language. Asymmetrical translation remains loyal only to the original language, which results in a translated version that "seems exotic and unnatural in the new language" (Jones & Kay, 1992, p. 187). Asymmetrical translation prevents conceptual equivalence between cultures and compromises the reliability of the items (Jones & Kay, 1992). To attain scientific reliability, hypnosis scales must follow a symmetrical translation; test items must be common to all cultures under study for a proper translation of meanings and symbols (Campbell & Werner, 1970). A superficial translation of the original scales cannot attain symmetry because American psychologists designed and tested the items in the United States and developed their psychometric properties according to the English language. A symmetrical translation requires additional research regarding the cultural relevance of each test item and the creation of new test items. Nonetheless, researchers avoid tampering with and adjusting the test items according to the cultures under study (Chapman & Carter, 1979). The main reason for this reluctance remains the fact that accomplishing a perfectly symmetrical translation involves a complex, lengthy methodological project. An asymmetrical translation, in which researchers translate the English hypnosis scales to the language of the target population, requires less time and fewer resources.

Contemporary Research

Most experiments aiming to disentangle cultural differences in hypnotizability translate the American scales and apply them to a new population, thereby ignoring issues of cross-cultural validity and reliability (e.g., Bergman, Trenter & Kallio, 2003; Carvalho, Kirsch, Mazzoni, & Leal, 2007; David, Montgomery & Holdevici, 2003; De Pascalis, Bellusci & Russo, 2008; Lamas, Del Valle-inclan, Blanco, & Diaz, 1989; Pyun & Kim, 2009; Roark, Barabasz,

Barabasz, & Lin-Roark, 2012; Sanchez-Armass & Barabasz, 2005; Zachariae, Sommerlund & Molay, 1996). The translation procedure typically involves one bilingual scholar translating the original scale, sometimes followed by as few as one other bilingual scholar reviewing the translation. Finally, a certified interpreter performs a back translation. The small number of people involved in the process, in addition to their lack of professional experience – the scholars are often volunteers recruited on site – weakens the validity of such translations. Researchers spuriously consider the translation successful when comparisons between populations yield similar results, and the minor differences left over fall under cultural factors. Many studies also use already translated versions of the scales that were arranged in the 1970s and 1980s, when translation procedures were more lax. Researchers usually assess reliability using the Kuder-Richardson (KR20) formula (Rubini, 1975). If the Cronbach's Alpha reliability coefficient is too low, researchers may recalculate the statistical analyses with the discontinuation criterion (Weitzenhoffner & Hilgard, 1962). These practices reflect faulty methodologies and paradigms, resulting in meaningless profiles of hypnotizability prevalence rates across cultures and languages (De Jong & Ommeren, 2002).

Critiques

Few authors have thoroughly addressed the negative implications of hasty, and ultimately defective, translations of scales and tests in research (Birbili, 2000; Temple, 1997; Temple & Young, 2004). Arthur Kleinman (1987), a leading figure in the criticism of translation, states that the very essence of ethnographic research centers on translation. In failing to address the issues attached to translation, researchers risk perpetrating a *category fallacy*, or the reification of a nosological category developed for a particular cultural group that is then applied to members of another culture for whom it lacks coherence (Kleinman, 1977). For example, individuals in

South American societies may experience a syndrome entitled *soul loss*, characterized by a feeling of fragmentation or dissociation of the soul after experiencing a trauma. The exact phenomenology of this depressive disorder does not appear in Western medical categories. In fact, psychiatrists consider soul loss a *culture-related specific syndrome*, defined as a syndrome that is “closely and significantly related to certain cultural features in [its] formation or manifestation of psychopathology” (Tseng, 2006, p. 565). A psychiatrist could decide to operationalize the symptoms of soul loss, organize them into a questionnaire, establish reliability for use in Western society, translate the items to English, and apply the final product to an American population. Despite a rigorous translation, the data would lack validity because soul loss has no coherence for North Americans (Shweder, 1985). Such an assumption – that high reliability leads to high validity – constitutes a central mistake in psychiatric research (Kleinman, 1987).

Validity

Validity – the extent to which an instrument accurately measures what it purports to measure – stands as one of the most difficult issues to face in transcultural psychiatry (Kleinman, 1987). High reliability, which indicates the consistency of observation, has proven more easily achievable in cross-cultural studies than high validity, which requires a more sophisticated approach. Validity needs to be established through understanding the particular cultural context (McHugh & Slavney, 1986). To illustrate this point, Kleinman (1987) uses the example of ten psychiatrists who were trained in the same assessment technique and who had to examine 100 Native Americans shortly after the participants had experienced the death of a family member. The psychiatrists determined with almost perfect consistency that the individuals reported hearing the spirit of the deceased calling to them, signifying a high reliability rate. However, the psychiatrists misattributed these hearings as auditory hallucinations. Native American tribes culturally encourage internal auditory experiences, rendering them an expected phenomenon that does not signify mental instability or psychosis. To report these experiences as hallucinations, with the pathological significance that *hallucinations* connote in the medical field, is reliable but not valid. Validity means more than the verification of concepts used to explain observations; it signifies the verification of the meaning of those observations in a particular socio-cultural system. To avoid major validity fallacies, cross-cultural research must be grounded in the local ethnographic context (Kleinman, 1987).

An Ethnographic Approach

Because the attainment of validity pertains to a fundamentally ethnographic enterprise, psychiatry would benefit from cooperating with the anthropological field. To date, the fields of Psychology and Medicine have dominated research on hypnotizability, with Social Sciences and Arts and Humanities meekly following far behind (Figure 3). To many psychiatric researchers, observations directly represent reality (McHugh & Slavney, 1986). Through the eyes of a psychiatrist, the word *hallucination* points to an empirical reality: an abnormal mental state. For the anthropologist, however, *hallucination* signifies a meaningful phenomenon in a world mediated by the cultural apparatuses of language, categories, and taxonomies. Thorough preliminary qualitative work and meticulous translation strategies can contribute to a stronger research foundation and lead to a superior understanding of transcultural populations (Jones & Kay, 1992).

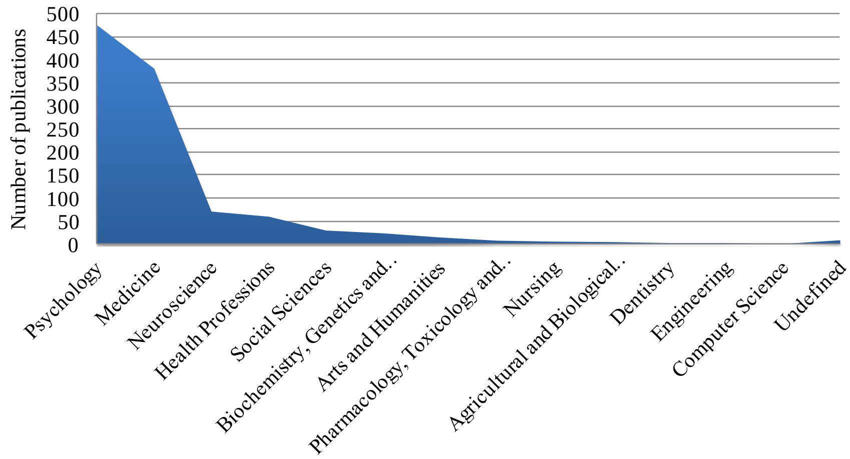


Figure 3. Scopus publication profile for "hypnotizability" (article and review) from 1930 onward by subject area.

A Model for Research in Transcultural Psychiatry

A standard ethnographic approach begins with the organization of focus groups, which involve group discussions among five to ten people from the relevant culture on topics proposed by a facilitator (Krueger, 1988; Morgan, 1988). Data collection relies on the interactions among the participants. Focus groups give insight into the sociocultural and political context of the population under study. By eliciting information on customs and identifying critical concepts, focus groups help researchers develop new test items and modify existing ones. Focus groups have several limitations (Morgan, 1988) that researchers can easily overcome (De Jong & Van Ommeren, 2002). For instance, focus groups tend to be unproductive when participants disagree on topics or feel uncomfortable talking about them. Pre-testing helps to determine whether certain topics will work in a specific focus group. To address concerns about the replicability of findings, researchers can run a sufficient number of focus groups per subpopulation, until the data generates consistent findings. The next step in an ethnographic approach involves in-depth interviews, otherwise called *person-centered ethnography* in anthropological literature (De Jong & Van Ommeren, 2002). These qualitative interviews elucidate subjective experiences and psychological processes affected by sociocultural factors. They provide background information that will aid in the appropriate translation and adaptation of hypnotizability scales, which should ensure the relevance of the items. The final step in preparing for the collection of transcultural data involves the organization of meetings in which researchers, colleagues, and representatives of the research population discuss the effects of culture and setting on the experience of future participants (De Jong & Van Ommeren, 2002). By integrating their conclusions into the research plan, researchers aim to link the design of the scales to the experience of participants and thus increase their relevance. Once researchers complete these steps, the hypnotizability scales will incorporate a stronger anthropological foundation, bolstering both their reliability and validity.

Translation Procedures

The most important challenge in this ethnographic model comprises the translation and adaptation of the instruments while ensuring content, semantic, concept, criterion and technical equivalences (Flaherty et al., 1988). Content equivalence requires items to be relevant within the cultural context in use. For instance, in certain low-income areas of the world, parents may not be able to afford school fees; as such, asking whether a child attends school proves useless when diagnosing Conduct Disorder (De Jong & Van Ommeren, 2002). Semantic equivalence signifies that the meaning of an item remains the same after translation. For example, with regard to PTSD, the word *nightmare* changes meaning when translated from English to Cambodian. In Cambodian, *nightmare* indicates a nightly visitation of a deceased family member, as opposed to a frightening dream in English. Concept equivalence – the antonym of a category fallacy – requires that an instrument measures the same theoretical construct in both cultures. The aforementioned assessment of soul loss in the United States exemplifies a lack of concept equivalence. Criterion equivalence means that the outcome of measurement of a variable matches another criterion, such as an independent assessment by a psychiatrist practicing in the culture under study. For instance, healthy participants in African countries may indicate that they believe someone wants to harm them. In contrast to a Western psychiatrist, who might note symptoms of paranoia, a local psychiatrist may consider these statements normal if cultural customs include witchcraft and sorcery (De Jong, 1987). Finally, technical equivalence entails a sensible administration of the instrument to avoid systemic biases. These biases may arise in several occasions, such as if the interviewer represents an emotionally loaded institution; if the setting lacks privacy; if the physical interpersonal distance proves to be culturally inappropriate; if social desirability encourages acquiescence rather than honesty; or if certain factors – such as gender, ethnicity, socio-economic status, or background – disturb the communication (De Jong, 1987). Good ethnographic practice merges psychiatry and anthropological epidemiology in such a way that the qualitative data collected increases understanding of the cultural context (De Jong & Van Ommeren, 2002). Such approaches enable easier validation of hypnotizability scales and improve interpretation of the results. The transcultural use of hypnotizability scales may benefit from following anthropological models, which boast more rigorous, systematic and contextual approaches to the adaptation of instruments (Kleinman, 1987).

Conclusion

Every language carries deeply entrenched meanings inherent to its parent culture. An appropriate determination of a tenuous term such as hypnotizability would therefore necessitate comprehensive prior knowledge of the cultural milieu in which the terms thrives beyond blind adherence to the psychometric parameters (e.g., reliability and validity) associated with the scales of choice. Behavioral scientists stand to benefit from drawing on anthropological models to ensure that hypnotizability scales are culturally sensitive and socially appropriate. Suitability of comparative measurements follows by grounding transcultural studies in local context through the organization of focus groups, in-depth interviews, and meetings with local leaders and members of the community. Moreover, by incorporating such considerations we would be able to foster meaningful cross-cultural comparisons of hypnotizability thereby permitting a more scientific understanding of the sociocultural factors that render certain populations more prone to hypnotic experiences than other groups, and the role such experiences play in specific communities. Clinician-researchers (e.g., psychiatrists) and social scientists (e.g., medical anthropologists) must work in concert to further unravel transcultural issues surrounding hypnotizability.

Acknowledgements

We would like to thank Mr. Mathieu Landry from McGill University (Canada) and Ms. Shelagh Freedman from Concordia University (Canada) for their constructive comments and edits on earlier versions of this manuscript, as well as Drs. Danielle Groleau and Allan Young from McGill University for their valuable insights and discussions. Dr. Amir Raz acknowledges funding from the Canada Research Chair program, Discovery and Discovery Acceleration Supplement grants from the Natural Sciences and Engineering Research Council of Canada (NSERC), Canadian Institutes of Health Research, and the Volkswagen Foundation (VolkswagenStiftung).

References

Allen, J., & Walsh, J. (2000). A construct-based approach to equivalence: Methodologies for cross-cultural and multicultural personality assessment research. *Handbook of multicultural/cross-cultural personality assessment* (pp. 63-85). Mahwah, New Jersey: Erlbaum.

Baker, A. (1990). *They call it hypnosis*. New York: Prometheus Books.

Barabasz, A.F., & Barabasz, M. (2008). Hypnosis and the brain. In M. R. Nash & A. J. Barnier (Eds.), *The Oxford handbook of hypnosis: Theory, research, and practice* (pp. 337–363). Oxford, UK: Oxford University Press.

Barber, T.X. (1965). Physiological effects of 'hypnotic suggestions': a critical review of recent research (1960-1964). *Psychological Bulletin*, *63*, 201-222.

Barber, T.X., Spanos, N., & Chaves, J. (1974). *Hypnotism, imagination, and human potentialities.* Elmsford, New York: Pergamon Press.

Barber, T.X., & Wilson, S.C. (1978). The Barber Suggestibility Scale and the Creative Imagination Scale: Experimental and clinical applications. *American Journal of Clinical Hypnosis, 21*, 84-108.

Bergman, M., Trenter, E., & Kallio, S. (2003). Swedish Norms for the Harvard Group Scale of Hypnotic Susceptibility, Form A. *International Journal of Clinical and Experimental Hypnosis, 51*(4), 348-356.

Biederman, I., Glass, A. L., & Stacy E. W. (1973). Searching for objects in real world scenes. *Journal of Experimental Psychology*, *97*, 22-27.

Birbili, M. (2000). Translating from one language to another. *Social Research Update, 31*.

Blinderman, I. (2014). Square to be HIP: The perils of the Hypnotic Induction Procedure. *The Journal of Mind-Body Regulation, 2*(2), 87-89.

Bourguignon, E., & Evascu, T. (1977). Altered states of consciousness within a general evolutionary perspective: a holocultural analysis. *Behavior Science Research, 12,* 199-216.

Bowers, K. S. (1993). The Waterloo-Stanford Group C (WSGC) scale of hypnotic susceptibility: Normative and comparative data. *International Journal of Clinical and Experimental Hypnosis, 41*, 35-46.

Bowers, K. S. (1998). Waterloo-Stanford Group Scale of Hypnotic Susceptibility, Form C: Manual and Response Booklet. *International Journal of Clinical and Experimental Hypnosis, 46*(3), 250-268.

Bravo, M., Canino, G., Rubio-Stipec, M., & Woodbury, M. (1991). A cross-cultural adaptation of a diagnostic instrument: The DIS adaptation in Puerto Rico. *Culture, Medicine, and Psychiatry, 11*, 465–494.

Brislin, R. (1993). Understanding Culture’s Influence on Behavior. San Diego, California: Harcourt Brace Jovanovich.

Brislin, R. (1970). Back-Translation for Cross-Cultural Research. *The Journal of Cross-Cultural Psychology, 1*(3), 185-216.

Brown, D. P., & Fromm, E. (1986). *Hypnotherapy and hypnoanalysis*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Campbell, D., & Werner, O. (1970). Translating, working through interpreters and the problem of decentering. In R. Naroll & R. Cohen (Eds.), *A Handbook of method in cultural anthropology* (pp. 398-420). New York: Natural History Press.

Carvalho, C., Kirsch, I., Mazzoni, G., & Leal, I. (2007). Portuguese Norms for the Waterloo-Stanford Group C (WSGC) Scale of Hypnotic Susceptibility. *International Journal of Clinical and Experimental Hypnosis, 5*(3), 295-305.

Chapman, D., & Carter, J. (1979). Translation procedures for the cross-cultural use of measurement instruments. *Educational Evaluation and Public Analysis, 1*(3): 71-76.

Cohen-Kadosh, R., Henik, A., Catena, A., Walsh, V., & Fuentes, L.J. (2009) Induced cross-modal synaesthetic experience without abnormal neuronal connections. *Psychological Science 20*(2), 258–265.

Council, J.R. (1999). Measures of Hypnotic Responding. In I. Kirsch, A. Capafons, E. Cardeña-Buelna & S. Amigó (Eds.), *Clinical Hypnosis and Self Regulation: Cognitive-Behavioral Perspectives* (pp. 119-40). Baltimore, Maryland: United Book Press.

David, D., Montgomery, G., & Holdevici, I. (2003). Romanian Norms for the Harvard Group Scale of Hypnotic Susceptibility, Form A. *International Journal of Clinical and Experimental Hypnosis, 51*(1), 66-76.

Davis, L., Husband, R. (1931). A study of hypnotic susceptibility in relation to personality traits. *Journal of Abnormal and Social Psychology, 26*, 175-182.

De Jong, J. (1987). *A Descent into African psychiatry*. Amsterdam: Royal Tropical Institute.

De Jong, J., & Van Ommeren, M. (2002). Toward a Culture-informed Epidemiology: Combining Qualitative and Quantitative Research in Transcultural Contexts. *Transcultural Psychiatry, 39*(4) 422-433.

De Pascalis, V., Bellusci, A., & Russo, P.M. (2008). Italian Norms for the Stanford Hypnotic Susceptibility Scale, Form C. *International Journal of Clinical and Experimental Hypnosis, 48*(3), 315-323.

Déry, C., Campbell, N.K.J., Lifshitz, M., & Raz, A. (2014). Suggestion overrides automatic audiovisual integration. *Consciousness and Cognition*, *24*, 33-7.

Dixon, M., & Laurence, J.R. (1992). Hypnotic susceptibility and verbal automaticity: Automatic and strategic processing differences in the Stroop color-naming task. *Journal of Abnormal Psychology*, *101*(2), 344-347.

Egner, T., Jamieson, G., & Gruzelier, J. (2005) Hypnosis decouples cognitive control from conflict monitoring processes of the frontal lobe. *Neuroimage, 27*(4), 969–978.

Elkins, G., Jensen, M., & Patterson, D. (2007). Hypnotherapy for the management of chronic pain. *The International journal of clinical and experimental hypnosis, 55*(3), 275-287.

Fassler, O., Lynn, S., & Knox, J. (2008). Is hypnotic suggestibility a stable trait? *Consciousness and Cognition*, *17*(1), 240-53.

Fingelkurts, A., Fingelkurts, A., Kallio, S., & Revonsuo, A. (2007). Cortex functional connectivity as a neurophysiological correlate of hypnosis: an EEG case study. *Neuropsychologia*, *45*(7), 1452-1462.

Flaherty, J., Gavira, F., Pathak, D., Mitchell, T., Wintrob, R., Richman, J., & Birz, S. (1988). Developing instruments for cross-cultural psychiatric research. *Journal of Nervous and Mental Disease, 176*, 257–263.

Freedman, S. (2012). The measurement of posthypnotic amnesia with the Harvard group scale of hypnotic susceptibility, Form A. (Unpublished master's dissertation). Concordia University, Montreal, Canada.

Friedlander, J., & Sarbin, T. (1938). The depth of hypnosis. *Journal of Abnormal and Social Psychology, 33*, 453-475.

Furst, P. (1977). "High states" in culture-historical perspective. *Alternate states of consciousness* (N. Zinberg ed., pp. 53-88). New York: Free Press.

Gaviria, M., Pathak, D., Flaherty, J., Garcia-Pacheco, C., Martinez, H., Wintrob, R., & Mitchell, T. (1984). Designing and adapting instruments for a cross-cultural study on immigration and mental health in Peru. Paper presented at the American Psychiatric Association Meeting.

Gheorghiou, V. A., Polczyk, R., & Kappeller, C. (2003). The Warmth Suggestibility Scale - a procedure for measuring the influence of suggestion on warmth sensations. *Personality and Individual Differences, 34*, 219-234.

Good, B. (1977). The heart of what's the matter. *Culture, Medicine and Psychiatry, 1*, 25-38.

Good, B., & Del Vecchio Good, M.J. (1986). The cultural context of diagnosis and therapy: a view from medical anthropology. In M. Miranda & H. Kitano (Eds.), *Medical Health Research and Practice in Minority Communities: Development of Culturally Sensitive Training Programs* (pp. 1-27). Washington, D.C.: United States Government Printing Office for NIMH.

Graci, G., & Hardie, J. (2007). Evidenced-based hypnotherapy for the management of sleep disorders. *The International Journal of Clinical and Experimental Hypnosis, 55*(3), 288-302.

Gudjonsson, G.H. (1984). A new scale of interrogative suggestibility. *Personality and Individual Differences, 5*(3), 303-314.

Guzder, J., & Rousseau, C. (2013). A diversity of voices: The McGill 'Working with Culture' seminars. *Culture, Medicine, and Psychiatry, 37*(2), 347-364.

Halligan, P.W., & Oakley, D.A. (2013). Hypnosis and cognitive neuroscience: Bridging the gap. *Cortex, 49,* 359–364.

Halligan, P.W., & Oakley, D.A. (2014). Hypnosis and Beyong: Exploring the Broader Domain of Suggestion. *Psychology of Consciousness: Theory, Research and Practice, 1*(2), 105-122.

Hilgard, E.R. (1965). Hypnotic susceptibility. Oxford, England: Harcourt, Brace & World.

Hilgard, E.R., Crawford, H.J., & Wert, A. (1979). The Stanford Hypnotic Arm Levitation Induction and Test (SHALIT): a six minute hypnotic induction and measurement scale. *International Journal of Clinical and Experimental Hypnosis, 27*(2), 111-124.

Hilgard, E.R., Weitzenhoffer, A.M., Landes, J., & Moore, R. (1961). The distribution of susceptibility to hypnosis in a student population: A study using the Stanford Hypnotic Susceptibility Scale. *Psychological Monographs*, 75 (8, Whole No. 512).

Hoeft, F., Gabrieli, J.D.E., Whitfield-Gabrieli, S., Hass, B.W., Bammer, R., Menon, V., & Spiegel, D. (2012). Functional brain basis of hypnotizability. *Journal of the American Medical Association Psychiatry, 69*(10), 1064-1072.

Holmes, T.H., & Rahe, R.H. (1967). The Social Readjustment Rating Scale. *Journal of Psychosomatic Research, 11*(2), 213–218.

Horton, J.E., Crawford, H.J., Harrington, G., & Downs, J.H. (2004). Increased anterior corpus callosum size associated positively with hypnotizability and the ability to control pain. *Brain: A Journal of Neurology, 127*(8), 1741-1747.

Hull, C.L. (1993). *Hypnosis and Suggestibility: an Experimental Approach*. New York: Appleton.

Hunt, S., & Bhopal, R. (2004). Self report in clinical and epidemiological studies with non-English speakers: the challenge of language and culture. *Journal of Epidemiology and Community Health, 58*, 618–622.

Hunt, S., & Bhopal, R. (2003). Self reports in research with non-English speakers: the challenge of language and culture is yet to be met. *British Medical Journal, 327*, 352-353.

Jones, E.G., & Kay, M. (1992). Instrumentation in Cross-Cultural Research. *Nursing Research, 41*(3), 186-188.

Kallio, S.I., & Ihamuotila, M.J. (1999). Finnish norms for the Harvard Group Scale of Hypnotic Susceptibility, Form A. *International Journal of Clinical and Experimental Hypnosis, 47*, 227-235. doi:10.1080/00207149908410034

Ketzer, E., & Crescenzi, A. (2002). Addressing the psychosocial and mental health needs of Tibetan refugees in India. *Trauma, war and violence: Public mental health in sociocultural context* (J. de Jong ed., pp. 204-280). New York: Plenum-Kluwer.

Kihlstrom, J.F. (2013). Neuro-hypnotism: Prospects for hypnosis and neuroscience. *Cortex, 49*, 365-374.

Kirmayer, L.J. (2005). Culture, context and experience in psychiatric diagnosis. *Psychopathology, 38*, 192-196.

Kirmayer, L.J. & Sartorius, N. (2007). Cultural models and somatic syndromes. *Psychosomatic Medicine, 69*(9), 832-840.

Kirsch, I. (2014). Wagstaff's Definition of Hypnosis. *The Journal of Mind-Body Regulation, 2*(2), 124-5.

Kirsch, I., Cardeña, E., Derbyshire, S., Dienes, Z., Heap, M., Kallio, S., et al. (2011). Definitions of hypnosis and hypnotizability and their relation to suggestion and suggestibility: A consensus statement. *Contemporary Hypnosis and Integrative Therapy, 28*(2), 107–115.

Kirsch, I., & Lynn, S.J. (1995). The altered state of hypnosis: changes in the theoretical landscape. *American Psychologist, 50*, 846-858.

Kirsch, I., Silva, C., Comey, G., & Reed, S. (1995). A spectral analysis of cognitive and personality variables in hypnosis: empirical disconfirmation of the two-factor model of hypnotic responding. *Journal of Personality and Social Psychology, 69*, 167-175.

Kirsch, I., Wickless, C., & Moffitt, K.H. (1999). Expectancy and suggestibility: Are the effects of environmental enhancement due to detection? *International Journal of Clinical and Experimental Hypnosis*, *47*(1), 40-45.

Kleinman, A. (1977). Culture, depression and 'new' cross-cultural psychiatry. *Social Science and Medicine, 11*, 3-11.

Kleinman, A. (1987). Anthropology and Psychiatry: The role of culture in cross-cultural research on illness. *The British Journal of Psychiatry, 151*, 447-454.

Krippner, S. (2000). Cross-Cultural Perspectives on Transpersonal Hypnosis. *Transpersonal Hypnosis: Gateway to Body, Mind, and Spirit* (E. Leskowitz ed., pp.141-162). Boca Raton, Florida: CRC Press LLC.

Krueger, R. A. (1988). *Focus groups. A practical guide for applied research*. Newbury Park, California: Sage.

Lamas, J., del Valle-inclan, F., Blanco, M., & Diaz, A.A. (1989). Spanish Norms for the Harvard Group Scale of Hypnotic Susceptibility, Form A. *International Journal of Clinical and Experimental Hypnosis*, *37*(3), 264-273.

Larkin, P.J., Dierckx de Casterlé, B., & Schotsmans, P. (2007). Multilingual Translation Issues in Qualitative Research: Reflections on a Metaphorical Process. *Qualitative Health Research, 17* (4), 468-476.

Laurence, J. R., Beaulieu-Prévost, D., & Du Chéné, T. (2008). Measuring and understanding individual differences in hypnotizability. In M. Nash & A. Barnier (Eds.), *The Oxford handbook of hypnosis: Theory, research and practice*. New York: Oxford University Press.

Lifshitz, M., Aubert-Bonn, N., Fischer, A., Kashem, I.K., & Raz, A. (2012). Using suggestion to modulate automatic processes: From Stroop to McGurk and beyond. *Cortex, http://dx.doi.org/10.1016/j.cortex.2012.08.007*

Lynn, S. J., & Green, J. P. (2011). The sociocognitive and dissociation theories of hypnosis: Toward a rapprochement. *International Journal of Clinical and Experimental Hypnosis, 59*, 277-293.

Macleod, C.M., & Sheehan, P.W. (2003). Hypnotic control of attention in the Stroop task: a historical footnote. *Consciousness and Cognition, 12*(3), 347-53. DOI: 10.1016/S1053-8100(03)00025-4.

Manson, S., Shore, J., & Bwosi, J. (1985). The depressive experience in American Indian communities: a challenge for psychiatric theory and diagnosis. In A. Kleinman & B. Good (Eds.), *Culture and Depression* (pp. 331-368). Berkeley, California: University of California Press.

McHugh, P. R., & Slavney, P. R. (1986). *The Perspectives of Psychiatry*. Baltimore, Maryland: The Johns Hopkins University Press.

Morgan, D. (1988). *Focus groups as qualitative research*. Newbury Park, California: Sage.

Morgan, A.H., & Hilgard, J.R. (1978). The Stanford Hypnotic Clinical Scale for adults. *The American journal of clinical hypnosis, 21*(2-3), 134-147.

Nash, M.R., & Barnier, A. (2008). The Oxford handbook of hypnosis. Oxford, UK: Oxford University Press.

Nash, M.R., & Benham, G. (2005). The truth and the hype of hypnosis. *Scientific American Mind*, *16*(2), 46-53.

Oakley, D.A., & Gandhi, B. (2005). Does 'hypnosis' by any other name smell as sweet? The efficacy of 'hypnotic' inductions depends on the label 'hypnosis'. *Consciousness and Cognition, 14*(2), 304-315.

Oakley, D.A., & Halligan, P.W. (2009). Hypnotic suggestion and cognitive neuroscience. *Trends in Cognitive Sciences, 13*(6), 264-270.

Oakley, D.A., & Halligan, P.W. (2013). Hypnotic suggestion: Opportunities for cognitive neuroscience. *Nature Reviews: Neuroscience, 14,* 565–576.

Orne, M.T., & O'Connell, D.N. (1967). Diagnostic ratings of hypnotizability. *International Journal of Clinical and Experimental Hypnosis, 215*, 125-133.

Page, R., Handley, G., & Green, J. (1997). Response expectancies and beliefs about hypnosis: Another look. *Contemporary Hypnosis*, *14*, 173–181.

Piccione, C., Hilgard, E., & Zimbardo, P. (1989). On the degree of stability and measured hypnotizability over a 25-year period. *Journal of Personality and Social Psychology, 56*, 289-295.

Pinnell, C., & Covino, N. (2000). Empirical findings on the use of hypnosis in medicine: a critical review. *International Journal of Clinical and Experimental Hypnosis, 48,* 168-192.

Pyun, Y.D., & Kim, Y.J. (2009). Norms of the Korean version of the Harvard Group Scale Of Hypnotic Susceptibility, Form A. *International Journal of Clinical and Experimental Hypnosis, 57*(1), 117-126.

Rainville, P, Hofbauer, R., Bushnell, M., Duncan, G., & Price, D. (2002). Hypnosis modulates activity in brain structures involved in the regulation of consciousness. *Journal of Cognitive Neuroscience*, *14*(6), 887–901.

Raz, A. (2004). Atypical attention: Hypnosis and conflict reduction. In Posner M. I. (Ed.), Cognitive Neuroscience of Attention (pp. 420-429). New York: Guilford Press.

Raz, A. (2007). Suggestibility and Hypnotizability: Mind the Gap. *American Journal of Clinical Hypnosis*, *49*(3), 205-210.

Raz, A. (2011). Hypnosis: a twilight zone of the top-down variety. *Trends in Cognitive Sciences*, *15*(12), 555-557.

Raz, A., & Buhle, J. (2006). Typologies of attentional networks. *Nature Reviews Neuroscience*, *7*, 367-379.

Raz, A., Shapiro, T., Fan, J., & Posner, M.I. (2002). Hypnotic suggestion and the modulation of Stroop interference. *Archives of General Psychiatry 59*(12), 1155–1161.

Roark, J., Barabasz, A., Barabasz, M., & Lin-Roark, I. (2012). An Investigation of Taiwanese Norms for the Stanford Hypnotic Susceptibility Scale: Form C (Mandarin Chinese Translation). *International Journal of Clinical and Experimental Hypnosis*, *60*(2), 160-174.

Roche, S., & McConkey, K. (1990). Absorption: Nature, assessment, and correlates. *Journal of Personality and Social Psychology*, *59*, 91-101.

Rubini, V. (1975). Theoretical bases for psychological testing. Bologna, Italy: Patron Editore.

Sanchez-Armass, O., & Barabasz, A. (2005). Mexican Norms for the Stanford Hypnotic Susceptibility Scale, Form C. *International Journal of Clinical and Experimental Hypnosis*, *53*(3), 321-331.

Sheehan, P., & McConkey, K. (1982). *Hypnosis and experience: The exploration of phenomena and process.* Hillsdale, New Jersey: Erlbaum.

Sheehan, P., & Perry, C. (1977). Methodologies of hypnosis. Hillsdale, New Jersey: Erlbaum.

Shor, R., & Orne, E. (1962). *The Harvard Group Scale of Hypnotic Susceptibility*. Palo Alto, California: Consulting Psychologists Press.

Shweder, R. (1985). Cross-cultural study of emotions. *Culture and depression: studies in the anthropology and cross-cultural psychiatry of affect and disorder* (pp. 182-214). Berkeley and Los Angeles, California: University of California Press.

Spanos, N.P. (1983). The Carleton University Responsiveness to Suggestion Scale (Group Administration). Unpublished manuscript. Carleton University: Ottowa, Ontario, Canada.

Spanos, N.P., & Chaves, J.F. (1991). History and historiography of hypnosis. In S. J. Lynn & J. W. Rhue (Eds.), *Theories of hypnosis: Current models and perspectives* (pp. 42-78). New York: Guilford Press.

Spiegel, H. (1974). Manual for hypnotic induction profile : eye-roll levitation method. New York: Soni Medica.

Stanghellini, G., & Raffaella, C. (2013). De Martino's concept of critical ethnocentrism and its relevance to transcultural psychiatry. *Transcultural Psychiatry, 50*(1), 6-20.

Temple, B. (1997). Watch your tongue: issues in translation and cross-cultural research. S*ociology, 31*(3), 607-618.

Temple, B., & Young, A. (2004). Qualitative research and translation dilemmas. *Qualitative Research*, *4*, 161-178.

Terhune, D., Cardeña, E., & Lindgren, M. (2010). Disruption of synaesthesia by posthypnotic suggestion: an ERP study. *Neuropsychologia*, *48*(11), 3360-3364.

Tseng, W. (2006). From Peculiar Psychiatric Disorders through Culture-bound Syndromes to Culture-related Specific Syndromes. *Transcultural Psychiatry*, *43*(4), 554-576.

Wagstaff, G. (1981). *Hypnosis, compliance, and belief*. New York: St. Martin's Press.

Weitzenhoffer, A. (1974). When is an instruction an instruction? *International Journal of Clinical and Experimental Hypnosis, 22,* 258-269.

Weitzenhoffer, A. (1978). Hypnotic susceptibility revisited. Paper presented at the 30th annual scientific meeting of the society for Clinical and Experimental Hypnosis, Asheville, North Carolina.

Weitzenhoffer, A. (1980). Hypnotic susceptibility revisited. *American Journal of Clinical Hypnosis, 22*, 130-146.

Weitzenhoffer, A., & Hilgard, E.R. (1959). *Stanford Hypnotic Susceptibility Scale: Forms A and B*. Palo Alto, California: Consulting Psychologists Press.

Weitzenhoffer, A., & Hilgard, E.R. (1962). *Stanford Hypnotic Susceptibility Scale: Form C*. Palo Alto, California: Consulting Psychologists Press.

Weitzenhoffer, A., & Hilgard, E.R. (1963). *Stanford Profile Scales of Hypnotic Susceptibility Scale: Form I and II*. Palo Alto, California: Consulting Psychologists Press.

Weitzenhoffer, A., & Hilgard, E.R. (1967). *Revised Stanford Profile Scales of Hypnotic Susceptibility Scale: Forms I and II*. Palo Alto, California: Consulting Psychologists Press.

Woody, E. Z., & Barnier, A. J. (2008). Hypnosis scales for the twenty-first century: What do we need and how should we use them? In M. R. Nash & A. J. Barnier (Eds.), *The Oxford handbook of hypnosis: Theory, research and practice* (pp. 255–281). Oxford, UK: Oxford University Press.

Young, A. (1980). The discourse on stress and the reproduction of conventional knowledge. *Social Science & Medicine*, *14B*(3), 133-146.

Zachariae, R., Sommerlund, B., & Molay, F. (1996). Danish norms for the Harvard group scale of hypnotic susceptibility, form A. *International Journal of Clinical and Experimental Hypnosis*, *44*(2), 140-152.

Appendix A

Table 1. Hypnotizability scales in use today.

Scale	Country of origin	Description
Stanford Hypnotic Susceptibility Scale: Form C (SHSS: C) (Weitzenhoffer & Hilgard, 1962)	USA	Gold standard for individual hypnotizability measure.
Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS: A) (Shor & Orne, 1962)	USA	Gold standard for group hypnotizability measure.
Stanford Hypnotic Susceptibility Scale: Forms A and B (SHSS: A and B) (Weitzenhoffer and Hilgard, 1959)	USA	The original version of Form C. These scales are essentially equivalent, with only slight changes in wording and procedure.
Davis – Husband Scale (Davis & Husband, 1931)	USA	While highly practical and covering a wide range of hypnotic behaviours, this scale did not meet minimal standards for scientific acceptability.
Friedlander – Sarbin Scale (Friedlander & Sarbin, 1938)	USA	Developed to better the Davis-Husband Scale. Includes more standardized items and scoring but problematic bimodal distribution and many extremely low scores.
Stanford Hypnotic Clinical Scale (SHCS) (Morgan & Hilgard, 1978)	USA	Brief scale suitable for individuals with limited movement. Designed to maximize the probability of a successful hypnotic experience and to provide useful clinical information.
Stanford Profile Scales of Hypnotic Susceptibility: Forms I and II (SPSHS: I and II) (Weitzenhoffer & Hilgard, 1963)	USA	Designed to provide a profile of hypnotic abilities, such as hallucinations and cognitive distortions.
Revised Stanford Profile Scales of Hypnotic Susceptibility: Forms I and II (R-SPSHS: I and II) (Weitzenhoffer & Hilgard, 1967)	USA	Revised SPSHS: I and II.
Stanford Hypnotic Arm Levitation Induction and Test (SHALIT) (Hilgard, Crawford, & Wert, 1979)	USA	A single item test, consisting of hypnotic induction/arm levitation, designed for clinical use and as a screening measure.
Creative Imagination Scale (CIS) (Barber & Wilson, 1978)	USA	Administration with or without hypnotic induction. Focuses on non-hypnotic suggestibility.
Barber Suggestibility Scale (BSS) (Barber & Wilson, 1978)	USA	Short scale, abandoned in favour of the CURSS.
Hypnotic Induction Profile (HIP) (Spiegel, 1974)	USA	Developed for clinical settings. Includes the controversial “eye roll test” which claims that highly hypnotizable subjects are better able to roll their eyes upwards while closing the lids.
Carleton University Responsiveness to Suggestions Scale (CURSS) (Spanos, 1983)	Canada	Short scale. Covers ideomotor and cognitive suggestions.
Waterloo Stanford Group Scale of Hypnotic Susceptibility (WSGS) (Bowers, 1993, 1998)	Canada	Group adaptation of SHSS:C modified for easier group presentation and self-scoring.
Warmth Suggestibility Scale (WSS) (Gheorghiou, Polczyk, & Kappeller, 2003)	Germany/Poland	Measures sensory suggestibility.
Gudjonsson Suggestibility Scale (GSS) (Gudjonsson, 1984)	UK	Measures interrogative suggestibility, which does not correlate with hypnotic suggestibility.

General Discussion

Control of cognition and emotion – required to achieve a hypnosis plane and targeted by attention training programs – involves the neural networks of attention (Posner & Rothbart, 2011). Consequently, some researchers have encouraged cognitive neuroscientists to use hypnosis as a lens to examine the development of attention (Raz, 2012). In addition, a growing number of publications employ hypnotic suggestion as a tool to explore the cognitive and biological substrates underlying normal and impaired psychological functions, including those related to the modulation of attention (for reviews see: Oakley, 2008; Oakley & Halligan, 2009). Some scholars even consider hypnosis an underexploited tool for possible neurocognitive rehabilitation due to its potential to reliably modulate performance at cognitive, behavioural and experiential levels (Oakley & Halligan, 2009). The scientific community is gradually delving into the opportunities and unrealized potential behind the shared qualities of hypnosis and attention training. Neuroscientists examining attention training and psychiatrists investigating cultural influences on hypnotic response would stand to benefit from such collaborations. Further research will likely aim to shed light on the potential pairing of these attentional mechanisms.

References

Oakley, D. A. (2008). Hypnosis, trance and suggestion: Evidence from neuroimaging. In M. R. Nash & A. J. Barnier (Eds.), *Oxford handbook of hypnosis: Theory, research and practice* (pp. 365–392). Oxford: Oxford University Press.

Oakley, D. A., & Halligan, P. W. (2009). Hypnotic suggestion and cognitive neuroscience. *Trends Cogn Sci, 13*(6), 264-270. doi: 10.1016/j.tics.2009.03.004

Posner, M. I., & Rothbart, M. K. (2011). Brain states and hypnosis research. *Conscious Cogn, 20*(2), 325-327. doi: 10.1016/j.concog.2009.11.008

Raz, A. (2012). Hypnosis as a lens to the development of attention. *Conscious Cogn, 21*(3), 1595-1598. doi: 10.1016/j.concog.2012.05.011