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Evidence-informed occupational therapy interventions for children with developmental coordination disorder

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EVIDENCE-INFORMED OCCUPATIONAL THERAPY INTERVENTIONS FOR CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER

by

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ABSTRACT

Children with developmental coordination disorders (DCD) inherently have neuromotor disruptions that impact their functional performance (Watemberg et al., 2007). The prevalence of developmental coordination disorder is high among children with diagnoses such as ADHD and autism (Maciver et al., 2011). DCD presents with motor coordination problems, visual motor integration difficulties, sensory processing differences, and communication and behavior challenges. These difficulties lead to specific learning delays that affect reading, writing, and math as well as related mental health problems.

There is an emerging body of evidence substantiating the need for effective diagnosis, which would lead to improved management of the population. Evidenced-based occupational therapy interventions for children with DCD are limited, which impacts the training opportunities for occupational therapists who are interested in using effective interventions in their practice. The literature highlights the Cognitive Orientation to daily Occupational Performance (CO-OP) method as the only evidence-based practice intervention method, however sensory integration treatment is the preferred treatment used by 90% of pediatric occupational therapists in the United States

(AOTA, 2015b). Although there is limited evidence supporting popular interventions such as sensory integration, neurodevelopmental therapies, and deficit-oriented interventions, there is a growing interest and desire for ways to address the needs of the DCD population. Consistent themes throughout the literature are to promote awareness and develop appropriate evidence-based interventions for children being diagnosed with DCD.

I propose that this clinical gap can be remediated by providing an evidence-informed, multi-faceted intervention model that is supported by current neuroscience research. With growing bodies of literature in the neuroscience research community, I propose using an integrated model such as the Margow Model (Margow, 2014). The model integrates several philosophies of treatment that can be easily implemented with a clear plan of intervention. Occupational therapists need an accessible tool that incorporates task-oriented interventions, sensory processing strategies, cognitive strategies and functional activities that can be carried over into daily living skills.

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LIST OF ABBREVIATIONS

BU ..... Boston University

DCD ..... Developmental Coordination Disorder

OT ..... Occupational Therapist

GLOSSARY

Adaptive Response: An appropriate response to an environmental demand. Adaptive responses demonstrate adequate sensory integration and drive all learning and social interactions.

Auditory Perception: The ability to receive, identify, discriminate, understand and respond to sounds.

Bilateral Coordination: The ability to use both sides of the body together in a smooth, synchronized, and coordinated manner.

Bilateral Integration: The neurological process of integrating sensations from both body sides; the foundation for bilateral coordination.

Body Awareness: The identifying of one's own body parts: where they are, how they interrelate, and how they move.

Co-contraction: All muscle groups surrounding a joint contracting and working together to provide joint stability, resulting in the ability to maintain position and balance.

Depth Perception: The ability to judge relative distances between objects, or between oneself and objects. Also affects ability to see objects in three dimensions.

Directionality: The awareness of directions (right/left, forward/back, and up/down), and the ability to move oneself in those directions.

Discriminative System: The component of a sensory system that allows one to identify differences among stimuli. This system is not innate but develops with time and practice.

Dyspraxia: Difficulty in planning, sequencing, and carrying out unfamiliar actions in a skillful manner. Poor motor planning is the result of dyspraxia.

Eye-Hand Coordination: The efficient teamwork of the eyes and hands, necessary for activities such as playing with toys, dressing, and writing.

Equilibrium: A term used to mean balance.

Extension: A straightening action of a joint (neck, back, arms, legs).

Fight-Or-Flight Response: The instinctive reaction to defend oneself from real or perceived danger by becoming aggressive or by withdrawing.

Figure-Ground Perception: The ability to perceive a figure in the foreground from a rival background.

Fine Motor Coordination: Referring to refined movement of the muscles in the fingers, toes, eyes and tongue.

Fine Motor Skills: The skilled use of one's hands in a smooth, precise and controlled manner. Fine motor control is essential for efficient handling of classroom tools and materials. It may also be referred to as dexterity.

Fixation: The ability to aim one's eye at an object and maintain gaze or shifting one's gaze from one object to another.

Flexion: A bending action of a joint or a pulling in of a body part.

Form Constancy: Recognition of a shape regardless of its size, position, or texture.

Gravitational Insecurity: The fear and anxiety of falling when one's head position changes.

Gross Motor Coordination: Movements of the large muscles of the body.

Gross Motor Skills: Coordinated body movements involving the large muscle groups. Activities requiring this skill include running, walking, hopping, climbing, throwing and jumping.

Habituation: The neurological process, which allows the tuning out of familiar sensations.

Hand Preference: Right - or left handedness, which becomes established in childhood as early as the age of 3, however does not become well established until the age of 8 or 9.

Hypersensitivity: (also Hyper-reactivity or Hyper-responsiveness). Oversensitivity to sensory stimuli, characterized by a tendency to be either fearful and cautious, or negative and defiant.

Hyposensitivity: (also Hyporeactivity or Hyporesponsiveness). Undersensitivity to sensory stimuli, characterized by a tendency either to crave intense sensations or to withdraw and be difficult to engage.

Kinesthesia: The conscious awareness of joint position and body movement in space, such as knowing where to place one's feet when climbing stairs, without visual cues.

Lateralization: The process of establishing preference of one side of the brain for directing skilled motor function on the opposite side of the body, while the opposite side is used for stabilization. Lateralization is necessary for establishing hand preference and crossing the body midline.

Modulation: The brain's ability to regulate its own activity.

Motor Control: The ability to regulate the motions of one's muscle groups in order to work together harmoniously to perform movements.

Motor Coordination: The ability of several muscles or muscle groups to work together harmoniously to perform movements.

Motor Planning: The ability to conceive of, organize, sequence, and carry out an unfamiliar or complex body movement in a coordinated manner, a component of praxis.

Muscle Tone: The degree of tension normally present when one's muscles are relaxed, or in a resting state.

Neuroplasticity: The ability of the brain to change or to be changed as a result of activity, especially as one responds to sensations.

Perception: The meaning the brain attributes to sensory input.

Position in Space: Awareness of the spatial orientation of letters, words, numbers, or drawings on a page, or of an object in the environment.

Postural Adjustments: The ability to shift one's body in order to change position for a task.

Postural Insecurity: A fear of body movement that is related to poor balance, and deficient "body and spatial" awareness.

Postural Stability: The ability to maintain one's body in a position to efficiently complete a task or demand, using large muscle groups at the shoulders and hips.

Praxis: Praxis is a broad term denoting voluntary and coordinated action. The ability to interact successfully with the physical environment; to plan, organize, and carry out a sequence of unfamiliar actions; and to do what one needs and wants to do. Motor planning is often a used as a synonym.

Prone: A horizontal position of the body where the face is positioned downward.

Proprioception: The unconscious awareness of sensations coming from one's joints, muscles, tendons, and ligaments that aids in knowing where one is in space; the "position sense".

Self-Care Skills: Competence in taking care of one's personal needs, such as bathing, dressing, eating, and grooming.

Self-Regulation: The ability to control one's activity level and state of alertness, as well as one's emotional, mental or physical responses to senses; self-organization.

Sensorimotor: Pertaining to the brain-behavior of taking in sensory messages and reacting with a physical response.

Sensory Defensiveness: A child's behavior in response to sensory input, reflecting severe over-reactions or a low threshold to a specific sensory input.

Sensory Diet: The multisensory experiences that one normally seeks on a daily basis to satisfy one's sensory appetite; a planned and scheduled activity program that an occupational therapist develops to help a person become more self-regulated.

Sensory Input: The constant flow of information from sensory receptors in the body to the brain and spinal cord.

Sensory Integration: The normal neurological process taking in information from one's body and environment through the senses, of organizing and unifying this information, and using it to plan and execute adaptive responses to different challenges in order to learn and function smoothly in daily life.

Sensory Integrative Dysfunction: The inefficient neurological processing of information received through the senses, causing problems with learning, development and behavior.

Sensory Integration Theory: A concept based on neurology, research and behavior that explains the brain-behavior relationship.

Sensory Integration Treatment: A technique of occupational therapy, which provides playful, meaningful activities that enhance an individual's sensory intake and lead to more adaptive functioning in daily life.

Sensory Modulation: Maintenance of the arousal state to generate emotional responses, sustain attention, develop appropriate activity level and move skillfully.

Sensory Processing Skills: The ability to receive and process information from one's sensory systems including touch (tactile), visual, auditory (hearing), proprioceptive (body position) and vestibular (balance). Behavior, attention and peer interactions are greatly influenced by the child's ability to process sensory stimuli.

Sensory Registration: Initial awareness of a single input.

Sensory Threshold: The level of strength a stimulus must reach in order to be detected. This is the mechanism that drives our reactions to sensory input and whether we over-react or under-register the input.

Spatial Awareness: The perception of one's proximity to or distance from an object, as well as the perception of the relationship of one's body parts.

Supine: A horizontal body position where the face is positioned upward.

Tactile: Refers to the sense of touch and various qualities attributed to touch: including detecting pressure, temperature, light touch, pain, and discriminative touch.

Tactile Defensiveness: The tendency to react negatively and emotionally to unexpected light touch sensations.

Tracking: Following a moving object or a line of print with the eyes.

Vestibular: The sensory system that responds to changes in head and body movement through space, and that coordinates movements of the eyes, head, and body. Receptor site is in the inner ear. Gravitational Insecurity is a function of the vestibular system.

Visual Discrimination: Differentiating among symbols and forms, such as matching or separating colors, shapes, numbers, letters, and words.

Visual Figure-Ground: Differentiation between objects in the foreground and in the background

Visual-Motor: Referring to one's movements based on the perception of visual information.

Visual Motor Skills: The ability to visually take in information, process it and be able to coordinate your physical movement in relation to what has been viewed. It involves the combination of visual perception and motor coordination. Difficulty with visual motor skills can result in inaccurate reaching, pointing and grasping of objects, as well as difficulty with copying, drawing, tracing and cutting.

Visual-Perception: The ability to perceive and interpret what the eyes see.

Visual Perceptual Skills: The ability to interpret and use what is seen in the environment. Difficulties in this area can interfere with a child's ability to learn self-help

skills like tying shoelaces and academic tasks like copying from the blackboard or finding items in a busy background.

Visual-Spatial Processing Skills: Perceptions based on sensory information received through the eyes and body as one interacts with the environment and moves one's body through space. Including: Depth perception, directionality, form constancy, position in space, spatial awareness, visual discrimination, visual figure-ground.

CHAPTER 1 - Introduction

Developmental Coordination Disorder is a well-documented but under-diagnosed disorder in the pediatric population. According to the CDC, 1 in 6 children or 15% of the population between the ages of 3 through 17 years have one or more developmental disabilities across diverse populations (CDC, 2015a). Of these varying disabilities up to 6% of children have a diagnosed developmental coordination disorder influencing their daily function (Watemberg, Waiserberg, Zuk, & Lerman-Sagie, 2007). Developmental Coordination Disorder often exists as a co morbid diagnosis with other diagnoses such as Autism, Learning Disabilities, and Attention Deficit Disorders. Additionally, there are children that are still undiagnosed and struggling with similar challenges to children with identified with DCD.

The need for intervention is increasing however occupational therapy treatments are not evolving at the rate needed to address this population (Rosenberg, Zhang, & Robinson, 2008). According to the New York Times (Harris, 2015), occupational therapy referrals have increased between 20–30% in the past 4 years but there are not enough therapists to meet the demand, making it harder for occupational therapists to provide typical 1:1 intervention. Missiuna et al. (2012) have proposed a school based delivery model to meet the need; this model emphasizes a partnership between educators and occupational therapists to provide a continuum of services. As the need increases, service delivery can be performed in many ways, including training educators and therapy teams in methods that facilitate improved occupational engagement and participation of children with DCD (AOTA, 2015b). According to a statement published by American

Occupational Therapy Association on intervention methods (such as sensory integration techniques) in school based practice, occupational therapists :

> "may provide professional development to educators to support the delivery of scientifically based instruction or interventions and, if state professional regulations allow, evaluations, services, and supports to general education children to increase their performance in general education. This encourages occupational therapy practitioners to provide systems (i.e., school wide) and team approaches as well as, possibly, individual services to enhance general education performance. For example, an occupational therapist may provide professional development based on SI theory and methods to general education teachers regarding ways to modify or adapt the environment and context to support participation and engagement in the classroom or on the playground" (AOTAb, 2015, p. 2).

Problem: At this time occupational therapists lack a comprehensive, evidenced-informed model of occupational therapy intervention for DCD that can be easily trained and replicated into broader educational programs. The goal of this project is to assess whether there is neuroscientific evidence to support such a therapeutic model – the Margow model – that uses an intensive, combined bottom-up and top-down approach to treatment.

Developmental Coordination Disorder

DCD presents with motor coordination problems, visual motor integration difficulties, sensory processing differences, communication and behavior challenges. As

these difficulties impact a child's development, the neurological system compensates, leading to specific learning delays that affect reading, writing, and math and cause related mental health problems.

Children with developmental coordination disorders (DCD) have neuromotor disruptions that impact their functional performance (Watemberg et al., 2007). The Diagnostic and Statistical Manual of Mental Health Disorders (5th ed.; *DSM-5*; American Psychiatric Association, 2013) classifies DCD as a discrete motor disorder under the broader heading of neurodevelopmental disorders. The specific *DSM-5* criteria for DCD are as follows:

- "Acquisition and execution of coordinated motor skills are below what would be expected at a given chronologic age and opportunity for skill learning and use; difficulties are manifested as clumsiness (e.g., dropping or bumping into objects) and as slowness and inaccuracy of performance of motor skills (e.g., catching an object, using scissors, handwriting, riding a bike, or participating in sports)
- The motor skills deficit significantly or persistently interferes with activities of daily living appropriate to the chronologic age (e.g., self-care and self-maintenance) and impacts academic/school productivity, prevocational and vocational activities, leisure, and play
- The onset of symptoms is in the early developmental period
- The motor skills deficits cannot be better explained by intellectual disability or visual impairment and are not attributable to a neurologic condition affecting

> movement (e.g., cerebral palsy, muscular dystrophy, or a degenerative disorder)" (Black & Grant, 2014, p. 52).

In summary the research identifies the following problems:

(1) Poor diagnosis of children with DCD leads to lack of referrals to occupational therapists. Medical practitioners tend to diagnose ADHD or Autism as a global medical diagnosis. Occupational and physical therapists are more aware of DCD as a functional diagnosis. If a child is not referred to a therapist, the DCD symptomology may be easily missed. (2) Lack of enough published evidence based practice related to treating clients with DCD. In today's medical and economic climate, parents, teachers and payers would like to see evidence behind programs before committing to a program. (3) There are few programs available to occupational therapists that help therapists understand integrated, comprehensive, intensive treatment models and how to implement them effectively with children with DCD. (4) Lack of funding to implement intensive, integrated programs into school systems or private practices. Historically insurance companies have not covered DCD as a medical diagnosis (Werner et al. 2012, Decker, 2011).

Within the larger therapeutic community, speech language pathologists, psychologists and physical therapists are measuring brain function in relation to their treatments and theories, resulting in comprehensive, neuroscientific based understanding of how and why the brain responds to various stimuli (Ylinen & Kujala, 2015). Occupational therapy may benefit from similar research, allowing for the development and training of a neurologically based therapeutic program that can be easily trained and replicated, with a strong foundation for research. Such a program affords occupational

therapists the opportunity to address the needs of children with developmental disabilities, such as DCD, in a manner that is supported by neuroscientific research (Burns, 2013). Occupational therapists have an opportunity and obligation to be front and center of this increasing need. Occupational therapists have the tools and training to assess, treat and accommodate the needs of varying populations both in schools and the private sector as well as bridging the gap between the two. Dr. Jean Ayres, noted occupational therapist and educational psychologist (1920–1989), authored test batteries and treatment theories in the area of sensory integration dysfunction – a significant factor in the etiology of children with DCD. In doing so, she redefined how we look at the relationship between the brain and the body; and the impact that processing information has on behavior, play and learning. Current research shows that sensory integration theories and methods are highly effective in addressing sensory processing and behavioral difficulties present in children with motor coordination disorders (Lane & Schaaf, 2010). When written into the IEP, students can benefit academically from sensory motor and sensory integration techniques (Parham et al., 2011). Although the research supports these interventions, the reality of implementing school wide services is limited by lack of resources, time constraints and poor carryover by teachers who may not have adequate training to support their students with such difficulties.

A brief look at intervention

Based on my clinical experience, an integration of varying therapeutic approaches can provide an effective intervention approach for children with DCD, positively impacting their occupational performance and engagement in school, home, and other

meaningful life contexts. However, to my knowledge, there has not been research that investigates an integration of such approaches to provide a more comprehensive occupational therapy intervention for children with DCD. In order to address these concerns, pediatric occupational therapists currently utilize interventions such as sensory integration techniques, the Cognitive Orientation to Daily Occupational Performance approach, neuromotor task training (NTT), goal oriented group interventions, exercise programs, visual perceptual training, motor coordination treatments, and compensatory strategies (Armstrong, 2012; Watemberg et al., 2007). Occupational therapy researchers such as Missiuna et al. (2012), Armstrong (2012), and Martini, Mandich, and Green (2014) are investigating various interventions and techniques for children with DCD. Many of these studies conclude that there is little research to substantiate the validity of various theories currently being used to facilitate intervention for children with DCD.

The Margow model is based on a combination of sensory integration, cognitive and motor control theories that suggest neurological changes occur through brain plasticity (Diaz Heijtz & Forssberg, 2015). As developed through clinical work and copyrighted in 2014, this intervention approach uses a combined bottom up and top down process of treatment opportunities (Margow, 2014). By using a clear, well-defined track of interventions in the specific order outlined below, the therapist is given the tools to facilitate significant change in the child's processing ability. As information processing, sensory integration and motor learning becomes more efficient, the child is able to learn more effectively resulting in fewer delays and improved functional performance.

In this treatment model, there are five levels of goal development that are

activated before functional goals such as activities of daily living and academic goals are addressed:

- Step 1 addresses sensory modulation/ feeling safe in one's environment.
- Step 2 addresses auditory/visual/vestibular function
- Step 3 addresses motor co ordination
- Step 4 addresses communication
- Step 5 addresses functional activities of daily living.

This model promotes an integrated approach within the classroom, home and therapeutic environments, thereby addressing the individual and system-wide needs of the students, educators, and school.

This project proposes the opportunity (1) to start the critical conversation of whether and how occupational therapy treatment facilitates brain changes and (2) to stimulate further research of intensive, evidenced-informed occupational therapy intervention using a combination of task-oriented and process-oriented therapeutic approaches (Howlin, 2011). Having a comprehensive, evidenced-based model of treatment with motor and sensory integration theories underlying the model is an important step toward supporting this population.

This is how I propose addressing the problem:

(1) Identifying neuroscientific research directly related to occupational therapy treatment and DCD interventions.

(2) Identifying research to support the Margow Method: A Step – up approach to

treatment (Sensory Integration simplified). Using sensory integration and sensory-motor theories and techniques to facilitate learning skills related to processing, motor skills and communication. Identifying research to support a bottom up, intensive therapy approach in pediatrics.

(3) Disseminating the findings of the project by publishing an article in SIS or OT practice and presenting at the AOTA conference 2018.

As children with behavioral, sensory processing challenges and developmental coordination disorders enter academic settings that cannot accommodate their needs, their ability to participate in academic activities of daily living is impeded (Baranek et al., 2002). This adversely affects family dynamics and the teacher's ability to teach, leading to high levels of frustration in the child (Camden, Wilson, Kirby, Sugden & Missiuna, 2014). Providing the individual client with a well-planned therapeutic plan will facilitate improved intervention within the IEP process in educational settings, or intensive programs in the clinic setting. Although the AOTA supports this method of occupational therapy intervention, many occupational therapy practitioners and assistants do not have the knowledge to implement sensory-motor/sensory integration strategies effectively. There appears to be less support from school administrators and payers who may not recognize the value of an integrated program that therapists and teachers can implement as an academic team. The Margow model can be easily trained and replicated into educational areas.

Secondly, this project has value to the individual clinician by providing a therapeutic tool to use with their clients in clinical settings. Developing and researching a

therapeutic model of intervention that uses a scientifically-sound neurological measurement can address the growing need for intervention in our pediatric population. It also provides an educational tool for the consulting therapist whose client base is parents and educators working directly with their children. As this model becomes widely accessible, the occupational therapist can be recognized as an effective, research-supported professional in child development. As the scope of intervention increases to the wider pediatric population, having an evidence base to support such a program can facilitate improved knowledge across disciplines in the medical community as a whole. Educators and administrators are more inclined to support a program if there is scientific evidence supporting the success of the program. The AOTA has "identified children and youth as a key practice area for the 21st century" (AOTA, 2015, "Children and Youth", par. 1) to support the Centennial Vision. My goal is that this project will contribute to that effort.

Finally, as children begin to learn more effectively, their behaviors become manageable. As communities understand the importance of these programs, intervention can shift from being hopeful to becoming impactful. The more effective children are at learning, the more productive they become in society. Productive members of society become contributors positively impacting public health (Glassel et al., 2011).

CHAPTER 2 - Theoretical and Evidence Base to Support the Project

Problem Overview

This chapter consists of two main sections. The first provides an overview of the problem and the theoretical base supporting the project. Developmental Coordination Disorder is a well-documented but under-diagnosed disorder in the pediatric population. According to the CDC, 1 in 6 children or 15% of the population between the ages of 3 through 17 years have one or more developmental disabilities across diverse populations (CDC, 2015b). Of these varying disabilities up to 6% of children have a diagnosed developmental coordination disorder influencing their daily function (Watemberg et al., 2007). Developmental Coordination Disorder often exists as a co morbid diagnosis with other diagnoses such as Autism, Learning Disabilities, and ADHD. Additionally, there are children that are still undiagnosed and struggling with similar challenges to children with DCD.

The need for intervention is increasing however occupational therapy treatments are not evolving at the rate needed to address these populations (Rosenberg, Zhang, & Robinson, 2008). The first part of this chapter will present a proposed theoretical explanatory model that outlines the factors influencing the problem. The second section synthesizes the current research, drawing on the evidence to substantiate existing interventions that are or are not supported by the research. The research is separated into studies evaluated before 2010 and those published from 2011 through 2016. The evaluation of the evidence identifies inherent problems that affect how occupational

therapists manage the evaluation and treatment of children with developmental coordination disorder.

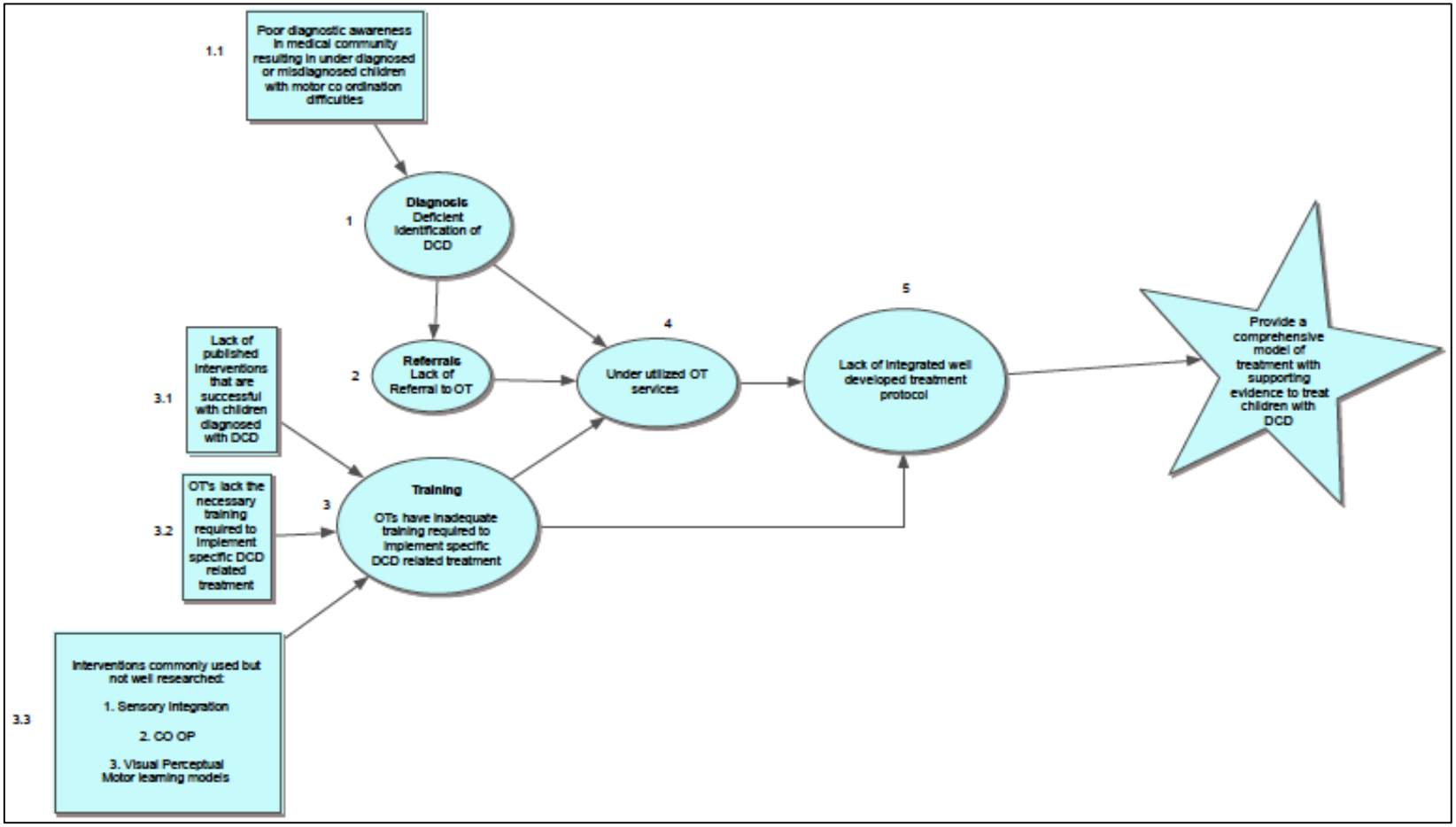
Overview of the Problem

Developmental Coordination Disorder is a diagnosis that most occupational therapists have encountered in their practice (Reeves & Cermak, 2002), however it is not a primary diagnosis that gets referred for OT services by psychologists or doctors. Treatment for DCD is not commonly sought out by medical professionals due to their lack of understanding that it frequently co-exists with other diagnoses such as ADHD and Autism. The result is an under- or misdiagnosis of DCD leading to fewer referrals for OT services either in the school or outpatient settings.

Figure 2.1 depicts a representation of underlying factors affecting diagnosis, referral and intervention that affect the management of children with DCD (1.1). Occupational therapists may know DCD as apraxia/developmental dyspraxia, however they are in fact distinct diagnoses (APA, 2013). Because DCD is a disorder with unknown etiology (Brown-Lum & Zwicker, 2015), but presents with a deficit in learning motor skills, determining effective intervention is challenging. Children presenting with these motor coordination difficulties are commonly treated (3.3) using (1) sensory integration techniques, visual perceptual motor procedures (process-oriented intervention) or (2) cognitive based programs such as the CO-OP (task-oriented interventions) (Dewey & Wilson, 2001). The need for integrated, evidence-informed interventions is critical to manage the growing needs of children exhibiting these symptoms, however occupational therapy practitioners often lack the necessary training

needed to treat DCD systematically (3.2). The literature shows that there is not a comprehensive, integrated model of treatment that is accessible and easy to implement specifically for children with DCD (5). These factors influence the lack of occupational therapy services for children with DCD (4). It is valuable therefore to provide a comprehensive model of treatment with supporting evidence to treat children with DCD. This project will present such a model: the Margow Model (Margow, 2014).

Figure 2.1: Factors affecting the proposed problem



Theoretical and conceptual frameworks to understand the identified problem

Two theoretical frameworks were used to define and understand the problem. **The Ottawa Model of Research Use** offers a dynamic approach that outlines 6 key elements involved in guiding the implementation of an evidenced-based intervention. The second theory discussed in this chapter is **Contemporary Motor Control Model** based on a *systems* model, and is an explorative way of looking at motor control.

The OMRU

The Ottawa Model of Research Use (Logan & Graham, 2010) provides a lens through which the factors for the clinical problem described in the visual model can be viewed. The goal of the OMRU is to use the elements discussed below to assess, monitor and evaluate the research behind innovation that is being adopted into practice (Logan & Graham, 2010). The first 3 elements are essential to the acceptance and uptake of the practice innovation.

The visual model (Figure 1) identifies four main factors that have led to the lack of an integrated occupational therapy intervention model for children with DCD. These factors are: under diagnosis, lack of referrals, lack of training for OT intervention, and lack of an accessible, integrated intervention. The first three elements of the OMRU are used to guide our understanding of the clinical problem by identifying barriers and gaps between the four main factors and the clinical problem.

The 6 elements of the OMRU model are briefly described as follows:

1. **The Research Informed Innovation** relates to the new evidence-based intervention that can be adopted by the user (The Margow Model). By starting

with this first of the element, to identify innovation attributes, the adopter can process the degree of use and evaluate the impact of the innovation. It also allows for a view of why there is a breakdown on the pathway between the adopters (3) (OTs), (4) underutilization and (5) implementation of intervention. For example, the literature indicates a lack of published occupational therapy interventions (3.1), a lack of the appropriate intervention training for occupational therapists (3.2), and limited research evidence for commonly used interventions (3.3). These factors impact adequate training for occupational therapists working with children with DCD (3). The barriers created by lack of published interventions (3.1), interventions commonly used but not well researched (3.3) and training (3) can influence the potential adopters' perceptions of the importance of the innovation and prevent innovation adoption. These barriers must be addressed through raising awareness, education, and facilitating adoption of the innovation.

2. **Potential adopters** include potential users of an intervention. Within this element are 3 sub elements: (a) awareness of the specific practice innovation, (b) intention to adopt the innovation, and (c) concerns about the innovation. It allows for exploration of the intentions of the adopters whilst identifying the potential barriers to adopting an innovation. This element relates to factors 2 and 3 of the visual model where the potential adopters are occupational therapists. Lack of referrals (2), published interventions (3.1), and necessary training (3.2) affect the awareness of and intention to adopt the innovation. Current interventions are still limited by lack of research (3.3) affecting adoption of practice.

3. **The practice environment** includes many environmental factors that affect professional standards and medico-legal issues. An important sub element is "current practice" which looks at the gap between how care is being provided now compared to what the research is recommending, whilst providing information about potential barriers to implementing the intervention. This relates to 1 through 5 of the visual model through exploring why there is a deficient diagnosis (1) leading to lack of referrals (2), lack of training and research (3), and adopters' levels of awareness, knowledge and skills (4, 5) that are impacting the use of evidence-informed occupational therapy intervention for children with DCD.
4. **Implementation interventions for transferring the research findings into practice.** This element focuses on how implementation is transferred to the potential adopters by ensuring that they have the appropriate strategies and skills to know how to apply the intervention appropriately. There are three categories that the OMRU identifies: a) barrier management strategies reduce or illuminate identified barriers b) passive and active implementation strategies ensure that the adopters (OTs) have the necessary skill to apply the intervention and c) follow up activities ensure adopters can sustain the intervention successfully. Follow up also addresses the fidelity of the intervention to ensure that the original intention is still maintained and mastered. The implementation intervention element of the OMRU relates to factor 5 of the visual model by providing information on why potential programming indicated in the research has not transferred successfully

from the research into practice. This element of the OMRU monitors effectiveness of current research into practice. It assists in identifying whether the breakdown is in training (3) or lack of an integrated intervention.

5. **The adoption of the innovation** addresses the sequential actions that an adopter uses to initially try the intervention and then continue using it. This element also explores how the adopter applies the innovation to their practice consistently.
6. **Health related and other outcomes** relates to the impact of the innovation. The outcome element of the OMRU looks at whether the expected impact of the innovation on patients, practitioners, financial and systems was realized.

Contemporary Motor Control Model

The contemporary motor control model is an explorative way of looking at motor control and is based on a *systems* model. Crutchfield and Barnes (1993) discussed the systems model as a heterarchical model that incorporates several factors interacting together to contribute to a dynamic whole, resulting in the "spontaneous occurrence of complex motor actions of person, task, and environment" (Kielhofner, 2009, p. 178). The model allows for the inclusion of looking at environmental influences that plays a role in motor learning.

Occupational therapists commonly use motor control theories in their intervention (Kielhofner, 2009). Gesell (1954) and McGraw (1945) developed the traditional neuromaturational theory of motor development, which suggested that as the nervous system matured, changes in neural structure caused changes in motor development. This

theory was traditionally overlooked by occupational therapists, as the theory implied that the therapist's interventions and child's experiences had little effect on motor development. Developmental sequences were also a part of this theory – Gesell (1954) discussed that children must progress through various levels of development in a particular sequence of events: a cephalo caudal and proximal to distal sequence. Bobath (1978) and Rood (1954) further developed the theory into an organizing framework for treatment known as Bobath's NDT (neurodevelopmental techniques) and Rood's approach respectively.

Though the evolution of understanding the nervous system, theories have advanced from traditional to contemporary approaches. Traditional theories had many limitations whereas contemporary theories are more flexible and incorporate multiple factors and systems that influence the various neurological changes proposed. In 1988, Schmidt defined motor learning as "a set of processes associated with practice or experience leading to relatively permanent changes in the capabilities of responding" (p. 346). Higgins (1991) then proposed an alternative way of looking at motor skill acquisition. She looked at a dynamical systems model of motor control, which suggests that clients are problem solvers and use their characteristics and resources to interact meaningfully with the environment. Newell (1996) suggested that there were multiple unique systems that facilitated task performance and were affected by a person's own characteristics. Closed and open loop systems work together to create feed forward and feedback loops. This proposed model was developed using occupational therapy terminology and framed by Mathiowetz and Haugen (1994) incorporating subsystems

that influenced occupational performance. These models have significantly influenced how motor development and learning theories have evolved.

Contemporary motor control theory has been articulated by Bass-Haugen, Mathiowetz, & Flinn (2008), Mathiowetz and Bass-Haugen (1994, 1995, 2002), and Radomski, Trombly, and Latham (2008). Kielhofner (2009) succinctly describes the theory as:

The CNS is viewed as a heterarchically organized system with higher and lower centers interacting cooperatively with each other and the musculoskeletal system. Moreover movement patterns are understood not as invariant sequences "prewired" into the CNS but as stable ways to accomplish occupational performance … Hence learning is dependent on the characteristics of the performer, the context, and the task being performed. (p. 187).

As motor theory has developed into multi system structures, various professions are continuing to research how motor control and development can be used to create effective programs and treatment protocols. De Ste Croix and Korff (2012) published *Paediatric biomechanics and motor control: Theory and application* and Rukavina, Randell and Foxworth (2009) developed teaching approaches using motor learning theory and occupational therapists.

Zwicker and Harris (2009) continue to look at whether motor learning theory offers a contribution to evidence-based pediatric occupational therapy practice. Zwicker and Harris have reflected on how motor learning theory has been successfully used in occupational therapy practice. They focused their discussions on modern theories

developed in the fields of physical education and sports in the 1970s, neurological rehabilitation during the 1980s that applied mainly to adult rehabilitation, and more recently to research relating to developmental coordination disorder (Missiuna, Mandich, Polatajko, & Malloy-Miller, 2001). They present main principles of major motor learning theories, and the implications and applications of these theories in occupational therapy practice. They conclude with a discussion of implications for practice and directions for future research. The key elements derived from their discussions are:

1. Motor learning theory is not clear or simple but can be an effective theory to incorporate in pediatric practice.
2. There is preliminary evidence to support functional gains in children with DCD and CP using contemporary motor learning theory, indicating the wide variety of populations that can be treated using such a theory.
3. The CO-OP is potentially a strong model that incorporates the principles of the theory well.
4. OTs may be applying motor learning theory tacitly without a formal model of motor learning practice.

The authors conclude that we have a rich history of motor learning theory that is under-utilized in pediatric occupational therapy treatment (Zwicker & Harris, 2009). They suggest that because we use the dominant sensory integration and neurodevelopmental theories, we may not be looking at motor learning theory as a cohesive practice model based on motor learning principles. There is great potential for pediatric occupational therapists to research and develop well-defined theories of practice based on motor

learning theory.

Both theories presented in this chapter provide the groundwork for understanding the factors affecting the adoption of an intervention innovation, and the literature that describes how motor control theories are being used within current evidence-based practice. The next part of this chapter synthesizes the evidence, which validates the problems and supports the theory that children with DCD can benefit from a multi-faceted intervention approach. Recognition of the need for evidence-informed interventions will be discussed in depth in the next section, with a focus on how the research distinguishes between task-oriented and process-oriented interventions. The section will conclude with a discussion of the contributions that neuroimaging techniques can bring to occupational therapy practice.

Evidence for Proposed Explanatory Model of Identified Problem

Within the field of pediatric occupational therapy, there is insufficient evidence to substantiate the use of the current intervention models in treating children with developmental coordination disorder. Through my clinical practice, I have observed that there is poor awareness in the medical community regarding the effective identification of developmental coordination disorder (DCD), and I propose that occupational therapists lack the necessary training to effectively treat this population. This section examines the literature related to the factors that I believe are influencing the lack of a well-developed, integrated treatment model for children with a primary DCD diagnosis. The explanatory model looks at three influencing factors. The first factor relates to misidentification or

lack of identification of DCD by the referring physicians, which influences the second factor: a lack of referrals to occupational therapists for intervention. The third factor focuses on the lack of training available to occupational therapists specifically for DCD intervention. The insufficient training may be influenced by a lack of published evidence on effective intervention, lack of access to training, and lack of supporting evidence for effective outcomes of the common interventions used to treat this population (e.g., sensory integration, NTT, Cognitive Orientation to daily Occupational Performance, visual perceptual and motor learning models).

With a significant rise (5–6%) in the identification of DCD within the elementary school population (Zwicker, Missiuna, Harris, & Boyd, 2012) and an increase in awareness and understanding of DCD, Henderson and Geuze (2015) reflect on the theoretical and practical problems that researchers and practitioners are experiencing with regard to this emerging diagnosis. They report disagreements about terminology and the use of the DCD diagnosis amongst various professionals. For example, the DSM-V (American Psychiatric Association, 2013) identifies "developmental coordination disorder" whereas the ICD-10 (World Health Organization, 1993) uses "specific disorder of motor function" to describe motor function difficulties. The lack of specificity of how and when to diagnose a child with DCD impacts referrals to occupational therapists. When occupational therapists do receive a referral, they typically use process-oriented and/or task-oriented interventions (Schoemaker & Smits-Engelsman, 2015). However, there is limited evidence of the effectiveness of these interventions. This prompts the question of whether therapists lack *access* to training, or are *inadequately* trained to

address the specific deficits related to these motor deficits.

In order to evaluate the accuracy of the proposed visual model, a review of the literature was completed to determine whether there is evidence to support the following 6 questions:

1. Is there evidence that developmental coordination disorder is overlooked as a diagnosis in the medical community?
2. Is there evidence demonstrating a lack of referrals for children with developmental coordination disorder (DCD) for occupational therapy treatment?
3. Is there evidence that occupational therapists lack evidence to support effective interventions for children with DCD?
4. Is there evidence that occupational therapists lack the necessary training to implement effective interventions for children with DCD?
5. Is there evidence to support the efficacy of occupational therapy treatment for children with DCD?
6. Is there evidence that supports underutilization of appropriate occupational therapy intervention in children diagnosed with DCD?

The MeSH search terms were limited to: developmental coordination disorder, occupational therapy intervention, evidence-based interventions, developmental coordination research, occupational therapy and developmental coordination disorders, praxis, apraxia, and evidence-based occupational therapy treatment. All the MeSH terms were used to search in the CINAHL, OTSeeker, PubMed and PsychInfo databases. Studies 10 years or older were eliminated unless there was specific evidence related to

current studies that was relevant to the proposed questions. All studies used elementary aged children with developmental coordination disorder as their population. Out of the 38 relevant studies reviewed, 13 were chosen to support the explanatory model based on these specific topics: intervention used in occupational therapy and developmental coordination disorder diagnosis. The 12 met the 10-year cutoff date of 2006, except for one study from 2001 that was the only pilot trial study of intervention relevant to children with developmental coordination disorder. The following is a synthesis of the most relevant and current publications related to the lack of a well-developed, integrated treatment protocol for children with a primary DCD diagnosis (Armstrong, 2012; Camden et al., 2015; Henderson & Geuze, 2015; Kirby & Sugden 2007; Miller et al., 2001; Missiuna et al., 2012; Missiuna & Magalhaes, 2015; Morgan & Long, 2012; Novak, 2013; Polatajko & Cantin, 2006; Schoemaker & Smits-Engelsman 2015; Zwicker & Harris 2009; Zwicker et al., 2012).

Is there evidence that developmental coordination disorder is overlooked as a diagnosis in the medical community? The literature reviewed within the above parameters suggests that there is a need for consistency in terminology and diagnostics particularly for young children who are at high risk (Kirby & Sugden, 2007; Missuina & Magalhaes, 2015). With advancements in technology (Gomez & Sirigu, 2015) it is now possible to identify DCD through neuroimaging techniques. Zwicker et al. (2012) state "Greater attention to identification and diagnosis is urgently needed to initiate support, education and intervention for children and their families" (p.578).

Is there evidence demonstrating a lack of referrals for children with developmental coordination disorder (DCD) for occupational therapy treatment? There are no articles that have looked specifically at referrals to occupational therapy. However, because there is evidence suggesting a lack of effective diagnosis, we can suggest that referrals to therapists would be affected.

Is there evidence that occupational therapists lack evidence to support effective interventions for children with DCD? There is substantial evidence within this small body of research articles indicating a need for ongoing research. Henderson and Geuze (2015) show how the number of citations specifically related to DCD published in international journals has increased from 0 before 1998 to 7053 in 2015. With such a dramatic increase in awareness, treatment approaches are less well researched (Armstrong, 2012; Polatajko & Cantin, 2006; Zwicker et al., 2012). Zwicker and Harris (2009) describe a need for research related to comparing motor learning interventions with the current dominant interventions being used in pediatric treatment. Armstrong (2012) identified six categories of interventions in the literature namely CO-OP; sensory integration approach; neuromotor task training (NTT); goal–oriented group interventions; exercise programs and compensatory strategies, she concluded that the studies "did not measure the effectiveness of interventions using occupationally based assessments" (p. 538). There is limited evidence supporting other interventions such as sensory integration and motor learning models. The CO-OP did yield the strongest approach. Authors of the Cognitive Orientation to daily Occupational Performance (CO-OP; Polatajko, Mandich, Miller, Macnab & Kinsella, 1994) have presented a number of

studies describing successful outcomes by using the CO-OP as an intervention tool. It uses a problem-solving approach encouraging the child to achieve their own self-selected goals, which can then be carried over into global strategies. The CO-OP however is limited by factors such as age and availability of training in this approach. The manual indicates that the program is developed for children from age 4 and up, however only children from age 7 and older have been studied (Armstrong, 2012). The CO-OP manual can be purchased from the Canadian Occupational Therapy Association. However it is recommended that therapists participate in training and become certified in the CO-OP approach in order to deliver the program effectively. This training is only available in Canada at this time. Therefore, access to the program is limited by training opportunities, lack of online accessibility to understanding how the program works, and overall difficulty finding out how to get trained (Camden, Rivard, Pollock, & Missiuna, 2015; Schoemaker & Smits-Engelsman, 2015). This examination of the evidence supports the problem of lack of published evidence and therapist training, which are required to implement effective interventions for children with DCD.

Is there evidence that occupational therapists lack the necessary training to implement effective interventions for children with DCD? As this exploration indicates that there is a lack of available research to support effective interventions, it seems fair to assume that therapists lack training. This question may be altered to ask whether therapists **lack access to effective training.** Two of the 13 studies reviewed indicated that occupational therapists are not well equipped to treat children with DCD (Camden et al., 2015; Schoemaker & Smits-Engelsman, 2015). Although there were no

studies that specifically looked at occupational therapy training, all 13 studies stated that occupational therapists lack the necessary tools to treat DCD effectively with significant outcomes. Polatajko and Cantin (2006) propose that there has to be a shift in the therapists' perspective from deficit-oriented to task-oriented intervention. This suggestion implies significant changes in a therapist's approach to intervention.

Is there evidence to support the efficacy of occupational therapy treatment for children with DCD? Morgan and Long (2012) reviewed qualitative research to determine parents' and children's perceptions of occupational therapy treatment. The outcomes of this study demonstrated that families were more concerned about interventions that addressed everyday function and social consequences rather than remediating motor disabilities. Occupational therapy intervention ought to focus on functional outcomes (AOTA, 2014). Schoemaker and Smits-Engelsman (2015) provide insight into the various factors influencing intervention effectiveness for children with DCD. They conclude that regardless of the intervention, explicit motor teaching with an emphasis on meta-cognitive problem-solving skills is a necessary part of the intervention. Their research highlights the lack of available evidence on the best way to deliver interventions in order to develop more definite conclusions supporting effectiveness of treatment.

Is there evidence that supports underutilization of appropriate occupational therapy intervention in children diagnosed with DCD? Missuina et al. (2012) describe a school-based service delivery model that they developed in order to meet the growing needs of children with DCD. The model emphasizes the partnership between

educators and therapists to promote effective collaboration, thereby ensuring students' needs are met without having to receive individual services from occupational therapists. The authors identified similar programs in the UK and New Zealand. They recognized an increasing need for collaborative (including teachers and paraprofessionals) occupational therapy services, instead of individual treatment because of the high demand for services.

Summary of evidence for explanatory model

Based on the literature, there is an emerging body of evidence substantiating the need for effective diagnosis, which would lead to more referrals for occupational therapy. Evidenced-based interventions for children with DCD are limited, which impacts the training opportunities for occupational therapists who are interested in using effective interventions in their practice. The literature highlights the CO-OP method as the only evidence-based practice intervention method. Although there is limited evidence supporting popular interventions such as sensory integration, neurodevelopmental therapies, and deficit-oriented interventions, there is a growing interest and desire for ways to address the needs of the DCD population. The one consistent theme throughout the literature was to promote awareness and develop appropriate evidence-based interventions for children being diagnosed with DCD. This exploration of the clinical problem (lack of an integrated, well-developed treatment protocol) as explained by these questions concludes that there is: (1) deficient diagnosis of DCD, particularly within the US and (2) definite lack of referrals to occupational therapists for effective treatment. Additionally, occupational therapy interventions that are commonly used (e.g., sensory integration, visual perceptual and motor learning models) are poorly researched or lack

evidence to support their effectiveness. Finally, occupational therapists lack published interventions for children with DCD and lack access to necessary training required to implement successful intervention approaches. These factors strongly impact utilization of occupational therapy services for children with DCD. I propose that this clinical gap can be remediated by providing an evidenced-informed comprehensive model of treatment that is supported by current neuroscience findings and neuroimaging techniques (Quantitative Electroencephalograph). Current occupational therapy research has established the need for effective interventions for children exhibiting the DCD diagnosis. With growing bodies of literature in the neuroscience research community, I propose using a multifaceted, integrated model of treatment such as the Margow model (Margow, 2014), which would be accessible to therapists in an online learning format. The model integrates several philosophies of treatment that can be easily implemented with a clear plan of intervention. Occupational therapists need an accessible tool that incorporates task-oriented interventions, sensory processing strategies, cognitive strategies and functional activities that can be carried over into daily living skills. The Margow model provides another clinical solution to the identified problems.

Previous Attempts to Address the Problem

The purpose of this section is to identify and evaluate the literature related to effective interventions that Occupational Therapists use to treat children with developmental coordination disorder (DCD). DCD presents with motor coordination problems, visual-motor integration difficulties, sensory processing differences, communication and behavior challenges. A literature review on effective interventions

for children with a developmental coordination disorder (DCD) diagnosis was completed to gather the most current evidence that supports occupational therapy practice within this growing population. The search was guided by the following questions: (1) Is there evidence to support the interventions that occupational therapists are currently using for children with DCD? (2) Do occupational therapists have the necessary training to treat children with DCD using evidence-informed practice? (3) Are there specific intervention protocols for children with DCD that are guiding occupational therapy practice? (4) Is there evidence to support the use of QEEG (qualitative electroencephalograph) software to measure interventions effectively?

Due to the lack of available studies found in the occupational therapy literature, the search was expanded to include neuropsychology and any interventions related to DCD. The evidence was compiled to identify and assess evidence-informed practice for the DCD population, determine the effectiveness of the current state of the research, and establish best practice strategies for occupational therapists to ensure that the research supports the rationale for the proposed intervention.

Search methods

Key words and MeSH terms used to identify research related to interventions for DCD included “occupational therapy treatment for developmental coordination disorder” and “occupational therapy intervention motor coordination.” These searches yielded very limited results. The terms were expanded to “apraxia,” “neuroscience research DCD,” “mental health DCD,” “DCD intervention,” “sensory integration DCD,” “CO-OP,” “sensory integration research,” “co morbid DCD,” “physical therapy intervention DCD,”

and "learning related to DCD." Searches were conducted through the following search engines: PsychInfo, OTSeeker, PubMed, CINAHL, all of which yielded similar studies. The searches yielded 108 studies. Fifty-five articles discussed interventions related to DCD.

One particular resource, The Clinical Practice Guideline on the Developmental Coordination Disorder (CPG-DCD; Blank et al., 2011) by the European Academy for Childhood Disability (EACD), synthesized all the literature available from 1995 to 2010 from varying fields of practice on developmental coordination disorder. An essential part of this document was a comprehensive evaluation of peer-reviewed literature specific to intervention for DCD. It provides a guideline that can easily accommodate the changes in the literature as the research evolves and should be distributed with more vigor than it currently is. The CPG-DCD provides valuable guidelines that occupational therapists could use to facilitate evidence-informed practice.

All the studies published through 2010 and reviewed by this author were also included in the CPG-DCD. This warrants a separation into two bodies of research related to DCD and interventions for this project (1) Evidence reviewed and synthesized until 2010 (Table 2.1: 38 articles) and (2) More recent evidence reviewed from 2011–2016 (Table 2.2: 17 articles).

Consideration of the evidence outlined in The Clinical Practice Guideline on the Developmental Coordination Disorder (CPG-DCD)

The CPG-DCD authors (Blank et al., 2011) completed a detailed systematic evaluation of the literature. The publication addressed the research in all areas of

diagnosis, assessment, and intervention. The goal of these recommendations was to provide a clinical guideline of best practice for the management of DCD from identifying the diagnosis to evidence-based interventions. Given the available research, the guideline offers a clinical model to follow. The model is all-inclusive for a medical team working with children with DCD.

For this project, only the relevant information related to intervention for DCD is discussed. After identifying 17 different terms related to interventions, the authors Blank et al. (2011) narrowed down the approaches to four main categories: therapeutic approaches in occupational and physical therapy, dietary supplementation, other methods, and educational approaches. Educational approaches were not included in the EACD guidelines, as they were not considered clinical. The EACD guideline authors refined this list by eliminating any approaches that "were without evidence" (p. 43) and differentiated the intervention into two main groups: (1) top-down and task-oriented approaches and (2) bottom-up and process-oriented approaches (also known as deficit-oriented). Bottom-up (process-oriented) approaches focus on deficit remediation. These include Sensory Integration Therapy (SIT), Kinesthetic training (KT) and Perceptual Motor Training (PMT). Top-down (task-oriented) approaches focus directly on functional skills. These include the Cognitive Orientation to daily Occupational Performance (CO-OP), Neuromotor Task Training (NTT), and Motor imagery training (MI).

The EACD authors divided the research evidence into two categories: (1) meta-analysis/systematic reviews and (2) original papers (which included clinical trials, RCTs, pilot studies, quasi-experiments, etc.). The evidence within these two categories was then

graded on a scale of 1 to 4, with 1 indicating the strongest level of evidence and four the weakest level of evidence (see Appendix A).

The EACD authors determined that a meta-analysis (Pless & Carlson, 2000) of 13 studies demonstrated moderate support for task-oriented and specific skills approaches. A systematic review (Hillier, 2007) of 31 studies resulted in moderate support for both task-oriented and process-oriented approaches to intervention. These two studies were ranked as high quality (GRADE 1) levels of evidence.

Original papers reviewed included seven pilot studies, four clinical trials, 17 RCTs, one case study, two quasi-experimental studies, one cross-over study, and one experimental description study. In the "original papers" category, five studies addressed process-oriented intervention, of which four focused on sensory integration treatment demonstrating moderate evidence (scores between 2–3 on the grading scale). 17 studies addressed task-oriented interventions with a moderate to high level of evidence (scores between 1–3 on the grading scale). Six studies focused on other interventions (e.g. Interactive metronome and group therapy) with moderate levels of evidence (scores of 2–3 on the grading scale). Four studies compared task vs. process-oriented interventions with high to moderate levels of evidence (scores of 1–2 on the grading scale). The studies are summarized in the table (1A).

Given the above methods of intervention (process vs. task oriented), the EACD determined that task-oriented interventions were most effective, but allowed for other interventions as long as the approach could be deemed appropriate within the intervention planning stage of the algorithm. In a Best Evidence Statement, Decker (2011) objectively

assessed similar literature to the EACD, confirming that there is a lack of available evidence with good methodological rigor to support recommending the use of one approach over another. Nevertheless, the CPG-DCD provides a valuable guideline that occupational therapists could use to facilitate evidence-informed practice. This guideline can easily accommodate the changes in the literature as the research evolves and should be revised on a periodic basis and distributed internationally.

Review of the past five years of research

Within the previous five years, 17 studies relevant to this paper were identified. The literature search was narrowed down to identifying evidence related to developmental coordination disorder, developmental dyspraxia, neuroimaging techniques related to DCD, and interventions for DCD within this five year period. Of the 17 relevant studies identified, 0 studies were published by occupational therapists within the US.

The literature was distributed as follows: 1 meta-analysis, 1 combined meta-analysis/systematic review, 2 systematic reviews, 4 literature reviews, 1 scoping review, 1 practice analysis, 1 quasi-experimental design, 3 perspective articles, 2 commentary and 1 conference editorial. These studies were further classified in the three categories: 6 of studies addressed the effective management of DCD, 7 studies addressed the research focused on task-oriented interventions, and 4 studies addressed the use of neuroimaging techniques to determine the etiology of DCD.

What about the 6 studies about effective management of DCD?

The 7 studies researching task-oriented interventions include a combined

systematic review and meta-analysis, Smits-Engelsman et al. (2013) reviewed 26 studies which were coded according to four common interventions: (1) task oriented (2) traditional physical and occupational therapy (3) process-oriented therapies and (4) chemical supplements. The results of the review indicated that task-oriented interventions yield stronger outcomes then the other common interventions. The other 6 studies addressing task-oriented interventions all presented moderate levels of evidence for this type of intervention (Armstrong, 2012; Camden et al., 2015; Chambers & Sugden, 2016; Martini et al., 2014; Novak, 2013; Schoemaker & Smits-Engelsman, 2015; Smits-Engelsman et al., 2013).

Here is the 3rd category about 4 studies about neuroimaging techniques

Of the four literature reviews, three focused on the neurobiology, etiology, imaging studies and interventions related to DCD (Gomez & Sirigu, 2015; Werner et al., 2012; Zwicker et al., 2012). The fourth review (Armstrong, 2012) assessed 19 relevant articles ranging from 1984–2011 that addressed occupational performance in children with DCD and concluded that task-oriented interventions demonstrated better functional performance then other interventions. A scoping review by Camden et al. (2014) indicated that many studies *identified* best practices in managing children with DCD based on expert opinion rather than empirical evidence, however few current service delivery models met clients' needs. This indicates the need for stronger quality studies.

Throughout this five-year period, there was only one quasi-experimental study (Chambers & Sugden, 2016) completed in an educational setting, with no occupational therapy involvement. The rest of the studies, although well-developed, did not present

any new research that had already been covered in the CPG-DCD. The four studies presenting new information are those that discussed the theoretical possibilities of using neuroimaging techniques to identify and diagnose DCD (Gomez & Sirigu, 2015; Reynolds et al., 2015; Werner, Cermak, & Aziz-Zadeh, 2012).

Evaluation of the Literature

The evidence from the past five years has not delivered any significant insights into intervention that are different from the EACD recommendations published in 2011. Although the most recent studies are still focusing on separating task-oriented and process-oriented interventions, the literature lacks specific, well-defined studies that can effectively compare the interventions or even demonstrate whether clinical practice is yielding effective treatment. The difference between the literature from the past five years compared to the literature from before 2011 is the introduction of neuroimaging evidence.

Occupational therapists in the United States have not been the primary researchers in the area of DCD. Much of the research was performed in Canada, Australia and Europe by educators (Chambers & Sugden, 2016), psychology, a physical therapist and occupational therapist (Schoemaker, & Smits-Engelsman, 2015), with a focus on task-oriented interventions such as the CO-OP. With the introduction of neuroimaging research (Werner et al., 2012), technology has made neuroimaging techniques more accessible to researchers. This may aid in substantiating neuroplasticity models and assist in identifying the etiology behind diagnoses such as DCD. Physical evidence from neuroimaging techniques affords accurate opportunities for measurements, which can

strongly influence study efficacy and fidelity. This opens up opportunities for occupational therapists to diagnose clients appropriately and measure their interventions successfully using QEEG technology.

Evaluating identified themes

In evaluating the research literature on DCD, four themes emerge:

- Theme 1 – Lack of effective use of DCD diagnosis
- Theme 2 – Limited evidence-based research on intervention
- Theme 3 – Practice versus research gap
- Theme 4 – Neuroimaging techniques may facilitate diagnosis and drive theoretical knowledge toward developing effective interventions

Theme 1: Effective use of DCD diagnosis

The literature has identified a lack of knowledge in the medical community for diagnosing and assessing developmental coordination disorder (discussed earlier in Chapter 2), which is directly affecting how occupational therapists treat their clients. Four factors seem to affect the use of DCD: (a) the DCD diagnosis is not identified and (b) not treated as a primary diagnosis, (c) but rather addressed as a comorbid diagnosis, (d) or discounted as a secondary diagnosis called developmental dyspraxia.

There is substantial evidence throughout all the literature that indicates that DCD is a rapidly growing health concern worldwide. According to the National Institutes of Health, 6% of our pediatric population has DCD (also referred to as developmental dyspraxia by the NIH) in the US (NICHD, 2013). This is 3 times higher than the Autism Spectrum Disorders (2% prevalence in children), yet Autism has much stronger

awareness and support. Occupational therapy researchers outside of the US are using these statistics in their research, yet the US-based occupational therapy literature very rarely acknowledges the *term* DCD. US based occupational therapists are very familiar with the term developmental dyspraxia, which is being used interchangeably with DCD, when in fact they have differing etiology (Werner et al., 2012).

It has been my experience as a clinician in private practice that the children who are not identified for services typically "fall through the cracks" and have ongoing difficulties with academics, sports participation and social interactions. The research literature confirms these long-term occupational participation issues (Henderson & Geuze, 2015; Miyahara & Baxter, 2011). These children are not referred for occupational therapy assessments because of the lack of understanding of the DCD etiology.
When a child does get referred for an occupational therapy evaluation with a diagnosis of Autism or ADHD for example, the assessment typically identifies motor coordination difficulties allowing for a comorbid diagnosis of DCD or more commonly a secondary diagnosis of developmental dyspraxia.

If the diagnostic criteria being used by the US medical professionals are based on the definitions of developmental dyspraxia (“failure to meet developmental milestones”) by the APA, then DCD is not being considered a primary, relevant diagnosis, even though the DSM-5 has succinctly provided diagnostic criteria that the rest of the world are using. According to the APA, motor dyspraxia exhibits different etiology to DCD. The lack of accurate diagnosis further widens the gap between research and effective clinical treatment implementations (Camden et al., 2013). Developmental dyspraxia,

DCD, DAMP (a disorder of attention, motor and perception), clumsy children syndrome etc. were all key search terms seen in occupational therapy intervention research. This indicates that occupational therapists are in fact treating the same motor coordination deficits seen in the studies done on the DCD populations, but they are using different terminology. This creates a grey area when determining which interventions are successful for children specifically diagnosed with DCD. Occupational therapists in the US are not using the DCD diagnosis in their research: they are using developmental dyspraxia (Werner et al., 2012). It is noteworthy to recognize that even though the diagnostic criteria have changed in the past 10 years there seems to be little change in the identification of DCD within the scope of occupational therapy. There is substantial evidence (Blank, 2012), qualifying the need for a stand-alone diagnosis of DCD since a child with a developmental delay can be very different from a child with DCD even though they may exhibit similar testing scores.

It seems that motor deficits are not always identified in children with varying diagnosis (ADHD, Speech Language Delays, Learning Disabilities etc.), even though it is highly likely that they do exist within these populations (Werner et al., 2012). The medical community is therefore missing a large segment of a population who could benefit from occupational therapy assessment and intervention. Instead, treatment options tend to be pharmaceutical and/or tutoring services.

These diagnostic concerns create the challenge of identifying appropriate interventions for this population in the research. The population is not being diagnosed with a primary motor diagnosis, they are not being referred for occupational therapy

assessments and when they do get referred, occupational therapists are using different terminology to the current DSM-V and APA published criteria. One last factor that may have impacted the use of the DCD diagnosis is the healthcare reimbursement system in the US. According to Dr. Thomas Decker (personal communication, December 20, 2016), attempting to get the DCD diagnosis covered by insurance (as a primary medical diagnosis) may have been a mitigating factor in how the child gets diagnosed, which impacted service delivery. This is another factor influencing knowledge to practice efforts.

In order to address effective interventions for children with DCD (a rapidly growing population within the occupational therapists scope of practice; Decker, 2011), it is critical to address the need for successful identification and diagnosis of these children through education within the medical and educational communities. Once accurate identification and diagnosis becomes standard practice within the US (like it is in other countries), then occupational therapists will be able to develop intervention studies with stronger fidelity for children with DCD. The state of the evidence demonstrates the significant gaps between identification, diagnosis and interventions. The second theme discusses the limited number of studies performed in the US specifically in relation to DCD intervention, even though there is clearly evidence from outside the US.

Theme 2 – Limited evidence-based research on intervention

Limited evidence-based research from the occupational therapy perspective has affected how occupational therapists in the US treat children with DCD (Decker, 2011). The emerging research continues to focus in task-oriented interventions (specifically the

CO-OP). Prior to 2011, much of the research looked at comparing interventions, whereas during the past five years, there were no studies found that looked specifically at process-oriented interventions for DCD. The literature has not changed much since the publication of the EACD recommendations. Whilst the evidence substantiates the need for occupational therapy interventions (Decker, 2011; Novak, 2013; Wilson, 2013; Zwicker et al., 2012) there is only moderate evidence (according to the GRADE scale of 2 in both the EACD and Decker's Evidence Statement) supporting the most effective treatment. Hillier (2007) determined that any physical and occupational therapy intervention for DCD was better than no intervention, but the authors state that the research still supports task-oriented intervention. Decker (2011) reviewed many of the same studies as the EACD and in his Best Evidence Statement (BESt) and concluded that "use of one approach over another has not been clearly demonstrated in the research" (p. 7).

One of the complications that I see in the literature reviewed by the EACD is that the research being compared is from widespread time frames. The comparison of the treatment effects are vastly different: (a) the sensory integration studies are 10–20 years older than the CO-OP studies and (b) the authors were limited by the terms used to search the literature as much of the literature on process-oriented interventions are not necessarily related to DCD. The quality of the interventions has also shifted over the past 25 years. In evaluating the process-oriented studies, it is noted that earlier studies focused on more intensive interventions, while later studies looked at hour long, weekly sessions, which were less effective. Process-oriented interventions are supposed to focus on

impacting neuroplasticity, which requires a more intensive program, whereas task-oriented interventions concentrate on improving task-specific functional ability. These factors should be considered when comparing interventions to each other. Conclusions of the research through 2010 lean heavily toward task-oriented interventions but all the research consistently states that more rigorous studies are necessary to identify effective intervention (Armstrong, 2012; Camden, et al., 2013; Decker, 2011; Smits-Engelsman et al., 2012).

Current interventions: Is there evidence to support the interventions that occupational therapists are currently using for children with DCD?

Current interventions commonly used to treat children with DCD include sensory integration treatment (in the US) and the CO-OP (in Canada, Australia and Europe). The evidence on sensory integration is particularly limited in relation to DCD interventions, whilst the CO-OP has significantly more research available. The limitation to this evidence is that the CO-OP is most effective for children with adequate cognitive abilities, thereby potentially limiting younger children or those populations with cognitive delays. The sensory integration research is limited by validity threats and small effect sizes (Decker, 2011) as well as lack of specificity to DCD.

Training: Do occupational therapists have the necessary training to treat children with DCD using evidence –informed practice? To clarify this question, I am not suggesting that occupational therapists are not trained to treat children exhibiting motor coordination disorders – we absolutely are. However, the current research is not driving necessary changes in intervention for children with DCD. Therapists in the US

are being trained in a variety of process-oriented interventions such as sensory integration techniques and perceptual motor interventions to address specific motor coordination deficits; the current research indicates a lack of validity of these intervention approaches for children with DCD. There is training available for the CO-OP (Polatajko & Mandich, 2004), yet there are only 13 certified therapists in the US (retrieved from http://www.ot.utoronto.ca/coop/resources/therapist.html) according to the CO-OP Academy. Regardless of training opportunities, it is my observation that occupational therapists are using interventions that they are familiar with. This may be due to the fact that sensory integration was developed in the US (making training opportunities more accessible), whereas the CO-OP was developed in Canada (making dissemination less accessible).

The literature offers emerging evidence that task-oriented intervention such as the CO-OP (which is manualized) has evidence supporting the interventions used by occupational therapists who are trained in the CO-OP methodology (Polatajko & Mandich, 2004). Due to the lack of evidence within the US, even though most pediatric therapists use sensory integration techniques as their primary intervention (AOTA, 2015b), there is little evidence to support the outcomes of this intervention (Decker, 2011; Morgan & Long, 2012; Schaaf et al., 2015). Lack of evidence supporting treatment is impacting occupational therapists' ability to learn how to address the needs of children with DCD effectively. The research consistently describes this lack of knowledge amongst professionals on how to successfully manage assessment and interventions for children with DCD (Armstrong, 2012; Camden et al., 2013; Camden et al., 2015

Henderson & Geuze, 2015; Maciver et al., 2011; Missiuna et al., 2012; Miyahara & Baxter, 2011; Morgan & Long, 2012 Novak et al., 2012; Novak, 2013; Scammell et al., 2016; Schoemaker & Smits-Engelsman, 2015; Zwicker et al., 2012).

Seven current studies indicate that the CO-OP is the most effectively researched intervention specifically for children with DCD (Armstrong, 2012; Camden, Pollock, & Missiuna, 2015; Chambers & Sugden, 2016; Henderson & Geuze, 2015; Hsu, 2015; Missiuna et al., 2012; Morgan & Long, 2012; Novak, 2013). The studies also tend to focus on groups of children who are described as having appropriate IQ and language skills, who can participate in a cognitively driven task-oriented intervention.

In a combined systematic review and meta-analysis, Smits-Engelsman et al. (2013) confirmed that the current research supports task-oriented interventions (e.g., CO-OP) over process-oriented interventions (e.g., SI), however they acknowledge that there was a strong body of research investigating sensory integration and kinesthetic training between 1970–1996, with very few studies after 1996. The study goes on to show that traditional occupational therapy is effective as well if a perceptual motor training approach is used to facilitate an integrated task-specific approach. Training for these interventions is generalized to therapists' own knowledge base not necessarily related solely to DCD. According to the summary key findings of this review (Smits-Engelsman et al., 2013), the results of the evidence regarding sensory integration from 1972–2007 were mixed. Outcomes were frequently better than no treatment, and the studies were encouraging however they needed improved methodological vigor. American researchers seem to focus less on separating task- and process-oriented interventions. Rather, they look at the

impact of the intervention on domains of function. The current research still indicates that process-oriented interventions such as Sensory Integration treatment show a slight treatment effect (Camden et al., 2013).

Given the lack of available evidence related to the US, but a substantial amount of research around the rest of the world, one has to look at how the presented research in the US compared to other countries. For example, Case-Smith, Frolek Clark, and Schlabach (2013) presented a systematic review on motor interventions used by occupational therapists. This study includes motor delays and mentions DCD, however the focus was on intervention outcomes typically used by occupational therapists and allowed for cross-over theories that are used in current practice. This study would not have been included in any of the current research on DCD nevertheless adds a different perspective. The research confirms the lack of evidence-based intervention. Occupational therapists do not have sufficient evidence supporting their practice or the necessary training to effectively manage the DCD population.

Theme 3 – Practice versus research gap

Therapists in the United States use process-oriented therapies (e.g., sensory integration) over task-oriented therapies as their primary treatment technique for children presenting with motor coordination difficulties (AOTA, 2015b). In the AOTA Critically Appraised Topics and Papers Series on Children and Adolescents with Sensory Processing Disorders/Sensory Integrative Dysfunction (2009), reviewers recounted that "Survey research shows that approximately 90% of American pediatric occupational therapists working in the schools use sensory integration principles as a basis for their

intervention" (p.). They noted that the numbers were growing in private practice and outpatient hospital settings at the time of publication in 1996.

The CO-OP is a popular approach amongst Canadian, Australian and European occupational therapists and appears to be integrated well into school, camp and group environments (Scammell et al., 2016). However, this is not the case in the United States. This leads to another question of why US occupational therapists are not utilizing this research to drive intervention protocols. There seems to be little change in occupational therapy assessment and treatment. The American literature is more focused on pursuing validation using sensory integration treatment over other therapies, possibly due to so many therapists applying the principles in practice.

Although there are clinical practice guidelines defined by the EACD Recommendations, there is still a small body of emerging evidence to guide service delivery (Blank, 2011). The guiding principles that have been developed are based on "opinion, expert consensus and recommendations following problematic situations rather than empirical studies of the solutions" (Camden et al., 2014, p. 154).

There is a wide gap between the evidence and the implementation of interventions that occupational therapists are putting into practice. The discrepancy between the research and practice may be influenced by the many methods of treatment that occupational therapists are so adept at integrating to ensure that their clients receive whatever they need to ensure progress. In clinical practice we have seen children with complex issues respond very well to a combination of process-oriented and task-oriented interventions using an intensive approach to theoretically facilitate neuroplastic changes

(Gomez & Sirigu, 2015). A concerning issue that arose from this literature review was the lack of studies performed in the United States on DCD. The reviewed studies based their definitions on US sources such as the American Psychiatric Associations definitions and ICD-9/10 coding; therefore one would expect to find more US studies on DCD intervention. The US studies have been more focused on sensory integration research that is not specifically focused on a diagnosis, resulting in being eliminated from this evaluative review, however, they are critical to include in this discussion to show that there is still relevant research being performed.

Sensory integration treatment is strongly supported by the AOTA (2015), and we see a considerable effort towards sound, published research (Schaaf et al., 2015). Given the two bodies of evidence reviewed, there is a need for informed assessment and interventions that can effectively treat children with a primary diagnosis of DCD. The research did not include sensory integration studies as they were not unique to DCD. However, a Critically Appraised Topic (AOTA, 2009) compiled by AOTA demonstrated that this is the most commonly used method of treatment in the US. The disparity in research between the US and other countries highlights the differences in how occupational therapists are treating. However, our collective goal is to ultimately provide high-quality services to meet the needs of our clients, thus it would be in our best interest to develop a cohesive research database to bridge the gap between research and practice.

Theme 4 – Neuroimaging techniques may facilitate diagnosis and drive theoretical knowledge toward developing effective interventions

With the rapid progression of technology, neuroimaging techniques show promise

for improved data collection for potential random controlled studies thereby providing "good methodological rigor in relation to all treatment approaches" (Decker, 2011, p. 3). I believe it is critical to increase the awareness of this significant disorder in the US and to ensure accurate identification and treatment of this population. One way we can ensure this is to use available neuroimaging techniques such as QEEG software to identify specific areas of weakness in the brain for children with DCD.

Is there evidence to support the use of QEEG (qualitative electroencephalograph) software to measure interventions effectively? The ability to identify deficits on a neurobiological level facilitates understanding of how the underlying deficits are influencing overall function. This provides a holistic view of the interactions between neurology, impairment, and function rather than a superficial assumption of symptomology.

Evidence supports this possibility for occupational therapists as Gomez and Sirigu (2015), Reynolds et al. (2015), and Zwicker et al. (2012) present the opportunity for using neuroimaging techniques to identify the underlying neurobiology and etiology of DCD. Diaz & . Forssberg, (2015) suggest that neurological changes occur through neuroplasticity. There is potential for occupational therapists to use a tool such as the QEEG to measure changes in brain function before and after intervention.

QEEG technology was developed from neurofeedback principles that mental health professionals incorporate into their practice. Neurofeedback has been well established since the early 1900s with 80 years of clinical research supporting these principles (Collura, 2014). Neurofeedback is a treatment, whereas acquiring EEG data is

used to measure and understand brainwave activity. Collura states “we are able to measure and identify brain states via recorded electrical activity …through straight forward instrumentation and computations. In the end, the brain is able to learn and adapt” (p. xiii). As occupational therapy practitioners, we are well aware of adaptive responses and the ability to learn new skills. Investigating the implications of acquiring EEG data for assessment offers a new contribution to occupational therapy practice and can incite stronger research potential.

Acquiring EEG data

The term “acquiring” electroencephalography (EEG) data refers to “the recording of electrical activity along the scalp produced by the firing of neurons within the brain. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp” (Warner, 2017 p. 4). Warner describes the EEG information as an “epiphenomenon” and likens the information received as the heat coming from a computer, therefore it is an indicator of relative activation or inhibition during the course of normal activity. Raw EEG data can be divided by a frequency band name: Delta (0–45Hz), Theta (0.5–3.5Hz), Alpha (8–12 Hz) and Beta (13–35Hz). Each of these wavebands is associated with a particular state of being in the brain. All waves are present all the time, however they are dominant when related to their specific function.

- *Delta* is associated with deep sleep and restoration; it is dominant during certain parts of sleep. When Delta becomes dominant whilst the child is awake, then it interferes with emotional and/or cognitive processing.

- *Theta* is responsible for creativity and pre-sleep functions. When theta dominates, the child can struggle with attention, distractibility and lack of focus. It also plays a role in memory consolidation and memory retrieval.
- *Alpha* maintains a sense of relaxation and is related an alert state. Too little Alpha may be related to anxiety and/or a "foggy" brain state.
- *Beta* encourages active attention to external events and is involved in concentration and attention. This is the wave that keeps children engaged in the classroom. Excess Beta can be related to high levels of anxiety.

Portable devices and user-friendly software make the process of acquiring QEEG data simple. The entire process can be completed within an hour. This type of acquisition is different to functional magnetic resonance imaging (fMRI), however QEEG provides a non-invasive, fiscally accessible brainmap that identifies how efficiently the brain is using its resources. It is important to distinguish between various terms that the literature describes. EEG is analyzed by a neurologist or psychiatrist who is qualified to visually inspect wave forms with the goal of identifying abnormalities. Quantitative EEG (QEEG) is a technique in which metrics are used to guide therapeutic planning and monitor treatment progress (Collura, 2014). In the introduction to his book, Collura mentions occupational therapists as professionals who can incorporate neurofeedback into their individual scope of practice.

QEEG technology can help occupational therapists evaluate brain activity data. Combined with standardized testing, building intervention plans can support neuroplasticity. For example, a child may have a diagnosis of ADHD and DCD and the

brain map will show specifically where the attentional issues are. The standardized testing will determine whether motor coordination and sensory processing skills are affecting attention. This allows the therapist to determine whether a process-oriented intervention such as sensory integration techniques will be more effective than a task-oriented intervention such as Interactive Metronome, or whether to use both and at what point in the treatment timeline. By identifying specific deficits and neuronal activity, therapists can collect effective data, compare the data more frequently and develop stronger research. Even though there is substantiation using neuroimaging techniques to identify DCD, therapists are not necessarily using these techniques to drive and deliver evidence-informed practice.

Implications for program design

The review of the literature concerning evidence-based interventions for children with DCD identified task-oriented interventions as most effective. However, 90% of US based occupational therapy practitioners use process-oriented sensory integration therapies to treat their clients (AOTA, 2007; AOTA, 2015), and we see a considerable effort towards published sound research of this intervention approach (Schaaf et al., 2015). Reynolds et al. (2017) discuss the value of using a multi-faceted approach to address the functional needs and increased participation of the client without focusing on just one approach. The authors include all the approaches already discussed in this chapter as having value for the child with DCD. They substantiate that the CO-OP "may be useful for children with differences in sensory processing" but "they are not intended to address the child's underlying issues in sensory processing and integration but may be

used to help children with motor planning or coordination difficulties learn strategies to enhance performance of specific functional skills" (Reynolds et al., 2017, p. 5). They add that the therapist must be aware of the child's "intellectual, speech, language and self-regulatory abilities to benefit from such problem-solving approaches" (p. 5).

The overall implications of the reviewed literature suggest client-centered, goal-directed interventions promote functional skill development and active participation. This presents an opportunity to describe in the next chapter the Margow model (Margow, 2014): an integrated, multi-faceted model that uses both a top-down and bottom-up approach to treatment and can be measured using brain mapping software to ensure fidelity of therapy. Instead of limiting the intervention to a particular method of treatment, the model incorporates detailed principles of Ayres sensory integration treatment, visual perceptual, behavioral, and cognitive components to ensure the highest standards of service delivery.

The latest studies (Reynolds et al., 2017) that focus on multi-faceted interventions support the development of an effective intervention model. The next chapter reviews the proposed intervention and theoretical basis of the Margow Model (Margow, 2014). A comprehensive discussion will present the components of the model as a best practice, clinical solution to address the identified gap in evidence-informed practice.

CHAPTER 3 - Description of the Proposed Program

Introduction

The need for occupational therapy services in the pediatric population is rising due to the significant number of children (5–6%) who are being diagnosed with developmental coordination disorder or motor dyspraxia (Zwicker et al., 2012). When a child struggles with developmental coordination disorder (DCD), all domains of life are affected (Morton, 2015). Brown-Lum and Zwicker (2015) describe DCD as a "neurodevelopmental disorder characterized by motor impairment that significantly interferes with a child's activities of daily living" (p. 131). This leads to secondary psychosocial difficulties such as anxiety, depression and poor self-esteem. It is important to include all these domains when assessing, implementing and reviewing effective interventions for this population.

Over the past 20 years, with the steady increase in awareness and understanding of developmental coordination disorder (DCD), the demand for effective management has increased significantly (Henderson & Geuze, 2015). As these children enter academic settings that cannot accommodate their needs, we are seeing a considerable impact on family dynamics, the child's ability to succeed, and the teacher's frustration to teach (Rukavina et al., 2009).

The purpose of the is chapter is to propose a therapeutic model that incorporates current evidence and theory and offers a new contribution to occupational therapy practitioners who work with children exhibiting developmental coordination disorder (DCD). This chapter will describe this therapeutic model – the Margow model (Margow,

2014),– that uses a multi-faceted, intensive, and combined bottom-up and top-down approach to intervention that addresses the occupational performance of children who are struggling with developmental coordination disorder.

Theoretical grounding

The Occupational Therapy Practice Framework (3rd ed.; AOTA, 2014) discusses the dynamic interrelationship between theories that occupational therapy practitioners use during the intervention process. The Margow Model is based on a combination of theories to promote the occupational performance of children with DCD. The overall model is a multi-faceted approach (Reynolds et al., 2017) to working with children with DCD. It incorporates theories of contemporary motor learning (Kielhofner, 2009) and sensory integration (Ayres, 1972), as well as principles of cognitive-based approaches, learning through play, intensive therapeutic approaches, and neuroplasticity. This section will describe the multi-faceted approach, the primary principles of the SI and ML theories, and principles of learning through play, intensive therapeutic approaches, and neuroplasticity.

Multi-faceted approach. The multi-faceted approach to occupational therapy intervention provides a holistic view of the client and his or her occupational needs in relevant contexts and environments. Reynolds et al. (2017) outlines three broad occupational therapy intervention approaches for working with children with sensory processing and sensory integration differences. These same three approaches are relevant to occupational therapists' multi-faceted work with children with DCD: (1)

environmental supports (2) caregiver-focused intervention and (3) child-focused, therapist-led interventions related primarily to skill building or eliciting neurological change.

Sensory integration theory. Sensory integration theory proposes that the brain organizes sensory information by taking in information through movement and sensation from the environment, then using it to organize and plan behavior (Bundy & Murray, 2002). Sensory integration theory is based on five assumptions (Bundy et al., 2002):

- Neural plasticity
- A developmental sequence of sensory integrative capacities
- The brain functions as an integrated whole
- Brain organization and adaptive behavior are interactive
- Children have an inner drive to participate in sensory motor activities.

The process of reaching developmental milestones is dependent on the brain's ability to synthesize and integrate sensory information from the internal and external environment in an efficient manner (Margow, 2014). Effective ASI treatment occurs when the client successfully participates in a sensory-rich environment through exploration and adaptive responses (Reynolds et al., 2017). With the appropriate environmental challenges using play-based strategies, the brain makes new neural connections leading to improved functional participation due to an adaptive response (Bundy et al., 2002). Children learn through play and experience. Ayres (1972) argued that children are driven by an inner drive to seek organizing sensations. When the child is motivated to seek out these sensations, positive experiences reinforce their need for

action. The child's occupation is play, which encourages orientation towards generating and processing sensory information thereby motivating the child to engage in learning activities (Kielhofner, 2009).

Motor learning theories. Zwicker and Harris (2009) describe the main principles of major motor learning theories and the implications and applications of these theories in pediatric occupational therapy practice. The key elements of contemporary motor learning theory are:

Stages of Learning – three stages include cognitive, associative and autonomous. During the cognitive stage, the child may have a general idea of the required movement but may not know how to execute the movement. The associative stage is the practice phase. By making mistakes, the child learns how to correct and practice until they master the skill. The final autonomous stage uses less cognitive input and the movements occur automatically with ease.

Types of tasks – motor learning is dependent on the type of task to be learned. Tasks can be divided into discrete (there is a beginning and end such as catching a ball), continuous (e.g., walking) and serial (discrete tasks strung together e.g., dressing). Open tasks occur in an ever-changing environment (e.g., playing football), whereas closed tasks occur in a static environment with predictability (e.g., bowling).

Practice – this is the most important tenet in motor learning. Permanent motor learning is dependent on the type of practice incorporated in the early phases of learning. Feedback – the ability to learn and integrate new skills is dependent on intrinsic and

extrinsic feedback. Intrinsic feedback occurs through sensory feedback based on movement, whereas extrinsic feedback comes from external sources such as the therapist providing verbal instructions to the child.

Zwicker and Harris (2009) describe a rich history of motor learning theory that is underutilized in pediatric occupational therapy treatment. They present preliminary evidence of interventions, such as the Cognitive Orientation to daily Occupational Performance and NTT, that using motor learning theory supports functional gains in children with DCD. They suggest that other OTs may be applying motor learning theory tacitly without a formal model of motor learning practice. They also suggest that because we use the dominant Ayres Sensory Integration (ASI) and Neurodevelopmental theories (NDT) in pediatric practice, we may not be looking at motor learning theory as a cohesive practice model based on motor learning principles. There is great potential for pediatric occupational therapists to research and develop well-defined theories of practice based on motor learning theory.

Cognitive-based approaches. Cognitive learning theories are explained as "the role that mental organization of knowledge including problem solving, reasoning and thinking, plays in the acquisition and performance behaviors of skills (Schunk, 2001). One of the key teaching techniques of top-down approaches is based on behavior modeling. Learning is viewed as an active mental process of acquiring, remembering and using knowledge (Polatajko & Mandich, 2004).

Intensive Therapeutic Approaches

The Margow model is also based on the effectiveness of intensive therapy and its influence on neuroplasticity as seen in programs such as Constraint Induced Therapy (Case-Smith, Froleck Clark, & Schlabach, 2013), Suit Therapy (Alagesan & Shetty, 2010), Interactive Metronome (Taub et al., 2015), and Fast Forword (Gillam et al., 2008). An intensive model of intervention offers the ability for the brain to make neuroplastic changes over a consistent, short period of time. All these programs are constructed on sound principles of the brain's ability to create neural networks that then function more efficiently, allowing for newly developed skills to carry over into function.

There are many factors that affect learning for children who struggle with sequencing, motor planning and communication. These factors are common to children with DCD who have difficulty learning and performing age appropriate motor skills. Although there are recognizable factors associated with DCD, the etiology is still unknown (Werner et al., 2012 p. 259). Therefore determining effective intervention can be challenging. The evidence suggests that repetitive learning is not a successful strategy, however cognitively based strategies can be effective when used in conjunction with intervention that facilitates neuroplastic changes (Reynolds et al., 2017). By borrowing from the neuropsychology research on motor learning (COBALT – control-based learning theory described by Willingham, 1998), OT's should be able to extrapolate already proven information into intervention development, to ensure fidelity of treatment within timely, fiscally sensitive treatment protocols. With brain imaging technology that is far superior to anything we have had in the past, it is exciting to think that researchers

have identified structures in the brain that show primary processes that support learning (Willingham, 1998). This emerging research indicates a possible deficit in the activation and connectivity of the mirror neuron system in children with DCD (Reynolds et al., 2015; Werner et al., 2012), which results in poor functioning at the motor behavior and neurological level (Reynolds et al., 2015). Functionally, these children demonstrate "marked neurodevelopmental immaturities" (Reynolds et. al. p. 235).

Developmental milestones are the precursors for more complex learning. These milestones provide a tangible point of reference that offers a platform for understanding how that child is developing in relation to their peers. The progression of skill development is dependent on how the brain connects the neurological pathways and lays down a neural network, which is known as brain plasticity. If the neural network is not formed through conventional pathways, then an adaptive response occurs, affecting the outcome of that specific network. If a child with DCD cannot learn a new skill efficiently, I propose that the neural network will adapt creating an alternate response that may affect learning that skill, so the child will either avoid the activity or redirect the action toward flight-fright-fight types of behavior. This proposition is supported by Brown-Lum and Zwicker (2015), who examined the evidence behind the use of advanced neuroimaging techniques to identify the neural mechanisms underlying DCD. They shared that there is preliminary evidence suggesting that children with DCD show different patterns of neural activation during motor tasks; therefore there is a possibility that the white matter architecture is different to neurotypical brain function.

The brain will innately protect itself from perceived failure, which then decodes

an alternative response. The purpose behind the Margow Model is to encourage intervention that assists the brain in reorganizing neural networks through process-oriented interventions that facilitate changes in cerebellar, corpus collusum, limbic, parietal and cortical networks. As these changes translate into functional skills which can be observed and measured through neuroimaging techniques such as QEEG acquisition (collecting raw data), the intervention begins to integrate cognitive based (task-oriented) strategies that the evidence has shown to be effective for children with DCD. Because we are seeing more neuroimaging evidence that is redefining the underlying constructs of DCD (Brown-Lum & Zwicker, 2015; Reynolds et al., 2015; Werner et al., 2012), occupational therapists have a responsibility to develop evidence-informed practices that support neuroplasticity.

The evidence also proposes that a significant factor affecting efficient, consistent movement is "excessive noise in the sensorimotor system" (Gomez & Sirigu, 2015, p. 276). The authors provide provisional conclusions suggesting that children with DCD need a "larger sensory discrepancy to generate error signal use for greater adaptation" (Gomez & Sirigu, 2015, p. 277). Sensory error generation is important for learning new motor skills; this is a significant factor affecting children with DCD (Gomez & Sirigu, 2015). If these children can learn increased error recognition, the thought is that their learning rate can increase too. Given that these theories are still within in the early phases of research, the information is still susceptible to challenges, however it supports the theoretical basis behind the Margow Model (Margow, 2014). Children with DCD should benefit from a program that incorporates the factors underlying the etiology that the

research is proposing. When proposing the intervention, it seems logical to incorporate treatment strategies that address:

- Vestibular-visual processing, which impacts body and spatial awareness and sense of personal space and safety. The cerebellum is responsible for motor coordination, postural control, execution, and motor control of movements.
- Vestibular-auditory processing, which provides feedback on external physical space and influences pragmatic language.
- Visual-auditory processing, which influences the sense of safety and limbic function.

Once these deficit areas are functioning more efficiently, the treatment strategies need to shift to task-oriented activities that encourage skill development through cognitive processing and communication strategies and participation by parents and teachers to ensure that the carryover into daily life are followed through. Specific technology designed to address neurological performance can be introduced to increase processing speed, timing, sequencing and motor performance. When the various components of the Margow Model are implemented in the suggested protocol, the child makes significant gains in short periods of time.

The Margow Model Program Description

The Margow model is a multi-faceted approach (Reynolds et al., 2017) to working with children with DCD. It incorporates theories of contemporary motor learning (Kielhofner, 2009) and sensory integration (Ayres, 1972), as well as principles of cognitive-based approaches, learning through play, intensive therapeutic approaches,

and neuroplasticity. The principles and theories underlying the Margow model were described in the previous section. This section covers the Margow model's purpose, goals, recipients, personnel, process of multi-faceted assessment and intervention, and desired outcomes.

Purpose. The purpose behind the Margow Model is to encourage intervention that assists the brain in reorganizing neural networks through process-oriented interventions that facilitate changes in cerebellar, corpus collusum, limbic, parietal and cortical networks. As these changes translate into functional skills which can be observed and measured through neuroimaging techniques such as QEEG acquisition (collecting raw data), the intervention begins to integrate cognitive based (task-oriented) strategies that the evidence has shown to be effective for children with DCD. Because we are seeing more neuroimaging evidence that is redefining the underlying constructs of DCD (Brown-Lum & Zwicker, 2015; Werner et al., 2012; Reynolds et al., 2015), occupational therapists have a responsibility to develop evidence-informed practices that support neuroplasticity.

The proposed therapeutic model suggests that by using a bottom-up approach to learning, the child becomes a more efficient, effective learner in various environments because they are no longer expending excessive amounts of energy processing information. The top-down approach incorporates cognitive and motor learning strategies to engage the client in goal development and provide alternative strategies to facilitate controlled adaptive responses. These adaptive strategies are based on cognitive problem solving rather than underlying sensory processing. This ensures that the intervention plan

is client-centered and the child is part of the goal setting process (a fundamental element of the CO-OP; Polatajko & Mandich, 2004).

Goals. The goals of the Margow model are to provide a framework for (1) evaluating whether sensory processing and integration and/or motor deficits and poor problem solving are affecting function and (2) intervention that is multi-faceted and utilizes process-oriented and task-oriented approaches (see chapter 2) in combination for providing occupational therapy intervention for children with DCD. The overall premise is that if therapists use a multi-faceted program such as the Margow Model, then children with DCD will demonstrate improved functional motor skills. This proposition is testable in a variety of ways: standardized tests can evaluate motor skills and questionnaires can evaluate the clients' functional improvements in school and home environments to assess skill carryover. Additionally, the client's participation in academic and social tasks can be objectively assessed in their ability to perform tasks more easily within age appropriate time limits. One of the most telling observations is the willingness of students to continue learning new skills with a reduction in negative behavior and an increase in enthusiasm for learning skills that they once may have avoided.

Recipients – The target populations for this model spans from toddlers through high schoolers with possible DCD (more commonly known as motor dyspraxia/developmental dyspraxia in the United States; Werner et al., 2012). The Margow Model addresses the developmental, sensory, motor, and language needs of children as young as 2 years old. When we receive a referral for toddlers, the assessment and intervention is typically related to motor or sensory issues affecting developmental

milestones. Early intervention is a key factor influencing the outcomes of therapy, however it is not common practice to diagnose such a young child with DCD. It is more common to see a child with a motor dyspraxia diagnosis as a comorbid or secondary diagnosis. Dyspraxia is described as a "similar and perhaps overlapping syndrome" (p. 258), according to Werner et al. (2012). The benefit to seeing a child this early allows the therapist to identify and address the deficits before there are secondary consequences such as poor social skills or poor handwriting and dexterity skills.

In the event that the older child (5 and up) participates in therapy, the intervention strategies need to be more complex and include more of the processing, cognitive and social interaction components of the model to address these secondary factors impacting function. As the child moves into preteen and teenage stages of their lives, the model provides opportunities to engage the client on a higher cognitive level. One of the important factors related to DCD is that cognition is not affected by the diagnosis. Therefore the teenagers are capable of developing their own goals, engaging in the development of their program, and being held accountable to manage their adaptive strategies. At this point, there is less emphasis on the deficit-oriented treatment and more focus on the cognitive strategies (e.g., The CO-OP or Interactive Metronome), to facilitate self-regulation and participation in meaningful activities. The teenager has control over their therapy sessions and the therapist provides the professional input through neurological programs and self-directed strategies to assist with improved skill acquisition.

The adaptability of the Margow Model allows for individualized programming to

address the client at their developmental level. Through quantitative data collection such as QEEG, the child or teenager can visually see their changes which motivates them to engage in more learning opportunities. As they become more successful, skill development and acquisition improves which fosters participation in the activities that may have been difficult to access before intervention.

Personnel. According to the AOTA OTPF 3rd edition (2014), "Occupational therapy practitioners use therapeutically selected occupations and activities as primary methods of intervention throughout the process" (p. 11). It is the OT's responsibility to facilitate "therapeutic use of occupation and activities" (AOTA, 2014, p. 12). The outcomes of multifaceted occupational therapy intervention are dependent on "occupations, client factors, performance skills, performance patterns, contexts and environments targeted" (AOTA, 2014, p. 16). We recognize the influence that the environment, performance patterns and performance skills have on the child's ability to adapt, learn and engage in activities. This framework encourages continual evaluation and review of the intervention process in order to achieve effective outcomes that are important to the child. These varied and inter related constructs that describe occupational therapy practice support the multifaceted approach used in the Margow Model.

Pediatric occupational therapists are highly qualified professionals who have a comprehensive knowledge on addressing functional, academic and social needs of children displaying amongst other issues, coordination and sensory processing difficulties. Therapists have access to children in the school system, outpatient facilities,

summer camps, and group settings. There are numerous interventions that occupational therapists are trained in. The ultimate goal of intervention is to facilitate improvements in children's participation in activities in all aspects of a their lives, thereby improving their overall quality of life. By using the principles of neuroplasticity, motor learning theory and clinical experience, the Margow model helps parents understand how their child is most likely interpreting information to learn and function. The model is also used to teach interdisciplinary teams of therapists to look at the child's deficits using a neurological frame of reference. After assessing a client's strengths and weaknesses, the therapists establish priorities of treatment together with the child and caregivers. This allows for a well-developed, efficient program to address the child's individual needs. The Margow Model is then operationalized into an intensive program that is carried out by professional therapists for 1–2 hours daily during a three-month period.

Interdisciplinary personnel. Initial use of the Margow model was for occupational therapists. As it has evolved, the scope has extended to physical, speech therapists and teachers working with children with special needs. It has been common to implement aspects of the model by each respective discipline; however there is always overlap between the disciplines, with variable goals. Each team member identifies what their priority is in the treatment plan, and the goals are developed as a team. The integrated program accelerates outcomes allowing for shorter, intense periods of intervention with successful engagement back into the classroom, social and recreational activities. These are the areas that children with DCD find challenging, so it is essential to foster the positive outcomes as quickly as the client can adapt. We do this by

encouraging engagement in their preferred activities first, then in non-preferred but essential activities in their daily lives. Additionally, this model promotes an integrated approach within the classroom, home and therapeutic environments, thereby addressing the individual and system-wide needs of the students and educators. With the challenges that children with DCD face, the model incorporates comprehensive, interrelated interventions that address all client factors and skills to facilitate change in body functions and structures; acquisition in motor skills, adaptive changes in processes and improved social interactions.

Training for Personnel. Formal Ayres Sensory Integration (ASI) training is not required to treat, however it is strongly recommended to ensure fidelity of treatment. Treatment outcomes can be compromised by lack of training and understanding of how neuroplasticity affects function.

Methods of Assessment and Treatment

Figure 3.1 visually depicts the interrelated process behind using this model. It helps identify the strengths and weaknesses of the child in relation to 5 areas:

Sensory Processing- is a complex interaction of neurological processes that manage how the nervous system receives, organizes and understands sensory input. Sensory processing is the ability to receive and process information from one's sensory systems including touch (tactile), visual, auditory (hearing), proprioceptive (body position), and vestibular (balance and coordination). Behaviors, attention and peer interactions are greatly influenced by the child's ability to process sensory stimuli.

Visual perceptual processing- the ability to interpret and use what is seen in the environment. Use cortical visual fields for focused tasks such as reading and writing and peripheral visual fields for navigating one's environment. The peripheral visual field is an important component in managing flight-fright-fight responses.

Motor coordination – the ability of several muscles to work together harmoniously to perform movements. Motor planning is the ability to conceive of, organize, sequence and carry out unfamiliar or complex body movement in a coordinated manner. Motor planning is a critical underlying component of efficient motor coordination.

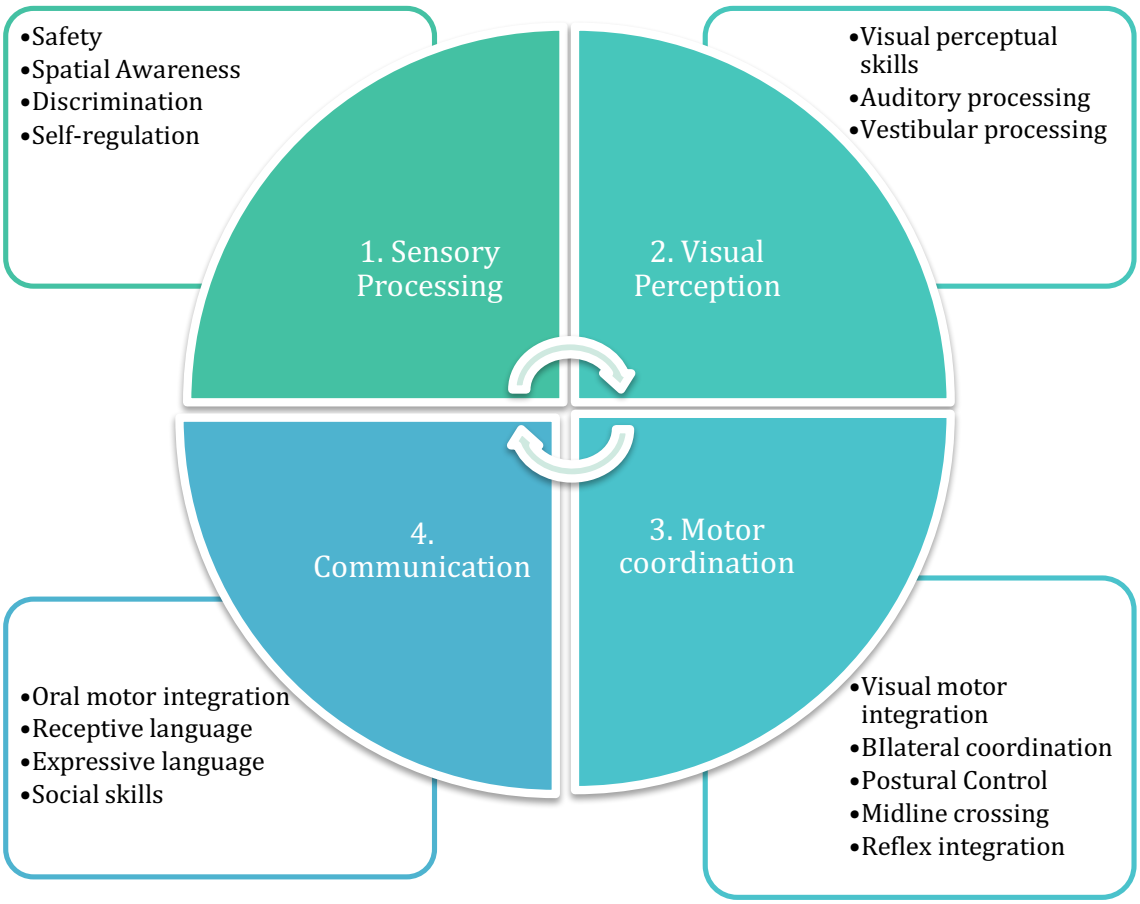
Communication – the ability to interpret verbal and non-verbal cues to process and interact through expressive and receptive language. Integrated communication skills are necessary for effective interaction and socialization.

Functional skills – the ability to perform activities of daily living (Represented by the center arrows in Figure 3:1)

Specific information is analyzed within each of these categories. For example, sensory processing can be divided into body/spatial awareness, sensory discrimination, self-regulation and self-protection. These are broad categories that involve numerous foundational and developmental pieces to coordinate in an energy efficient manner and are typically a result of this well-tuned system. When one of these components is inefficient, there is a trickle-down effect causing a functional deficit that may manifest in mal-adaptive behaviors such as poor concentration or poor social skills. In a comprehensive assessment together with a brain map, a therapist can make clear

distinctions between the various patterns of function and dysfunction. This improves the diagnostic process as recommended by the EACD (2011) and provides a platform for effective treatment planning. The treatment process then becomes logical and is defined by the data.

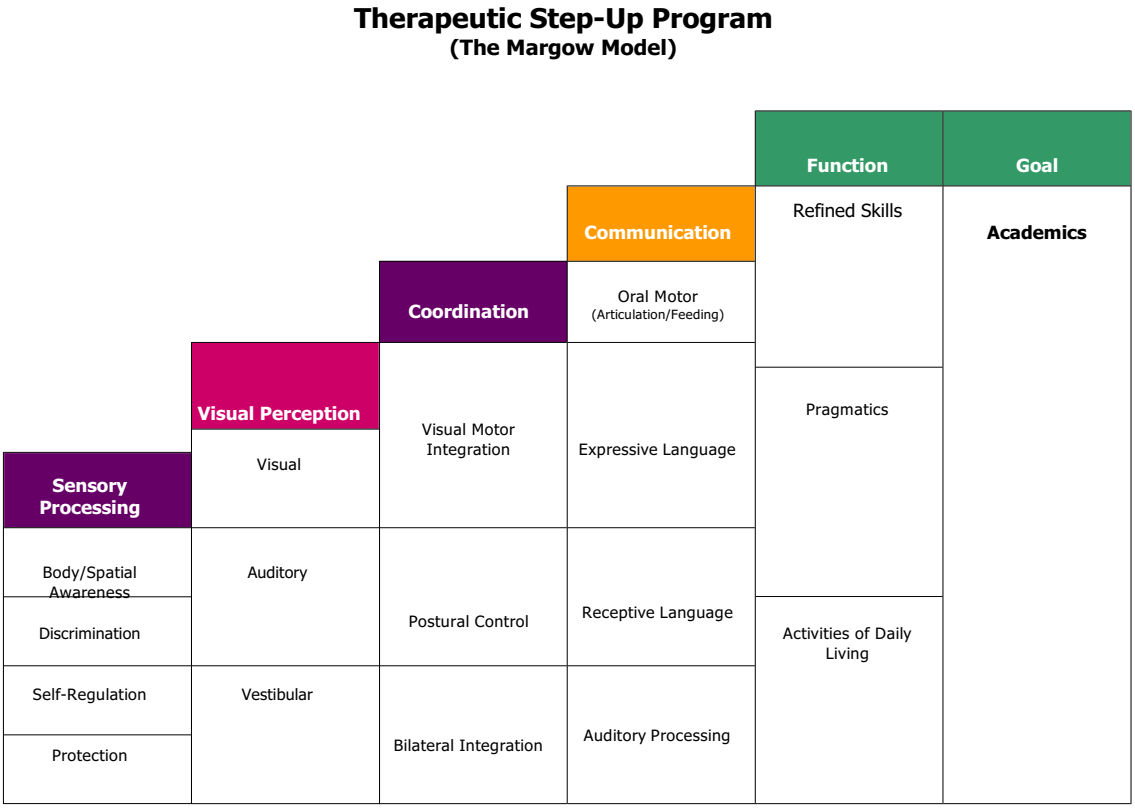
Figure 3:1 Visual Representation of the Proposed Assessment and Treatment process



Through comprehensive testing and brain mapping, the therapy team determines deficit areas within the scope of 5 areas described above. Parent and child interviews incorporates client-centered participation to ensure that the goals are developed, aligned

and prioritized according to their needs. The team then addresses the therapeutic needs using a step-up approach defined by the Margow Model over a period of three months for two hours per day (or if preferred, a one-month program for 4–5 hours per day, if appropriate for that specific child).

Figure 3.2 The Margow Model



The Margow Model Objectives

The Margow protocol has 4 specific objectives that are incorporated throughout the program. These are:

- *Developing a sense of safety* is a primary objective for the program. When the child is able to move past the "flight, fright, fight" response, the brain becomes more pliable for learning (Werner, 2013. When the child is feeling "safe," then

they can take in and process sensation from movement and the environment and use it to plan and organize behavior and play (Bundy & Murray, 2002).

- *Adaptive responses to the environment* involve efficient processing of the child's sensory experiences to encourage meaningful play or learning responses in a timely, organized manner. Adaptive responses are assessed in the treatment environment, home and classroom. Children are given an opportunity to assess the environments that they are exposed to – the OT can assist the child in implementing functional strategies that allow for optimal functioning. This can be done by removing stimuli and barriers, or by helping children to develop strategies that they can implement themselves. Another important component is helping the children advocate for themselves when the environment becomes stressful (Reynolds et al., 2017).
- *Skill acquisition* is grounded in the child's intrinsic motivation and success in learning new skills. This objective incorporates task-specific interventions but can only be successful when the child feels safe and has experienced successful adaptive responses that they may not have previously experienced (Margow, 2014). The child and family are typically included in this process, with the ability to implement positive behavioral supports to reinforce positive behavior and reduce negative behaviors.
- *Functional participation* in activities of daily living, academics and extra-curricular activities are the final outcomes of the Margow Model. As the children develop their skills; self-esteem, motivation and participation improve. It is

important that these skills carryover into their daily lives to ensure successful engagement, participation and well-being (AOTA, 2014).

Activities. The following is an example of a protocol outline that a therapy team can follow. Before the program starts, the child participates in a comprehensive battery of testing. This may include occupational therapy, physical therapy, and speech therapy standardized testing. If the child is able to tolerate a brain map, this will be included in the battery of tests. It is important to look at all the areas noted in table 3:1, therefore the OT will use (a) sensory integration tests (sensory profile or sensory processing measure); (b) a motor based test (Movement Assessment Battery for Children second Edition or the Bruininks-Oseretsky Test of Motor Performance) (c) visual processing tests (Test of Visual-Motor Skills and/or Test of Visual perceptual skills). These tests are commonly used for children to identify developmental coordination disorder (DCD). Upon completion of the all the testing, the team determines the highest priorities preventing the child from successfully participating in age appropriate tasks. It is important to include all these areas of testing for a child/teenager with DCD as they commonly have a primary diagnosis of Autism Spectrum Disorder (ASD) or Attention Deficit Disorder (ADD). This is further assessed to establish whether there are underlying deficits creating the dysfunction. For example, if the child has a significant attention issue, it is important to determine if there is an underlying sensory component, visual component or motor component. This aids in determining the course of action for the intervention plan.

The first two weeks of the program focus primarily on process-oriented (bottom-

up) interventions. As the child develops efficient sensory processing, task-oriented (top-down) treatments are introduced if the child is feeling safe and is initiating activities with less assistance from the therapists. The top-down interventions require higher level cognitive processing, increased specific skill performance and consistent recognition of feedback, which increases the children's awareness toward their own function. They use these strategies to change their responses to the activity. With increased awareness, the children build higher levels of confidence and they typically choose to participate in more complex activities. With the younger children, sessions encourage various forms of play whilst incorporating specific tasks to address the determined deficits.

Week 1: Focus is on developing a sense of safety and trust within the treatment room. Specific activities would be client-directed with minimal redirection from the therapist to ensure that the child was participating and engaged in the activity. The first week would focus on vestibular and tactile activities to determine how the child responded to the input. The therapist would set up the environment with these specific activities that allowed for success. For example, the occupational therapist may set up a 4-piece obstacle course and encouraging the child to complete it independently with a tactile activity at the end. By increasing intensity during the week and using Ayres Sensory Integration techniques to drive arousal level, we should see improvements in the child's sense of safety (objective 1) by the end of the week. There may be some adaptive responses (objective 2), but this usually depends on the severity of the sensory processing deficits. It is my clinical experience that if sensory integration is not a significant deficit, then adaptive responses occur more quickly.

Week 2: Increasing the demand on the child by adding more challenging sequences to the obstacle courses and encouraging the child to come up with their own activities to add in, whilst increasing the "just right challenge." The focus would be on testing the limits of vestibular input, increasing tactile intensity and using proprioceptive activities to help the child learn calming strategies. Continuing to increase the challenge encourages changes in arousal level whilst improving motor and sensory performance.

Week 3: Continue to increase demands and start to redirect complexity of motor skills, whilst observing the effect on arousal levels and incorporating strategies to help the child and parent manage arousal levels. Begin to introduce activities that focus on visual-motor integration and visual perceptual skills to drive attention to task. This incorporates more top-down activities, that encourage skill acquisition and generalized learning as described in the CO-OP (Polatajko & Mandich, 2004. Visual motor integration is a higher-level skill and a functional outcome of skills acquisition (objective 3). This higher-level skill depends on synthesizing relevant information quickly and efficiently. A child is capable of acquiring these skills once they have the underlying sensory and motor components to do so.

Week 4: Incorporate previously learnt skills that have been introduced over the 4-week period and encourage child's participation in recreating what they have learnt. Observe what the child has retained and areas that are still deficient. This is one of the hallmarks of the DCD diagnosis: the child does not learn effectively through repetition, therefore it is important to use various strategies to encourage neurological changes. This is an important phase to incorporate the theoretical strategies shown to be effective by

top-down approaches such as the CO-OP. The evidence supports top-down (task-oriented) approaches. The evidence demonstrates that there is stronger carryover into daily living skills when children with DCD realize that they are successful and are motivated to try their new skills in their daily lives (Scammell et al., 2016). This is the point in the Model that encourages children to discover and identify the strategies that help improve their performance. This is a key principle of the top-down, client-centered approach that has been identified as best practice according to the EACD Recommendations (Becker et al., 2011).

Given the potential variations in treatment, it is critical to ensure that the therapist administering the treatment is highly qualified to do so. Ayres Sensory Integration treatment uses suspended equipment, tactile opportunities, oral motor toys and devices that generate proprioceptive feedback. Programs such as Interactive Metronome or Fast ForWord require certification in order to administer them. Top down approaches such as the CO-OP have specific principles that need to be implemented to ensure intervention effectiveness. For the purpose of a single-subject study/pilot study (see chapter 4), I would specify exactly which swings/suspended equipment could be used per week, when to introduce oral motor aspects of treatment, and how to administer tactile and proprioceptive feedback. This would further ensure that the core elements of the ASI aspects of treatment were present and could be replicated by another therapist. Similarly, the components of the CO-OP and top-down interventions would be clearly stated. It also provides enough variation for the therapist to effectively redirect the treatment session to ultimately reach the “Just Right Challenge” which is correlated to arousal level

(Schellenberger, 2016). The “Just Right Challenge” can be described as that moment when all the pieces fall into place, and the child “gets it.” We can observe these successes when the therapy session flows and there is a change in energy, behavior and full engagement without barriers.

Potential Barriers and challenges

There are a number of challenges facing this type of proposal. The most significant challenge is the lack of evidence supporting process-oriented interventions for children with DCD, which is a key component of the Margow Model. Secondly, identifying children with a primary diagnosis of DCD is dependent on the referral sources, which the author has already established is a significant issue in the greater medical community. Third, a training program would have to be implemented to ensure fidelity of treatment and the protocol needs to be manualized. Fourth, time constraints affect the ability to produce the manual with technical experts before this project is presented.

Implications for occupational therapy practice

The impact of this project has value to the individual clinician by providing a therapeutic tool to use with their clients in all settings. It also provides an educational tool for the consulting therapist whose client base is parents and educators working directly with their children. As this model becomes widely accessible, the occupational therapist can be recognized as an effective, research supported professional in child development.

Conclusion

This chapter presented emerging evidence in occupational therapy pediatric

practice to support the proposed Margow Model. In doing so, the author proposes the opportunity (1) to start the critical conversation of how occupational therapy treatment potentially facilitates neuroplasticity and (2) to stimulate further research of intensive, evidenced-based occupational therapy intervention using a multi-faceted therapeutic approach (Reynolds et al., 2017). The end goal of this project is to publish a preliminary paper describing a model of treatment for children with developmental coordination disorder, with the intention of operationalizing this model. A second element is to provide training for occupational therapists to implement the model effectively. A third element is to propose a pilot study to assess the effectiveness of the model. In the next chapter, the author introduces an evaluation plan of a single subject study using the 4-week intensive protocol of the Margow Model.

CHAPTER 4 - Evaluation Plan

Proposal for Single Subject Study

Purpose of the Study:

A child with a presenting diagnosis of Developmental Coordination Disorder can be at a disadvantage in regards to intervention options. The research clearly indicates that there is little evidence-based practice to support the current interventions being used to treat children with DCD. The purpose of using a measurement tool such as QUEEG is to obtain quantitative data to determine whether the intervention is effectively changing brain wave patterns, corresponding to changes in functional skills.

Clear changes in patterns of brain wave activity measured before and after intervention can provide data that demonstrates changes in function due to the intervention. This information can potentially be matched to typical standardized testing that occupational therapists use to measure function in this population e.g., motor skills, sensory processing, visual perceptual skills, visual motor integration skills and social skills. This information is needed in pediatrics to provide an alternative to the current research that is available which is so limited.

Determining the best type of intervention for this specific client can impact the time and financial commitment that a parent would have to spend to obtain the desired outcomes. The impact on the client is significant because they can achieve their goals faster and more efficiently and demonstrate more effective carryover into their daily

lives, which ultimately improves health and wellness, reduces disability and improves learning.

The impact on having a client reach their potential sooner rather than later reduces stress levels within the family dynamic, allows confidence to develop in the client and encourages overall success in the program. The goal for these children is to provide strategies to enable learning the motor skills they lack and transfer them to their regular environment such as school, sports and social skills. Researchers agree that by improving the motor skills, secondary difficulties (e.g., low self-esteem, lack of participation in sports) can be reduced or avoided.

Research question:

Will treatment based on the Margow Model of intervention improve arousal level scores on the QEEG in children with developmental coordination disorder resulting in improved participation in academic and social activities?

Description of the participant and setting:

The child is an 8 year old boy with a primary diagnosis of developmental coordination disorder. He demonstrates low self-esteem, prefers to play alone and does not want to participate in any team sports. His parents are concerned about his social skills even though he is liked by all his peers. He lacks confidence going into social situations such as on the playground and attending birthday parties. He has lost interest in trying to learn how to ride a bike after numerous attempts at trying to teach him. This affects the entire family as biking is a preferred activity for weekend leisure and it has

become more of a stress as the child has grown older. He has higher than average intelligence but academics are challenging for him and he avoids his homework, which is impacting overall academic performance. The main factor affecting his functional performance is a fluctuating arousal level that causes behavioral outbursts.

Arousal level is a core factor that affects the child's ability to learn new tasks, attend to and complete ADLs, engage in social interactions and perform academic tasks efficiently. When arousal level is affected, all areas of function are affected. For children with developmental coordination disorder who struggle to learn and integrate new motor skills, one of their greatest struggles may also be maintaining their arousal level, which impacts all neurological processes, including those needed to learn new motor skills. It also affects social interactions between family members and friends.

Arousal level has typically been measured using standardized assessments such as The Sensory Profile or the Sensory Performance Measure (SPM); or through using subjective information from parents, teachers and the child. These measures have been challenging to use to test short-term gains as they are generally based on the parents' and teachers' experience. By using a quantitative measure such as the QEEG, we can assess short-term changes as often as necessary to show whether there is a rapid change due to the intervention. As therapists, we could benefit from being able to measure arousal level within short periods of time (e.g., weekly) to ensure that the intervention is affecting change.

Measuring the dependent variable

QEEG software is a quantitative measurement tool that allows testing as often as needed. Due to the nature of this type of study, I propose we record the first set of data points before treatment, then after every 2 sessions, resulting in 10 sets of data during the intervention phase. To establish whether the intervention has successfully carried over into functional activities, measuring at 30 days after the intervention and 6 months after that would provide a comprehensive data set to show whether change had occurred and was maintained over time.

Before testing, we would measure motor and processing skills using standardized tests including the Sensory Profile, the Movement ABC and the Test of Visual Motor Skills-3rd Ed. (TVMS-3). This data will provide a baseline of the functional skills affecting a child with DCD. The tests would then be completed at the 6-month mark after the Margow Model of interventions. By gathering data in 2 different ways, I propose that we will be able to establish clear assumptions about the sensory integration treatment in relation to children with DCD. I am also interested in seeing whether the standardized tests will show changes in these variables which can lead to assumptions that arousal level is related to efficient sensory and motor processing skills.

Overview of the structure of the study

Intervention fidelity has been established by researchers regarding the use of sensory integration (Schaaf et al., 2014) for children with autism spectrum disorders who are strongly impacted by changes in arousal level. Researchers in the sensory integration

field acknowledge how important arousal level is to learning new skills and overall functioning in day-to-day activities therefore using this intervention is congruent with established theoretical assumptions and treatment techniques. The nature of this study is to test the effectiveness of an intensive multi-faceted program on children with developmental coordination. The desired outcome is to determine whether this intervention protocol (The Margow Model) can improve arousal level in the child. Due to the continuous type of treatment proposed, a *multiple baseline design* meets the needs of the study.

Baseline phase: All treatment is suspended for one month and a brain map is performed 1 per week to establish a baseline.

Sequence and duration: A child participates in a single standard occupational therapy session once per week for 4 weeks as part of the control group. Arousal level is measured via a brain map weekly.

Intervention phase: Child participates in 5 consecutive days, with 1- hour treatment sessions per day. At the end of two consecutive sessions, a brain map is performed and arousal level measurement documented. Brain maps are completed after the 5th session.

Upon completion, the child goes back to regular daily living skills with no therapy for 3 months. After 3 months, a brain map is completed to determine whether the outcome has been maintained and a final brain map is completed at 6 months.

Multiple measurements: If the child does not already have standardized testing that measured motor coordination and sensory processing, the child will complete the

Movement ABC and the Sensory Profile to establish a functional baseline of motor skills, sensory processing skills and functional outcomes. This testing will be repeated at the 6-month mark. Even though motor skills and sensory processing are not being measured as the dependent variable, the treatment will still facilitate a change. By demonstrating a change in these areas, too, I would be interested in showing a correlation between motor and sensory processing skills and the impact that these functions have on arousal level.

The QEEG (Qualitative Electroencephalograph) measures the electrical activity of the brain. Research has shown strong statistical analysis between brain waves and actual function. The QEEG has been a well-accepted measuring tool since the 1960s in the psychiatry world and with the growth in technology, it has become accessible to therapists. The QEEG will be used to measure academic skills and arousal level.

Experimental Condition: The OT conducts 1 hour per day of sensory integration treatment in an outpatient clinic that has suspended equipment, tactile and proprioceptive opportunities. A protocol incorporating specific strategies to deliver these will be used to maintain fidelity of treatment. All sessions are performed in the morning to reduce factors that may affect arousal level throughout the day. Parents are asked to keep a journal to jot down their experience related to changes in the child's arousal level.

Hypothesis: Intensive sensory integration treatment delivered within a 4 week period, to children with developmental coordination disorder, will result in positive changes in arousal level thereby improving academic performance and socialization. The thought process behind this study is two-fold. First, sensory integration is a well-used intervention method that has very little research supporting its effectiveness for children

with DCD, yet that is the reason Jean Ayres developed this treatment in the 1960s. Second, research is supporting the hypothesis that intensive therapy creates neurological change due to neuroplasticity, yet this hypothesis is not transferring to children with DCD. I hypothesize that inefficient processing and integration of the sensory and motor functions of the brain affect arousal level, causing disorganization of the neurological processes that are required to help children learn new skills. By reorganizing these neural pathways through intensive sensory integration intervention, we can facilitate efficient, effective processing, which will improve motor and sensory skill development, arousal, attention to task and overall wellbeing in the child.

Key components of the intervention

Sensory integration treatment is considered a highly skilled, specialized method of treating children with processing disorders. In order to effectively be able to observe nuances and direct treatment effectively, this individual would have to be Sensory Integration and Praxis Test Certified (SIPT) along with having higher-level training on how to treat sensory integration disorders. There are many excellent therapists who can treat children effectively without this certification, however for the purposes of the study and to ensure fidelity, I believe this should be a prerequisite. A SIPT certified therapist has learned the neurology behind sensory processing, demonstrates higher-level evaluation and clinical reasoning skills and is able to utilize those skills in a treatment session. This allows for the adherence to the Ayres theory of sensory integration treatment and maintains the fidelity of the study (AOTA, 2014).

The protocol is one that our clinic has developed over the past 15 years; this

would be the first study to test out the theory. There is very little research supporting ASI treatment for children with DCD, which is one of the reasons that I believe it is important to look at the potential of this Single Subject Study through a different lens then the research has proposed.

The following is an example of a protocol outline that a therapist can follow. Because SI treatment is dependent on the "here and now," the protocol has to allow for immediate responses from both the treating therapist and the child. This is reason why SI treatment can be difficult to operationalize; therefore it is up to the therapist's expertise to control the dependent variable in a succinct manner.

Week 1: Focus is on developing a sense of safety and trust within the treatment room. Specific activities would be client-directed with minimal redirection from the therapist to ensure that the child was participating and engaged in the activity. The first week would focus on vestibular and tactile activities to determine how the child responded to the input. The therapist would set up the environment with these specific activities that allowed for success. For example, the occupational therapist may set up a 4-piece obstacle course and encourage the child to complete it independently with a tactile activity at the end. By increasing intensity during the week and driving arousal level, we should see changes by the end of the week.

Week 2: Increasing the demand on the child by adding more challenging sequences to the obstacle courses and encouraging the child to come up with their own activities to add in, whilst increasing the "just right challenge." The focus would be on

testing the limits of vestibular input, increasing tactile intensity and using proprioceptive activities to help the child learn calming strategies. Continuing to increase the challenge encourages changes in arousal level whilst improving motor and sensory performance.

Week 3: Continue to increase demands and start to redirect complexity of motor skills, whilst observing the effect on arousal levels and incorporating strategies to help the child and parent manage arousal levels. Begin to introduce activities that focus on visual-motor integration to drive attention to task.

Week 4: Incorporate previously learnt skills that have been introduced over the 4-week period and encourage the child's participation in recreating what they have learnt. Observe what the child has retained and areas that are still deficient. This is one of the hallmarks of the DCD diagnosis: the child does not learn effectively through repetition. Therefore it is important to use various strategies to encourage neurological changes.

Given the potential variations in treatment, it is critical to ensure that the therapist administering the treatment is highly qualified to do so. SI treatment uses suspended equipment, tactile opportunities, oral motor toys and devices that generate proprioceptive feedback. For the purpose of this study, I would specify exactly which swings/suspended equipment could be used per week, when to introduce oral motor aspects of treatment, and how to administer tactile and proprioceptive feedback. This would further ensure that the core elements of the treatment were present and could be replicated by another therapist. It also provides enough variation for the therapist to effectively redirect the treatment session to ultimately reach the "Just Right Challenge" which is correlated to

arousal level (Schellenberger, 2016).

Establishing internal validity

In order to maintain internal validity, it is important to recognize the potential threats. Maturation must be considered, which can be minimized by establishing a consistent baseline 1 month before the treatment phase. Maintaining consistency in instrumentation can be controlled by the high quality data collection of the QEEG software. This software is developed to "disqualify" excessive "noise" during testing. A factor that may not be controlled for is if the child is having a tough day, he or she may not be compliant with wearing the head gear to obtain the data. This can be controlled for by using a positive feedback system and schedule that is given to the child at the beginning of the study thereby reducing any anxiety around the testing. Regression toward the mean and diffusion of treatment can be consistently controlled as the software data is unlikely to be extreme, and if there is interference during the testing, this can be eliminated to maintain the consistency.

Data Analysis

Upon visual inspection of the graphed data, if there is a trend in the baseline data, then confirming with the C and Z statistics must be completed. If there is no change in the data then a two standard deviation band or binomial test must be performed. This must be performed to confirm if there is no trend after confirming with the C or Z statistic. If there is a significant trend after confirming the C and Z statistic, the data can be further confirmed by determining the change through celeration analysis. There are enough data points in the study to meet the minimum 8 measurements; therefore

determining the C- Z statistic is possible. If there are less than the 8 data points, statistical analysis will have to be done only through the two standard deviation band and binomial test.

Practical issues

A host of practical issues must be considered when performing a Single Subject study with a child. It is highly likely that daily consistency will be affected by illness either related to the child him- or herself or someone in the family. It is important to understand all the factors affecting the participant to ensure that we establish generalizability at the beginning of the study. One of the challenges that face pediatric therapists is intervention fidelity especially in relation to sensory integration treatment. It is critical in this study to adhere to the intervention protocol and maintain the essential elements of the intervention. Consistency and reliability of using the QEEG has been established in the psychology field, but not amongst occupational therapists as a measurement tool; therefore it would be important to establish test-re-test reliability, inter-rater and internal consistency reliability in relation to this particular use of the tool. In order to minimize bias, an independent therapist should perform the brain maps. In working with a child, this can pose a challenge as the child has established a relationship with the treating therapist. An option to overcome this is to establish a relationship with all therapists and personnel involved in the study before it begins through play experiences, without actually implementing any intervention.

In conclusion, occupational therapists have numerous tools at their disposal to evaluate and treat a variety of populations and disorders. We must continue to build a

strong body of evidence to support our interventions and qualify what we do to stakeholders, whether they are our clients, payers or colleagues. Learning how to do research such as single subject design and having tools such as Goal Attainment Scaling affords us the opportunity to enhance our profession, build credibility and facilitate evidence- informed practice.

Figure 4.1 DATA ANALYSIS PLAN

CHAPTER 5 - Funding Plan

Project Description:

Occupational therapists have used interventions guided by neurological approaches based on a variety of motor control and motor learning theories for decades. These theories have evolved over the past 30 years in many other fields such as neuropsychology and physical education however OTs have been a little slower to follow the shifting research (Mathiowetz & Haugen, 1994). As recently as March 2016, we are seeing the impact that qualitative and quantitative studies have on OT treatment (Kilduski & Rice, 2016), but generalizing this back into practice is always a challenge. Our goal is to help our clients improve their function. In pediatrics we want our children to be successful scholars, be able to socialize effectively, feel confident in who they are in their worlds and participate within their family unit effectively. With the time and financial constraints that our clients are faced with, therapists are constantly challenged to address all areas of function efficiently and effectively. In an effort to provide a structured program, this doctoral project focuses on presenting a sensorimotor based intervention model that incorporates motor learning principles to implement a combination of process-oriented and task-oriented intervention for children with DCD.

Over the past 10 years, this author has worked on developing a combined step-up/top down approach to integrating sensory integration treatment and neurological interventions into a child's intensive therapeutic program. By developing an individualized program and incorporating specific sensory and motor strategies into the child's day, we have seen positive responses to *remediating* dysfunction and *learning*

new skills. Without a specific focus on academics, all students have shown improvements in academic achievement of anywhere from 35% to 180% within a 9 month school year (Margow, 2015). These changes are measured through QEEG brain mapping software, which allows the comparison of maps throughout the program. These improvements consistently harmonize into the rest of the child's life. Throughout the program, the children, regardless of diagnosis, show significant improvements in self-esteem, body concept, social skills, and motor skills and inter family relationships.

Funding Plan Introduction:

The funding plan for this program is divided into 3 phases: (1) creating a manual to operationalize the Margow model, (2) marketing the complete program to potential clients (occupational therapists who are interested in implementing the program into their own practice), and (3) aligning with a university to research the effectiveness of the model.

The Phase 1 consists of consulting with a team of professionals who specialize in program development to operationalize and manualized the intervention model proposed in Chapter 3.

Phase 2 consists of a needs assessment to determine who the best potential clients would be and then marketing the program to these pediatric occupational therapists on a national and international level.

Phase 3 focuses on partnering with academic institutions who have the ability to research the validity of the model together with community pediatric practices and school systems. Through well-developed research, fidelity can be established which will

positively impact the marketing component and drive a commercial product.

Available resources:

As a private practice owner, the following resources are available to the first phase of the funding plan: an interdisciplinary team of salaried therapists including occupational, speech and physical therapists; students completing their Level II Fieldwork placements with us; students from local high schools who volunteer their services; employed facilitators who are trained in the neurological programs; accessibility to brain mapping software, evaluation tools and computer technology needed to administer and track programs. Finally, we have access to customer service representatives and developers of the programs that we implement, whose services are covered by the licensing fees.

Needed Resources: Budget

Given the large undertaking of three phases from development to dissemination and research, the budgets for this project require substantial financing.

Phase 1:

Although the theoretical model has been implemented on a small scale within the private setting, it is important to operationalize for wider use and distribution. This requires time and expertise in adding detail and description to the existing model that allows for the development of a manual. Outsourcing to hire a professional contractor who can take the model and work with me to put it into a manual format is an important first step.

Phase 2:

Marketing the program requires tools such as a website, search engine optimization, a training/ consulting component and the ability to access therapists through resources such as

- AOTA/ ASHA/ APTA website advertising
- Autism organizations
- Dyspraxia Foundation
- Google Ad Words
- Facebook Marketing
- Internet Display Marketing
- Email Marketing

Phase 3:

As a Boston University Alumni, there are many opportunities to align with researchers who are interested in pediatric interventions. Using platforms such as Research Gate is a valuable resource that connects researchers with similar interests. Another opportunity is to offer undergraduate and graduate students the opportunity to use this model as their research dissertation, for example as an OTD project to carry out a single subject study. The study could be carried out at our location, which would provide all the necessary equipment and training to ensure fidelity of the study. The costs incurred would be the same as Phase 1 and 2 for facility, equipment and salaries. Through collaboration with an academic institution, the study needs and components of the study would be determined

before funding was secured. Phase 3 of the project would include: (1) writing the proposal to connect with researchers who are interested in exploring intervention models for children with DCD (2) offering training pro bono to the prospective students and providing support throughout the project at the expense of the clinic and (3) expenses related to writing and publishing the study. Phase 3 grant funding would be dependent on the size of the study and involvement of the academic institutions and their available resources. A professional grant writer would be hired to secure the funding.

Next, the Tables will provide a detailed budget for the first two years of development. The first year will primarily focus on operationalizing and publishing the theoretical model. The upfront expenses for Phase 1 include consulting with a professional writer who has the skillset to operationalize the model. Services such as fiverr.com or freelancer.com offer professionals who bid on the project. Due to the nature of this intellectual property, an intellectual property attorney and business attorney respectively will be consulted to file the necessary paperwork with the U.S. Copyright Office. Upon completion of the manual, a marketing plan will be developed to disseminate the manual through a website portal built by a professional company (WebhostMx). Simple training videos will be produced through a web-based service such as Vimeo or YouTube to explain the basis of the program and how to implement the program into practice. The training videos will then be uploaded onto an eLearning platform (Proprofs.com).

Tables 5:1 and 5:2 provide expected detailed budget descriptions of the first two years

Budget Items	Year one		Year two	
	Phase 1 Operationalizing Model	**Phase 2 Marketing Model**	**Phase 1 Operationalizing Model**	**Phase 2 Marketing Model**
Equipment : **Mac Computer** **Video Camera** **Brain Mapping Equipment** **Interactive Touch Screen**	 $2500 $650 $4600 $3000	0	0	
Attorney Fees	$15,000	$10 000	$5000	0
Editing and publishing	$5000		$3000	
Copyright costs	$85		0	
Marketing		$55,000		$24 000
Website development and SEO	$15,000			$12 000
Proprofs subscription	$295 annually			
Vimeo Professional subscription	$204 annually			
Program development including my time	$60 000		$60 000	
Consultation services	$10,000		$10 000	
Freelancer or fiverr platform	$1000– 3500 per project		$500 monthly for revisions	
Grant writer	10% of grant funded		10% of grant funded	
GrantWatch Subscription	$199		$199	
NASE Annual membership	$120		$120	
Training protocol development	$25 000		$25 000	
Total Costs	Approx. cost of $225 000		Approx. cost of $185 000	

Table 5:1 Budget for Phases 1 & 2

Budget Items	Year 1	Year 2
Salaries	$65 000 X # of therapists involved in administering treatment during study. Projected: 3 occupational therapists	$65 000 X # of therapists involved in administering treatment during study. Projected: 3 occupational therapists
Facility rent	$18 000	$18 000
Utilities	$6000	$6000
Therapy equipment	$15 000	0
Administration support	$32 000	$32 000
Professional Grant Writer	10% of grant funded	10% of grant funded
Statistics software	$1295	$1295
Approximate total	$300 000	$285 000

Table 5:2 Budget for Phase 3

Potential Funding Sources

Potential funding sources for this three-phase program are broken down into two tables (Table 5.2 for Phase 1 and 2; Table 5.3 for Phase 3). The nature of the funding differs for the various stakeholders. Table 5.2 provides small business funding opportunities that are not necessarily focused on occupational therapy development, rather on supporting growth for small business women and/or community health and welfare. Investing in small business encourages innovation. Phase 1 meets these criteria in taking a theoretical model and developing a profitable product, which can be implemented into a much larger market such as school systems and daycare centers. The potential impact on child development training and education is always a passionate cause for large companies who have a grant funding arm. Most of these grants are fairly small, but can be allocated to specific phases of the project. Most of these grants will not

fund the equipment, but will allow for the marketing and manpower development of the project. Private funding through Children's Therapy Works will remain a major contributor to the program development.

Phase 3 is research based. It is hoped that it could be funded through academic and governmental institutions (such as the National Institute of Health) for purposes of supporting healthcare and enhancing the profession through evidence-informed practice. Pediatric OTs have the opportunity to demonstrate their value in early intervention and appropriate programming for children with disabilities. With three distinct pediatric models (1) school-based/ educational model (2) outpatient medical model and (3) private practice (AOTA, 2015b), having an integrated evidence-informed program can potentially improve the management of occupational therapy services for children with DCD. This can further influence the allocation of resources in these settings. Although this has not been the scope of this project, there is ongoing discussion that the medical model may be requiring more consultative interventions then costly 1:1 interventions. One of the goals of a research phase is to demonstrate the cost effectiveness of an integrated, therapeutic model such as the Margow Model.

A professional grant writer will be able to present the program according to the required criteria for the various grants. The goals of the initial studies will be to demonstrate the validity of the intervention protocol and a secondary outcome of the study will demonstrate the cost effectiveness of implementing this type of model within the three different pediatric models of practice.

Potential funding sources presented in table 5:3 were chosen because many of

them fund women-owned, small businesses that focus on innovation and making a difference in the community. The grants tend to be smaller then research grants ranging from $3000– $120 000 however there is considerable publicity for the winning company. An advantage to using a professional grant writer is the ability to carefully assess the grant requirements and adapt each grant accordingly.

Table 5:3 Potential Funding Sources

Potential Funding sources	Requirements
GrantWatch to find Federal and State grants	With a paid membership there is access to grant writers and alerts to relevant grants in your areas of expertise.
Medstartr	Crowd sourcing funding for healthcare innovation. Must have a developed product to fund. This would be more appropriate for Phase 2 of the project.
Eileen Fisher	The EILEEN FISHER Women-Owned Business Grant supports innovative, women-owned companies that are beyond the start-up phase and ready to expand their business and their potential for positive social and environmental impact. Presently, we award $120,000 in grants for up to 10 grant recipients (minimum grant $12,000) on an annual basis **Eligibility Criteria** All businesses applying for the program must meet the following criteria: • Majority women-owned and women-led (majority defined as minimum 51%)* • In operation for a minimum of three years at time of application and able to provide accompanying financials • Revenues not exceeding $1 million in year prior to application • Business founded on creating environmental and social change

The *InnovateHER Challenge*	*InnovateHER* provides an opportunity for entrepreneurs throughout the U.S. to showcase products and services that have a measurable impact on the lives of women and families (30%), have the potential for commercialization (40%), and fill a need in the marketplace (30%). Up to $70 000 awarded through the SBA. Applications are open until May 12, 2017.
JPMorgan Chase & Co.	20 $100 000 grants for small business who share their vision and story with JP Morgan Chase. Together with LinkedIn, customers vote for the business that they believe would benefit most from the grant.
FedEx Small Business Grant Contest	$250,000 in small-business grants to entrepreneurs with a deep passion for their businesses Eligibility: The Contest is open to only legal residents of the fifty (50) United States and the District of Columbia who at the time of entry are independent owners/operators of a for-profit small business that is domiciled in the fifty (50) United States or District of Columbia which has been in continuous operation selling a product or service for not less than six (6) months at the start of the contest. In order to be considered an eligible "small business" for purposes of this Contest, the business must meet all of the following criteria: a. Entrant/owner must be at least eighteen (18) years of age at the time of Submission; b. The business must be registered with the Secretary of State in the home state where the business is domiciled and, upon request, Entrant must provide at least one of the following as proof: i. Copy of valid Secretary of State Certificate; ii. Copy of valid Business License; iii. Copy of utility service or other recurring bill in the name of the small business, reflecting the street address of the small business; c. Entrant/owner must be an authorized agent of the registered business; d. The business must be in good standing as of the

	date of Submission and must remain so through the end of the Contest; e. The business must have between 1–99 employees on its payroll. f. Not a previous FedEx Small Business Grant Contest Winner. g. Not in any way affiliated with a franchised business. h. Not under bankruptcy protection or have judicial liens or attachments. To enter the Contest, entrants ("Entrants") are required to visit the Contest website located at fedex.com/grant contest (the "Contest Site") and submit an entry (the "Entry") between February 21, 2017 and March 29, 2017. A FedEx account is not required to enter the contest. Entrants will be required to provide responses to the following: (1) Give us your elevator pitch (tell us what you do, what you sell, the service you offer…) (2) Tell us about your business, what inspired you to get into it, what makes your business stand out and what difference it makes on you, your community or the environment and (3) How would you use the FedEx Small Business Grant money to make a significant impact on your business? The narrative responses of the Entry must be no more than 1140 characters in length (maximum of 140 characters for the elevator pitch and 500 characters per each additional response) During the Judging Period, the Top 600 will be judged by Sponsor or its designated representatives and narrowed down to 100 finalists (the "Top 100"). Sponsor will consider the following in determining the Top 100: • Clear, compelling and engaging essay answers and video • How Entrant proposes to use the Grant money • Use of social media to develop Entrant's brand voice, including use of visuals, cohesiveness, humor, engagement and uniqueness • Website ease of navigation, ease of ordering services or products (if applicable), product availability (in stock or not, if applicable)

	• How well the Entrant's brand aligns with the FedEx brand • Whether the Small Business Owner is prepared to be a Small Business Ambassador or mentor to other small businesses Extra credit will be given for those Entrants exhibiting any of the following elements: • Unique or innovative product or service offering • Sustainability/environmentally friendly business • Positive impact on the community **CONTEST PERIOD:** The FedEx Small Business Grant Contest (the "Contest") begins on February 21, 2017 at 12:00:00 AM Eastern Time (ET) and ends with the announcement of winners on April 25, 2017. The Contest consists of three (3) periods as set forth in the chart below: Submission Period 2/21/2017 3/29/2017 Voting Period 3/1/2017 4/5/2017 Judging Period 4/6/2017 4/24/2017
National Association for Self Employed (NASE)	Grants awarded for up to $4000 each for financing. Grants can be used for marketing, advertising, hiring employees, expanding facilities and other specific business needs. To be eligible for an NASE grant: - Be an NASE Member in good standing - Demonstrate a business need that could be fulfilled by the grant - Provide a detailed explanation of how you will use the grant proceeds - Show how the grant will improve your business growth and success - Offer supporting documentation such as a résumé and business plan

National Science Foundation	The National Science Foundation funds research and education in most fields of science and engineering. It does this through grants, and cooperative agreements to more than 2,000 colleges, universities, K–12 school systems, businesses, informal science organizations and other research organizations throughout the United States. The Foundation accounts for about one-fourth of federal support to academic institutions for basic research. SOCIOLOGY PROGRAM - Doctoral Dissertation Research Improvement Awards (Soc-DDRI) The Sociology Program supports basic research on all forms of human social organization — societies, institutions, groups and demography — and processes of individual and institutional change. The Program encourages theoretically focused empirical investigations aimed at improving the explanation of fundamental social processes. Included is research on organizations and organizational behavior, population dynamics, social movements, social groups, labor force participation, stratification and mobility, family, social networks, socialization, gender roles, and the sociology of science and technology. The Program supports both original data collections and secondary data analysis that use the full range of quantitative and qualitative methodological tools. Theoretically grounded projects that offer methodological innovations and improvements for data collection and analysis are also welcomed. **Full Proposal Target Date** February 28, 2017 February 28, Annually Thereafter Invited Resubmission October 16, 2017 October 15, Annually Thereafter **For-profit Organizations** - US commercial organizations, especially small businesses with strong capabilities in scientific or engineering research or education. An unsolicited proposal from a commercial organization may be funded when the project is of special concern from a national point of view, special resources are available for the work, or the proposed project is especially meritorious. NSF is interested in

	supporting projects that couple industrial research resources and perspectives with those of universities; therefore, it especially welcomes proposals for cooperative projects involving both universities and the private commercial sector.
Small Business Innovation Research	SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs. Three phases of development: Phase 1: Concept development (6 months) >$150 000 Phase 2: Prototype Development (24 months) > $1,000,000 Phase 3: Commercialization – No SBR Funding
Walmart	National Giving Program : Awards grants of $250,000 and above. Eligible nonprofit organizations must operate on a national scope through chapters/affiliates in many states around the country or through programs that operate regionally/locally but seek funding to replicate program activities nationally. State Giving Program: Awards grants of $25,000 to $200,000. Eligible nonprofit organizations must operate on a regional/state level or be affiliates/chapters of larger organizations that operate on the regional/state level. Community Grant Program: Awards grants of $250 to $2,500 through Walmart stores, Sam's Clubs and Logistics facilities. Eligible nonprofit organizations must operate within the service area of the facility from which they are requesting funding.

A description of funding sources related to phase 3, is presented in Table 5:4.

Phase 3 requires separate identification and application to potential funding sources.

Table 5:3 funding sources, awards grants to small business development, whereas research grants have an academic focus with the goal of supporting evidence-based practice. The costs involved in phase 3 are related to implementing a research study that will validate the model after the model has been developed.

Table 5:4 Phase 3-Grant Funding for Research

Funding sources	
GrantWatch: 1251 available grants for children with special needs	A comprehensive grant search engine identifies grants for: universities, hospitals, government agencies, schools, community based organizations, faith-based organizations, research institutions and some small businesses and individuals. Special education grants for educating students with special needs with specially designed instruction, as per the No Child Left Behind Act, ADA, 300.39 IDEA, addressing individual differences and needs, including: grants for speech, travel training, vocational education, adaptive physical education, EIS early intervention services, resource rooms, special education teachers, classrooms and technology.
Eunice Kennedy Shriver National Institute of Child Health and Human Development	The NICHD uses a variety of funding mechanisms to support research at other institutions, organizations, and facilities. The sections below provide general descriptions and information about the research support mechanisms used by the NICHD.
Administration on Intellectual and Developmental Disabilities (AIDD)	UCEDDs are a nationwide network of independent but interlinked centers, representing an expansive national resource for addressing issues, finding solutions, and advancing research related to the needs of individuals with developmental disabilities and their families. Four core functions frame the UCEDD program: • Interdisciplinary pre-service preparation and continuing education • Research, including basic or applied research, evaluation, and public policy analysis • Information dissemination • Community services, including direct services, training,

	technical assistance, and model demonstrations Representing a broad range of disabilities, UCEDDs support activities that address various issues, from prevention to early intervention to supported employment. Additional grants may be awarded to UCEDDs to conduct national training and other initiatives. Current training initiatives are funded to support post-secondary education opportunities for people with developmental disabilities and to enhance self-determination skills, and two grants focus on partnerships with minority serving institutions.
U.S. Department of Education: Preschool Grants for children with disabilities	The Preschool Grants program provides formula grants to states, the District of Columbia, and Puerto Rico to make available special education and related services for children with disabilities aged 3 through 5. In order to be eligible for these grants, states must serve all eligible children with disabilities aged 3 through 5 and have an approved application under Part B of the *Individuals with Disabilities Education Act* (*IDEA*). A state that does not make a free appropriate public education (FAPE) available to all children with disabilities aged 3 through 5 cannot receive funds under this program or funds attributable to this age range under the *IDEA* Grants to States program. Currently, all States are making FAPE available to all children aged 3 through 5 with disabilities.
Caplan Foundation for Early Learning	The Caplan Foundation for Early Childhood is intended to be an incubator of promising research and development projects that may ultimately enhance the development, health, safety, education or quality of life of children from infancy through seven years of age across the country. Each of its grants is made with the expectation that a successful project outcome will be of significant interest to other investigators or developers, within the grantee's field of endeavor, and will be amenable to beneficial application or adaptation elsewhere. In essence, the foundation's goal is to provide seed money for those imaginative endeavors, addressed to the needs of young children, which appear most likely to bear fruit on a national scale.

Summary and Conclusion

The funding plan for a three-phase project is substantial. It involves operationalizing a model, developing a business and marketing plan and researching the validity of the program. The scope of this project is dependent on building a team that understands the social, economic and therapeutic value of introducing new concepts and creating a marketable product that is evidence-informed.

The role of pediatric occupational therapists is critical in the management of children with DCD as this population is growing and the need for services is essential. However, the medical community is not successfully identifying these children as discussed in Chapter 2. Therefore, OTs lack the knowledge to assess and treat this population effectively. The costs to healthcare and education become significant when a population such as this is not proficiently managed. An initial investment of approximately $225 000 for the first year and approximately $185 000 for the second year of Phase 1 and Phase 2 combined is required to develop the Margow Model. Once the model is marketable, training will be available to OTs and educators for a fee. Costs of developing the training are included in the initial investment as part of the manual development, however buffers have been added for unforeseen costs that will arise as part of the development process. Phase 2 involves dissemination of the information thereby bridging the gap between theory and practice. Phase 3 focuses on measuring the effectiveness of the program through single subject studies and Goal Attainment Scaling. Determining fidelity is a critical step in reinforcing the value of having a cost-effective, integrated model. Through education and innovation, OTs can function as a contributing

member to educational and medical teams in a much more comprehensive, holistic manner.

The prospect of creating a successful, reproducible model for pediatric intervention is exciting for occupational therapy practitioners who are looking for ways to improve their practice and offer successful outcomes for their stakeholders.

Effective dissemination of the Margow model should: (1) educate occupational therapy practitioners on effective assessment and implementation of the model (2) improve awareness of the greater medical and educational communities on the extent of the DCD population and the value of the occupational therapists' role in intervention. The dissemination of this program will be discussed in detail in the next chapter.

CHAPTER 6 - Dissemination Plan

Description of the proposed program

Occupational therapy practitioners specializing in pediatrics integrate several tools into their practice. Clinically the tools "feel" like they are effective, but very few interventions in the pediatric field have evidence-informed research supporting their validity. With the rise in children diagnosed with developmental coordination disorder (Zwicker et al., 2012) and the lack of comprehensive management of this disorder (Morgan & Long, 2012), it is the goal of this doctoral project to: (1) identify the current research on effective interventions for children with Developmental Coordination Disorder (DCD) (2) understand the current state of the evidence regarding diagnosis and treatments used by occupational therapists and (3) deliver a therapeutic option for occupational therapy practitioners who are looking for an evidence-informed intervention.

A thorough investigation of the evidence literature confirms that there is a lack of evidence supporting process-oriented interventions (e.g., sensory integration treatment), even though 90% of pediatric occupational therapy practitioners use this intervention in their practice both in school and private outpatient settings (AOTA, 2015b). There is more emerging evidence supporting task-oriented interventions such as the Cognitive Orientation to daily Occupational Performance (CO-OP) (Camden et al., 2015). The proposed intervention, outlined in chapter 3 describes the Margow Model. It was designed based on best-practice, evidence-informed model and then implemented into private practice as a useable protocol. By formalizing the Margow Model into a manual,

occupational therapists will have an opportunity to integrate it into their practice.

Neuroimaging techniques are providing emerging evidence about the etiology and motor imagery of DCD. Certain types of techniques such as Quantitative electroencephalograph (QEEG) offer occupational therapists the capability of measuring changes in brain activity. With improved data collection and outcomes, stakeholders are more likely to support the intervention. The primary goal of this chapter is to present a dissemination plan for The Margow Model to occupational therapy practitioners specializing in pediatrics (primary audience). A secondary audience is medical providers responsible for diagnosing this population, teachers and parents.

Dissemination Goals

The dissemination plan is divided into long and short term goals. The goals focus on the development and implementation of the Margow Model into clinical practice.

Long-Term Goals (2–4 years)

1) Project will provide an evidence-informed therapeutic model for occupational therapists to implement into their pediatric practice.

2) Occupational therapy practitioners specializing in pediatric therapy will have an opportunity to participate in research to ensure best practice of the proposed intervention.

3) Occupational therapy practitioners, educators and medical professionals specializing in pediatrics will understand the importance of using developmental coordination disorder as a primary diagnosis.

Short-Term Goals (12–18 months)

1. The author will operationalize the Margow Model and develop a manual for distribution.
2. Occupational therapy practitioners will have an opportunity to implement the Margow Model and provide feedback to the author about recommended modifications.
3. The author will identify and partner with academic institutions that are interested in researching the intervention model.

Target Audiences

The primary audience for the Margow Model is occupational therapy practitioners specializing in pediatric practice. Secondary audiences include occupational therapy graduate students who are interested in research and educators who are working with children diagnosed with DCD.

- **Primary audience**: occupational therapy practitioners who specialize in pediatrics often work within a team environment, e.g., within a public-school setting. By having access to the Margow Model, therapists can disseminate the principles of the program to other team members thereby incorporating a holistic intervention plan for the client.
- **Secondary audience**:
    - Graduate students who are interested in researching interventions have an opportunity to do so by assessing the model, collecting relevant data and measuring outcomes. This continues to support the emerging evidence and

adds to the exploration of evidence-informed practice.

- Educators are an important audience to focus on as they typically see this population before anyone else. If they are able to identify and refer children with DCD to occupational therapy, then occupational therapists can facilitate evaluation and treatment. This allows for a stronger team effort towards navigating the options for treatment.
- Pediatricians and psychologists are the professionals who are diagnosing children, typically after educators and parents express their concerns about the child's function. The simplest known course of action seems to be to medicate the child before occupational therapy is considered. The goal is to promote occupational therapy services and encourage medical professionals to refer the family for an evaluation, including the OT into the primary care process.
- Clients' families may benefit from understanding that a DCD diagnosis does exist and can be used to support and navigate the therapy process. Many times, families rely on educational materials via the Internet to understand how to help their children. Through education and promotion of occupational therapy services and understanding that the OT is a key player in their child's therapeutic program, parents can make informed choices for their child.

Key messages

In order to successfully achieve long term changes in the management of children

with DCD, the following key messages must be clearly articulated to each audience.

For occupational therapists

1. Developmental Coordination Disorder is often overlooked in the pediatric population. It is a neuromotor disability that interferes significantly with a child's functional and academic skills (Zwicker et. al. 2012). Occupational therapists are key players in addressing motor performance skills to facilitate optimal participation in activities of daily living, social and academic activities.
2. Occupational therapy practitioners specializing in pediatrics play an important role in educating stakeholders about diagnosing and treating children who may have DCD.
3. As occupational therapy practitioners, we are responsible for informing our coworkers and clients about best evidence practice and available evidence informed interventions.

For educators and parents

1. Developmental Coordination Disorder is a potential diagnosis that may be relevant to children that may not be meeting their developmental milestones within the expected time frames. Through correct diagnosis, the child may have more opportunity to participate in the appropriate therapies, which prevents secondary issues such as poor self-esteem.

2. The Margow Model provides a multi-faceted intervention model that will teach you the practitioner, educator and parent how to manage the difficulties experienced by the child using integrated, everyday strategies that can be incorporated into the school day and home life.

For medical professionals

1. Early referral to occupational therapy will assist in qualifying your patient's diagnosis of DCD. DCD is a growing problem and the need for intervention is rapidly increasing (Chambers & Sugden, 2016). Interdisciplinary collaboration is key to ensuring that all options of therapeutic intervention are made available to your patient (and caregivers) and the current evidence supports multi-faceted intervention.

Teachers are often the first professionals to recognize motor deficits (Camden et al., 2014). By recognizing the markers that affect children with potential coordination difficulties and referring them to occupational therapists for evaluations, teachers can continue to be the primary facilitators of child development by implementing the principles of the Margow Model, as part of the multi-disciplinary team.

Sources/ messengers

The most effective messengers for a new intervention are those who have experienced successful outcomes of the proposed program. Although parents and teachers are secondary audiences, they offer a powerful, message that moves swiftly through their communities.

- *Model Designer*: Shelley Margow MS, OTR/L has owned her multi-disciplinary private practice since 1998. She developed the Margow Model to train the multi-disciplinary teams that provided intensive therapy to the clients coming to the practice. She is currently a student in the post-professional doctorate in occupational therapy (OTD) program at Boston University.
- *Occupational therapists:* The most credible messengers to educate and disseminate information about the DCD diagnosis and interventions are the occupational therapists who are recognizing and assessing children in their practice. As they talk to the parents about this "new" diagnosis, parents educate their pediatricians and other medical professionals that they are working with.
- *Teachers:* are excellent at sharing information with the families whose children they work with. Through education and understanding, they can help parents identify how the difficulties associated with DCD are affecting their children on a daily basis in the learning environment.
- *Parents:* Parents offer a powerful voice through social media, support groups and blogs. When a parent believes that their child's needs have been met, they eagerly share information with their support groups, through their Facebook groups or sitting in carpool. Their voices have become much stronger as information can be shared so efficiently through social media. They are a driving force behind social policy change and advocacy.

Dissemination Activities

Dissemination activities include written information, electronic media, social media and person-to-person contact. There are nine broad activities described as follows:

Published Book: Sensory Integration Simplified, is this my child? Was published in 2014 and offers an easy, but detailed understanding of how motor difficulties affect a child's development on all levels. Parents, doctors and teachers have responded well to book. The Margow Model is briefly discussed in the book.

Training Protocol: A comprehensive training protocol is in the process of being developed in an online software program (Proprofs). The software offers opportunities to disseminate the program to audiences of one's choice and adapt it accordingly. The protocol will be available to Children's Therapy Works employees initially to test it and make necessary modifications before being offered to a wider occupational therapy audience. Once it has been fully developed, it will be available to occupational therapists who are looking for continuing education units necessary to maintain their occupational therapy license or registration with the National Board for Certified in Occupational Therapy (NBCOT). The course will meet all American Occupational Therapy Association (AOTA) guidelines for a continuing education (CE) course and advertised as such once approved by AOTA. The cost to develop this protocol is included in the funding plan (See Table 5:1). The course can be administered as an online learning format or in-person seminars for professionals who prefer to work in-person.

Social Media: Social media is an excellent opportunity to share information. Children's Therapy Works currently has a comprehensive website with a blog, twitter account,

Facebook page, LinkedIn, Instagram, Pinterest, YouTube and Constant Contact newsletters that are linked to all these accounts. Ongoing discussions on our blogs will describe DCD and how to manage it effectively with the offer to participate in professional training to learn how to use the Margow Model. The social media component of the dissemination plan is to increase awareness amongst the secondary audiences. Targeted social media campaigns towards potential occupational therapy practitioners, will focus on increasing awareness *and* signing up for a CE course to learn the Margow Model for intervention.

Lunch and Learn: Medical professionals are typically short on time. *Lunch and learn* is a good strategy to increase the awareness that DCD is an important diagnosis option. An 8-mile geospecific area will be chosen based on the proximity to the practice. Lists of pediatricians, social workers and psychologists have been developed into a database.

Checklist: An easy to follow checklist will be given to medical professionals and educators to assist them in identifying whether to refer for an occupational therapy evaluation. This checklist will be part of the development of the manual. At this time there do not seem to be any easy to follow checklists available specifically for DCD.

WFOT Congress 2018: A presentation or poster proposal will be submitted for consideration for the World Federation Occupational Therapists (WFOT) Congress 2018 in Cape Town, South Africa. South Africa is the author's country of birth and the place that she received her occupational therapy degree. She understands some of the struggles that occupational therapists face in this country. This is an opportunity to present a cost-effective model to therapists working in under-funded communities. A proposal will be

submitted to the WFOT Call for Papers by the end of March 2017.

Promotional video: "A guide to understanding Developmental Coordination Disorder" will be produced through a service such as Vimeo. This is accounted for in the funding plan budget (See Table 5:1).

Fact sheet: The fact sheet developed for this project will be reproduced and printed for pediatrician's offices, daycare centers, elementary schools and parents. The cost of 2000 flyers through an online company such as vistaprint is $208.58.

Peer reviewed journal article published: An article outlining the Margow Model will be submitted to a peer-reviewed journal such as the (SIS) quarterly, Early Intervention and School, Sensory Integration and Early Intervention sections of the AOTA publication. Furthermore, OT Practice and American Journal of Occupational Therapy (AJOT) offer a platform to describe the intervention model once the results of the studies are completed. The completed pilot study and a single subject study will be submitted for consideration in AJOT. A perspective article will be written and submitted to OT practice for the purpose of informing those therapists who are interested in learning about a potential intervention.

The dissemination activities require the time of the author to provide content to the marketing specialists who will use it to manage the social media. The Sensory Integration Simplified book is available in hardcopy and digital format from amazon.com and the authors website www.sensoryintegrationsimplified.com.

The fact sheet, peer reviewed journal articles and WFOT presentation are accounted for in the author's salary as described in the funding chapter (Chapter 5) of this

project. The marketing resources are also outlined in Chapter 5 as part of Phase 1 and 2 of the funding plan budget. Table 6:1 provides an overview of the dissemination activities by audience.

Table 6:1 Dissemination Activity Matrix

	Activity	**Primary Audience OT**	**Other healthcare professionals Pediatricians, Psychologists, Social Workers, Teachers**	**Clients General Public**
Written Material	Published Book	X	X	X
	Tip Sheets	X	X	X
	Journal Articles	X	X	
	Poster	X		
Electronic Media	Website	X	X	X
	Blog	X	X	X
	Social Media (Twitter, Facebook)	X	X	X
	E-newsletters	X	X	X
Person to Person	Training seminars	X	X	
	WFOT Congress	X		
	Lunch & Learn	X	X	X

Budget

The priority of the project is to inform occupational therapy practitioners (primary audience), medical professionals, parents and educators (secondary audiences) that there is a theoretical model that can be used in their specific area of practice or lifestyle (as a parent) to address the needs of children with potential DCD. The priorities of the

dissemination plan and budget related to these activities are as follows:

1. Electronic Media: Website development, blogs written, social media managed.
2. Written material: author's time compensated through her salary
3. Training opportunities
    a. training development online
    b. training seminars paid for by attendees
    c. lunch and learns included in salary
4. WFOT Congress –

a. Travel expenses	$3000
b. Food & Accommodations	$3500
c. Conference attendance	$895
Total Expenses	$7395

The costs for the content development of the dissemination plan are outlined in Chapter 5 (Table 5:1). Expenses for the WFOT Congress are explained previously and are include in the dissemination plan budget. The key messages can be promoted through all activities of this project to both primary and secondary audiences. Once the written materials and training modules are complete by the author, the information can be distributed in these various formats as a powerful promotional opportunity.

Evaluation

The evaluation of the success of the dissemination efforts will be measured as follows:

1. Tracking the number of referrals from doctors and educators after a lunch and learn
2. Tracking social media interaction through Google statistics, Facebook interactions, number of followers on social media, quality of responses to the blogs.
3. Number of participants who sign up for the online training. A survey will be completed at the end of the training course to measure participants' suggestions and feedback.
4. Number of participants who attend live seminars. Participants will provide feedback via an end of course survey.
5. Feedback and interaction with occupational therapists and educators who implement the model into practice. A Facebook or LinkedIn group will be set up to encourage ongoing dialogue and share their experiences in using the model.
6. Number of copies of the book (Simplified) sold or downloaded from a vendor's website. This is tracked through www.IngramSpark.com.

Conclusion

The dissemination activities outlined in this project are critical components to educating occupational therapy practitioners, medical professionals and educators who spend their time working with children who have special needs on some level. These professionals are key stakeholders in determining how to manage children with DCD. Through widespread education and promotion of the Margow Model, parents, teachers

and occupational therapy practitioners can feel empowered to help the children they serve. There is a tremendous gap in this population and parents are scrambling to find answers. Effective dissemination can generate a significant contribution to evidence-informed pediatric intervention for children with DCD.

CHAPTER 7 - Conclusion

The outcomes of this project focused on describing the theoretical grounding of the Margow Model as a potential evidence-informed intervention model that can be successfully used for children with developmental coordination disorder (DCD). The results of this project provided an in-depth view of the current research, best practices and barriers facing occupational therapists specializing in pediatrics and who work with the DCD population. The research identified the lack of awareness (particularly in the United States) of this stand-alone diagnosis, the increasing need for occupational therapy services, and the lack of evidence-informed interventions that occupational therapists have access to, to manage the child with DCD effectively. The current evidence highlights top-down interventions (e.g., the Cognitive Orientation to daily Occupational Performance, cognitive-behavioral and task specific interventions) rather than bottom-up (e.g., sensory integration treatment and other process-oriented) interventions. The evidence gap shows that the most popular interventions in the US are still bottom-up (process-oriented) interventions such as sensory integration treatment, irrespective of the current evidence.

Integration of theories

The results of the project highlight the need for an accessible intervention that pediatric therapists can use in all areas of their practice. By using a multi-faceted approach to treatment and incorporating a combined bottom-up/ top down approach, the proposed intervention can meet the multiple needs of a child with DCD. This project

reviewed the theories underlying the proposed model, and its contribution to improving pediatric occupational therapy intervention for children with DCD.

Innovation in pediatric therapy practice

The model that I am proposing uses a step up approach to understanding and planning treatment for children with DCD. The Margow Model is based on sensory integration, motor learning theories and cognitive strategies that suggest neurological changes occur due to brain plasticity (Diaz Heijtz & Forssberg, 2015). The model incorporates factors such as movement organization, sensory processing, cognitive processing, experiential learning and the influence of environmental factors such as home and classroom environments, which influence motor learning (Jarus, 1994). Sensory integration theory suggests that the brain organizes sensory information and with the appropriate environmental challenges using play-based strategies, and that the brain makes new neural connections leading to improved functional participation due to an adaptive response (Bundy et al., 2002). An important consideration is that although the theories are used to improve motor skill, motor deficits have a profound impact on emotional and social development, leading to secondary psychosocial difficulties such as anxiety, depression and poor self-esteem. By using a multi-faceted approach, secondary struggles can be prevented or remediated fairly quickly. The model promotes an integrated approach within the classroom, home and therapeutic environments, thereby addressing the individual and system-wide needs of the students and educators. With the challenges that children with DCD face, the model incorporates comprehensive,

interrelated interventions that address all client factors and skills to facilitate change in body functions and structures; acquisition in motor skills, adaptive changes in processes and improved social interactions.

Future Implications

According to the AOTA (2014), clinical reasoning is a fundamental skill that occupational therapists use within their treatment. Throughout the intervention process, OTs continually assess clients' occupational performance, with the intention of guiding client-centered intervention. The Margow model facilitates clinical reasoning, therapeutic use of self and activity analysis to refine the intervention process and drive stronger outcomes.

In closing, the DCD population is outgrowing the resources available to them. Occupational therapists have an opportunity to educate stakeholders in effectively managing this population. The Margow model provides an innovative, evidence-informed intervention that addresses the comprehensive needs of children with DCD in an easily accessible format. Using this model along with technological advances such as QEEG provides an opportunity for more effective outcome tracking and the ability to modify interventions rapidly. Together with clinical reasoning and the ability to intensively drive therapy, the child can return to performing daily living skills within their environments successfully. AOTA (2015b) states that "occupational therapy is provided toward the aim of affording opportunities for full participation in everyday activities and occupation in which the individuals choose to engage" (p.3). They continue with "through accurate functional baseline data, measurable goals, and data collection to

monitor a child's successful participation…. Occupational therapy practitioners provide accountability for a child's progress…" (p. 3). This statement emphasizes the importance of having occupational therapists participate as a primary member in the child's team of experts. As Sally Fryer Dietz stated "I believe the only real limits in life, are the ones we put on ourselves and/or others….so I say forget the limits and "go for it." You may be surprised at what is really possible!"

APPENDICES:

Appendix A – Reviewed Studies

Table A1 (a). Table of Studies Reviewed in CPG-DCD

	Author and Year	Study Type	Treatment Approach	Level of Evidence
1	Pless M, Carlsson M. 2000[193]	Meta-Analysis – 13 studies	Task-oriented vs. Process-oriented	1
2	Hillier S. 2007	Systematic Review - 31 studies according to EACD	Task-oriented vs. Process-oriented Psychomotor training	1
	ORIGINAL PAPERS			
3	Allen S., 1995	Pilot study (n=5)	Process-oriented approach (one hour SIT by OT)	3
4	Alloway, T.P 2008	Pilot study (n=20)	Process-oriented plus Task-oriented (Brain Gym and motor coordination activities in classroom)	2
5	Cohn, ES. 2000	Case study Interviews (n=16)	Process-oriented approach (SIT 32, 1-hour sessions)	3
6	Case-Smith J. 1996	Clinical Trial (n=26)	Some aspects of Task oriented and process-oriented approach (weekly OT in classroom)	
7	Cosper S. 2009	Clinical trial (n=16)	Other approach Interactive Metronome (1 hour, weekly sessions for 15 weeks)	3
8	Davidson, Williams. 2008	Pre-post (n=37) No control group	Process-oriented approach plus Perceptual motor training (SIT, PMT for ten weeks)	3

9	Flapper BCT, Schoemaker MM. 2006	Controlled Trial (n=12)	Other approach (MPH daily)	2
10	Flapper BCT, Schoemaker MM. 2008	Controlled Trial (n=23)	Other approach (MPH daily)	2
11	Green, D. 2008	Stratified RCT (n=43)	Task-oriented (CO-OP – 20 sessions)	2
12	Jongmans MJ. 2003	Quasi-experimental (n=4)	Task-oriented (Group intervention by teachers – motor learning principles NTT, strict letter instruction)	2
13	Jongmans MJ. 2003	Quasi-experimental (n=60)	Task-oriented	2
14	Hall, 2005	RCT (n=117)	Nutritional	2
15	Klein s., 2008	Pilot study (n=6)	Task-oriented approach (Handwriting training)	3
16	Leemrise C. 2000	Cross-over study (n=6)	Aspects of task oriented vs. process-oriented approach (LBD and SIT)	2
17	McWilliams S. 2005	Clinical trial (n=12)	Task-oriented approach (Group therapy weekly using motor based activities)	2
18	Miller LT. 2001	Pilot Trial (n=10 CO-OP) (n=10 CTA)	Task-oriented vs. Process-oriented approaches (CO-OP and CTA)	2
19	Niemeijer AS. 2003	Study to develop teaching principle taxonomy (n=23)	Task-oriented approach (NTT)	3
20	Niemeijer AS. 2006	Pilot study (n=19)	Task-oriented approach (NTT)	3
21	Niemeijer AS. 2007	Controlled trial (n=26)	Task-oriented approach (NTT)	2

		(n=13 no intervention)		
22	Parush S. 1997	Randomized study (n=53)	Other approach (Gross motor perceptual treatment)	2
23	Peens A. 2008	RCT (n=58)	Other approach (MIV- motor based intervention, psychological program, psychomotor intervention)	2
24	Peters JM. 1999	Preliminary pilot study (n=14)	Other approach (motor skills in group setting given by teacher for 1 hour weekly for ten weeks)	3
25	Pless M. 2000	RCT (n=17 intervention) (n=20 control)	Task-oriented (motor skills group)	2
26	Pless M. 2001	RCT (n=37 intervention) (n=60 control)	Other approach (motor skills group)	2
27	Pless M. 2002	Non-experimental descriptive study (n=37)	Other approach Natural outcome, no intervention	3
28	\Polatajko H. 1995	RCT (n=76)	Process oriented approach vs. other approach (Traditional therapy vs. KT)	2
29	Richardson AJ, 2005	RCT (n=117)	Other approach (nutritional – fatty acids)	1
30	Schoemaker MM. 2003	Controlled trial (n=15)	Task-oriented approach (NTT)	2
31	Sims K. 1996	RCT (n=20)	Process oriented intervention (KT)	2
32	Smits-Engelsmann	Controlled trial (n=24)	Task-oriented approach NTT	2

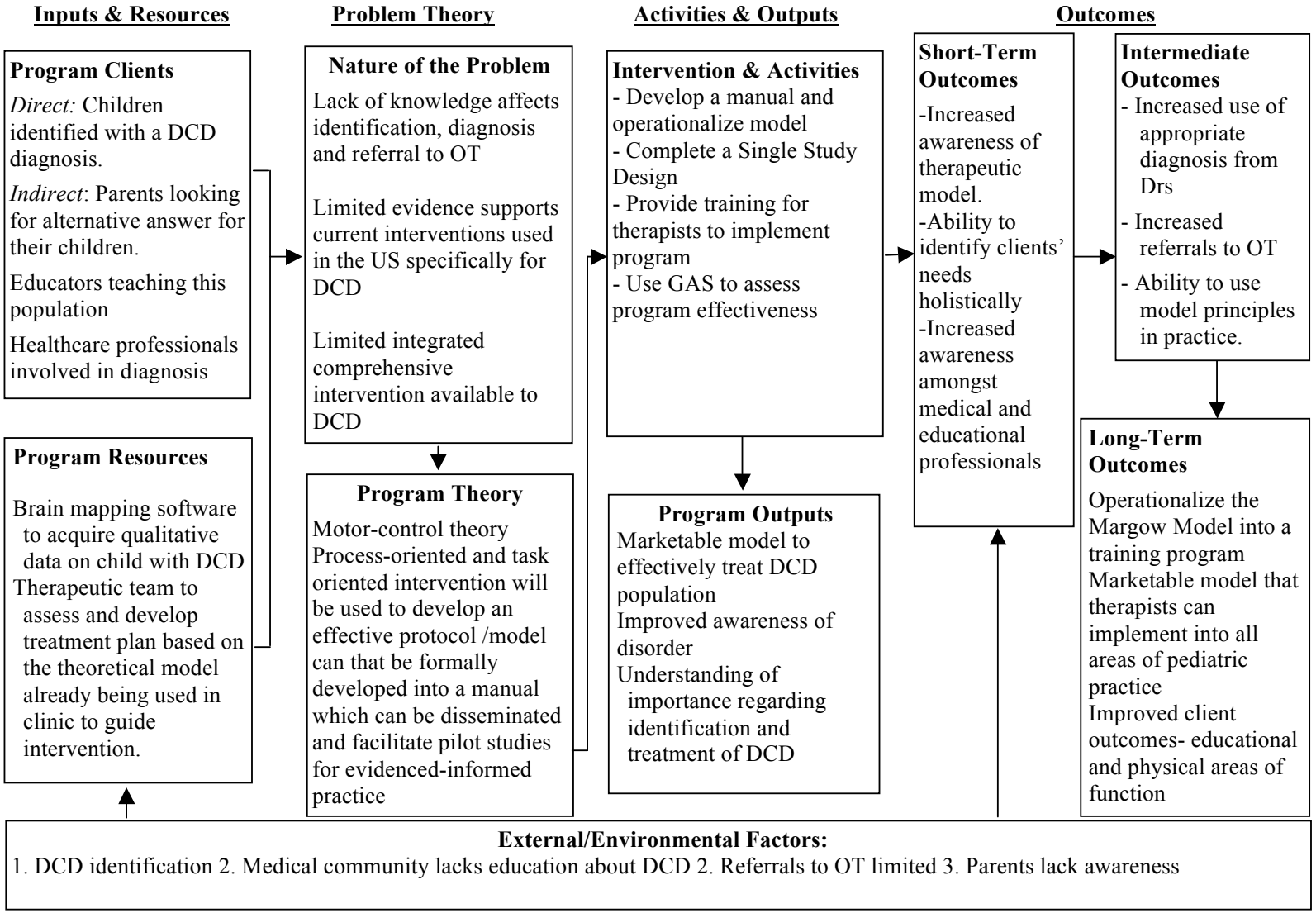
	BCM. 2001			
33	Sudsawad P. 2002	RCT (n=45)	Task-oriented approach vs. process-oriented approach (KT vs. handwriting training)	2
34	Sugden DA. 2003	RCT cross-over (n=31)	Task-oriented approach (activities in classroom)	2
35	Tsai CL. 2009	Quasi-RCT (n=14 table tennis) (n=14 non-training) (n=29 TD)	Task-oriented approach (table tennis)	2
36	Watemberg et. al 2007	RCT (n=28)	Task-oriented approach Cognitive-oriented approach	2
37	Ward A.2004	Single case study (n=2)	Task-oriented approach CO-OP	3
38	Wilson PH. 2002	RCT (n=18 Imagery training) (n=18 PMT) (n=18 control group)	Task-oriented approach vs. some aspects of the process-oriented approach. (Imagery training, PMT)	1

Table A1 (b). Table of studies reviewed 2011–2016

	Author Year	Type of study	Treatment Approach	Level of Evidence
1.	Smits-Engelsman et al.(2012)	Combined systematic review and meta-analysis	Task-oriented	1
2.	Reynolds, Thornton, Elliott, Williams, Lay, Licari (2015)	Systematic review	Neuroimaging techniques can identify etiology, which can inform future intervention approaches.	1
3.	Wilson et al. (2012)	Meta-analysis	Explored patterns of performance deficits	1
4.	Armstrong (2012)	Critical Review of Literature	Task Oriented approach (CO-OP)	2
5.	Morgan & Long (2011)	Qualitative Literature Review	No treatment	2
6.	Missiuna (2015)	Conference Editorial	Future of research	4
7.	Camden, Wilson, Kirby, Sugden, & Missiuna (2013)	Scoping review	Task-oriented and process-oriented approaches	2
8.	Camden, Leger, Morel, & Missiuna (2015)	Perspective article	Task-oriented on community level (Discussion of Apollo model)	2
9.	Chambers & Sugden (2016)	Quasi-experimental	Task-oriented approach	2
10.	Gomez & Sirigu (2015)	Literature review	Neuroimaging discussion	2
11.	Martini, Mandich, & Green (2013)	Practice Analysis	Task-oriented. Modified CO-OP in intensive camp and group approach	3
12.	Novak (2013)	Commentary Journal Article	Task-oriented interventions	2

13.	Henderson & Geuze (2015)	Journal Article – Brief Commentary	DCD management: complex, multilevel continuum that needs more research. No approaches discussed	2
14.	Shoemaker, & Smits-Engelsman (2015)	Perspective Article	Task oriented intervention	2
15.	Werner, Cermak, & Aziz-Zadeh (2012)	Literature Review	Neuroimaging Provides a basis for understanding underlying pathology of DCD.	2
16.	Zwicker, Harris, & Klassen (2012)	Systematic Review	QOL domains discussion, not intervention.	1
17.	Zwicker, Missiuna, Harris, & Boyd (2012)	Literature Review	Neuroimaging. Brief task oriented, vs. process-oriented interventions	2

APPENDIX B: The Margow Model (Logic Model)



Appendix C - Executive Summary for developing an evidence-informed model for children with developmental coordination disorder

Introduction

According to the Center for Disease Control (CDC), 1 in 6 children or 15% of the population between the ages of 3 through 17 years have one or more developmental disabilities across diverse populations (CDC, 2015b). Of these varying disabilities up to 6% of children have a diagnosed developmental coordination disorder influencing their daily function. Developmental Coordination Disorder exists as a co morbid diagnosis with other diagnosis such as Autism and Attention Deficits Disorders. Additionally, there are children that are still undiagnosed and struggling with similar challenges to those with a DCD diagnosis. The increasing rates of diagnosed disabilities in children is acknowledged by the American Academy of Pediatrics as not only affecting the child and family, but significantly impacting the need for services to address these issues. Occupational therapists can have a meaningful impact on DCD however occupational therapy treatments are not evolving at the rate needed to address these populations (Rosenberg, Zhang, & Robinson, 2008). According to the New York Times (Harris, 2015), occupational therapy referrals have increased between 20–30% in the past 4 years but there are not enough therapists to meet the demand in New York City schools. This is one reported example of the challenges that educators, parents and therapists face in identifying and treating children with motor coordination difficulties. As the need increases, service delivery can be performed in many ways, including training educators and teams in methods that facilitate improved occupational engagement and participation

of children with DCD.

Children with developmental coordination disorders (DCD) inherently have neuromotor disruptions that impact their functional performance (Watemburg, 2007). The prevalence of developmental coordination disorder is high among children with diagnoses such as ADHD and autism (Maciver, 2010). DCD therefore presents with motor coordination problems, visual motor integration difficulties, sensory processing differences, communication and behavior challenges. With so many of these difficulties impacting development, the neurological system compensates, leading to specific learning delays that affect reading, writing, and math and cause related mental health problems.

As children with behavioral, sensory processing challenges and developmental coordination disorders enter academic settings that cannot adequately accommodate their needs, their ability to participate in activities of daily living is hampered (Baranek et al., 2002). This adversely affects the child's ability to succeed, thereby affecting family dynamics and the teacher's ability to teach effectively; all leading to high frustration levels. Providing the individual client with a well-planned therapeutic plan will facilitate improved intervention within the IEP process in educational settings or intensive programs in the clinic setting.

Project Overview

The Margow model is based on a combination of sensory integration, cognitive and motor control theories that suggest neurological changes occur through brain plasticity (Diaz Heijtz & Forssberg, 2015). As developed through clinical work and

copyrighted in 2014, this intervention approach uses a combined, bottom up/top down process of treatment (Margow, 2014). By using a clear, well-defined track of interventions in the specific order outlined below, the therapist is given the tools to facilitate significant change in the child's processing ability. As processing and sensory-motor integration improves, the child is able to learn more efficiently and effectively resulting in fewer developmental delays, improved academic performance, social interaction and overall participation in age related activities.

In this treatment model, there are five levels of goal development that are activated before functional goals such as activities of daily living and academic goals are addressed:

- Step 1 addresses sensory modulation/ feeling safe in one's environment.
- Step 2 addresses auditory/visual/vestibular function
- Step 3 addresses motor co ordination
- Step 4 addresses communication
- Step 5 addresses functional activities of daily living.

The funding plan for this program is divided into 3 phases: (1) creating a manual to operationalize the Margow model, (2) marketing the complete program to potential clients and stakeholders, and (3) aligning with a university to research the effectiveness of the model. The total costs for phase 1 & 2 are approximately $410 000 over a 2–3 year period. Phase 3 is dependent on research opportunities and grant funding estimated at $585 000. The potential impact on child development training and education is always a passionate cause for large companies who are interested in funding programs that can

improve health and wellness in children. The funding plan for this three-phase project is substantial. It involves operationalizing a model, developing a business and marketing plan and researching the validity of the program. The scope of this project is dependent on building a team that understands the social, economic and therapeutic value of introducing new concepts and creating a marketable product that is evidence-informed.

Key Findings

It is becoming more challenging for occupational therapists to provide typical 1:1 intervention with the increasing demand for services and pressure from payer sources. The research shows that there is little information about how to implement a specific, model of intervention that meets the needs of children with developmental coordination disorder. Factors contributing to this problem are:

1. Poor diagnosis of children with DCD leading to lack of referrals to occupational therapists. Medical practitioners tend to diagnose ADHD or Autism as a global medical diagnosis. Occupational and physical therapists are more aware of DCD as a functional diagnosis. If a child is not referred to a therapist, the DCD symptomology may be easily missed.
2. Lack of enough published evidence based practice related to treating clients with DCD. In today's medical and economic climate, parents, teachers and payers would like to see evidence behind programs before committing to a program.
3. Few programs available to occupational therapists that help therapists understand integrated, comprehensive, intensive treatment models and how to implement them effectively with children with DCD.

Recommendations

Occupational therapists have used neurological approaches to intervention that incorporate sensory integration and motor learning theories for decades. In order to ensure occupation-centered engagement in the intervention process, task-oriented interventions are also a key component to client-centered treatment. Identification and effective management of children with DCD is an important factor affecting occupational therapy interventions. Secondly, emerging evidence supports the use of multi-faceted programming within the occupational therapy profession to meet the complex needs of these children and their families (Reynolds et al., 2017). Through neuroimaging techniques such as QEEG, occupational therapists can measure and compare their outcomes of the intervention.

General Conclusions

This project has value to the individual clinician by providing a therapeutic tool to use with their clients in both school and clinical settings. Developing and researching a therapeutic model of intervention that uses a scientifically sound neurological measurement can address the growing need for intervention in our pediatric population. Such a program has significant impact on occupational therapists that are looking for effective tools to address their individual clients' needs; the ability to train multiple stakeholders to implement such a program and the opportunity to validate occupational therapy practice amongst colleagues, payers and consumers. It also provides an educational tool for the consulting therapist whose client base is parents and educators working directly with their children. As this model becomes widely accessible, the

occupational therapist can be recognized as an effective, research-supported professional in child development. Educators and administrators are more inclined to support a program if there is scientific evidence supporting the success of the program.

The proposed therapeutic model suggests that by using a bottom up approach to learning, the child becomes a more efficient, effective learner in various environments because they are no longer expending excessive amounts of energy processing information. The top down approach incorporates cognitive and motor learning strategies to engage the client in goal development and provide alternative strategies to facilitate controlled adaptive responses. These adaptive strategies are based on cognitive problem-solving rather than underlying sensory processing. This ensures that the intervention plan is client-centered and the child is part of the goal setting process (a fundamental element of the CO-OP; Polatajko & Mandich, 2004).

With brain imaging technology that is far superior to anything we have had in the past, it is exciting to think that researchers have identified structures in the brain that show primary processes that support learning (Willingham, 1998). Motor learning theory potentially provides strong predictors of success because of the ability to measure planning and execution of skill. If incorporated into a model that uses strategies to facilitate the acquisition of motor skills, then OT's can feel confident in administering the intervention without having to go through extensive neurological training. This project will hopefully stimulate a conversation that is needed within our profession to further expand our ability to stand behind our treatment and provide a solid theoretical base on which it is built. With the challenges that children with DCD face, the model incorporates

comprehensive, interrelated interventions that address all client factors and skills to facilitate change in body functions and structures; acquisition in motor skills, adaptive changes in processes and improved social interactions.

Finally, as children begin to learn more effectively, activity engagement improves. As communities understand the importance of these programs, intervention can shift from being hopeful to becoming impactful. The more effective children are at learning, the more productive they become in society. Productive members of society become contributors positively impacting public health (Glassel, 2011).

Appendix D - Fact Sheet

BOSTON UNIVERSITY

EVIDENCE-INFORMED OCCUPATIONAL THERAPY INTERVENTIONS FOR CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER

Shelley Margow, MS.OTR/L
OTD Candidate

Developmental Coordination Disorder Definition:

* A disorder characterized by an impairment in the development of an individual's motor coordination skills, not due to a medical condition.
* Marked impairment in the development of motor coordination such that the impairment interferes with activities of daily living. (from DSM-IV, 1994) (http://www.icd10data.com/ICDCM/Codes/F01-F99/F80-F89/F82)

DCD Facts

DCD presents with motor coordination problems, visual motor integration difficulties, sensory processing differences, communication and behavior challenges (Armstrong, 2012,Chambers & Sugden, 2016)

Occupational therapists (OT) may know DCD as apraxia/developmental dyspraxia (Werner et.al., 2012)

The onset of symptoms is in the early developmental period

https://www.bigstockphoto.com

The motor skills deficit interferes with activities of daily living appropriate to the chronologic age (eg, self-care and self-maintenance)

Impacts academic/school productivity, leisure, and play. (Zwicker, 2013)

www.childrenstherapyworks.com

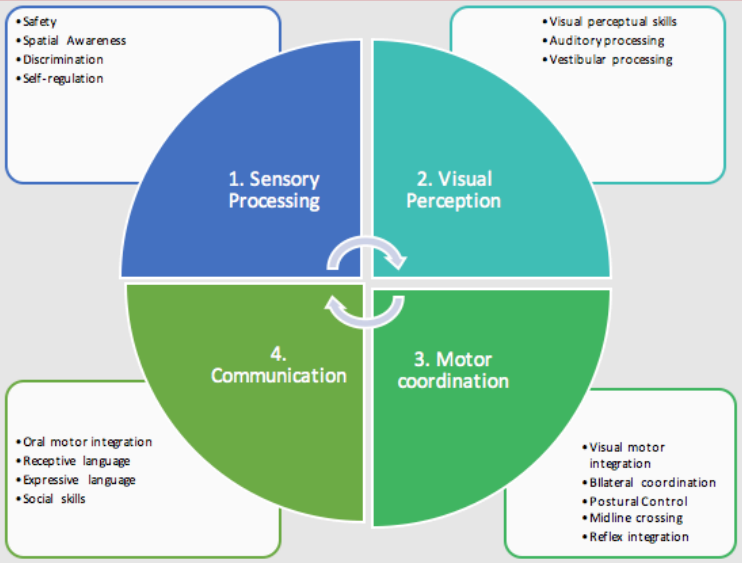
DCD often exists as a co morbid diagnosis with other diagnoses such as ASD, LD, and ADHD. (Wilson et.al. 2013)

There are still undiagnosed children struggling with similar challenges to children with a DCD (Zwicker et.al.,2012)

https://www.bigstockphoto.com

Barriers to Effective Intervention

* Lack of identification by diagnosing professionals
* Lack of referrals to occupational therapy for evaluation and treatment
* Lack of available training for occupational therapists
* Little research to substantiate the validity of various theories currently being used to facilitate intervention for children with DCD (Blank et.al. 2012).
* No comprehensive, integrated model of treatment that is accessible and easy to implement specifically for children with DCD



Goals of the Margow Model:

- evaluating whether sensory processing and integration and/or motor deficits and poor problem solving are affecting function

- intervention that is multi-faceted utilizing process-oriented and task-oriented

- encourages continual evaluation and review of the intervention process utilizing client-centered

Implications for occupational therapy practice

* A therapeutic tool to use with their clients in all settings
* An educational tool for the consulting therapist whose client base is parents and educators working directly with their children
* As this model becomes widely accessible, the occupational therapist can be recognized as an effective, research supported professional in child development.

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