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Investigating the applicability of the neurodevelopmental framework to enhance learning for all students, especially those with mild to moderate disabilites

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INVESTIGATING THE APPLICABILITY OF THE NEURODEVELOPMENTAL FRAMEWORK TO ENHANCE LEARNING FOR ALL STUDENTS, ESPECIALLY THOSE WITH MILD TO MODERATE DISABILTIES

By

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Abstract

The overall focus of this study was to investigate the applicability of the neurodevelopmental framework to enhance learning for all students. The present study sought to provide educators with a sufficient foundation for how movement influences neurodevelopmental maturation for learning, with possible implications for reading, by creating a handbook to assist educators to become comfortable incorporating developmental movement patterns into lessons. One goal was to bring attention to primary reflex persistence interfering with typical movement development, leg length inequality (LLI) connected to primary reflex persistence, and the possible use of LLI assessment to be used as a screening tool for students at-risk for reading. The handbook was submitted for review to two groups with considerable knowledge of the research topic; a national group (n – 6) for content validity and an educator group (n – 6) for social-use validity. The three research questions centered on their responses to the five survey questions regarding content and social validity, and generalizations on developmental movement instruction. Survey data were compared examining interests in and among groups. There was substantial agreement with national experts from various fields such as adapted physical education, physical therapy, movement science, and medicine regarding the relevance, usefulness, and validity of handbook content. However, the national expert in reading strongly disagreed with the premise of the handbook. The educator group reported high agreement for acknowledging handbook relevance and strengths, but lower for usefulness. On a scale from 1-5, with 5 as the most, a mean score of 3 for the educator group indicated that the handbook would be helpful for teaching PE. The national experts suggested audiences that would benefit from the handbook, including APE specialists, general PE teachers, OTs and PTs, and early intervention/resource specialists. Both groups suggested revisions to clarify the introduction; to separate content for the neurology and practical applications components; and to describe a step-by-step intervention program. Insufficient feedback was received for LLI assessment, so this topic might be further investigated.

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CHAPTER I

Introduction

Humans are known for their strong categorical thinking, including establishing labels to identify those categories, so reaching knowledge according to a "continuum" paradigm might take an alternate incentive. Historically, the general education and special education fields have experienced polarizing attitudes that have differentiated approaches for concepts in education. In the current field of special education, the present focus strives for refining viable outcomes by identifying and accommodating the developmental crossover between students in both general and special education, so that the continuum of varying learning needs might be addressed; now with the assistance from advances in science and medicine (Illingsworth & Bishop, 2009).

Historical Relevance

A significant historical influence on the existence of the present special education (SPED) system began with compulsory education laws going into effect at the beginning of the twentieth century, as child labor emerged, including *all* children, not only children from elite backgrounds. As there was an increase of "industrial" children entering schools, the working class children found school education to be difficult, and were placed in classrooms with simplified curricula (Seaman & De Pauw, 1989).

In 1954, the U.S. Supreme Court decision of *Brown v. the Board of Education of Topeka,* in Kansas*,* permitted children of African-American descent to be integrated into classrooms where "separate but equal" for African-American students was determined illegal (*Brown v. Board of Education of Topeka*, 1954). The Brown decision, together with the Civil Rights Act of 1964 (specifically outlawing discrimination based on race), influenced parents of children with disabilities to advocate for equal constitutional rights and legal protection for their children

(Friend & Bursuck, 2002; Horvat, Kalakian, Croce, & Dahlstrom, 2011). A further decision in 1972, *Mills v. Board of Education of the District of Columbia,* was made to provide individuals with intellectual disabilities the opportunity to a "suitable publically-supported education regardless of the degree of the child's mental, physical, or emotional disability," with program funds being distributed evenly, so that no child would be excluded from a public education.

Adding to the legislative momentum, Section 504 of the Rehabilitation Act was enacted to provide the legal framework to force agencies receiving federal funding to eliminate discrimination based on disability, mandate physical access to public institutions for individuals with disabilities, and specify that anyone with a significant physical or mental impairment that limits one or more major life activities is eligible to be considered for special services (Rehabilitation Act, 1973). According to Seaman and DePauw (1989):

> Physical impairment refers to any physiological disorder or condition, cosmetic disfigurement, or anatomical loss affecting one or more of the body systems. Mental impairment refers to any mental or psychological disorder such as mental retardation organic brain syndrome, emotional or mental illness, or specific learning disabilities. Major life activities include care of one's self, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working. (p. 6)

The subsequent public law effort, Public Law 94-142, the Education for All Handicapped Children Act of 1975 remains the basis for our present SPED law (Friend & Bursuck, 2002; Horvat, et al., 2011; Kovar, Combs, Campbell, Napper-Owen, & Worrell, 2007; U.S. Department of Education [USDOE], 2012; Winnick 2005), by clearly outlining the expectation to locate, identify, and evaluate individuals in need of SPED, without regard to the severity of disability (Education for All Handicapped Children Act*,* 1975). PL 94-142 calls for children to be educated in the least restrictive environment among individuals without disabilities, to consider their individual needs *before* SPED placement occurs, to be entitled to a free and appropriate public education, and to be protected, with their parents, under due process (Education for All Handicapped Children Act*,* 1975). PL 94-142 also requires that an annual Individualized Education Plan (IEP) be written for each student whose needs are not met within the general education curriculum (Education for All Handicapped Children Act*,* 1975).

In 1990, PL 94-142 was amended to the American with Disabilities Act (ADA), which specifically outlines a national mandate to eliminate discrimination of individuals with disabilities (ADA, 1990). According to Horvat, et al. (2011), the entirety of the law essentially states, "individuals with disabilities *must* be provided equal opportunities in all aspects of life" (p. 15); individuals with disabilities must have access to *all* activities, in any part. Whereas the rights under Section 504 of the Rehabilitation Act were limited to agencies receiving federal financial assistance, the ADA theoretically assures individuals with disabilities freedom of discrimination *anywhere*.

In 1990, PL 94-142 was also amended to the Individuals with Disabilities Education Act (IDEA), by integrating the previous laws in effect. IDEA was amended in 1997, and in 2004 became the Individuals with Disabilities Education Improvement Act. Among other requirements, IDEA 2004 mandated developing IEPs for students with physical education needs not able to be met under the regular curriculum (U.S. Department of Education [USDOE], 2004).

Several amendments to these prior laws have ensured their continuance, with incorporating explicit mandates for physical education. The U.S. Office of the Federal Register defined special education for physical education. "Special education means especially designed instruction, at no cost to the parents, to meet the unique needs of a child with a disability, including—…

(ii) Instruction in physical education" (Code of Federal Regulations, 34 CFR 300.39, Chapter III, August 14, 2006). Physical education in special education law is defined:

> (1) Special education means specially designed instruction, at no cost to the parents, to meet the unique needs of a child with a disability, including—(i) Instruction conducted in the classroom, in the home, in hospitals and institutions, and in other settings; and (ii) Instruction in physical education…(2) Physical education means— (i) The development of—A. Physical and motor fitness; B. Fundamental motor skills and patterns; and C. Skills in aquatics, dance, and individual and group games and sports (including intramural and lifetime sports); and (ii) includes special physical education, movement education, and motor development. (34 CFR 300.39, Chapter III, August 14, 2006)

Typically, the process for referring a student for a SPED evaluation takes place even before initiating formal testing, with screening, intervention and modification procedures (Pierangelo & Giuliani, 1998). The steps include: Student study team (SST) meetings; parent interviews; classroom management techniques; student support help classes; resource specialist assistance; reading services; remedial reading or math services; recommendation for in-school counseling; daily/weekly progress monitoring reports [including evaluating fall, winter, and spring benchmark tests prior to standardized state testing in the late Spring]; hearing and vision testing; evaluating educationally relevant medical findings [including motor abilities and developmental factors]; disciplinary action; or a change of program, among other options.

According to Cecil (2003) informal reading assessments can be documented with curriculum-based assessments. Teachers can monitor student progress according to: running records (analyzing miscues that the student has read), anecdotal notes (logs of teacher observations regarding a student's participation in literary events), cloze tests (teacher leaving periodic words blank in the context of reading passages, to hear how the student fills in meaning), writing portfolios, phonics or sight word surveys (high frequency sight words are tested for immediate recognition, without hesitation of sounding letter sounds), and story retelling by students.

If the student is referred for a SPED evaluation, after eliminating pre-testing measures, then educational specialists would be consulted for a collaboration of services with parents including: school psychologist; special education teacher; administrator; general education teacher; general physical educator; adapted physical educator; speech/language pathologist; social worker; school nurse; medical personnel; reading teacher; occupational therapist; physical therapist; the child or advocates; and any others having knowledge of the child (Bos & Vaughn, 2006; Friend & Bursuck, 2002; Friend & Cook, 2003; Pierangelo & Giuliani, 1998). According to Pierangelo and Giuliani (1998), the school district, the classroom teacher, or anyone from the school district and/or a student's parents may request for the student to be evaluated, then, with parental permission, the formal assessment process would be administered by a multi-disciplinary team, in a non-discriminatory way, in the student's primary language, "unless it is clearly not feasible to do so." (pp. 8 - 9)

If the student is found to qualify for SPED services, an IEP would be developed, and the student would be placed in a Resource Specialist Program (RSP), a Special Day Class (SDC), or a more restricted environment, with adapted physical education (APE) IEP goals if necessary. In addition, if a student does not initially qualify for services the parents of the student may require a further SST evaluation, and then SPED eligibility could be determined at a later time.

In 1977, the procedures for evaluating the largest category of "Specific Learning Disabilities" (SLD) in the Federal Register were written to accompany the Education for All Handicapped Children Act giving states guidelines to identify a child for a SLD (United States Office of Education [USOE], 1977, pp. 65082 - 65085). Eligibility for SPED services was based on the determination of the team regarding whether there was a severe discrepancy between achievement and intellectual ability corresponding to the student's age and ability levels in one or more of the following areas: (1) oral expression; (2) listening comprehension; (3) written expression; (4) basic reading skill; (5) reading comprehension; (6) mathematics calculation; or (7) mathematics reasoning (USOE, 1977, p. 65083). The child would not be identified as having a specific learning disability if the discrepancy between ability and achievement was primarily the result of: (1) a visual, hearing, or motor handicap; (2) mental retardation; (3) emotional disturbance, or (4) environmental, cultural, or economic disadvantage (USOE, 1977, p. 65083).

The recent 2004 authorization of IDEA mandated that states are *not required* to use the IQ test to demonstrate discrepancy (USDOE, 2004). To determine the existence of an SLD, the group must find that the child does not achieve adequately according to the child's age in one or more of the eight areas (e.g., oral expression, listening comprehension, etc.), when learning experiences according to age-appropriate instruction were provided in regular education settings, and geared toward State-approved grade-level standards (USDOE, 2006, p. 46543). To clarify the State-adopted criteria for evaluating children with SLD, the revised procedures "must permit the use of a process based on the child's response to scientific research-based intervention" (USDOE, 2006, p. 46543). Additionally, the group must provide written documentation for the eligibility determination concerning the other effects of visual, hearing, or motor disability, etc…including "limited English proficiency on the child's achievement level" (USDOE, 2006, p. 46544).

Statement of the Problem

"Although the term *learning disabilities* has been understood to be a heterogeneous term, most laypeople and many teachers interpret it to mean difficulties in reading" (Semrud-

Clikeman, 2005, p. 563). There are many considerations for determining and achieving reading success, even beyond the argument that there exists contrasting evidence regarding the language indicators for reading success (Tran, Sanchez, Arellano, & Swanson, 2011). Students showing difficulty with learning to read may demonstrate difficulty regarding recognizing, remembering, articulating, and connecting letter form sounds into words and ideas; sometimes students are able to connect the decoding of language, but still are unable to understand the meaning of the written passage.

In 1977, it was acknowledged that SLD was difficult to define "based on current knowledge," so the law was written to include SPED funding for SLD, as for more easily defined categories of disability (USOE, 1977, p. 65085).

> It is generally agreed by parents and professionals alike that the isolation of various labels used by different theorists, as cited in the legislative history, are overlapping and represent assumptions about conditions which cannot with current technology be successfully determined or discretely categorized. (USOE, 1977, p. 65085)

Presently, Learning Disability (LD) is defined according to *Diagnostic and Statistical Manual for Mental Disorders, 4th edition, Text Revision* for an individual's academic achievement that is substantially below the expectations for age-equivalent education and intelligence, as measured by standardized tests (American Psychiatric Association [APA], DSM-IV-TR, 1994, p. 49). Teachers identify students at risk for reading success by notifying concerned parents; to be eligible for SPED services the students must go through a lengthy formal referral process, including being examined according to the discrepancy model.

Although SPED law provides a monumental civil rights effort on behalf of lawmakers and their constituents, the language of the legal requirements to determine eligibility for special education funding and services have continuously been in conflict with academics, bound by the interpretation of the words, "a severe discrepancy between achievement and intellectual ability." Culminating research and practice over the past thirty years have been supporting the need for change to this historic model, although currently a sufficient model has still not been formulated for identification and intervention (Hale, et al., 2010). Evidence to identify and support children with SLD through early academic interventions is a complex process. Medical examinations are not required to help identify children with SLD.

In the 1977 Federal Register, it was documented: “A few commenters expressed concern that medical examinations were not mandated for every child suspected of having a learning disability,” and it was said that “medical services that are necessary for diagnostic purposes are covered by the definition of related services” (USOE, 1977, p. 65085). Then, when “asked for more detail on some of the requirements, for example, a more extensive description of length of observation and specific behaviors observed,” the answer was, “no change has been made... the office of education believes the education procedures are already very extensive and should prevent mislabeling” (USOE, 1977, p. 65085).

Physical attributes have been connected to children with SLD. “The concept of developmental motor problems has been discussed for over 100 years” (Cermak & Larkin, 2002, p. 2), and has been examined by pediatricians, pediatric neurologists, physical educators, movement scientists, physical and occupational therapists, psychologists, and neuropsychologists. Cermak & Larkin (2002) stated, “while each of these groups has contributed to our knowledge base, each has also approached it from its own perspective, contributing to a richness of information, unfortunately obscured by differences in terminology and lack of communication” (pp. 2 - 3). “Learning Disorders may also be associated with a higher rate of Developmental Coordination Disorder

[DCD]…[including] underlying abnormalities in cognitive processing (e.g., deficits in visual perception, linguistic processes, attention or memory, or a combination of these)" (APA, 1994, p. 50). DCD has been defined as qualitatively inferior motor behavior of children with "difficulty in learning and performing everyday tasks in home, school, and play environments" (Cermak & Larkin, 2002, p. 2). In addition, the motor deficiency must be:

> distinguished from motor impairments that are due to a general medical condition. Problems in coordination may be associated with specific neurological disorders (e.g., cerebral palsy, progressive lesions of the cerebellum), but in these cases there is definite neural damage and abnormal findings on neurological examination. (APA, 1994, p. 57)

Which neurological examination is meant here? Motor impairments associated with neurological disorders might also be related to treatable or improvable medical conditions. "Motor handicap is considered as being included in the definition of orthopedically impaired" (USOE, 1977, p. 65085). Orthopedic relates to the skeletal structure, whose impairments might be treatable.

Neurological assessments have been formulated to identify struggling learners (Ayres, 1980; Bruininks, 1978; Fiorentino, 1981; Godfrey & Kephart, 1969; 1974, *MBD Compendium;* Pyfer, 1983; Roach & Kephart, 1966; Strauss, 1943), and for early investigations on perceptual-motor functions (Ayres, 1964; Frostig, 1972; Kephart, 1964). Despite efforts in designing tools to provide assistance to educators for identifying students with neurological learning challenges, many in the education field continue to be influenced by much controversy regarding perceptual-motor assessment and perceptual-motor training "not [being] an effective intervention technique for improving academic, cognitive or perceptual-motor variables" (Kavale & Mattson, 1983, p.165). Stephenson, Carter, and Wheldall (2007) stated that the rationale for using perceptual motor programs "with typically developing students as well as students with academic difficulties is justified by claims that these programs will promote academic learning, particularly in literacy" (Stephenson, et al., p. 6). Hoehn and Baumeister (1994) wrote a critique for "sensory integration therapy" claiming that the treatment for academic and motor problems was "not merely unproven, but a demonstrably ineffective, primary or adjunctive remedial treatment for learning disabilities and other disorders" (p. 338).

In 1987, a position statement issued by the Board of Trustees of the Council for Learning Disabilities opposed "the measurement and training of perceptual and perceptual-motor functions as a part of learning disability services" (Council for Learning Disabilities, p. 350). Clarification for the Council for Learning Disabilities (1987) position included:

> Since little scientific evidence exists to show that assessment and training of perceptual or perceptual motor functions are beneficial to learning disabled individuals, schools must view the time and money, and other resources devoted to such activities as wasteful, as an obstruction to the provision of appropriate services, and as unwarranted for any purposes other than those of pure research…(p. 350)
>
> Assessment and remediation of learning disabilities should focus on primary disorders (i.e., listening, speaking, reading, writing, reasoning and mathematics) as specified in the definition of learning disabilities adopted by the National Joint Committee on Learning Disabilities and in federal rules and regulations…(p. 350)

Still, controversy remains within the educational field regarding the relevance of the role for physical education on the learning process. Possible contributors to a lack of agreement have to do with inconsistent measurement (Zagrodnik & Horvat, 2009), and commercially designed programs that do not specifically address progression for an individual's developmental level of physical education proficiency; resulting in unquantifiable factors for cognitive influences.

Part of the controversy regarding how teachers are required to incorporate movement activities for students might be according to interpretation of the law by varying professionals who serve children. For example, mandates for IDEA 2004 include developing IEPs for students with physical education needs not able to be met under the regular curriculum (USDOE, 2004). Additionally, written documentation must be provided for the eligibility determination concerning effects of visual, hearing, or motor disability…"on the child's achievement level" (USDOE, 2006, p. 46544).

Perhaps, the definitions to identify children with learning disabilities have not been fully interpreted or described clearly enough among medical and academic fields, so definitions within the law for identifying sensory components are treated separately, instead of reflecting more a comprehensive neurological basis. Contrasting variables for measurement for the educational and medical fields include disparities within particular systems. Dwyer (1996) examined the categorical educational testing process in general, and stated that "cut scores (a) always entail judgment; (b) inherently result in misclassification; (c) impose an artificial dichotomy on an essentially continuous distribution of knowledge, skill or ability; and that (d) no "true" cut scores exist" (p. 360). Zeffiro and Eden (2000) described confusion for the interpretation of neurological imaging techniques in localizing specific cognitive processes of information processing (p. 22).

Recently, educational studies have now recognized a multifactorial perspective for children with learning challenges (Kibby, Kroese, Krebbs, Hill, & Hind, 2009; McPhillips & Jordan-Black, 2007; Menghini, et al., 2010). Presently, studies in the educational field are acknowledging the need to create more specific identification and screening tools to assess levels of neurological systems by addressing the possible causes, than relying primarily on tests regarding the behavioral manifestations for developmental disabilities (Nicolson & Fawcett, 2009). Multifactorial is described through multidisciplinary views, or areas of expertise.

Sufficient understanding among the team of professionals influencing special education referrals (i.e., family; administrators; regular and physical education teachers; special educators; reading teachers; school nurses; and medical personnel) regarding the impact of atypical physical motor development, and its neurological effect on overall learning is critical. Levine and Kliebhan (1981) acknowledged the need for physicians to have a basic knowledge of the theory of movement for neurodevelopmental assessment in order to coordinate their efforts with physical and occupational therapists. Essentially, visual, hearing, and motor abilities are neurologically integrated.

Additional neurological indicators for information processing include considerations for the responses of primal cervical reflexes. An interdisciplinary literature review yielded the common prevalence of leg length inequality (LLI), including how LLI relates to poor posture (Kraus & Eisenmenger-Weber, 1945), which might include the connection to upper cervical reflexes. "Some discrepancy in leg length is measureable in 65 to 70 per cent of any normal group of human beings, provided the technique of measurement is accurate enough" (Green & Anderson, 1955, p. 1137). The literature describing LLI and upper cervical reflex reactions seem to be explaining similar concepts, although with different terminology.

In my own research for this project I have found that in the physical therapy (PT) and occupational therapy (OT) literature it is essential to check struggling learners for a persistent asymmetrical tonic neck reflex (ATNR), although, in my search for professional references in central California, I have not yet identified this procedure taking place in practice.

It was recommended by Dr. Michael Horvat (personal communication, September 28, 2010) to investigate muscle endurance in Kendall, Kendall-McCreary, Provance, Rodgers, & Romani (2005) in relation to a possible connection between upper cervical reflexes and LLI; head tilt shoulder and hip imbalances were treated together as a related condition, but separately from LLI. Presently, there is not enough material connecting knowledge across the disciplines to find the possible relationships between upper cervical reflexes and LLI; considering the developmental progression of muscle strength for classroom requirements of muscle use.

So far, there is not a common assessment among the medical and educational fields, within the neurodevelopmental framework, that can be used to differentiate struggling learners. Neurological assessment is not categorical, it is based on a common continuum, and can be addressed across all cultural, racial, social, linguistic, and gender distinctions; all relating to seeing and hearing, and ultimately toward academic success (Seaman, DePauw, Morton, & Omoto, 2007). Significantly, such an individual screening approach might address students' needs *before* being referred to a SPED label. In addition, an awareness of the neurodevelopmental framework would be valuable to special educators when addressing the learning needs of students (Kline, Karwas, & Nares-Guzicki, 2012).

In Ysseldyke's (2001) article, "Reflections on a Research Career: Generalizations from 25 Years of Research on Assessment and Instructional Decision Making" the author stated, "The major problems in our discipline will not be solved by single investigators or investigators from a single discipline working in isolation. Rather, major contributions will come from collaborative and multidisciplinary and interdisciplinary efforts" (Ysseldyke, 2001, p. 306).

Purpose of the Study

In 1972, the researcher sustained a serious brain injury, and in 1986 began a treatment which resulted in lessening the sensation of gravitational pull on physical movement ability through assessing LLI; ultimately demonstrating a profound physical and mental improvement, including for memory and speech. For the researcher, many classical SLD symptoms became no longer apparent in the course of treatment. In 2006, the researcher expressed an interest to her advisor, to investigate how such a change could take place. The researcher was referred to the "Neurological Impairment" and "Physical Education for the Elementary School Child" classes taught at that same university. It was through this coursework, in 2006-2007, that the researcher's neurological experience of injury was soon confirmed, and investigating formal empirical literature was presented.

Working as a substitute teacher in the public schools, since 2007, has given the researcher an availability to witness students across a wide range of ages and abilities (from pre-school through early adult; in general education, and special education for the Mild/Moderate, Moderate/Severe, and Emotionally Disturbed). It is the goal of the researcher to share what has been learned, so that additional individuals might benefit from some influences of neurology on the learning process; relating to assessment, curriculum, and instruction. Perhaps, the need for additional exploration will be recognized by expert researchers in the field of education to further connect content from cross-disciplinary boundaries for struggling learners.

Approximately fifty years ago, theoretical models of perceptual-motor theory began with a developmental approach stemming from professionals and authors in physical education, although, "the impetus toward this understanding and acceptance of this approach has primarily been provided by professionals from the subdisciplines of motor development, motor learning, elementary physical education, and adapted physical education" (Seaman & DePauw, 1989, p. 44). According to Seaman and DePauw (1989), the developmental approach:

> facilitate[s] growth and development among individuals with performance disorders, so that these individuals may approximate the norm and achieve their maximum potential…[with] the interrelatedness of levels of education programming.
>
> The developmental model describes the emergence of culturally determined forms of movement based on the innate neural capacity of an individual. Through understanding the developmental sequence evolving from the integrity of the central nervous system and reflex activity…students with special needs [can be considered] in terms of the functioning of sensory and motor systems… (p. 44)

Founding theorists formulated a developmental interrelationship between vision and balance for individuals with learning difficulties include: Ayres (Ayres, 1964), de Quirós (de Quirós, 1976), Frostig (Frostig, 1972), and Kephart (Kephart, 1964). More recently, in the past twenty years, with the advent of functional neuro-imaging measuring variances in metabolic activity that can detect regions where blood flow is present during cognitive tasks, education researchers now have the advantage to see the visual effects of learning to read according to neurological blood flow (Shaywitz, Gruen, & Shaywitz, 2007), as well as other brain tasks. A prominent goal was to examine evidence regarding the lack of blood flow [ischaemia] for eye muscles, possibly influencing the reading process for some atypical readers. Many individuals with dyslexia have demonstrated an increased amount of eye saccades (Biscaldi, Gezeck & Stuhr, 1998), and impairment with peripheral visual processing; including slower moving attention speeds (Facoetti, Paganoni, Turatto, Marzola, & Mascetti, 2000).

Currently, a neurological LLI assessment, determined by a supine leg check (SLC), (Gregory, 1979; Woodfield, Gerstman, Henry-Olaisen, & Johnson, 2011) is typically able to detect an upper cervical bone placement disparity which has shown to be linked to reduced and increased cervical blood flow (Bakris, et al., 2007; Knutson, 2001). Increased cerebral blood flow would lengthen eye muscle fibers (Edwards, et al., 2007), and perhaps strengthen eye muscle movement for longer, more controlled peripheral eye saccades for some individuals with dyslexia; possibly resulting in facilitating the tracking of linguistic characters during reading.

This project was directed toward general and special educators, especially in regard to elementary school readers, to investigate introducing a handbook with references from a multidisciplinary empirical literature base describing themes related to: typical and atypical motor development; hypo-/hyper-tonic muscle strength; lateral disparities; balance deficits; eye muscle weakness; auditory dysfunction, atypical neurological blood/oxygen flow; and inconsistency for criteria to identify, and provide services to children with reading disabilities. The handbook included neurodevelopmental movement education, assessment, activities, with State and National standards. The purpose of the study was to assist in providing educators with a foundation for understanding how movement influences neurodevelopmental maturation for classroom learning; the foremost objective for the booklet was to help teachers become more comfortable with incorporating developmental movement patterns into their classroom lessons.

Additionally, the handbook included a survey to begin to engage educators in the prospect of participating (and informing other potential participants, such as service providers, and parents, etc…) in a certification training for LLI assessment to be used as an early screening tool to inform parents and SSTs, to help distinguish between a possible physical cause, and other contributions for low reading achievement.

Research Questions

The focus of this study was to investigate the applicability of the neurodevelopmental framework to enhance learning for all students, especially children with mild to moderate disabilities. One of the goals was to create a handbook to assist educators to become comfortable incorporating developmental movement patterns into lessons. Therefore, the handbook needed to be evaluated for content and social validity. For the purpose of this research project, the central questions asked were:

1) Can this created handbook for general and special educators on the neurodevelopmental framework for learning have content and social validity for future use in education?
2) What are the similarities and differences between the content-use and social-use experts' findings of the handbook, especially on relevance and usefulness?
3) What are some generalizations on developmental movement instruction and the use of this handbook for future implementation in supporting elementary educators on teaching students with or without disabilities?

Definition of Terms

Atlas Subluxation Complex (ASC): The terminology defining the Atlas Subluxation Syndrome was originated by Ralph R. Gregory to define signs for the Atlas Subluxation Complex (ASC) as objectively observable and measurable (Thomas, 1991). In the Atlas Subluxation Syndrome, the signs are always present in proportion to the intensity of the ACS, which include: misalignment factors shown on X-ray; center of gravity body displacement; spastic contracture of the pelvic and lumbar muscles; pelvic girdle distortion; deviation of the spinal segments from the vertical axis of the body; and a contractured leg (Gregory, 1973).

<u>Blood Flow</u>: The mathematical formula of Ohm's law, F = P/R, describes the relationships between pressure, resistance, and blood flow (where F is blood flow, or cardiac output; P is pressure; and R is resistance). Blood flow is "directly proportional to the pressure, but inversely proportional to the resistance." Many different factors influence resistance, while the most important factor is the diameter of the blood vessel for changing blood flow; resistance changes "by the fourth power of the radius." Vascular resistance is increased by a constriction in the vessel diameter, while a resistance is decreased by a dilation of the vessel. "Thus, a 4 - fold increase in vessel diameter theoretically could increase the flow as much as 256 - fold. (diameter = 1, flow = 1ml/minute; diameter = 4, flow = 256 ml/minute)." (National Heart, Lung, and Blood Institute Health Information Center, personal communication, November 10, 2010).

<u>Dyslexia and Learning Disabilities:</u> Dyslexia is referred to as a neurologically-based learning disability regarding language, especially in reading. Characteristics for individuals with dyslexia can include difficulties in accurately and/or fluently recognizing words, identifying distinct speech sounds in words and/or attributing sounds to letters, with poor spelling and writing. The development of brain function for individuals with dyslexia has shown atypical differences. Dyslexia can fluctuate within a lifetime. Individuals with dyslexia typically do not show a deficit for intelligence, although lack of reading experience and reading comprehension can result in acquiring less new vocabulary or ability to connect to background knowledge. (The International Dyslexia Association [formerly the The Orton Dyslexia Society], 2007).

Definitions and usage for the terms "dyslexia" and "learning disabilities" continue to be controversial among professions; educators and educational administrators more often use "learning disabilities," and "dyslexia" is most frequently used by medical professionals (West, 1997). "However, some neurologists and others find it more useful to employ the term [dyslexia] in a broader sense, one that corresponds more closely to the complex and interrelated manner in which different forms of language are processed in the brain" (West, 1997, pp. 15 - 16). Related problems would include: remembering lines of text; finding the correct word; recalling names; and hesitant or stuttering speech (West, 1997).

Eye Saccades for Reading: Eye saccades are "a series of short-latency ocular movements" that occur during the complex activity of reading (Facoetti, et al., 2000). The main purpose for eye saccades is to orient a new section of text toward the central vision. Additionally, "saccades are separated by brief fixations during which a detailed visual processing is carried out" (Facoetti, et al., 2000, p. 110).

Postural Control Development: Postural control development depends on the integration of the sensory and motor systems according to a sequential process, and then uses capability to incorporate new methods for achieving each one's potential for postural control. "The postural control system of children with disabilities is often compromised. These postural problems have serious consequences for movement, as adequate postural control is a prerequisite for adequate mobility" (Horvat, et al., 2011, p. 79).

Primary Reflex Persistence: Brain stem reflex behavior in infants is considered typical. Although, some "residual reflex behavior," that should have been incorporated into larger movements during infancy growth, impedes the development of motor patterns and movement skills “very often seen in school-aged children with specific learning disabilities and speech or language disabilities” (Seaman, et al., 2007, pp. 117 - 118).

Supine Leg Check: The measurement of the “relative difference” between one heel and the other [including the relative position of the medial malleolus (S. MacDonald, personal communication, December, 21, 2009)] is determined by the supine leg check. The upper cervical atlas misalignment has been correlated to this relative measurement, “since equalization of leg length after adjustment usually correlates with leveling of the pelvis in the frontal plane…this indicates that the relative measurement of the leg check is a sign of functional imbalance” (Thomas, 1991, p. 13).

Chapter II

Literature Review

Due to the complexity of this topic, the overall literature review is comprised of several categories of smaller sub-reviews according to a variety of disciplines that were necessary to examine the research questions, and that were useful in connecting the concepts. The literature review examined in the fields of special education, neuroscience (including neurological cognitive research, psychology, biology, physiology, auditory and vision), kinesiology and motor development science (including adapted physical education, occupational therapy and physiotherapy, and physical therapy), osteopathy and surgery, orthopaedics and pediatric orthopaedics, neuro-developmental medicine (including rehabilitation), behavioral science, and upper cervical research. Frequently, evidence demonstrated a cross-over among disciplines, especially incorporating the departments of medicine and psychology, although it was necessary to search in these varied perspectives because of a lack of specific material from the educational field relating to physical neurology connected to strengthening children's abilities to read.

Systematic searches for specific articles, book chapters, and books were conducted through computerized databases, including: Science Direct-Elsevier; Academic Press; Academic Search Elite (Ebsco); CINAHL; PsychARTICLES; PsychINFO; Hotwire Press; Google; JSTOR Retrospective Journals; Sage Journals; Science Direct-Elsevier; SpringerLink; and Wiley Interscience Journal Backfiles. The following key words were used: (a) dyslexia, (b) postural instability, (c) primary reflex persistence, (d) eye saccades, (e) atlas subluxation, (f) leg length inequality. These descriptors were either used alone or in combinations of words.

Sources were used if (a) the procedures and data-based results are marked as published between 1896 - 2012, and (b) the topics were relevant to connecting the concepts of dyslexia, atypical movement, head tilt, and leg length disparity; related to learning to read.

This review of the literature was organized into seven sections according to the following content areas: Special Education for LD; Multifactorial Hypothesis; Neurological Foundations for Human Movement (including Sensory Motor Development from Earlier- to Later-Maturing Systems); Visual Deficits and Reading; Posture, Ocular Motor Control, and Balance**;** Atypical Posture and Movement, Body Asymmetry, and LLI; and Upper Cervical, Correction.

Special Education for LD

Examining historical perspectives provides opportunities to notice trends. Almost fifty years ago, in 1963, a series of task forces were established to "study the status and needs of children with minimal brain dysfunction (MBD) and/or learning disabilities" (Haring & Bateman, 1969, p. 1). Clements, Cole, Gallagher, and Kunstadter (1969a), from the medical field in the area of neurological disease and blindness, introduced the focus:

> No concern has higher priority in the national interest than does that of providing for every child the fullest opportunity for physical and intellectual development. Yet, for one group of children, those now being spoken of as suffering minimal brain dysfunction, or learning disabilities, the special resources required to permit the effective exploitation of latest abilities appear to be lacking in our society. (p. iii)

Haring and Bateman (1969) reported that agencies from both of the medical and educational fields were included in a collaborative effort. The co-sponsors included:

> 1) The National Institute on Neurological Disease and Blindness, U.S. Department of Health, Education and Welfare; 2) the Easter Seal Research Foundation, National Society

> for Crippled Children and Adults; 3) the U.S. Office of Education, Department of Health, Education, and Welfare, and 4) the Neurological and Sensory Disease Control Program, Division of Chronic Diseases, U. S. Public Health Service. (p. i)

Haring and Bateman (1969) stated that the committee of Task Force I included mostly personnel from the medical field, and Task Force II focused their investigation on "areas of educational identification and assessment, educational practices, teacher training, and legislation" (p. 1). Haring and Bateman (1969) described some initial "important areas of agreement" between the two Task Forces:

> Task Force II agreed with Task Force I that multidisciplinary communication, requiring precise, descriptive nomenclature, is essential for effective identification, assessment, and total management of these children. Secondly, it was agreed that both medical and educational assessment are essential for complete diagnosis. (p. 1)

Additionally, "Medical evaluation may also further our basic knowledge of the existence and nature of relationships between brain and behavior" (Haring & Bateman, 1969, p. 1). Furthermore, the Haring and Bateman (1969) acknowledged some complexity regarding the scope of this multidisciplinary effort, with concerns regarding defining terms among professions:

> Problems in terminology arise when two different disciplines attempt a common description of the child to accommodate different purposes for obtaining diagnostic information. Viewing the child from the medical vantage point provides the physician the kind of diagnostic information relevant to ameliorating or preventing causative factors from disease or injury. For the educator who must approach the problem of identification from the purpose of child management in the classroom however, a more functional and hence more behavioral definition is essential. The educator requires identification and

> assessment of learning disabilities which can be incorporated functionally into educational services, training and evaluation. (p. 1)

The specific outcomes for Task Force I dealt with the terminology, definition and symptomatology (Haring & Bateman, 1969). Clements (1966) defined the children in question as "near average, average, or above average in general intelligence with certain learning or behavioral disabilities ranging from mild to severe, which are associated with deviations of function of the central nervous system" (p. 9). Haring and Bateman (1969) summarized that with the recognition of the construct of Task Force I by Task Force II, when considering the definition provided for children with learning disabilities, the educators from Task Force II arrived to four conclusions (Table 1).

Table 1
Four Conclusions by Task Force II Regarding the Definition of LD by Task Force I

1) To "formulate realistic recommendations," the children in question would have to be considered as "an educationally heterogeneous group."
2) "Because special educators in the field of learning disabilities must base educational management and teaching strategies on functional diagnostic information, a redefinition of this group of children for educational purposes was required."
3) Intelligence scores should be broadened to reach a larger number of children in the average range, and educational identification here should not have the "unrealistic burden required of making estimates of potential."
4) "Effective educational identification and specification of remediation of learning disabilities are functional without any reference to associations with functional deviations of the central nervous system. Identification of an educational deficiency is adequate for remediation plans with or without positive neurological signs. Further, requirements of positive neurological signs might preclude or delay necessary remediation."

Note. From Haring and Bateman (1969, p. 2).

Clements, et al. (1969b) recognized that understanding the compromise of life adjustments and achievement for children with learning disabilities might be imperfect, and they indicated for individuals providing services to children to be committed to making "optimum use of the best understandings available to intervene in what may be a difficult and pernicious developmental process. Availability of appropriate services during developmental years may well be the factor most decisive for optimal functioning in later years" (p. 53). Clements, et al. (1969b) responded to the educators' analysis with definitions including more extensive symptomatology:

> The previous report defined minimal brain dysfunction as a state descriptive of… children of near average, average, or above average general intelligence with certain learning and/or behavioral disabilities ranging from mild to severe, which are associated with deviations of function of the central nervous system. These deviations may manifest themselves by various combinations of impairment in perception, conceptualization, language, memory, and control of attention, impulse, or motor function. These aberrations may arise from genetic variations, biochemical irregularities, perinatal brain insults or other illnesses or injuries sustained during the years which are critical for the development and maturation of the central nervous system, or other unknown organic causes. (p. 53)

Additionally, Clements, et al. (1969b) suggested individualizing services for children with LD, "The diversity of problems among these children emphasizes the need for highly individualized considerations. Different kinds of services will be paramount at different ages and for different children" (p. 53). Clements, et al. (1969b) clarified the prior report's findings that described influential conditions in the developmental progression for a child with LD; to address the relevance for an *early* neurological intervention need for each child:

> The definition allows for the possibility that early severe sensory deprivation can result in manifestations of the central nervous system that can be permanent. It further states

that, during the school years, a variety of learning disabilities is the most prominent manifestation of the condition. (p. 53)

Diagnostic attention focuses on the years of early childhood, when subtle deviations in development may precede symptoms more obviously related to minimal brain dysfunction. Even then, except for a few rare conditions events productive of minimal brain dysfunction have usually ceased in activity, so that the basis for therapy no longer rests on a traditional disease-specific curative approach. Concern focuses instead on the plasticity of the developing nervous system which may allow compensation for loss of circumscribed functions either in the natural course of development by means of training, special educational techniques, and attenuation of emotional stress. Against this background, and in the interest of preventing neglect or mismanagement of children with minimal brain dysfunction, the following approach to medical and health-related services is set forth. (p. 53)

Conventional neurological examination is heavily weighted in testing noncortical regions, i.e., spinal cord, brain stem, cerebellum, basal ganglia, primary motor and sensory pathways and peripheral nerves. Since it is important in minimal brain dysfunction to have more information concerning behavioral and cognitive function, the examination (Rabe, 1969, pp. 69 - 71; Appendix A) has been appropriately modified. Appendix A contains an outline describing a neurological examination devised for children ranging in age from 3 to 12 years and containing modifications which are especially applicable to children suspected of having minimal brain dysfunction. (p. 55)

Examination of children with minimal brain dysfunction usually will reveal one or more of the following signs of abnormal neurological function after taking into account

> the patient's age: Hyperactivity, short attention span, abnormalities of resting muscle tone, clumsiness of gross or fine motor movements, hyperactive deep tendon reflexes, extensor plantar responses, abnormal extraocular movements, apraxia of face or tongue, abnormalities of position sense or simultagnosia, choreiform movement of fingers, abnormal resting postures reflecting the persistence of a dominant avoiding reaction, synkinesias, mild ataxia, minimal gait abnormalities with asymmetries of associated movement, right-left confusion, abnormalities of visual motor skills, perceptual abnormalities, dysphasia, finger agnosia and dyslexia. (p. 56)

Many physical symptoms of LD had been identified, even before education law came into place. Clements, et al. (1969b) proposed three purposes regarding the importance for educators to include an early neurological examination for a child with LD (Table 2).

Table 2
Three Purposes for Neurological Examination of the Child with Minimal Brain Dysfunction

1) It assists in identifying the child with organic brain disease who may require further diagnostic procedure and specific therapy.
2) It helps to clarify reasons why the child may not perform up to his expected level as judged from scores on intelligence tests.
3) Finally, it helps to allay suspicion of organic brain disease in children with adjustment reactions of childhood whose overactivity and other symptoms may have endogeneous cerebral dysfunction.

Note. From Clements, et al. (1969b, p. 56).

Haring (1968) concluded with the need to investigate educational readiness assessment tools. Assessment can be used as an *indicator of readiness* for instructional programs, as Haring stated:

> From this survey it is evident that education still has its major contribution to make in educational assessment. Further, a high probability exists that this advancement will be

> made both through instructional programming and through the assessment of entering responses to these programs. (p. vii)

So, in the grand transition to formulate special education law for providing additional support for individuals with disabilities, the language to describe LD definitions was ultimately drafted with an educational emphasis. "Because the [medical] definition did not include [educational] criteria by which practitioners could identify children with LD, the federal government proposed regulations to operationalize it" (Fuchs, Fuchs, Mathes, Lipsey, & Roberts, 2002, p. 738).

Lawmakers' enduring and inclusive efforts still have resulted in holding educators to a discrepancy model which is insufficient for addressing each individual student's earliest intervention needs; despite controversial research for over thirty years, the comparison between the IQ test and achievement scores is still used to qualify or not qualify students with LD for special education services (Francis, et al., 2005). There have been numerous efforts to create tools to measure this discrepancy, including IQ and standardized achievement tests, but research and practice have demonstrated the inefficiency of these methods for children with reading disabilities (Siegel, 2009). Semrud-Clikeman (2005) described IQ testing deficiency:

> An evaluation that centers solely on the simple process of subtracting, or regressing IQ from achievement, is a narrow one that misses many of the difficulties frequently seen in these children. The processing of information is a complex and distributed operation. To evaluate the child's learning skills, one must understand the child's ability to process language, to understand what he or she hears, and to organize information; the speed with which the child processes information; and the child's attention, ability to hold information in mind while solving a problem, and ability to self-monitor the reading process. (p. 564)

The typical problem is that children have to wait a few years until a discrepancy becomes apparent, and then their best learning opportunity has passed; by that time they do not typically catch up to their peers (Stuebing, et al., 2002). Stuebing, et al. (2002) focused on a meta-analysis of 46 studies regarding the validity of methods used to classify poor readers, behavior, achievement, and cognitive ability, and found little evidence supporting the validity of the IQ discrepancy classification of children with LD, and poor achievers. "The two groups have been proposed to differ on several dimensions, including instructional needs, response to intervention, neurological integrity, cognitive characteristics, prognosis, gender, and the heritability of LD" (Stuebing, et al., 2002, p. 474). Stuebing, et al. (2002) described a *hypothetical* classic example for the process to identify a struggling reader:

> Remember that the child was not referred for special education until Grade 2 and was not found to be eligible. In Grade 4, as the child's actual reading level had shown little change, the norm-referenced reading quotient decreased because the child's peers had continued to grow at a faster rate, so that the discrepancy was obtained. The child's reading difficulties were apparent in Grade 1, but placement did not occur until Grade 4. (p. 476)

Furthermore, Stuebing, et al. (2002) stated:

> From a psychometric perspective, it takes time for a child to move beyond the floor of an achievement test. The types of pre-reading items used to assess early reading skills on achievement tests (e.g., letter matching) are not necessarily difficult for many children at risk for reading problems. More important, the number of items used to discriminate levels of performance in kindergarten and Grade 1 may not be adequate to reliably differentiate these young students. So, the problem is that the emerging research

> knowledge is not the basis for classifications of LD in federal regulations. The overlap between poor readers identified as LD and those not so identified is substantial, and little external validity exists for the differentiation of reading disabilities (RD) on the basis of IQ-discrepancy. (pp. 509 - 511)

Francis, et al. (2005) explained an apparent convenience for IQ testing as, "students are often placed in special education on the basis of a single assessment" (p. 105). Differences between longitudinal groups of poor readers were examined, where cut-off points for identifying LD, either by discrepancy or low-achievement definitions, were found to be unstable (Francis, et al.). The margin of error associated with psychometric IQ and achievement testing demonstrated that insufficient scores strongly influenced the validity of decisions determined by the scores, so the need was acknowledged to develop "more robust procedures for employing assessments in the process of identifying students with LD" (Francis, et al., p. 105). Francis, et al. compared the educational model for identifying LD with the medical model for identifying hypertension; contrasting the inaccuracies of static testing measures for LD with ongoing examination for determining patterns for hypertension:

> Approaches to the identification of children as having LD based solely on individual test scores not linked to specific behavioral criteria lead to invalid decisions about individual children. Low-achievement definitions are not a viable alternative to IQ-discrepancy definitions in the absence of other criteria, such as the traditional exclusions and response to quality intervention. If we accept the premise of multiple classes of low achievers, then we must develop identification systems that are valid and abandon systems whose only merits are their historical precedence and convenience. (p. 98)

Francis (2005) continued by explaining:

> The Individuals with Disabilities Education Act (IDEA; 1997) has flexibility that permits interdisciplinary teams to go beyond test scores. It encourages the use of clinical judgment, which is necessary because of these psychometric issues. Although the basis for clinical judgment should include performance on psychometric tests that at least involve achievement levels, even these types of test scores should not be the sole basis for identifying children as having LD. If there were a natural discontinuity in the score distribution, setting cut points [i.e., cut scores or identification markers] would be straightforward. But such natural discontinuities are not apparent in the achievement distribution and, thus, do not help us in the identification of children with LD. (pp. 99, 104)

Furthermore, Francis (2005) described an example from medicine:

> There are dimensional disorders, such as hypertension, where there is an absence of true pathological markers. The attribute (i.e., blood pressure) is normally distributed in the population. In contrast to LD, cut-points for hypertension can be set because studies have been done that help establish where on the distribution of blood pressure some form of treatment is indicated to prevent heart attacks and strokes. It is recognized that blood pressure assessments are not completely reliable and that the decision to treat hypertension is a clinical decision that is not completely dependent on whether one particular blood pressure measurement falls above or below the cut-point. To get around the problems associated with unreliability in the measurement of blood pressure and normal fluctuations in blood pressure due to a variety of factors, the diagnosis of hypertension requires a pattern of blood pressure readings consistently meeting the criteria for hypertension. One reason why blood pressure is measured at each doctor's visit is to establish a historical

> record of blood pressure against which to judge any changes that might be observed over time. Because blood pressure rises during physical activity and then returns to normal afterward, the diagnosis of hypertension is typically made when an individual suspected of hypertension is subjected to a cardiac stress test and their blood pressure remains high for an extended time following the physical stressor. This process has been established through research on human physiology, but also through studies that confirmed the predictive validity of these signs and associated symptoms of hypertension. Unfortunately, we do not have studies of this sort in LD, partly because the idea that definitions should be evaluated in relation to response to intervention or long-term outcome in the absence of intervention is inconsistent with the focus on static assessments of eligibility that dominates the field. The example is highly relevant, as hypertension, like LD, is normally distributed in the population. Any establishment of a cut-point for IQ discrepancy or low achievement is inherently arbitrary in the absence of criterion-related research that attempts to establish its validity. Decision making about performance around that cut-point should also incorporate confidence intervals in an effort to address measurement issues that lead to inaccurate classifications, but even a confidence interval will not be adequate.
> (pp. 104 – 105)

Stuebing, et al. (2009) evaluated the relationship of different IQ and intervention response assessments in a meta-analysis of 22 studies. Based on reviews from Fletcher, Lyon, Fuchs, and Barnes (2007), and Fuchs and Young (2006), the validity of IQ as a useful predictor for early reading intervention was found to be negligible. Stuebing, et al. (2009) explored the impact of IQ-achievement discrepancy testing, stating that IQ can be correlated with achievement, but does not determine a cause of achievement. Much evidence is associated with the reduction of IQ and cognitive problems that minimize achievement (e.g., language), and in time, declining IQ scores become apparent for students who do not learn to read (Stuebing, et al., 2009). According to Stuebing, et al. (2009), if indicators of reading success such as phonological awareness and rapid naming were included on IQ tests, students with reading problems would receive lower IQ scores.

According to Aaron (1997), Berninger and Abbott (1994), Bocian, et al. (1999), Dombrowski, et al. (2004), Fletcher, et al. (2002), Fuchs, et al. (2002), Gunderson and Siegal (2001), Peterson and Shinn (2002), Reschly and Hosp (2004), Scruggs and Mastropieri (2002), Stanovich and Siegal (1994), Sternberg and Grigorenko (2002), Stuebing, et al. (2002), Tilly, et al. (1999), VanDerHeyden, et al. (2007), Vaughn, et al. (2003), Vellutino, et al. (1996), Ysseldyke and Marston (2000), as cited in Hale, et al. (2010), the authors identified some difficulties when the discrepancy model is used alone for identifying SLD (Table 3). According to the previously cited authors in Hale, et al. (2010) these examples are not exclusive.

Table 3
Some problems with the discrepancy model for identifying SLD

1) Uniform discrepancy application is insensitive to developmental differences in cognition and achievement
2) Unclear which IQ score should be used to establish “ability” for discrepancy calculation
3) Difficulty with distinguishing between children with SLD and low achievers
4) Inconsistent application of the approach across schools, districts, and states
5) Over-identification of students from diverse backgrounds
6) Measurement problems that result in poor decision-making
7) Early identification is unlikely although it is critical for ameliorating problems (a “wait-to-fail” model)
8) Encourages “test and place” practices which are neither an accurate nor an effective use of resources.

Note. From Hale, at al. (2010, p. 227).

So, regulations for the 2004 reauthorization of IDEA (USDOE, 2006) were changed based on research investigating a lack of validity for using IQ to define aspects associated with learning disabilities; now states cannot *require* school districts to use IQ tests (Stuebing, et al., 2009). For the first time, the 2004 reauthorization of IDEA brought an alternative for using the IQ-achievement discrepancy model by incorporating the early identification Response to Intervention (RTI) model; allowing practitioners in the general and special education fields to address students' varying needs on multitiered proficiency levels, with the intent to minimize students' awareness of failure (Grimes, 2002; Stuebing, et al., 2009). Fuchs and Young (2006) defined RTI:

> regulations to accompany the law and specify RTI have not yet been published. According to proponents, RTI starts with the teacher providing scientifically validated, or "generally effective," instruction; identifying at-risk students; and monitoring their academic progress. Those who do not respond to classroom instruction get something else or something more from the teacher, reading coach, or someone else. Again, progress is monitored. Children responsive to the more intensive instruction are returned to the classroom where practitioners continue to monitor their performance. Students still unresponsive either qualify for special education by virtue of their unresponsiveness or are provided a comprehensive evaluation to determine special education eligibility, depending on the version of RTI. (p. 9)

Versions of RTI are still being formulated. The RTI model relies on “formative assessment,” that is still currently in the theoretical process of acquiring a definition (Black & Wiliam, 2009). Chech (2008) described “formative assessments” in the testing industry:

> Formative assessments, also known as “classroom assessments,” are in some ways easier to define by what they are not. They're not like the long, year-end, state-administered, standardized…required exams that testing professionals call “summative.” Nor are they like the shorter, middle-of-the-year assessments referred to as “benchmark” or “interim” assessments. Or they shouldn't be, at least according to experts inside and outside the testing industry, who believe that truly "formative" assessments must blend seamlessly into classroom instruction itself. (p. 1)

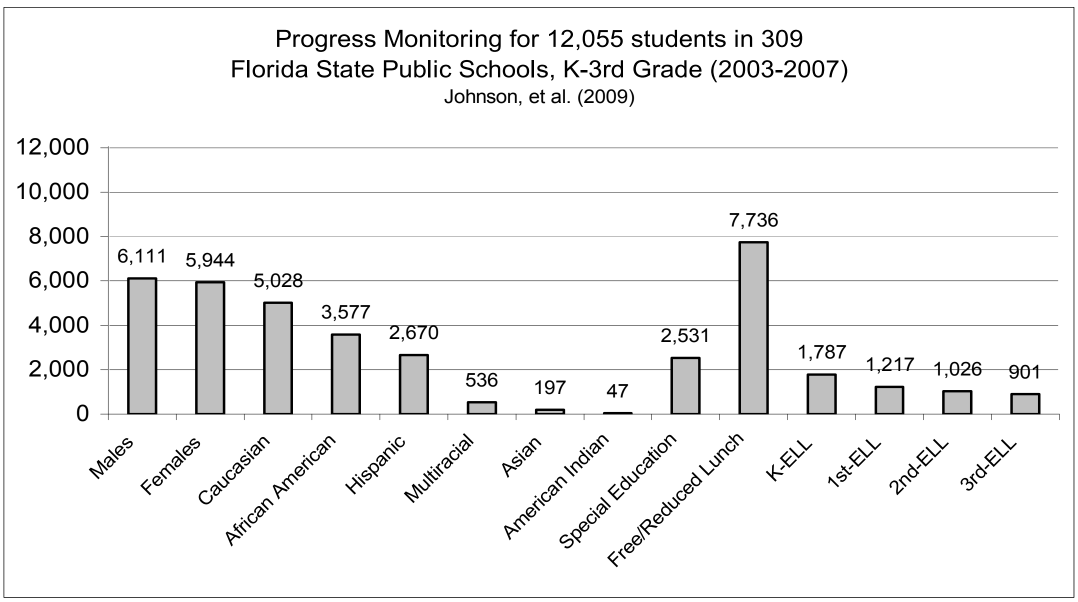
The inefficiency of the IQ discrepancy model has been addressed by multi-tiered levels of RTI, through providing more immediate and specific individualized instruction to students (Grimes, 2002) during gradual levels of intervention. Even with this attempt to refine the instructional process, still there is not a standard RTI model (Berkeley, Bender, Peaster, & Saunders, 2009); one that still is essentially based on discrepancy of achievement.

It is acknowledged that “screening for early reading problems is a critical step in early intervention and prevention of later reading difficulties” (Johnson, et al., 2009, p. 174). Although efforts to standardize reading assessments through informed instruction, which takes into account the many educational and social considerations influencing a child's ability to read, no agreement related to the reliability of the widely used screening tools for reading intervention has been made (Johnson, et al., 2009).

Johnson, et al. (2009), examined the effectiveness of commonly used early reading intervention screening tools. The purpose was to: a) identify a state standardized reading measure in 1st grade that best predicted performance at the end of 3rd grade; b) to test the usefulness of commonly used screening measures, as the predictor for 1st grade outcomes; c) to examine whether false negatives would be reduced by combining screening measures;

and d) to establish whether subgroups of at-risk students of English Language Learner (ELL), non-ELL, Free or Reduced Lunch (FLR), and non-FRL categories would be required to have different cut scores to reflect screening results identified with 90% accuracy. The measures used consisted of five quick tests. Classroom teachers did not do the testing; only trained school or district-based testing teams administered the tests over a 4-year period at varying times. Only the students in the progress monitoring database who had scores for all of the test variables were included for this study. In Figure 1, the distribution of student participants for Johnson, et al. is demonstrated.

Figure 1



The outcomes of Johnson, et al. (2009) showed: a) the state standardized test indicated the best predictor for future reading in the third grade, b) nonsense word fluency was found to be the most accurate kindergarten screening tool; nonsense word oral reading fluency the most accurate 1st grade screening tool; 254 false negatives, 611 false positives, and 5,219 students were found in the "some risk" category according to the published screening tool cut scores, c) the greatest improvement indicated a 2% specificity when combing two or more screening tools for

Kindergarten and 1st grade, and d) with obtaining 90% sensitivity for ELL and FRL subgroups, it was necessary to lower the cut scores for Kindergarten nonsense word fluency (4 points), and Grade 1 oral reading fluency (5 points) (Johnson, et al., pp. 182 - 183). Due to the high number of false positives for children at risk, including for ELLs, Johnson, et al. demonstrated a good indictor for the need to improve reading screening tools. Johnson, et al. investigated the screening process, and not progress monitoring.

In contrast, Boscardin, Muthén, Francis, and Baker (2008) identified phonological awareness and rapid naming as being substantially predictive of word reading (word recognition) with "developmental profiles formed in kindergarten…directly associated with development in Grades 1 and 2" (Boscardin, et al., p. 192). In an RTI meta-analysis, classification measures for students at-risk for reading were considered by Tran, et al. (2011) (Table 4).

Table 4
Classification Measures for Students At-Risk for Reading

1. Real word reading. Word recognition was the focus.
2. Rapid naming speed. Speed (timed trials) related to the overt verbalizing of letters, sounds, words, objects, or colors, including color naming, digit naming, picture naming, number naming, letter naming, object naming, and naming of words (e.g., nonwords [pseudowords], regular words).
3. Phonological awareness. Oral tasks were the focus that required dividing spoken words into segments of sounds smaller than a syllable or learning about individual phonemes (e.g., blending sounds, naming letter sounds, phoneme deletion, phoneme elision, phoneme segmentation, phonemic blending, phonological awareness, phonological oddity, phonological skills, rhyme, rhyme judgment, rhyming letter naming, sound categorization, syllable deletion, and phoneme detection).
4. Pseudo word reading (word attack). Word attack skills, considered as a separate entity of phonological processing, required the reading of printed nonwords (e.g, reading of nonwords or sounding out of nonwords of increasing complexity).
5. Vocabulary. Word meaning considered receptive vocabulary.
6. Reading comprehension. General reading measures were used for text comprehension.
7. Reading fluency. Oral reading fluency was the focus.
8. General intelligence. Standardized general intelligence measures were considered.

9. Verbal intelligence. Vocabulary for verbal IQ was considered as a separate category.
10. Phonological memory. Phonological memory included digit span, and word span.
11. Behavior. Behavior was determined thorough behavior ratings.

Note. From Tran, et al. (2011, p. 286).

The most important factors in predicting posttest outcomes were connected to “initial level of real word reading, word attack, passage comprehension and rapid naming speed” (Tran, et al., p. 293). There were no significant distinguishing effects for number of sessions, length of intervention, or types of methods used to identify responsive students (Tran, et al., p. 291), with a pretest and posttest achievement gap between responding and low responding students remaining consistent. Inconsistencies persist for defining the most influential classification measures for reading success (Tran, et al., 2011).

So far, according to Reynolds & Shaywitz (2009) there is not consensus for an effective standard RTI model. Some of the problems involving accurate diagnosis and appropriate intervention for students with SLD in the RTI system include:

> a) RTI fails to identify bright, albeit, struggling readers who require and would benefit from intervention and accommodation; (b) RTI delineates neither which specific components of, for example, reading (phonological awareness, fluency, vocabulary, orthographic processing, attention or other) require intervention, nor which specific strengths can assist in bootstrapping weaker areas; (c) how is RTI best implemented: intensity and duration of intervention are currently unknown, and, of course; (d) what constitutes the R in RTI? (p. 140)

Hallahan, et al. (2007) found there is no consistent manner to differentiate students among special education categories, and comparisons between states and their prevalence rates have been “radically different” (p. 136), with RTI criteria ranging “from few criteria to very stringent”

(Semrud-Clikeman, 2005, p. 565). The lack of consistency for the eligibility process among states, districts, schools, including grade levels has demonstrated concern for both discrepancy and RTI models (Berkeley, et al., 2009, p. 94).

Ysseldyke (2005) described a systemic inaccuracy with identifying LD in the RTI system. The author contrasted the occurrence of identification decisions based on fact vs. opinion:

> "RTI resistance" is here now, and will get serious when too many students are identified as LD using RTI approaches. And, then we will do what we always have done and what government agencies like welfare agencies and departments of natural resources always have done: We will put upper limits and/or "slot limits" on conditions to control eligibility. Departments of natural resources use "slot limits" (e.g., one may keep only fish between 16-24 inches) to define "keepers." When the harvest gets too high, they modify the slot (say from 16-24 to 20-24) and redefine "keepers." As in the classification decisions we make, definitions and numbers are more politically than scientifically determined. (Ysseldyke, 2005, p. 127)

During the years, there have been contributions from parent and professional groups interested in defining learning disabilities, as well as those from varying fields (e.g., language, education, psychology, and medicine) that have considered ideas related to processing disorders, neurological impairment, perceptual handicaps, cognitive deficits, discrepancy, exclusion factors, and academic deficiencies (Mercer, Jordan, Allsop, & Mercer, 1996). The academic field appears to be lacking consistency for identifying the needs for individuals with LD or reading disability, so perhaps it would be beneficial to further investigate broader disciplinary views that might contribute to a common consensus among educators regarding the necessity for more specific reading ability indicators.

The education field relies on academic and observational tests to inform instruction, and now with non-invasive medical tools such as functional magnetic resonance imaging, functional transcranial Doppler ultrasound, positron emission tomography, Voxel Based Morphometry, magnetic source imaging, and magnetic resonance spectroscopy, by tracking blood flow, there is the advantage to visually document physical properties of neurological learning and dyslexia. “The resolution is excellent and sufficient so that precise measurements of brain structure can be completed” (Vellutino, Fletcher, Snowling, & Scanlon, 2004, p. 19). Continuing progress has been evident for discoveries regarding the learning process, “Advances in our knowledge of the neuroanatomical and physiological foundations of higher-order cognitive functions are occurring faster than diagnostic criteria can accommodate this knowledge” (Hughes, 2008, p. 124).

Hillman, Erikson, and Kramer (2008) located activation for specific cognitive processes in particular brain regions; the frontoparietal network was activated for learning traditional academic areas such as mathematics and reading. Semrud-Clikeman (2005) emphasized the necessity for a comprehensive learning approach for students with learning challenges, aside from the traditional areas of learning: “An evaluation of children with learning problems must consider measures of working memory, attention, executive function, and comprehension (listening and written), particularly for children who do not respond to intervention” (p. 563).

The essential neurological foundation for students with LD must include evaluation of movement disparities. Although medical and educational diagnoses for “conditions seem to indicate different levels and types of disability, the motor development issues among them are…similar” (Cheatum & Hammond, 2000, p. 3). Henderson and Hall (1982) found that children identified as “clumsy” showed significantly poor scores on several motor performance measures, in comparison to a control group, including showing a “higher incidence of other educational and social problems" (p. 459). It was previously recommended by educators to treat LD as "an educationally heterogeneous group" (Haring & Bateman, 1969, p. 2). Evidence has shown that *clumsiness* is heterogeneous (Gubbay, 1975, 1985; Henderson & Hall, 1982), and, Henderson and Hall (1982) stated that "clumsy children do not form a single group but vary widely in their characteristics" (p. 459). There is evidence to suggest "a higher incidence of reading difficulties in the clumsy children" (Gubbay, 1975, p. 235).

The central nervous system influences learning to read. Cause of the "learning disability is a known or presumed dysfunction in the central nervous system…by-products of traumatic damage to tissues, inherited factors, biochemical insufficiencies or imbalances, or other similar conditions that affect the central nervous system…intrinsic to the individual" (Hammill, 1981, p. 340).

Atypical shapes and sizes of anatomical brain structures, including the for cerebellum, have been evident for dyslexia (Rae, et al., 2002; Eckert, et al., 2003; Kronhichler, et al., 2008; Vlachos, Papathanasiou, & Andreou, 2007). Rumsey, et al. (1999) found a connection between a functional lesion in the left angular gyrus with severity of dyslexia. The malfunction of cortical structures strongly influences individuals with dyslexia (Punt, DeJong, DeGroot, & Hadders-Algra, 2010), with evidence showing that atypical cerebral lateralization persists into adulthood (Illingsworth & Bishop, 2009).

The field of special education has relied on significant contributions from authors in the areas of medicine, neurology, pediatrics, psychology. These areas, in addition to others, have provided scientific inquiry regarding issues related to special education, and learning to read.

Multifactorial Hypothesis

Researchers have been addressing varying symptoms for individuals with reading deficiencies, and by now there have been studies to support previous findings relating to multifaceted deficits for dyslexia (Habib, 2000; Nicolson & Fawcett, 2009). Kibby, et al. (2009) found correlations between the shape and length of the pars triangularis brain region relating to the function of language, including for children with attention-deficit hyperactivity disorder (ADHD). Within the search to understand Autism Spectrum Disorder (ASD), children have demonstrated considerable deficits associated with those for ADHD (Allen & Courchesne, 2001; Corbett & Constantine, 2006). Evidence has shown children with dyslexia experience both phonological coding and visual deficits (Eden, Stein, & Wood, 1993; Valdois, Bosse, & Tainturier, 2004), when tested for nonsense words (Lovegrove, Martin, & Slaghuis, 1986). Menghini, et al. (2010) recognized wider implications for defining and treating developmental dyslexia (DD):

> [DD is] a composite disorder in which other competencies besides linguistic ones are compromised…a diagnostic system that collects only linguistic symptoms of dyslexics is not sufficient for understanding their reading difficulties, making a correct diagnosis and, consequently, developing a consistent program of treatment. (p. 870)

Menghini, et al. (2010) investigated the multifactorial hypothesis of DD by simultaneously testing several neurocognitive functions with 125 children and adolescents with dyslexia (n = 60), and normal readers (n = 65). Students were selected according to speed accuracy on reading words and non-words with at least 2 standard deviations below the mean for their chronological age. Instruments included assessments for phonological fluency**,** for phonological awareness, repetition of a non-word task, and spoonerisms**.** In testing spoonerisms, "the examiner pronounced two words aloud and participants had to swap the initial phonemes to form two new real words. They were asked to transpose the beginning sounds of the two words as quickly as possible," (Menghini, et al., 2010, p. 865). Two tests were used to assess general intelligence. Additional measures evaluated visual-spatial perception, motion coherence, and selective visual-spatial attention by distinguishing color and size. Sustained auditory attention, executive function, and implicit memory abilities were also investigated. None of the children with DD had "intensive or specific reading training" (Menghini, et al., 2010, p. 865). "None of the children in our sample with DD showed co-morbidity with ADHD" (Menghini, et al., 2010, p. 865).

Testing children for dyslexia took place at the Children's Hospital Bambino Gesù in Santa Marinella (Rome, Italy), and the control group was individually tested at their schools. Chronological age and scoring in the normal range for the word and non-reading tests were matched for the control group. The testing occurred in 3 to 4 sessions, for around an hour and a half at a time on separate days. The intelligence and reading tests were administered during the first sessions, and then the other tasks in the later sessions. Tests were administered randomly.

It was presumed that these tests required activating many abilities at once, rather than one domain at a time. The general linear analysis was to compare the group differences, although interaction among the cognitive domains was considered. In addition, participants were selected from a large group of children in different stages of development with DD. An additional goal was to examine if non-phonological cognitive functions would predict word and non-word reading in children with dyslexia, even with controls for age, IQ, and phonological skills.

Results indicated, of the largest group of children with DD had phonological deficits with spoonerisms and non-word repetition task, almost half also had deficits on an attentional task, and a third on executive function tests. Aside from a test to see how many words could be articulated beginning with a particular phoneme, nearly 20% of the children with DD had deficits in visual-spatial tasks, and with the test of categories completed on an executive function task. Menghini, et al. (2010) reported:

> to support this interpretation we conducted also a deviance analysis, which confirmed the high presence of phonological impairments in our children with DD as well as more diffused cognitive impairments in attentional, executive function and visual-spatial tasks. In fact, the frequency of occurrence of children with DD who only exhibited a phonological deficit was 18.3% while the most of the children with DD (76.6%) showed other deficits in addition to phonological deficit. For instance, 16.6% displayed executive deficits, 13.3% visual-spatial perception deficits, attention and executive deficits, 8.3% attention and perceptual deficits and 8.3% attention and executive deficits. (p. 869)
>
> Results confirmed in our children with DD the presence of deficits on phonological awareness and processing tasks, as well as more diffused cognitive impairments on tasks assessing auditory sustained attention, executive function and category fluency, and visual-spatial abilities. Our findings are consistent with the hypothesis that individual with DD may show multiple impairments in different cognitive domains, thus suggesting that DD may result from multifactorial impairments. (p. 870)

Furthermore, Menghini et al., (2010) examined dyslexia by emphasizing the "developmental" aspect of learning, and addressed the possibility that reading difficulty might have broader systemic-neurocognitive influences extending beyond the linguistic brain area. For example, memory has been investigated.

Students with reading difficulty have gained additional support with further evidence of a specific working memory deficit (Beneventi, Tonnessen, Ersland, & Hugdahl, 2010). Wolf, et al. (2010) identified specific brain regions showing the working memory deficit for DD:

> Within an “executive” neural network, dyslexics exhibited decreased connectivity in key regions associated with executive function during working memory (WM), but

> also increased functional connectivity in parietal, hippocampal and thalamic regions. The relationship between task accuracy at high load levels of manipulation demand and connectivity indices in parietal and hippocampal areas suggests the presence of alternative neural pathways in dyslexics in order to compensate for deficient executive neural processing. (p. 317)

DeLuca, Borrelli, Judica, Spinelli, and Zoccolotti (2002) demonstrated a close relationship between motor and cognitive development, and the cerebellar and pre-frontal cortex. To better understand the importance of recognizing specific brain regions relating to dyslexia, it is necessary to have a basic knowledge of neurological functions relating to movement.

Neurological Foundations for Human Movement

Seaman, et al., (2007) described the basic foundation of the central nervous system (CNS), starting with the neuron (the body and processes of the cell), made of axons (pathways from the cell) and dendrites (branchlike receptors transferring stimuli to the cell). Seaman, et al., (2007) described the process for CNS growth and development:

> CNS maturation depends on several factors: axonal growth, maturation of neuronal dendritic systems, maturation of the synapses, and myelination. The maturation of the synapses is interdependent on axonal growth and the functioning of the dendritic systems. Myelination occurs as a separate process and is considered a measure of the maturity of the individual cell and its ability to transmit impulses efficiently. Not all nerve cells become myelinated, nor does all myelination occur at the same time. In general, myelination begins before birth and continues for nearly 30 years of life. (p. 45)

Seaman, et al. (2007) explained the structure and function of the CNS as "hierarchical" (p. 45), although it is important to also recognize and understand the CNS functioning "as a whole" (p. 44). They specified the comparison between the "old" and "new":

> The evolutionary older structures are found at the anatomically lowest level (i.e., spinal cord) and are the least functionally complex…the newer structures are found in the highest anatomical position (i.e., telencephalon or cerebral cortex) and have the most complex functions. For optimum functioning, the higher levels of the brain depend on adequate lower-level function. The following general concepts apply:
>
> 1. Growth, development, and maturation begin in the spinal cord and end in the cortex.
> 2. Hierarchy of control and complexity of function increase with higher CNS structures.
> 3. Inhibitory centers tend to predominate over excitatory centers.
> 4. Reflexes and feedback loops become progressively more complex with higher structures.
>
> The spinal cord is at the lowest anatomical level and is structurally and functionally the simplest in the CNS…Its importance lies in its mediation of spinal cord reflexes and conduction of neural impulses. Located anatomically higher, the brain stem receives sensory input from many sources, handles significant and massive integration, and has widespread influence over the rest of the brain. Within the brain stem is housed, at least in part, the **reticular formation**, considered to be *the master control mechanism in the CNS.* The reticular formation serves a general arousal and alerting function, as well as a central integrative role (e.g., inhibition, facilitation, augmentation, synthesis). It is also a selective network that decides which information is to be perceived and focused on. (Seaman, et al., 2007, pp. 45 - 46)

Seaman, et al. (2007) also defined the **cerebellum** as "*a huge integration center, the primary functions of which are integration and regulation*...its function has been linked most frequently to motor output, smoothing and coordinating action and influencing muscle tone" (p. 46). The cerebellum coordinate motor function, influence long-term memory, spatial perception, impulse control, attention, and cognitive function (Sousa, 2006).

The higher brain centers are more diverse and numerable than the lower ones. Seaman, et al. (2007) identified some of the higher brain centers:

> The diencephalon and telencephalon, respectively, are the next to highest and highest levels of the CNS. Their functions are more complex. The **diencephalon** (thalamus, hypothalamus, and other structures) serves as *a relay station for sensation and movement.* The **telencephalon** includes the basal ganglia, limbic lobe system, and the cerebral cortex. The basal ganglia assist with the initiation and execution of purposeful movement. The **limbic lobe system**, or "old cortex," is *the primary memory storage area of the brain*. The **cortex** consists of *two hemispheres (right and left) and five lobes (two temporals, occipital, parietal, and frontal)*. The two hemispheres are connected through a bundle of fibers known as the corpus collosum, which transmits impulses between hemispheres. These higher centers organize sensory activity at their respective levels and influence integration at the lower levels. Processing at the cortical (cortex) level depends on subcortical (levels below the cortex) processes. As the level of function increases, behavior becomes less stereotyped and more individualized. As the level of sensory organization decreases, more emphasis is placed on sensorimotor integration. (Seaman, et al., 2007, p. 46)

Appropriate development relies on essential sensory and environmental factors, regardless of innate potential (Haywood & Getchell, 2009; Seaman, et al., 2007). Seaman, et al. (2007) emphasized that the *strength* of the higher CNS relies on the lower CNS:

> Sensory input (e.g., tactile, vestibular, proprioceptive, visual, and auditory) continually impinges upon the human organism, placing demands that help foster the growth of the nervous system…The process begins with enhancing development in the lower, less complex levels of structure and response that, in turn, enables the individual to become more competent at the higher, more complex levels. (p. 46)

Seaman, et al. (2007) summarized the process of sensory input to sensory motor output response (e.g., movement, writing, speaking). Furthermore, the authors included the importance of the feedback loop for refining future motor responses or movement:

> In order for a person to move, sensory stimuli must be received (reception) and attended to (selective attention). Following neurological arousal and attention, the sensory information is available to be modulated, analyzed and integrated. The result is the perception or image of the desired and appropriate motor response. This is matched with memory and then translated into the motor program. The actual motor response is influenced by selected motor control mechanisms of the brain (e.g., basal ganglia, cerebellum). Once neural impulses are sent to the muscles, the motor response occurs. (Seaman, et al., 2007, pp. 49 - 50)

According to Ayres (2005), directing one's own movements provides internal feedback by "record[ing] the motor command…before it is completly executed" (p.96). "When the body is moved passively, the brain does not send out a motor command, and so there is no internal feedback...self-directed movement is one of the keys to developing better motor planning" (p. 96).

Sensory Motor Development from Earlier- to Later-Maturing Systems

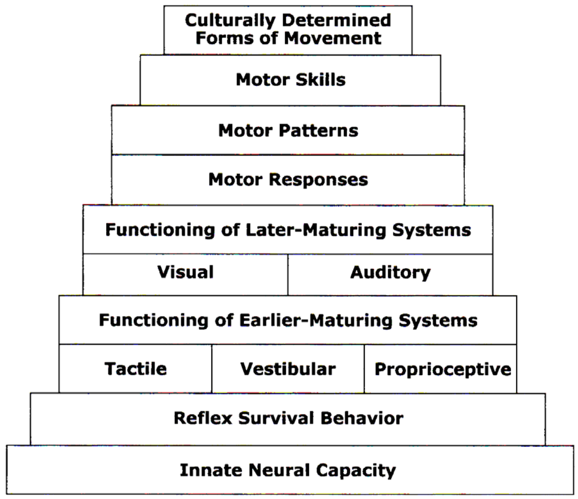
The growth process takes place according to particular physical directions of development. Horvat, et al. (2011) explained the process of growth and motor development:

> Motor skills develop in a predictable sequence from basic to more complex movement patterns beginning at the head and proceeding to the feet [cephalo-caudal], and beginning from the midline of the body and proceeding to the extremities [proximo-distal]. The head develops initially and has the greatest degree of control in the upper extremities. During the process of maturation, the arms will develop in mass and control before the lower extremities. Similarly, control of the large muscles of the trunk and shoulder girdle develops before control of the hands and fingers…the sequence of motor development and postural control is orderly, although not all abilities will be mastered at a specific age. (Horvat, et al., 2011, p. 69)

In the developmental model "it is generally accepted that each developmental step depends on a certain degree of maturation at previous steps…early developmental stages serve as building blocks for later stages" (Seaman, et al., 2007, p. 58). The developmental pyramid model (Figure 2) demonstrates the progression of development for the three lower systems; initially, for the innate neural capacity or reflexes; secondly, for the earlier-maturing systems, including the tactile, vestibular, and proprioceptive; *then*, for the later-maturing systems, the visual and auditory systems (Seaman, et al., 2007, p. 59; M. Karwas, personal communication, 2006, 2007). The development of movement sequences within each of the later stages of motor-sensory responses, motor patterns, and motor skills are dependent on the sophistication of the previous stages. The sensory systems interrelate. The most refined movements, and higher level functioning are at the top of the pyramid.

Figure 2

Developmental Pyramid for Motor Development



Motor Skills – **culturally determined**

running while bouncing balls, walking on the balance beam, dancing

Motor Patterns – **common to all humans**

rolling over, hand raising, walking, running, creeping, crawling, sliding, throwing, jumping, hopping, skipping (combination of hopping and walking), leaping, kicking, striking, galloping

Motor-Sensory Responses – **planning and executing purposeful movement**

twisting, bending, lifting head, eye-hand coordination, eye-foot coordination; ability to use both sides of the body independently from each other, isolate one body part, cross midline, and maintain balance

Functioning of Later-Maturing System – **visual, auditory**

hand-eye and eye-hand coordination; most closely linked to the vestibular

Functioning of Early-Maturing System – **vestibular, tactile, proprioceptive**

understanding right from left, memory playing an important role; the same anatomic age

Innate Neural Capacity − **reflexes**; according to **survival behavior**; gene pool

Note. From Seaman & DePauw (1989, p. 31) "The Developmental Model" [above]; adapted from Seaman & DePauw (1989) by Karwas (2006, 2007), used with permission by Seaman (M. Karwas, personal communication, October 10, 2012) [below].

> The astonishing accuracy with which normal human subjects can estimate their straight ahead body orientation under normal conditions argues for a stable body-centred [*sic*] reference frame for the evaluation of body orientation in space and further shows that under normal conditions the sensory systems [visual, vestibular, and proprioceptive] tested act together in a very precise manner, supplying us with a close to optimal estimate of body orientation. (Karnath, Sievering, & Fetter, 1994, p. 145)

Seaman, et al. (2007) indicated, "reflex development and inhibition occur along a continuum rather than an 'all or nothing' manner" (p. 54). Horvat, et al. (2011) explained the function of reflexes that are typically present to assist infants:

> Reflexes are automatic responses of the nervous system that are present at birth and controlled by the primitive regions of the nervous system, spinal cord, labyrinth of the inner ear, and brain stem. They are responsible for changes in muscle tone and movement and gradually become integrated into voluntary movements as the higher center of the brain develops. Reflexes also aid children in assuming postures and controlling movement. During infancy reflexes will dominate movement until 6 months of age. (p. 207)

The following represents a glimpse of the individual sensory systems. Each system, intricate on its own, typically integrates with the others.

Spoor, Wood, and Zonneveld (1994) examined the dimensions of the inner ear's bony labyrinth vestibular system, the oldest evolutionary and developmental sense, among hominid fossils as "a major component of the mechanism for the unconscious perception of movement" (p. 645). The study explored the question of why "the upright posture and obligatory bipedalism of modern humans are unique among living primates" (Spoor, et al., 1994, p. 645). "Among the fossil hominids investigated, the earliest species to demonstrate the modern human semicircular canal morphology is *Homo erectus*" (Spoor, et al., 1994, p. 647). An advantage to studying the bony labyrinth is that it develops to its "adult shape and size long before birth" (Spoor, et al., 1994, p. 648).

The vestibular sense regulates sensory processing by coordinating the visual, auditory, proprioceptive, and tactile senses (Ayres, 2005; Cheatum & Hammond, 2000), with neuroplasticity (Ayres, 2005; Sousa, 2006). Seaman, et al. (2007) described the vestibular:

> It functions to maintain equilibrium, muscle tone, position of the head in space, and an awareness of motion. It exerts widespread influence throughout the CNS and contributes to the coordination and timing of all sensory input for the enhancement of perception… and chiefly acts through the vestibular-spinal tracts and the vestibular-oculomotor pathways, sending impulses to the rest of the CNS…via the cerebellum. (p. 52)

Grasso, et al. (2011) investigated the responses of the vestibular system according to leg rotation and head position. Grasso, et al. (2011) found evidence that the labyrinthine apparatus responds to positions of the legs and the entire body:

> In particular, within the cerebellar cortex, the direction of animal tilt giving rise to the best response of the neurons tend to rotate by the same angle and in the same direction as the body under the head, so that labyrinthine responses become dependent on the direction of body displacement, rather than head displacement…(p. 312)
>
> We postulate that the cerebellum integrates somatosensory information from the whole body and adapts the voluntary and reflex movements to the orientation assumed by the body in space and to the relative position of the different body segments…(p. 312)

> The results of the present experiments support the hypothesis that somatosensory signals related to leg rotation and/or copies of the corresponding voluntary motor commands modify the pattern of VS [vestibulospinal] reflexes and, thus, maintain this postural response appropriate to counteract body sway in the direction inferred by labyrinthine signals. (p. 312)

The tactile system receptors respond to touch, pressure, temperature and pain, and are located in layers of the skin; most sensitive in the mouth, lips, tongue, fingers, and hands (Cheatum & Hammond, 2000, pp. 223, 225). Seaman, et al. (2007) stated, "Touch refers to the primary sense, characterized by the reception of nondiscriminating, nonlocalized, and generalized information... tactile is the later-developing sense able to discriminate among and localize tactile information" (p. 53). "Spaces in the sensory cortex created by impulses [from the fingers, thumbs and lips] are larger than the combined space reserved for impulses for all the other body parts" (Cheatum & Hammond, 2000, pp. 226 - 227). "One of the most important functions of the tactile system is to enable the brain to suppress or ignore a vast amount of information it receives through the skin" (Cheatum & Hammond, 2000, p. 230).

Body schema coordination understands how body parts are in relation to each other, including the concept of laterality or lateral preferences for favoring one eye, hand, and foot, and movements crossing the midline, so directional discrimination can be learned (Cheatum & Hammond, 2000). Cheatum and Hammond (2000) explained that proprioceptive receptors detect:

> relationships of the body parts and joints to each other in both stationary (static) and moving (dynamic) positions...at any time, the proprioceptive system sends information to the brain concerning the (a) location of the joints and body parts; (b) movement of

> the joints and muscles; (c) pressure on the skin and underlying tissue; (d) pain [or relief from pain] felt in the joints, tissue, or muscles; and (e) temperature (p. 187).

Seaman, et al. (2007) stated, developmentally, the proprioceptive sense has three main objectives: "1) it helps to maintain normal muscle contraction; 2) it influences muscle tone; and (3) it aides in space perception…regarding size and shape of the environment" (p. 52).

The auditory system detects vibration that creates sounds. Seaman, et al. (2007) described the auditory system as:

> a very intricate and complex system. The stimuli enter at the ear and are routed bilaterally almost as soon as they enter. As input passes through the nervous system, it makes many different connections and travels directly or indirectly to the cortex. The direct path leads through brain structures that contribute to the general arousal and inhibition of the CNS at the cerebellar level. As impulses travel through integrative brain structures, the auditory system becomes closely associated with the visual system. The auditory system also has a close association with the vestibular system because the receptors are in proximity to one another in the inner ear and share the same cranial nerve. (p. 53)

"The visual system is the most complex of all the sensory systems. The auditory nerve contains about 30,000 fibers, but the optic nerve contains one million, more than all the dorsal root fibers entering the entire spinal cord!" (Mason & Kendel, 1991, p. 420). According to Porter, Porter, Baker, Ragusa, and Brueckner (1995) "Eye muscles can execute pursuit and vergence movements to maintain fixation upon smoothly moving targets at velocities at which motion is barely perceptible, yet also are capable of saccadic peak velocities of as high as 600 [degrees]/second" (p. 454). Regarding oxidative capacity, the extra-ocular eye muscle fiber "[is likely] the most fatigue resistant mammalian skeletal muscle fiber type" (Porter, et al., 1995,

p. 459). In humans, "extraocular muscle blood flow, and thus potential oxidative capacity, is the highest of any skeletal muscle" (Porter, et al., 1995, p. 466). "The eye movement reflexes, vestibulo-ocular and optokinetic, represent phylo-genetically old systems that provide a baseline ocular stability that is vital for clear vision and thereby provide a platform from which to execute voluntary movements" (Porter, et al., 1995, pp. 453 - 454).

Muri (2006) found evidence that eye movement control or oculomotor processes and visuospatial attention are closely integrated in a common neural network. Cheatum and Hammond (2000) stated that the visual system is composed of “several visual skills: binocular vision, accommodation (convergence and divergence) fixation, visual pursuit (pursuit fixation), depth perception (stereopsis), visual memory, and visual sequential memory” (p. 267). Ocular motor control is described as “the ability…to use the six eye muscles…[to] allow the eyes to move in all directions for tracking” (Cheatum & Hammond, 2000, p. 269). Stoffregen, Pagulayan, Bardy, Hettinger, and Hettinger (2000) explained how eyes typically move together, “binocular convergence…is controlled by rotating the eyes relative to one another” (p. 208). Kirkby, Webster, Blythe, and Liversedge, (2008) described functional binocular control, as each eye adjusts its position to the other:

> An important implication of this conclusion is that the traditional description of the human binocular system in which the two lines of sight adhere to a tight, rigid trigonometric, angular arrangement in relation to the fixated stimulus is untrue. This description is frequently depicted in undergraduate text books, and it may be time to revise it. The two eyes are coordinated such that each eye fixates within a degree of proximity to the other in order to allow fusion to occur. Thus, the oculomotor control system subserves a visual system that is efficient in constructing a clear and

> unified perceptual representation from retinal inputs that can differ to a substantial degree. Arguably, this may be the most important implication to emerge from our review. (p. 759)

Kulkarni, Chandy, and Babu (2001) studied human fetuses, post-mortem from stillborn, to find a very high muscle spindle (sensory receptors) content in the suboccipital muscle triangle, compared to other muscles. "The complex integrative mechanisms involved in head-eye coordination probably demands complex proprioceptive inputs from the neck muscles which probably is the reason for their high spindle content" (p. 358). Kulkarni, et al. indicated the importance of the cervical muscles for postural and eye movement control, and found evidence that suboccipital muscles move according to length changes, instead of muscle contractions.

Edwards, et al. (2007) stated that increased blood flow would influence the cervico-sympathetic reflex for suboccipital muscles. Additional blood flow "would result in altering the length of fibers in the suboccipital muscle group" (Edwards, et al., p. 8331).

Bringing together the senses; internal and external neurological feedback shapes an individual's motor planning while motor skills are learned through repetition, via hypo- and hyper-sensory input responses, as they avoid and seek stimuli toward a balanced homeostasis (Cheatum & Hammond, 2000; Horvat, et al., 2011; Seaman, et al., 2007) (Figure 3). "As stimuli enter the sensory systems, they act as stressors and disturb homeostasis, which must then be gained anew by means of a respective, appropriate motor response" (Seaman, et al., 2007, p. 50).

Figure 3
The Responsivity Continuum

Hypo(---	**X**	--)Hyper
gets little/seeks stimulation	**HOMEOSTASIS**	gets too much/stays away

Note. Adapted from Seaman, et al. (2007, p. 74) by Karwas (2006, 2007), used with permission by Seaman (M. Karwas, personal communication, August 14, 2012).

"An unknown amount of sensory input, unique to each individual, is necessary for adequate functioning" (Seaman, et al., 2007, p. 59), while "a process disorder of responsivity may manifest itself in one of three ways: hyperresonsivity, hyporesponsivity, or vacillating responsivity" (Seaman, et al., 2007, p. 74). Integrating the concepts of the developmental pyramid with those of the responsivity continuum results in combinations of sensory responses (e.g., hypo/hyper vestibular, hypo/hyper tactile, hypo/hyper proprioceptive, hypo/hyper auditory, and hypo/hyper visual) (Cheatum & Hammond, 2000). Seaman, et al. (2007) described compensating behaviors according to sensory system responses for the vestibular, tactile, proprioceptive, auditory, visual, including integrating lateral sides of the body (Appendix B). Horvat, et al. (2011) stated the importance of addressing individualized movement development:

> programming for special needs must be implemented at the appropriate functioning level, with age providing a general guideline of expected skill development. If children can overcome or compensate for deficiencies, they will attain similar levels of functional ability. For children with movement disorders, the more completely we understand the stages of development and underlying mechanisms of disease or injury, the more likely we can develop an instructional program based on individual needs. (p. 69)

Visual Deficits and Reading

As early as 1896, visual deficits were examined for individuals learning to read; comparing the recognition of whole words and smaller components of letters comprising words (Hinshelwood, 1896). "Inappropriate use of vision only adds to the child's literacy problems; he is likely to keep losing his place and to scan poorly" (Baker, 1981, p. 360). Children with reading disability have performed significantly worse than children without disabilities on several eye-movement and visual tasks, in addition to testing poorly with verbal indicators (Eden, Stein, Wood, & Wood, 1995). Investigators studying dyslexia have suggested the presence of a serious spatial orientation problem or a visual-spatial deficit resulting in taking longer to read than normal readers, by using additional longer fixations, poor saccadic control due to shorter or increased saccades (Prado, DuBois, & Valdols, 2007), and more regressions (Biscaldi, et al., 1998; Miles & Segel, 1929; Rayner, 1998). A reduction in saccadic eye movement frequency relates to gaining better control over fixation and tracking (Ayres, 2005; Cheatum & Hammond, 2000; McPhillips, Hepper, & Mulhern, 2000). Scores have been significantly lower on tracking, binocular depth perception, and focusing difficulty for students who were academically and behaviorally at-risk (Johnson, Nottingham, Stratton, & Zaba, 1996). Pavlidis (1981) documented an ocular motor disability for individuals with DD regarding inability to follow a sequentially illuminated light, and proposed using the light as a pre-reading diagnostic tool.

Facoetti, et al. (2000) investigated abilities for focusing and orienting visual attention using a simple detection task, and found a visuospacial automatic attention deficit while orienting the peripheral vision, with slower eye movement planning for children with DD. According to Van der Heijden, (1992) (as cited by Facoetti et al., 2000, p. 112) “a simple detection task allows the investigation of the simple allocation of spatial attention involved in orienting and focusing, excluding other attentional factors such as ‘expectation’ and ‘intention’, which would be otherwise present in a choice reaction task.”

For experiments #1 and #2, participants included 10 adults and 20 children with normal or corrected vision. The adults worked at the Neuropsychiatry Department in Bergamo, Italy (5 females, 5 males, average age of 30). The 10 children identified with dyslexia (3 females, 7 males, average age of 10), scored 2 standard deviations below normal on a reading test, were not taking medication, nor had any known sensory, neurological or emotional impairment. The other 10 children (3 females, 7 males, average age of 9.4 years) were proficient readers. Children were matched with controls for IQ and age. Experiments #1 and #2 consisted of 144 trials arranged into two sections of 72 trials each, including 32 valid trials, 8 invalid trials, 20 neutral trials, and 12 catch trials (where there was no cue given, and it wasn't necessary to respond), while the cue was only valid on 80% of the trials.

The first experiment wanted to address the automatic orienting of attention for children with dyslexia, proficient readers, and adults, for deficiency with the transient or magnocellular pathway. In a dimly lit room, participants were shown a cue (a white dot) in the visual peripheral field on a fixation point in the center of a monitor screen that was placed 40cm from their eyes, as their heads were on a headrest. Participants were asked to press a spacebar on computer to register their quickest responses, while the computer recorded their reaction times. There was a one second maximum time to respond.

The results for experiment #1 showed the reaction time for children with dyslexia to be slower than the normal readers and adults, and a cue in the peripheral area for the children with dyslexia did not attract attention. Experiment #2 was designed to investigate whether the group with dyslexic was generally unable to process the cue information, or if it was because the visual cue was shown in the periphery. Additionally, the conditions for experiment #2 were the same as experiment #1, except that the cue was an arrow shown above the central fixation point.

For experiments #1 and #2 the children with dyslexia generally responded slower than the adults and proficient readers, but showed evidence of voluntarily directing attention following the cue. The study suggested to question the hypothesis that children with dyslexia are not able to use the spatial information from a cue, or that a general attention disorder exists (Facoetti, et al., 2000). The results support evidence for a specific automatic orienting deficit, most likely due to a dysfunction in the processing mechanism of peripheral signals.

Participants for experiment #3 were the same twenty children as in the previous experiments. For experiment #3 there were 152 trials in two sections of 76 trials each, with 30 trials including a small cue, 30 with a large cue and 16 catch trials. A pre-cue (a green dot) oriented the participants' attention to the exact point where the cue (two white circles of different sizes) was shown “to orient subjects’ gaze to the precise point of the visual field where the cue would appear” (Facoetti, et al., 2000, p. 118), so then only focus had to be adjusted later for size. Findings for experiment #3 confirmed that the children with dyslexia generally read slower than proficient readers, and when presented a peripheral cue that they were unable to automatically shift their attention.

The authors suggested that the automatic orienting mechanism deficit could be due to impairment in the “1) a selective impairment of the ability to process peripheral visual onset stimuli, and/or 2) a reduced speed in the elementary operation of moving of attention...affect[ing] the planning of ocular movements that are essential for reading” (Facoetti, et al., 2000; p. 121). In addition, the children with dyslexia maintained focused attention for shorter time periods than normal readers, perhaps affecting the processing of visual information, and possibly affecting higher cognitive processing. Facoetti, et al. (2000) suggested that dyslexia might be an ocular fixation disorder, where laterally-distracting information is not ignored, so is distracting to the reading process.

Lateral visual disparities have been evident for dyslexia. “Without visual information, human subjects are not able to maintain displacement in a straight line” (Boyadjian, Marin, & Danion, 1999, p. 21). The results from Boyadjian, et al. (1999) suggested that “veering was the result of a peripheral mechanism linked to an imbalance between the two sides of the body" (p. 23). For dyslexia, Facoetti, Turatto, Lorusso, and Mascetti (2001) found "significantly slower reaction times in the left visual field than in the right visual field…[possibly] due to an asymmetric control of visual spatial attention" (p. 46).

It is critical to better understand interrelated neurological processes necessary for following the physical reading process. Brenner and Gillman (1966) stated, of the children surveyed, that visuomotor and visuospatial deficiency is associated with behavior disorders, and "clumsiness either in gait or movement, or in fine motor control, or both" (p. 700). Dare and Gordon (1970) emphasized, "children with visuo-motor disabilities are often in need of special help…and are often classified as having minimal cerebral dysfunction, minimal brain damage" (p. 178).

Posture, Ocular Motor Control, and Balance

The majority of sensory integration takes place in the brain stem where primitive postural reflexes change the effects of muscle tone in the entire body (Fiorentino, 1981). Horvat, et al. (2011) stated that the righting reflexes emerge from the brain stem, through the input of sensory information into the vestibular apparatus, for posture and vision. "Tilting (equilibrium) reactions…righting reactions and primitive reflexes are considered evoked responses" (Stuberg, Dehne, Miedaner, & Romero, 2010, p. 2). "Sensory information is…sent to the brain stem, which controls contraction of the appropriate postural muscles necessary to obtain upright posture. The brain stem also controls the visual muscles that fixate eyes while the head is moving" (Horvat, et al., 2011, p. 70). Horizontal eye movements are controlled by nerves in the brain stem (Martin, 1996). Results from Karnath, Reich, Rorden, Fetter, and Driver (2002) showed that when determining the "subjective straight ahead" some visual memory integrates with proprioceptive inputs, "and that this integration is sensitive to the delay over which the visual memory must be held" (p. 357). Stoffregen, Bardy, Bonnet, Hove, and Oullier (2007) explained the relationship between posture and the visual: "overall results are not consistent with the view that eye movements and postural control compete for limited central processing resources. The results are consistent with the thesis of a functional integration of postural control with visual performance" (p. 86).

Reflex-based coordination assists infants at first with hand-eye coordination (ocular reflex), and then develops later with eye-hand coordination (Seaman, et al., 2007), possibly to facilitate reaching toward and ultimately touching an object they can see (Holt, 1991). The asymmetrical tonic neck reflex (ATNR) is closely connected to the early balancing system (Ayres, 2005; Cheatum & Hammond, 2000; McPhillips & Jordan-Black, 2007), with visuomotor responses for close-up vision occurring around the same developmental time. Horvat, et al. (2011) described the ATNR: "in a supine position [the ATNR] is elicited by rotation or lateral flexion (tilt) of the head leading to increased extension of the limbs on the chin side with accompanying flexion of limbs on the head side" (p. 73). The ATNR is typically inhibited, or incorporated into more sophisticated movement patterns by the second half year of life (Peiper, 1963). Initiating voluntary movement control includes inhibiting primitive postural reflexes (Horvat, et al., 2011).

Postural development depends on the sensory and motor systems, and occurs in a sequential progression. According to Horvat, et al., (2011):

> Development of skilled, goal-directed movements requires complex and subtle postural adjustments involving the head, trunk, and limbs so as to maintain the body over its center of gravity…functions of postural control occur because of multisensory inputs regulating orientation and stabilization body segments, flexible postural reactions for balance recovery after disturbances, and anticipatory body segment positioning during

> voluntary movements. The development and application of postural control mechanisms is dependent on spinal reflex activity…higher order adaptive mechanisms involving vestibular, visual, and somatosensory (proprioceptive and touch/pressure) systems as well as information processing in the cerebral cortex. Postural control development can be best described as a discontinuous, step-like process of integrating multiple sensory and motor systems, and the ability to incorporate new strategies into the repetoire for postural control. Hence, postural control development involves three components—perception (integrating sensory information); cognition (attention, motivation, information processing, and developing appropriate movement strategies); and action (generating muscular forces to control body position). The ability to modify both sensory and motor strategies to change task and environmental conditions develops in late childhood, thereby reducing the child's ability to the environment until this time. (pp. 78 - 79).

In the developmental progression of muscle growth for the proximo-distal manner, or "from the center of the body outward" (Seaman, et al., 2007, p. 55), later-developing "distal muscles are generally used to produce finer gradations of force and are more difficult to control; thus, the use of distal muscle activity to regulate balance may represent a more refined and effective level of motor control" (Williams & Castro, 1997, p. 48). The postural control system for children with normal motor development in Williams and Castro (1997) demonstrated both proximal and distal leg muscle force activated when balance was perturbed, but distal muscles responded with additional force. Furthermore, the effects of vision influenced the order of muscle activation: "when the sensory framework for postural control is modified by removing vision….[then] children with normal motor development continue to maintain a pattern of disto-proximal muscle activation" (Williams & Castro, 1997, p. 50).

The erector spinae (ES) muscles act to stabilize the trunk against gravity (Floyd & Silver, 1951). Comparing sitting and standing, Clair, Okuma, Misiaszek, and Collins (2009) examined the ES for regulating posture and balance, and found that ES muscles in the lower back responded through reflex pathways connected to the lower leg.

The neck is critical for considering the strength of the postural and balancing systems, including for vision. Haywood and Getchell (2009) explained balance as “refined control of degrees of freedom of movement in the neck” (p. 227). Karnath, et al. (1994) found “strong experimental evidence that neck afferent activity plays an important role in maintenance of posture, in ocular motor control, and in the perception of body orientation in space” (p. 144). Stoffregen, et al. (2000) recognized the effects of posture on vision: “Postural control can be used to improve visual performance” (p. 203).

Blood flow influences posture. Confirming results from their prior study, Vaitl, Mittelstaedt, and Baisch (1997), Vaitl, Mittelstaedt, Saborowski, Stark, and Baisch (2002) demonstrated that shifts in posture perception, with upward and downward shifts in head tilt, are influenced by shifts in blood volume distribution in the lower body; according to positive and negative blood pressure in the lower body traveling in and out of the thoracic cavity.

Boyd, Blincoe, and Hayner (1965) found evidence for the quadratus lumborum (QL) muscle, working in conjunction with the diaphragm, to support the breathing system. “The quadratus exerts a braking action to oppose the normal elastic recoil of the lungs during expiration” (Boyd, et al., 1965, p. 579). Chung, et al. (2004) found evidence that visuospatial performance improved with breathing additional 30% oxygen. The functional quality of the QL, influencing respiration, might also influence eye movement for reading.

Atypical Posture, Eye Coordination, and Movement; Body Asymmetry and LLI

Posture and movement influences have been examined for DD in relation to control groups. Pozzo, et al. (2006) identified postural and muscle tone impairment, with or without vision, for boys with DD. Balance deficits for children with DD (Moe-Nilssen, Helbostad, Talcott, & Toennessen, 2003) and adults with DD (Brookes, Tinkler, Nicolson, & Fawcett, 2010), including deficits in gait (Moe-Nilssen, et al., 2003), have been evident. Wolff (1990) found bimanual timing deficits for adolescents and young adults with DD, and Geuze and Kalverboer (1994) for children with DD and DCD.

Interference in the brain stem reaches to structural deficiencies. "Without an appropriate balance or postural framework, any number of action patterns could be expected to deteriorate" (Williams & Woollacott, 1997, p. 9). Seaman, et al. (2007) described the "structural interdependence" of the brain stem in relation to motor performance:

> When the brain stem—the master control area for muscular activity—is performing its function adequately, performing on tasks such as moving through an obstacle course is controlled automatically, and the attention of the cortex can be directed to the planning, processing, and adapting required to complete the obstacle course successfully. If the brain stem is not doing its job, then the cortex or the conscious attention must be focused on the muscular activity rather than on planning how to get through the obstacle course, thus deterring or interfering with motor performance. (p. 155)

Integrating the function of the vestibular, tactile, proprioceptive, and visual sensory systems results in "praxis…the ability to plan and execute purposeful movement…for the necessary input and appropriate motor output" (Seaman, et al., 2007, p. 83). Furthermore, Seaman, et al. (2007) described "disorders in interpretation, assimilation, organization, and transmission of sensorimotor information" can be demonstrated in some of the following characteristics of disordered praxis:

> 1) Clumsiness; 2) Messy handwriting; 3) Difficulty imitating movements; 4) Lack of body awareness; 5) Observable slow, deliberately sequenced (calculated) movements; 6) Poor fine motor coordination; 7) Poor gross motor coordination; 8) Poor eye-hand or eye-foot coordination; 9) Uneven or hesitant gait (p. 83)

Gubbay (1985) defined "clumsiness" as "a child whose ability to perform skilled, purposeful movement is impaired, yet whose motor coordination is virtually normal by the standards of routine, conventional neurological assessment, and who also has normal bodily habitus, intellect, physical strength and sensory function" (p. 159). Authors have compared children with "clumsiness" to similar characteristics of DCD (Dare & Gordon, 1970; Geuze, 2005; Gubbay, 1975; Huh, Williams, & Burke, 1998; Johnston, Burns, Brauer, & Richardson, 2002; Williams & Woollacott, 1988). Williams, Fischer, and Tritschler (1983) stated that muscular control did not show "a clearcut pattern of age-related development" for slowly developing children (p. 25). Delayed muscle timing responses for DCD have been evident (Williams & Castro, 1997; Williams, Woollacott, & Ivry, 1992). A distinguishing factor for the "clumsy child" is poor cocontraction for muscles, or "the inability to contract antagonistic muscle groups simultaneously" (Seaman, et al., 2007, p. 79). Geuze (2005) identified the most significant characteristics of poor control for DCD as "an inconsistent timing of muscle activation sequences, co-contraction, a lack of automatization, and slowness of response" (p. 194).

In contrast to children with normal development, muscle activation for children with DCD demonstrated more frequent occurrence of a proximo-distal pattern when testing balance (Williams & Castro, 1997; Williams & Woollacott, 1997), and children with DCD sometimes seemed "to need visual information and were unable to shift control from vision to other sources of sensory information when needed. This often resulted in postural responses that were either developmentally inappropriate or characteristics of central nervous dysfunction, or both" (Williams & Castro, 1997, p. 51).

Shoulder girdle, pelvic girdle, and trunk instabilities have been observed in "clumsy children" (Baker, 1981, p. 357). Johnston, et al. (2002) observed conditions for muscle activation in DCD:

> Poor upper-limb coordination is a common difficulty…One hypothesis is that deviant muscle timing in proximal muscle groups results in poor postural and movement control…significantly [taking] longer to respond to visual signals and longer to complete the goal-directed movement…shoulder muscles, except for serratus anterior, and posterior trunk muscles demonstrated early activation. Further, anterior trunk muscles demonstrated delayed activation…anticipatory function was not present in three of the four anterior trunk muscles. These differences support the hypothesis that in children with DCD, altered postural muscle activity may contribute to poor proximal stability and consequently poor arm movement control when performing goal directed movement. These results have educational and functional implications for children at school and during activities of daily living and leisure activities and for clinicians assessing and treating children with DCD. (p. 583)

The oldest evolutionary animal reflex behaviors, usually present and necessary shortly after birth, do not always integrate into motor development to allow the emergence of volitional movement against gravity (Ayres, 2005; Horvat, et al., 2011; Milani-Comparetti & Gidoni, 1967; Seaman, et al., 2007; Silver, 1952; Stuberg, et al., 2010). Seaman, et al. (2007) indicated, "reflex inhibition, not disappearance, is accomplished in stages: not discretely designated, but individually, developmentally sequenced" (p. 55). The primal brain stem reflexes that are most-likely to interfere with developmental motor learning, but if not inhibited, include: the tonic labyrinthine; asymmetric tonic neck [ATNR]; and symmetric tonic neck (Cheatum & Hammond, 2000; Horvat et al., 2011; Levine & Kliebhan, 1981). Horvat, et al. (2011) described conditions for persistent righting reflexes:

> unable to run, change directions, and maintain body alignment in movement requiring proper head control. Without the persistence of these reflexes or any maturational delays, the reflex movements are replaced by equilibrium reactions. Reactions are automatic responses that proceed from reflexes as the individual's central nervous system matures. These reactions allow individuals to maintain body support and to develop posture and balance control. Problems encountered in this stage of development include the inability to establish basic stability, body positioning, and muscle tone necessary for movement. (p. 72)

Additionally, the protective extension reflex might be lacking. Interference with the appropriate amount of movement development typically occurs with lacking of the protective extension due to a child's propensity for getting hurt, and by *avoiding* movement to be "safe" (Seaman, et al., 2007, p. 78).

The ATNR can persist for older children causing motor development confusion (Cheatum & Hammond, 2000; Horvat, et al., 2007; Levine & Kliebhan, 1981; Milani-Comparetti & Gidoni, 1967; Morrison, 1985; Parmenter, 1983; Seaman, et al., 2007). Poor eye movement control is associated with primary reflex persistence (Ayres, 2005; Cheatum & Hammond, 2000; Horvat, et al., 2011; McPhillips & Jordan-Black, 2007; Seaman, et al., 2007), and Pyfer (1983) specified the effects of balancing and eye movement coordination: "inadequate or inappropriate vestibular signals could delay development of muscular control of the eyes" (p. 159). Horvat, et al. (2011) explained some of the influences of a persistent ATNR on posture and eye movement:

> Persistence of the reflex will cause difficulty in rolling, because the extended arm impedes rolling...the ATNR interferes with holding the head in the midline, resulting in visual perceptual problems commonly associated with tracking or fixating on objects. (p. 73)

Silver (1952) documented developmental postural and neck righting responses, connected to the occipital-sided arm extremity activated by left and right head rotation for children with organic brain disturbances and maturational lags. Rider (1972) studied early motor development and found a correlation between children with early primitive reflex integration deficits and poor academic achievement. Morrison (1985) observed the "extension of arm and leg on face side…and flexion of limbs on the occiput-side" (p. 49) when assessing for ATNR presence in children with LD. Overactive reflexes can interfere with refined movement needs such as reading and writing (Ayres, 2005; Cheatum & Hammond, 2000).

McPhillips and Jordan-Black (2007) compared core literacy skills in dyslexic and non-dyslexic poor readers with ATNR persistence in the general education setting from thirteen primary schools. ATNR persistence was also compared among groups of males and females, and in groups with social advantages compared to the socially disadvantaged. Participants were 739 children between the ages of 7 - 9 years (363 of 7 year olds, and 376 of 9 year olds).

At the end of school year, students were tested by experienced psychological educational testers for spelling, reading, and non-word reading, verbal IQ, and were videotaped for accuracy while assessed during clinical diagnosis for ATNR persistence. Results indicated that ATNR persistence was a strong predictor of reading, spelling, non-word reading, and of verbal IQ attainments, with 62% of the students showing high levels of reflex persistence in the bottom

10% of reading level. No differences were determined between students with dyslexia and poor readers. In addition, results revealed males with higher levels of persistent ATNR than females, and socially disadvantaged children exhibited higher levels of persistent ATNR than without social disadvantages.

McPhillips and Jordan-Black (2007) proposed that many students in general education settings might be influenced by a "brainstem mediated reflex system that should have been inhibited in the first year after birth" (p. 748), and they suggested that the term *dyslexia* is not a specific category of poor readers based on IQ scores, but perhaps it is best to use the term *dyslexia* to describe poor readers. "Reflex persistence…may be viewed as an early developmental risk factor for some children where subsequent effects are dependent on the interplay of a range of cognitive, environmental, and biological factors" (McPhillips & Jordan-Black, 2007, p. 753).

Shaheen (2010) stated that persistent ATNR, and apraxia tests were predictors of dyslexia. Teitelbaum, et al. (2004) found evidence to suggest that persistent ATNR evaluation can be used as an early pre-language indicator for autism.

Typically, in the ATNR response for children with cerebral palsy the arm *and leg* contract on the opposite side of the direction the head is turned (Goddard, 2002; Haywood & Getchell, 2009; Hoskins & Squires, 1973). "Some ['clumsy children'] demonstrate patterns of movement or balance responses suggestive of a minimal cerebral palsy" (Baker, 1981, p. 357). Dare and Gordon (1970) stated that the study of "'clumsy' children with visuo-motor disabilities confirms that…some may show evidence of minimal cerebral palsy, while others may present a specific disability, apparently affecting only the acquisition of skilled movement" (p. 181). Gubbay (1985) recognized mild symptoms of cerebral palsy that might influence learning:

> Although anoxic birth injury has been implicated as the fundamental aetiology [*sic*] in most patients with cerebral palsy, there must be many which are due alternatively to cerebral maldevelopment. Very mild degrees of cerebral palsy without overt evidence of the hallmarks of weakness, spasticity and involuntary movements may result in ungainly motor activity possible partly due to impairment of perceptual abilities. Paradoxically, the child with no conventional neurological signs of cerebral palsy may manifest defects of motor functioning of greater personal impact than cerebral palsy and which interfere more profoundly with function of learning and performance. (pp. 162 - 163)

Some researchers have concluded that balance deficiencies for "clumsy children are more related to dysfunction of the motor control system than to a delay in the development of the system" (Williams & Woollacott, 1997, p. 20). Bilateral motor coordination seemed to be evident for children with and without DCD around the age of six, although only children with DCD demonstrated balance control problems showing significant inefficiency in organizing bilateral muscular activation responses, temporal inconsistencies, and use of "different motor-control strategies" than normal children (Huh, Williams, & Burke, 1998, p. 483). Williams and Woollacott (1997) found that only *selected* deficits of neuromuscular postural responses for "clumsy children" were evident when studying leg muscle responses (p. 21). So, the authors stated that they could *not* conclude that "the motor control deficits of these children lie solely within the postural control system…[but, perhaps] could be related to a more general problem of timing of all movement sequences" (Williams & Woollacott, 1997, p. 21). Larger amounts of muscular activity for leg and trunk muscles were evident for children with DCD attempting to hold a quiet stance, than the control group (Williams, et al., 1983). In Williams (1999), as cited in Cermak & Larkin (2002) control children activated postural control in the order of:

ankle, upper leg, trunk, and neck; whereas children with DCD activated postural control in the order of: upper leg muscles, ankle muscles, trunk and neck (pp. 132 - 133).

Bove, Diverio, Pozzo, and Schieppati (2001) described, "Neck muscle vibration disrupts steering of locomotion" when human neck muscle vibration was used to examine the influences of atypical neck proprioceptive input for the organization and execution of gait (p. 581). Muscle length of ES, and leg length have been investigated for analyzing and comparing gait in children to quantify "physical handicap" (Butler, et al., 1984, p. 607). In contrast to children without DCD, children with DCD displayed varied ES muscle timing when responding to visual prompts for postural muscles (Johnston, et al., 2002). There has been a comparison between LLI and the endurance of the ES and the QL (Knutson, 2005).

Head tilt, shoulder and hip imbalances, and leg length disparities have been investigated for muscle strength discrepancies (Kendall, Kendall-McCreary, Provance, Rodgers, & Romani 2005), and according to Lasko and Aufsesser (n.d.) (as cited in Horvat, Block, & Kelly, 2007), for postural instability. Problems with postural control can be influenced by musculoskeletal limitations of strength or range of motion in joints of the upper or lower extremities and trunk, and can negatively impact cognition (e.g., memory, attention, spatial relations, body schema, and praxis) (Horvat, et al., 2011).

The dysfunction resulting in leg length equality might be strongly connected to structural and postural impairment for individuals with LD. Boyadjian, Marin, and Danion (1999) studied the properties of correcting body orientation, and found, "systematic deviations occurring in two-limb displacements originate from a peripheral mechanism (slight different properties of the right and left limbs) rather than a central mechanism (systematic bias in the perceived body trajectory)" (p. 21). "The spine, pelvis, and lower extremities are all involved in the compensation of limb-length asymmetry. The symptoms associated with limb-length discrepancies are often due to the mechanisms involved in trying to equilibrate functionally the asymmetry" (Kaufman, Miller, & Sutherland, 1996, p. 149). When participants were walking blindfolded, Lund (1930) observed a correlation between the structural and functional strength of a shorter or longer leg, and the tendency to veer in the opposite direction as the shorter leg. Kaufman, et al. (1996) found a connection with LLI and gait: "as the limb-length inequality increased, the degree of gait asymmetry also increased" (p. 146).

Anatomical leg length inequalities have been addressed by orthopedic surgeons for many years (Carpenter & Kirk, 1952), and differences between anatomical and functional leg length disparities have been examined (Eichler, 1977; Gurney, 2002; McCaw & Bates, 1991; Reid & Smith, 1984). Eichler (1977) defined "functional length" as "leg shortening or lengthening caused by joint contractures or by axial malalignment" (p. 30). Injury or compromise to central nervous system pathways can result, as muscles on one side of the body tighten, creating leg length disparity (Bakris, et al., 2007; Knutson, 2001; Rochester, 2009); referred to as a functional, opposed to anatomical, leg length inequality (Eriksen, 2004; Thomas, 1991).

Methods for assessing LLI have been investigated (McCaw & Bates, 1991; Sabharwal & Kumar, 2008). Measuring pelvic crest height alignment has been implemented for establishing leg length discrepancy (Petrone, et al., 2003), with heel comparison (Gregory, 1979). Lateral pelvic imbalances have been evident for school children to distinguish asymmetries in leg length inequality (Klein & Buckley, 1968; Pearson, 1951). "Femur head lowness, commonly termed 'leg shortness'…[was] visualized in 80 per cent of rural school children between the ages of 5 and 13" (Pearson, 1951, p. 166). According to Lasko and Aufsesser (n.d.) (as cited in Horvat, et al., 2007; P. Aufsesser, personal communication, October 4, 2010; M. Horvat, personal communication, September 28, 2010), the San Diego State University Adapted Physical Education Posture Evaluation checks a short leg according to the evenness of popliteal creases [in the back of knees] (Horvat, et al., 2007, p. 145). In Fong, Mak, Swartz, Walsh, and Delgado-Escueta (2003), brain imaging was used for differentiating body asymmetry, and found that evaluating popliteal crease levels for shorter or longer legs to be useful for examining possible origins of seizures. Reinhart, et al. (2006) examined leg length, and atypical gait patterns in children with autism:

> Spatiotemporal gait data for children with autism were compatible with findings from patients with cerebellar ataxia: specifically, greater difficulty walking along a straight line, and the coexistence of variable stride length and duration. Children with autism were also less coordinated and rated as more variable and inconsistent (i.e. reduced smoothness) relative to the comparison group. Postural abnormalities in the head and trunk suggest additional involvement of the fronto-striatal basal ganglia region. Abnormal gait features are stable across key developmental periods and are, therefore, promising for use in clinical screening for autism. (p. 819)

Esposito, Venuti, Maestro, and Muratori (2009) detected lower levels of symmetry (LLS) for infants with ASD lying in a supine position, and suggested that LLS might be used to define subgroups of ASD in the early months of life. de Quirós (1976) described the usefulness for connecting symptoms for infants related to atypical vestibular function, with LD later in life:

> equal or different arm abduction, homo- or heterolateral raising of arms or legs, sterno-cleimastoid contraction, tonus modification, trunk position, need for visual support…can provide extremely valuable medical data. This information is particularly helpful in the diagnosis of some learning disorders, especially those in vestibular disabled children. (p. 44)

Upper Cervical; Correction

Upper cervical research has been connected to brainstem responses. It is suggested that positive effects from chiropractic care for individuals with dyslexia, speech disorder, learning disabilities, and correcting vertebral subluxation have improved cognitive functioning (Lerner & Lerner, 2009; Pauli, 2007).

Since the 1940s, investigators have used physics and mathematical measurements in increments of degrees to examine the upper cervical placement of the atlas bone, or 1st cervical vertebra (Eriksen, 2004). The atlas encircles the spinal cord under the medulla, the lowest part of the brain stem (Martin, 1996). The atlas, in its central position, relative to the gravitational vertical, orients the central axis, balance and weight of the skull, including the spine, shoulders, and pelvis below. The atlas relies on soft tissue for support, so it can be displaced or subluxated from its central position, as the head tilts and the brain stem becomes compressed (Bakris, et al., 2007). “Persistent tilt of the head is abnormal at any age” (Rabe, 1969, p. 70). The visceral sense is located in the brain stem for regulating blood flow (Ayres, 2005; Edwards, et al., 2007; Knutson, 2001). Martin (1996) described that “occlusion of the vertebral artery can produce discrete set of limb and sensory motor signs” (p. 401). According to Kendall, et al. (2005), “Pelvic rotation or lateral tilt will change the relationship of the pelvis to the extremities enough to make a considerable difference in measurement” (p. 438).

There are some that support the fact that contracted reflex muscles occurring on one side of the body for an atlas displacement are associated with a rotated or torqued atlas activating the ATNR (Knutson, 1997; Knutson & Owens, 2005); influencing differences in lateral awareness and reduced blood flow. Bakris, et al. (2007) stated, “Anatomical abnormalities of the cervical spine at the level of the atlas vertebra are associated with relative ischaemia of the brainstem circulation and increased blood pressure. Manual correction of this malalignment has been associated with reduced arterial pressure" (p. 1). Presently, there has been investigation showing good interexaminer reliability in discriminating LLI for upper cervical structural instability (Woodfield, et. al, 2011; C. Woodfield, personal communications, October 15, October 16, November 5, November 19, November 25, November 29, 2009, January 16, October 25, November 25, and December 20, 2010).

Bakris, et al. (2007) proposed that correcting misalignment of the atlas, reduces and maintains lower blood pressure, increases blood flow, and lengthens a functional short leg; by assessing alignment of the pelvic iliac crests with a heel position comparison for leg length disparity (Gregory, 1979). Bakris, et al. examined 50 patients (26 drug naïve, and 24 with washed out systems) who were: a) between 21 and 75 years; b) positive for a preliminary screening of atlas misalignment (with comprehensive X-ray analysis determining head tilt [based on three dimensional physics and mathematical calculations relative to the center of gravity axis of the skull; S.N. MacDonald, personal communication, November 12, 2009]), and a supine contracted leg length check (comparing heel positions when patients turned their heads to the far right and left); and c) documented with a history of Stage 1 hypertension. Participants were excluded if there was: a) no evidence of atlas subluxation; b) stage 2 or higher hypertension, and/or with prescription for two or more antihypertensive medications; c) not with the capacity or willingness to suspend anti-hypertension treatments for the duration of the screening; d) with a second or third degree heart block; and e) with history of a recent stroke or cardiovascular surgery in the last 12 months. The selection process was random, and double blind with a placebo controlled group. Participants took part in an official blood pressure check, and NUCCA [including UCRF] X-ray analysis, and all 50 finished the study.

The participants were manually adjusted for a difference in both a rotational and lateral central atlas positioning on a low adjusting table. For 8 weeks, patients showed the atlas holding position, and a reduction in blood pressure with no detrimental effects. The conclusion indicated that the restoration of an atlas misalignment related to substantial and ongoing reductions of blood pressure; similar to using a two-drug combination therapy (Bakris, et al., 2007).

The atlas, in its central position, relative to the gravitational vertical, orients the central axis, balance and weight of the skull, including the spine, shoulders, and pelvis below. McKnight and DeBoer (1988) found evidence for blood pressure changes, and Scott, Kaufman, and Dengal (2007) for blood flow, with chiropractic manipulations of the atlas. Knutson (2001) studied the effect of a vectored atlas correction affecting an abrupt drop in blood pressure, perhaps due to a cervico-sympathetic reflex stimulation, relaxing muscle tone, and the releasing of pressor reflex effects.

Ahmetoğlu, et al. (2003) investigated the effects of an antihypertensive drug for extraocular muscles in patients with hypertension. "These findings suggest that blood flow in the extraocular vessels decreased due to increased peripheral resistance in hypertensive patients" (Ahmetoğlu, et al., 2003, p. 182). Relieving hypertension might coordinate peripheral vision for extraocular muscles.

Relaxing lateral muscles typically result in lengthening the shorter leg of a LLI. Aligning the skeletal system might have beneficial effects by reducing brainstem compression for improved sensory organization, and increasing blood flow for strengthening the vulnerability of postural and eye movement systems for reading.

Summary

The U.S. civil rights history in the past fifty years was influential for upholding important basic human rights for individuals with disabilities, with the idea of addressing special needs by formulating special education law (Friend & Bursuck, 2002). The medical and educational fields were initially consulted in the beginning efforts to identify LD, and even though the medical field identified children with LD as having minimal neurological dysfunction or MBD, special education law was formulated according to the recommendations by educators to base identification of individuals with LD on functional educational diagnostic information, as a heterogeneous group, and without considerations regarding neurological conditions (Haring & Bateman, 1969). Visser (2003) stated, "In later years, the terminology used to describe these children changed from MBD into 'Deficits in Attention, Motor Control and Perception' (DAMP)" (p. 486), attributable to brain dysfunction involving an "automatization deficit" (p. 489).

Historically, varied disciplines have outlined neurological symptoms for individuals with LD or reading difficulties (Ayres, 1980; Brodney & Kehoe, 2006; Bruininks, 1978; Decker, 2008; de Quirós, 1976; Godfrey & Kephart, 1969; Habib, 2000; Johnson, et al. 1996; Kephart, 1964; MBD Compendium, 1974; Menghini, et al. 2010; Miles & Segel, 1929; Morrison, 1985; Nicholson & Fawcett, 2009; Orbrzut et al., 1983; Punt, et al., 2010; Rider, 1972; Roach & Kephart, 1966; Silver, 1952; Strauss, 1943). Motor coordination deficits are sometimes misinterpreted to mean that a child is not trying hard enough. "Often parents think their child is being naughty or lazy, and this increases the pressures he is already under" (Baker, 1981, p. 356).

To compound the confusion for LD, it has been demonstrated that so far there are no sufficiently reliable academic assessments tools that determine identification for *individuals* with LD (Reynolds & Shaywitz, 2009; Stuebing, et al., 2009). Current LD identification does not reflect the developmental continuum, by examining the developmental step progression of the lower CNS influencing the higher CNS corticle structures. By now the perspective of the medical community has been reflected into the fields of physical education and APE (Horvat, et al., 2011; Kovar, et al., 2007; Winnick, 2005). Evidence shows common physical symptoms for children with LD and DCD according to insufficiencies occurring during atypical neurological motor development; persistent primitive reflexes with hypo- or hyper-sensory responsivity affecting poor muscle tone, lateral disparities, balance deficits, postural instability, and eye muscle weakness (Cheatum & Hammond, 2000; Horvat, et al., 2011; Rabe, 1969; Seaman, et al., 2007). Levine and Kliebhan (1981) described, "The posture and movement problems of children with neuromotor handicaps affect their social, perceptual, cognitive, verbal, linguistic, and emotional development" (p. 209).

Pearson (1951) recognized the importance of early intervention: "Problems of structural [postural] nature, serious but not producing symptoms…suggest the need for routine structural examination…during the preschool years or during the first year of school" (p. 166). Cherng (2007) emphasized that poor balance control for children with DCD is "more likely due to a deficit in sensory organization than compromised effectiveness in individual sensory systems. It is important that such deficits be identified at an early stage in a child's development" (p. 925). Horvat, et al. (2011) described the importance of addressing "soft neurological signs" for children in a timely manner, so that neuroplasticity can be utilized for learning:

> The most important thing to remember about neurological dysfunction, or soft neurological signs, is that some damage has occurred to the brain. If teachers can address the specific problem area early in the child's development, other areas of the brain may take over impaired functions before the process of mylinization takes place. (p. 138)

Understanding the physiology of movement plays an important role for the outcomes of appropriate educational planning (Levine & Kliebhan, 1981). Any therapeutic program to improve balance control should implement a multisensory approach with repeated opportunities for the child to incorporate and refine vestibular and proprioceptive information (Williams & Castro, 1997). Extensive, regular, and systematic opportunities of carefully designed therapeutic activities to strengthen distal muscle control should be given to children with DCD (Williams & Castro, 1997, p. 52; M. Karwas, personal communication, September 15, 2011), including varying "levels of force production (e.g., minimal, mild, moderate, maximal)" (Williams & Castro, 1997, p. 52). Levine and Kliebhan (1981) formulated a prescription to be used to identify developmental motor disparities, including assessing for: 1) postural tone; 2) movement patterns; and 3) primitive, postural, and abnormal qualities for reflexes and reactions (pp. 209 - 210). Additionally, they addressed the significance of recognizing persistent reflexes: "when accompanied by increases in tone and seen in an exaggerated, obligatory form…[they] are again useful for diagnosis" (p. 210).

The importance of motor function deficits are now recognized as "pervasive across diagnoses, thus, a cardinal feature of ASD" (Fournier, Haas, Naik, Lodha, & Cauraugh, 2010, p. 1227), being relevant for psychologists diagnosing autism (Dowd, Rinehart, & McGinley, 2010), and with the strong need for interventions (Bhat, Landa, & Galloway, 2011). Reed (2007) suggested the importance of early detection of persistent primary reflexes for Autism Spectrum Conditions:

> If persistent Primary Reflexes [including ATNR] that predict the possible development of ASC-related behaviors, and ASC itself, could be inhibited by approaches that are known to help with the removal of Persistent Primary Reflexes, this might allow the development of a preventative intervention for some aspects of ASC that could be taken long before the

> typical point of diagnosis of ASC. That is, the potential precursors of ASC problems may be remediated long before they impede typical development. (p. 22)

It is important to acknowledge the integral learning processes of reading *with* writing (Cecil, 2003). Assessment for developmental dysgraphia has been investigated (Gubbay, 1995). Impairment to a child's fine motor control would be influenced by lower CNS structures including, balance disorders and delays in gross motor development (Baker, 1981; Johnson & Williams, 1988). Baker (1981) indicated that children with gross motor disparities might have difficulty copying postures that might translate to "higher perceptual processes of space and form relationships," including poor ability for copying letters (p. 360). Cermak and Larkin (2002) recognized muscle tone and weak pencil grip for problems with handwriting for children with DCD, "despite meeting early intervention goals in foundation motor skills, most children with DCD encounter serious problems with writing" (p. 257). Johnson and Williams (1988) explained that hand use might be distracted by postural responses:

> A child with inadequate postural control may…have difficulty producing the additional muscular activity needed to maintain a stable sitting posture and also use the hands to perform a task skillfully. For such children, sitting unsupported may require conscious attention or even use of the hands to maintain balance. Thus, minimal energy may be available for controlled activity of the distal musculature. (p. 25)

Lee, Yoo, and Lee (2010) studied treatment to improve the ATNR influence on muscle weakness in dominant-hand grip strength, while Ocklenburg, et al. (2010) evaluated detected head tilt for infants, and supported that "increased visual control of the hand during early childhood seems to modulate handedness" (p. 447).

Much emphasis in the academic field has to do with awareness of the quality of articulating sound for the beginning reader (Shaywitz, et al., 2007). Dyslexia has been explored according to brainstem responses affecting central auditory function (Banai, et al., 2009; Banai, Nicol, Zecker, & Kraus, 2005; Billiet & Bellis, 2011). It is possible that "these findings are among the first to establish a direct relationship between subcortical sensory function and a specific cognitive skill (reading)…this cortical-subcortical link could contribute to the phonological processing deficits experienced by poor readers" (Banai, et al., 2009, p. 2699). Roth, Muchnik, Shabtai, Hildesheimer, and Henkin (2012) found first evidence of atypical auditory brainstem responses "already apparent in young children with suspected ASD and language delay" (p. 23). Relieving brainstem compression would be important to investigate for delayed speech-motor articulation; possibly connected to poor muscle tone.

Eye movement disparities have been the focus of research for dyslexia (Biscaldi, 1998; DeLuca, et al., 2002; Facoetti, et al., 2000; Facoetti, et al. 2001), and for autism regarding deficiencies in "broadening the spread of visual attention" (Mann & Walker, 2003). Vogel (1995) presented a review of theory, testing, and therapy for eye saccades by evaluating eye-tracking for reading disabilities and academic success, with suggestions for successful eye muscle strengthening techniques. Brodney and Kehoe (2006) investigated assessing eye movement vulnerabilities with dyslexia, and showed significant potential for elementary school teachers "to identify children at-risk for related vision problems" (p. 13).

Physical fitness has been linked to the prefrontal and parietal cortices brain regions for inhibitory functioning and spatial selection (Colcombe, et al., 2004). Motor development and cognitive development have been correlated with activation of the prefrontal cortex and the cerebellum (Diamond, 2000). Some studies have investigated the possible relationship of physical exercise on cognitive thinking, but positive results have varied (Hill, et al., 2010; Hillman, et al., 2008; Reynolds & Nicolson, 2007; Tomporowski, et al., 2008; Zagrodnik & Horvat, 2009). Exercise treatments have shown gains for phonology, speech/language fluency, working memory, motor skill, and "highly significant reduction in the incidence of symptoms of inattention" related to DD (Reynolds & Nicholson, 2007, p. 78). Students with ADHD and autism have seen significantly improved focusing ability by implementing movement and other intense sensory experiences (Sousa, 2006).

There have been critics regarding sensory integration through perceptual-motor movement techniques for individuals with LD (Hoehn & Baumeister, 1994; Kavale & Mattson, 1983; Stephenson, Carter, & Wheldall, 2007). Doubt exists regarding some study assessments that might be comparing items that are unrelated. According to Tomporowski, et al. (2008):

> A plausible explanation for researchers' failure to detect the effects of exercise on children's intelligence is that IQ tests provide only global measures of functioning, which may not be sensitive enough to detect subtle changes in specific aspects of cognitive functioning brought about by exercise training. (p. 117)

Additionally, there are cross-disciplinary criteria for understanding cognition. "Comprehensive theories have yet to be formulated that address numerous contextual and psycho-social factors that may moderate or mediate the relation between exercise and children's cognitive function." (Tomporowski, et al., 2008, p. 126).

Zagrodnik and Horvat (2009) stated that there is a lack of research investigating exercise and cognition for students with developmental disabilities, perhaps due to the lack of control for exercise frequency, type, intensity and duration, and pre-determined heart rate level. "Developing studies where the intensity of exercise is known throughout the intervention is critical" (Zagrodnik & Horvat, 2009, p. 280), and continued on to address the concern that comorbity among populations of individuals with disabilities are "major roadblocks for the generalizability of the research findings on, not only the impact of exercise on cognition, but any investigation in these populations" (Zagrodnik & Horvat, 2009, p. 282). Furthermore, Zagrodnik and Horvat (2009) advocated utilizing the influences of nutrition and exercise for understanding the impact of developmental movement on cognition, and the necessity for using double blind studies in the future.

Although there is evidence of pediatric musculoskeletal examination to include LLI (Jandial & Foster, 2007), presently, LLI is not a procedural pediatric assessment (B. Bannon, personal communication, November 7, 2009; Stanford Pediatrics, Los Gatos, California, personal communication, November, 2009), nor for occupational therapy (T. Ammon, personal communication, October 22, 2009). In physical therapy there is LLI assessment measuring from the umbilicus to the medial malleoli (Kendall, et al., 2005; E. Folkins, personal communication, September 23, 2009; R. Croce, personal communications, October 8 and 12, 2010). Aligning the medial malleoli, as a marker for determining functional LLI, has been investigated for the NUCCA/UCRF SLC procedure (S.N. MacDonald, personal communications, November 12, 21, & December 21, 2009, January 18, August 8, & October 8, 2010).

There is evidence to support that a functional LLI is specifically due to an atlas displacement (Bakris, et al., 2007; Eriksen, 2004; Thomas, 1991; Woodfield, et al. 2011) possibly influencing an ATNR (Knutson, 1997, 2005), with this evidence showing that brain stem responses are closely linked to eye movements (Kulkarni, et al, 2001), and eye movement strength (Ayres, 2005; Cheatum & Hammond, 2000; Horvat, et al., 2011; Seaman, et al. 2007). Presently, there is evidence that the most influential vestibular sense relies on leg position (Grasso, et al., 2011).

"It may well be that somatosensory leg afferents act at the cerebellar level by tuning the neuronal responses to vestibular stimulation" (Grasso, et al., 2011, p. 312). It seems plausible that correcting LLI might improve the most influential vestibular response.

Martin (1996) described investigation regarding the influence of the upper cervical nervous system pathways on the legs, and a possible influence for LLI: "Animal experiments…have shown that propriospinal neurons located in the upper cervical spinal cord can transmit control signals from the medial pathways to more caudal levels…thus, pathways terminating in the cervical cord may also influence trunk and lower limbs muscles" (p. 260). Additionally, Martin (1996) stated the importance of lessening the obstruction of cerebral blood flow: "occlusion of the vascular supply to the midbrain produces a complex set of neurological deficits that disrupts eye movement control, facial muscle function, and limb movements" (p. 412). Brownlee, Flatt and Miller (2004) found that "Intraocular pressure was significantly reduced, and pulsatile ocular blood flow was significantly increased, following moderately intense exercise" (p. 44). Areas of "brain blood flow abnormalities" (Burroni, et al., 2008, p. 155) have been apparent for children with autism, especially relating to language and understanding sounds and music (p. 150). The suggestion of a left-hemisphere blood flow anomaly for adults who had DD as children (Flowers, Wood, & Naylor, 1991) might be connected to head tilt associated with an atlas displacement.

Presently, speech and language therapist services have been cut from budgets, so students are not receiving adequate time allotted for sufficient movement outcomes (retired Veteran Speech and Language Pathologist, personal communication, December 20, 2011). Currently, the educational system is not set up to assess for LLI or an atlas displacement, and if an LLI condition were recognized, it would be necessary to be designated on an IEP; ultimately school districts would be responsible for treatment costs. Most likely it will be a long time into the future before X-ray technology, or a safer alternative, is incorporated into educational assessment, but in the meantime it is relevant to acknowledge the effects of head tilt, pelvic, shoulder and hip imbalances, possibly associated with an atlas displacement. Early LLI screening might provide opportunities for referrals to treatment for an atlas displacement. Perhaps, if LLI were incorporated into the framework for developmental educational screening assessments, classroom learning environments might ultimately reflect the importance of movement by incorporating persistent primitive reflexes into more sophisticated developmental movement patterns, and the overall affects on strengthened muscle tone and increased cerebral blood flow might become more evident. Developmental movement activities for the classroom (Cheatum & Hammond, 2000; Colvin, Markos, & Walker, 2008; Horvat, et al., 2011; Kovar, et al., 2007; Seaman, et al., 2007) might be regularly incorporated into classroom teachers' lesson plans via identifying LLI.

In the future, educational support teams and parents might be trained to assess the relationship between a persistent ATNR and LLI, as a screening tool for reading success. Perhaps, collecting LLI data eventually might be able to easily document and distinguish relevant neurological patterns for *individual* struggling readers, eventually resulting in *reducing* school district costs by averting more expensive and time-intensive identification processes and treatments. Addressing the importance of a sound visual system might reflect a better understanding for more immediate benefits for *all* students' reading abilities, and ultimately for their quality of a functionally independent life.

Chapter III

Methodology

The focus of this study was to investigate the applicability of the neurodevelopmental framework to enhance learning for all students, especially children with mild to moderate disabilities. This project was directed toward general and special educators, to investigate introducing a handbook with references from a multidisciplinary empirical literature base describing themes related to the neurodevelopmental framework. The purpose of the study was to assist in providing educators with a foundation for understanding how movement influences neurodevelopmental maturation for classroom learning; the foremost objective for the handbook was to help teachers become more comfortable with incorporating developmental movement patterns into their classroom lessons.

Therefore, after the development of the handbook, the first research objective was for national experts to evaluate the handbook for content relating to literature review themes which might assist teachers to become more confident in understanding, addressing, and identifying influences of atypical neurological movement development on their students' learning, and reading skills. The national experts reviewed content for relevance, and usefulness, in topics relating to assessment tools, with national and state standards- and clinically evidenced-based movement activities supported by an empirical literature base.

The second research objective was for the handbook to be evaluated by special and general educators for considerations regarding social-use validity. By utilizing this handbook, teachers might become more comfortable with incorporating physical education into their lesson plans, promoting appropriate attitudes for physical development, and to become more informed for collaborative speaking regarding neurodevelopmental impacts on learning, and reading.

Participant Selection Process

Participant selection included six national experts with published research for best practices in books and/or peer reviewed journals, with university and open lecture expertise, in the fields of reading instruction, APE/PT/movement science, APE National standards, pediatrics, and UCRF criteria. Six educators were selected to participate, including: general education (one each for 1st grade, 3rd grade, and 5th grade); special education (one each for K-6 RSP, and 2nd-3rd grade SDC); and APE specialist (one for high school). Therefore, there were six participants in each group.

The participants were selected based on their background knowledge and experience. The national experts were selected from my own research and acquaintance, excluding the reading instruction specialist contact through a professor from the university, and the APE/PT/movement science author from a textbook referred by one of the thesis project advisors, past faculty of our university, now faculty at a North/East American University. The general education 1st grade teacher is a personal acquaintance, and the general education 3rd grade teacher was referred by my APE thesis project advisor. The special education RSP teacher was referred by the special education university advisor, and the second special education SDC teacher the researcher met through university courses, and on the job. The pediatrician is a personal contact.

Rationale for selection of these particular national expert participants included having background in 1) a crossover between special education and neurology; 2) differentiating sights and sounds in language and reading instruction; 3) movement science; 3) APE National standards of practice; and 4) expertise as a practioner and instructor for the mechanics of the UCRF technique. Training in pediatric neurochemistry, with a pharmacological approach, the pediatrician evaluated for content-validity; possibly to compare societal trends regarding approaches for student success.

The teacher participants were selected based on their background with 1) bi-lingual instruction to low-income early elementary students; 2) teacher interest regarding the developmental neurological aspects of learning, including for reading instruction; and/or 3) long-time experience teaching in the fields of general and special education. The high school APE teacher was chosen, even though this booklet is geared to address K-5th grade, due to professional experience in rehabilitation, and with the perspective of considering how early interventions might be useful for younger students to possibly avert familiar conditions for older students.

Thirteen initial inquiries were sent to national experts to participate in the research; five did not respond, and two more declined with e-mail responses (with one after a requested follow-up phone call). One national expert accepted, although with a time-constraint deadline. Since the project timeline went over the deadline, a replacement was incorporated; a follow-up e-mail was sent by the researcher to express a thank you for the willingness to participate. One national expert in the field of special education initially agreed to participate, but then cancelled the commitment at a late date. One pediatrician, as well as one retired pediatrician each did not acknowledge requests to participate. Therefore, a total of six national experts participated in the study.

For the initial requests for thirteen educators' participation, seven teachers did not acknowledge the contact (four general education; two special education; and one general physical education), with one additional special education teacher declining by e-mail response. Two retired special education teachers did not acknowledge the request to participate, as well as one private special needs school director. Additional requests for participation were not resent to those who did not accept the first invitation (except for resending the message to alternate e-mail addresses to two general elementary education 5th grade teachers; one 5th grade teacher accepted to participate the next time), because there were other potential participants to ask. The timing for this handbook review happened during the beginning of the school year, so it was extremely understandable for teachers to decline participation. Therefore, a total of six educator participants agreed to partake in the study.

Data Collection

Handbook

It was relevant to investigate textbook, internet, printed newsletter, library references, and course resources, with authors and community service providers being interviewed in person, by telephone, and e-mail contact, to gather information for the handbook. Selected material for the handbook was coordinated with my special education and APE thesis advisors.

Permission to use the handbook content material was coordinated with the appropriate sources. Permission to use the atlas subluxation illustration by Marianne Menderli, 1985 was granted through personal contact, in addition to an e-mail sent to the NUCCA President. The images of neuroanatomy were made through my own tracings from Martin, (1996). Permission to use the "Developmental Pyramid" and "Responsivity Continuum" figures in the handbook was given by the adapting author. An original version of the "Developmental Survey of Assessments" document was delivered by e-mail to me by the APE thesis advisor; my adaptations were conducted with the original author by telephone and e-mail contact, and by e-mail with another assessment author included in the assessment list. The "General Programming Ideas for All Sensory Modalities" list was acquired at an open lecture, and used with permission by the author; items listed were also cited with the original authors. Publishers for Cheatum & Hammond (2000); Horvat, et al. (2011); Kovar, et al. (2007); Seaman, et al. (2007) were contacted, and permission was granted regarding the use of text passages. Permission was granted by the Adapted Physical Education National Standards (APENS) Chair to use the copy of standards taken from the website; a request was also made by the APENS Chair to include his contact information in the handbook. The handbook is titled: A Handbook for an Introduction to the Neurodevelopmental Framework for Elementary Educators (see Appendix G for the handbook).

Survey

All participants were pre-contacted by e-mail (excluding the 1st grade general education teacher, whom was encountered in passing) to introduce the research project designed for my California State University, Monterey Bay Special Education Masters of Arts in Education action thesis until sufficient numbers had agreed to participate. In the closing of the pre-contacted e-mail message, the participants' professional concentrations or interests were mentioned, in order to emphasize the value of their perspectives in answering the survey. Attached to the e-mail requests for participation was the abstract called: "A Comprehensive Literature Review: Adapted Physical Education and Related Disciplines, in Neurological Development and Reading" (Appendix D). This abstract was submitted and accepted for a student oral presentation at the October, 2012 conference for the North American Federation of Adapted Physical Activity. For the introductory e-mail, this abstract provided a content summary of the handbook for potentially interested participants.

The handbook was presented to the participants for their review with a brief electronic message serving as a cover letter. The reason for making this cover letter message brief was due to the lengthy quality of the actual booklet (72 pages), so to keep the reader's interest and focus on the actual booklet. The surveys to both groups included five questions each (see Appendices E & F). Each group had approximately a four-week period for review of the handbook, including completing and returning the survey by e-mail. A thank you e-mail was addressed to each participant to acknowledge their extended efforts.

All of the national experts, educators, UCRF doctor, and pediatrician participants were not identified according to their return e-mail responses showing interest to participate, nor by my e-mails of review due-date reminders, and thank you responses. E-mail survey responses were kept private. All e-mail correspondence was destroyed upon the project's completion.

Data Analysis

The present study used content and social-use validity to analyze participant responses. Defining content validity measures, according to Carmines & Zeller (1991), as cited in Howell, et al. (2012): "Content validity is based on the extent to which a measurement reflects the specific intended domain of content (Carmines & Zeller, 1991, p. 20)." According to Wolf (1978), defining social validity might be considered as:

> society would need to validate our work on at least three levels: 1. The social significance of the *goals*. Are the specific behavioral goals really what society wants? 2. The social appropriateness of the *procedures*. Do the ends justify the means? That is, do the participants, caregivers and other consumers consider the treatment procedures acceptable? 3. The social importance of the *effects*. Are consumers satisfied with the results? *All* the results, including any unpredicted ones? (p. 207)

The data collection procedure for this project was to record the survey results using common themes. Graphic display was arranged in tables according to each set of data for national experts and educators. In addition, there were additional tables to show comparisons regarding conceptual overlays between the two groups.

Therefore, the process of compiling and testing this handbook took place in four stages. First, an extensive multidisciplinary review of the literature identified integrated content connections. Second, resources were selected, edited, arranged, with permissions granted for use. Third, participants were selected, and given the surveys for completion. Lastly, the reviews were recorded, graphed, and analyzed according to patterned responses of themes.

Chapter IV

Results and Discussion

The purpose of this study was to provide educators with a foundation for understanding how movement influences neurodevelopmental maturation for classroom learning. Investigation by the researcher considered historical ramifications for how students become eligible for instructional programs to address learning needs. Multidisciplinary literature reviews were conducted to connect concepts for the development of neurological foundations and sensory systems essential for the learning process. A handbook on the neurodevelopmental framework for learning was compiled to possibly assist educators to better understand how elementary school learning might be influenced by physical activities enhancing neurodevelopmental maturation. The foremost objective for the handbook was to help teachers become more comfortable with incorporating developmental movement patterns into their classroom lessons. Individuals were consulted with expertise in disciplines necessary for understanding the handbook's content, usefulness, validity, and strengths.

Data was collected related to the content and social validity of the handbook for future uses in education; the similarities and differences on the findings by the experts; and the generalizations of developmental movement instructions for students with or without disabilities. Information obtained from the national experts indicated the handbook content relevant, useful, and empirically sound. Some considerations were determined for educators using the handbook. Six national experts and six elementary educators volunteered to participate in the study. Each participant reviewed the handbook and completed a survey. The study's research questions were used to guide the organization of the data.

Research Question I:

Can this created handbook for general and special educators on the neurodevelopmental framework for learning have content and social validity for future use in education?

The results depict data collected from two groups, a national group of experts (n – 6), and a group of educators (n – 6) with considerable practical knowledge of the research topic. Pre-designed questions, with a technical dimension, elicited responses from the educators. An open-ended data collection procedure was utilized to take advantage of meaningful, descriptive data in the respondent's own words. The data was coded and grouped to provide a totaled tally of responses (Tables 5, 6, 7, 9, 10). Numerical responses were recorded with a total mean score tabulated for Table 8 whose entries were based on a 1-5 scale (5 most). Results can be found in Tables 5-10.

For relevance, usefulness, and validity of content, national experts demonstrated substantial agreement with five out of six responses (83%) in Table 5. The national reading instruction expert showed no agreement for any criteria (Table 5).

Table 5
Results of National Experts

Participants	1	2	3	4	5	6	TOTAL % of positive responses
Relevance	-	✓	✓	✓	✓	✓	5 = 83%
Usefulness	-	✓	✓	✓	✓	✓	5 = 83%
Validity of Content	-	✓	✓	✓	✓	✓	5 = 83%

Note. 1 = reading instruction; 2 = APE advisor; 3 = APE National standards; 4 = APE/PT/ movement science; 5 = pediatrician; 6 = UCRF practitioner/educator

All participants of the educator group responded to the survey. Table 6 demonstrates that educators demonstrated substantial agreement with five out of six responses (83%) for relevance, six out of six (100%) for acknowledging strengths, and three out of six responses for usefulness (50%).

Table 6
Results of Educators

Participants	1	2	3	4	5	6	TOTAL % of positive responses
Relevance	✓	-	✓	✓	✓	✓	5 = 83%
Strengths	✓	✓	✓	✓	✓	✓	6 = 100%
Usefulness	✓	-	✓	-	-	✓	3 = 50%

Note. 1 = 1st grade; 2 = 3rd grade; 3 = 5th grade; 4 = SDC (2nd – 3rd); 5 = Resource (K– 6th); 6 = APE (high school)

Research Question II:

What are the similarities and differences between the content-use and social-use experts' findings of the handbook, especially on relevance and usefulness?

In Table 7 comparisons for relevance and usefulness were shown according to the responses by each field. The portion of national experts agreeing to relevance and usefulness was 83%, whereas only 66% of the educators agreed.

Table 7

Comparison of National Experts and Educator Responses

Participants	Relevance	Usefulness
reading instruction expert	-	-
APE advisor	X	X
APE National standards	X	X
APE/PT/movement science	X	X
pediatrician	X	X
UCRF practitioner/educator	X	X
1st grade general educator	X	X
3rd grade general educator	-	-
5th grade general educator	X	X
SDC (2nd – 3rd) special educator	X	-
resource specialist (K– 6th) special educator	X	-
APE (high school) special educator	X	X

Research Question III:

What are some generalizations on developmental movement instruction and the use of this handbook for future implementation in supporting elementary educators on teaching students with or without disabilities?

Whether educators would feel comfortable using the resources and activities in the handbook to teach PE is shown in Table 8. The total mean score was 3 out of a 5 point scale.

Table 8
Results of Educators for Teaching PE

Participants	1	2	3	4	5	6	MEAN TOTAL: (on 1 – 5 scale; 5 most)
Would use resources and activities to teach PE	4	2	3.5	2.5	1	5	3.0

Note. 1 = 1st grade; 2 = 3rd grade; 3 = 5th grade; 4 = SDC (2nd – 3rd); 5 = Resource (K– 6th); 6 = APE (high school).

Five out of the six national experts suggested possible audiences for the handbook (Table 9). Of the group respondents, the most frequent suggestions included: 3 (50%) for readers of the handbook to be parents, general educators, special educators, and medical professionals; 4 (66%) showed possible audiences to be general PE teachers, OTs, PTs, and early intervention/resource specialists; and 5 (83%) showed APE specialists as a possible audience to use the handbook.

Table 9
Results of National Experts on Possible Audiences for Handbook

Suggestions for Possible Audiences	1	2	3	4	5	6	TOTAL:
parents	-	X			X	X	3
general educators	-	X			X	X	3
special educators	-	X			X	X	3
general PE teachers	-	X		X	X	X	4 *
APE specialists	-	X	X	X	X	X	5 *
para-professionals	-	X					1
principals	-	X					1
OTs and PTs	-	X	X	X		X	4 *
early intervention/ resource specialists	-	X		X	X	X	4 *
medical professionals	-	X			X	X	3
psychiatrists	-				X		1
osteopathic	-					X	1
chiropractic	-					X	1
alternative health professions	-					X	1
recreational therapists	-			X			1
group home workers	-	X					1

Note. 1 = reading instruction; 2 = APE advisor; 3 = APE National standards; 4 = APE/PT/ movement science; 5 = pediatrician; 6 = UCRF practitioner/educator; * most frequently suggested

Table 10
Suggestions for Handbook Modifications by National Experts and Educators

Suggestions	National Experts	Educators	TOTAL:
Eliminate content	X	XX	3
Incorporate "Developmental Pyramid" or "Developmental Model" Seaman & DePauw (1989)	X		1
Change order of "Misaligned Spine" Menderli (1985) after explanation; begin with popular theme	X		1
Include reading specialist standards	X		1
Define terms of disabilities (etiologies, symptomology)	X		1
Describe how learning is influenced by motor, fitness, and cognitive problems	X	XX	3
Include research from motor invention programs showing improved learning	XX		2
Define the body's distortion and restoration of center of gravity	X		1
Clarify an introduction of atypical neurodevelopment possibly related to atlas displacement, and dyslexia	X	XXX	4 *
Separate the handbook into sections; neurology and practical applications	X	XXX	4 *
Paraphrase, rather than use direct quotations		XX	2
Describe a step-by-step intervention program	XX	XX	4 *
Simplify concepts; use humor		XX	2
Expand resources for practical use		X	1

* Most frequently suggested

All suggestions for handbook modifications were analyzed for patterns and put into 14 categories of modifications (see Table 10). In 5 of 14 categories the groups overlapped suggestions. Most frequent suggestions for revisions were to: clarify an introduction for atypical neurodevelopment possibly related to atlas displacement, and dyslexia; separate the handbook into sections for neurology and practical applications; and describe a step-by-step intervention program.

The national participants who had expertise regarding a neurological framework found the content in the handbook to be relevant, useful and valid, although the national reading expert dismissed the content as it related to reading instruction; information among research disciplines might be highly isolated or there still has not been sufficient evidence to influence field of learning, and learning to read. Educators indicated sufficient merit for relevance and acknowledging strengths, although expressed less support for the usefulness of the handbook; these outcomes favor restructuring the handbook. Because the national experts scored higher than the educators for acknowledging relevance and usefulness, it might be said that there is a need for educators to incorporate a stronger neurodevelopmental background. On average, educators showed an increase in the value and willingness to teach physical education. To suggest which audience might profit from this information, most responses acknowledged professionals in the fields of adapted physical education, although early intervention or resource specialists, typically represented in the field of education, were included together with OTs, PTs, and general physical educators. It is important to acknowledge that the next most frequently listed group of audiences included parents, general educators, special educators, and medical professionals together; these audiences most likely spend more time with students.

The most suggested handbook revisions by the participants included: to clarify an introduction for atypical neurodevelopment possibly related to atlas displacement, and dyslexia; to separate the handbook into sections for neurology and practical applications; and to describe a step-by-step intervention program for all learners. It is interesting that the next two categories for suggested revisions appear to be in stark contrasts of each other: eliminating content, and to describe how learning is influenced by motor, fitness, and cognitive problems!

Implications for Further Research

In considering future implications, the revised handbook might provide references regarding developmental movement education (Godfrey & Kephart, 1969; Horvat, et al., 2011; Seaman et al., 2007), assessment (Horvat, et al., 2007), classroom interventions, activities (Cheatum & Hammond, 2000; Colvin, Markos, & Walker, 2008; Kovar, et al., 2007), State, National and APE standards (California Department of Education, 2009; National Association for Sport and Physical Education, an Association of the American Alliance for Health, Physical Education, Recreation and Dance, 2004; T. Davis, personal communication, August 2, 2012) to educators, service providers, and parents. The handbook might assist educators, service providers, and parents with a better understanding for atypical developmental physical attributes influencing school success.

Presently many physical education programs are being reduced or eliminated due to budget cuts, and frequently elementary classroom teachers are responsible for teaching PE. With the large responsibilities of classroom teachers, sometimes even legally mandated PE minutes have been reduced. Now, budget cuts have also minimized services for OTs, PTs, and individual APE teachers now serving multiple schools, so time to incorporate movement into the instructional day has diminished. With the time deficits for physical movement, perhaps teachers with neurodevelopmental background might have an increased potential for significant influences on helping children to obtain their neurodevelopmental health, by helping to relay information, resources, and attitudes to other caregivers during and outside of school hours. Multidisciplinary views might have a greater impact on influencing societal trends.

Endurance is a necessary part of learning for the individual. Sometimes particular students are not able to sufficiently respond to exercise requirements for learning motor control because the demands of the exercise are too complex for the brain, or exercise might not be stimulating enough (Zagrodnik & Horvat, 2009). It is more important for children to have fun learning to be active for a lifetime, than to risk being discouraged to move because of an emphasis for young individuals to reach high levels of competitive skills (Martens, 1996). Perhaps when children are pushed beyond their maximum threshold for attainment of developmental movement capabilities (or not pushed hard enough), their sense of inadequacy also translates to approaching their academics with learned helplessness. “Learned helplessness” can be describes as: less persistence; less initial estimates for success; failures attributable to lack of ability and successes distinct from personal control; and less expectation for success after failure (Butkowsky & Willows, 1980). Information from this handbook might guide teachers, support providers, and parents to better address particular levels of physical maturation affecting attitudes for success.

Perhaps, through a better foundation of knowledge regarding neurodevelopment for motor skills more elementary school requirements might reflect a sense of play often associated with movement activities. Ultimately, even some reluctant students might become more willing to engage in school participation through play (S. Brown, personal communication, May 9, 2007).

The categorical model emphasizes addressing the needs of individuals in relation to distinct disability labels. The neurodevelopmental model approaches learning from the perspective that often children have not much in common, aside from their disability label (Horval, et al., 2011). With a broader understanding among educators for neurolgical influence on learning, the focus of the individual strengths for students might be broadened to new creative capacities.

Future studies might examine the impact of post-atlas alignment on increased neurological blood flow, and oxygen in varying brain regions according to sensory neurological functions; how a potentially treatable condition for atlas orientation with straightening head tilt might affect the function of the brain stem, including from the positioning of the fetus (or for multiple births) in the womb, and later in development. Other considerations might include the effects of increased oxygen for individuals with autism, and for the impacts on learning and behavior disorders from impaired breathing during sleep.

It seems apparent now that in the educational field the ATNR reflex might be identified and interpreted differently than in the medical field (G.A. Knutson, personal communication, October 20, 2008 & March 30, 2009). It must be recognized that particular treatments that allegedly align the atlas might differ, so alleviating head tilt might require additional studies to assure validity (Bend, R., personal communication, May 4, 2011). In time, multidisciplinary teams might be consulted to interpret common findings, and future efforts might examine more consistent terminology for similar conditions. Multidisciplinary professionals might coordinate physical exercise plans (DePauw, K., personal communication, June 29, 2011), and educational assessments (MacDonald, S., personal communication, June 14, 2012).

Developing appropriate diagnostic and evaluation tools is *essential*. LLI research might reveal more comprehensive approaches for strengthening sensory motor development in the brainstem. Post-atlas alignment posture and vision analysis might be investigated (J. Palmer, Professor of Physics/UCRF researcher, personal communication, February 22, 2010). There might be exploration for whether shorter eye saccades, and impaired peripheral vision for some individuals with dyslexia relate to shorter eye muscle fibers due to less blood flow in the suboccipital eye muscles. In the future, a screening tool for LLI might contribute to the etiology of poor reading skills.

Chapter V

Summary

The overall focus of this study was to investigate the applicability of the neurodevelopmental framework to enhance learning for all students, especially children with mild to moderate disabilities. One of the goals was to provide educators with sufficient foundation for how movement influences neurodevelopmental maturation for learning with possible implications for reading, by creating a handbook to assist educators to become comfortable incorporating developmental movement patterns into lessons. The history of special education law was investigated in regard to understanding the foundation, and ongoing revisions for providing civil rights and opportunity to individuals with learning difficulty in public schools. It was necessary to outline and define the typical process to establish eligibility for students at-risk for learning, to ultimately receive free and appropriate educational services. It was also important to note the educational approaches that have become an integral part of the field of special education. This was especially critical for this thesis, because investigating the applicability of sensory motor integration as a viable learning approach for educators not only required an exhaustive review of the literature, but a keen awareness of what sensory motor activities might be palatable for educators in public schools.

To substantiate the integration of motor development into an already crowded educational curriculum, several past and present issues were thoroughly analyzed in the literature review to give rise to the contention that motor development might be instrumental in catalyzing academic performance. Several major distinguishing problems were investigated in this paper. Some considerations that were addressed included: 1) contrasting variables for identification, definition, and measurement among research disciplines for SLD; 2) contradictory definitions within the law, and interpreting the law for procedures to identify SLD; 3) difficulty for defining SLD within the educational field by minimizing medical definitions; 4) adherence by the educational field to insufficient perspectives for how atypical neurology influences learning; 5) contradiction and controversy among professionals from varied disciplines over incorporating the mandated legal requirement for physical education, and regarding the relevance of the role for physical education on the learning process; 6) persistent implementation of insufficient historical models for special education identification, placement, and intervention; and 7) inadequacy of commercially designed assessments and programs, utilized by the education field, that do not specifically address the progression for an individual's neurological developmental level of learning. Historically, and especially now with advanced scientific technology, researchers from varied disciplines aside from the educational field continue to be interested to investigate neurological properties of learning, including for reading.

From approximately 450 reviewed sources, 268 references were included in the literature review relating to the following themes (numbers of citation resources are in parentheses): educational (48); physical fitness on motor and cognitive development (11); specific to ASD (12); multidisciplinary neurology for LD or dyslexia (48); atypical posture, eye coordination, movement, body asymmetry and LLI (78); posture, ocular motor control and balance (29); visual deficits and learning to read (25); and upper cervical and correction (17). Some authors overlapped theme categories (14).

Some additional overlapping reference categories connecting movement development to reading ability included: postural control, balance and visual performance; atypical neurology; postural instability, atypical balance and motor development; atypical postural control, balance, gait and dyslexia; persistent ATNR, postural instability and poor eye muscle coordination; poor eye muscle coordination and dyslexia; auditory brain stem processing deficits and dyslexia; persistent ATNR, reading and learning difficulties; vertebral subluxation, speech and dyslexia; head tilt, body asymmetry, hip and LLI; head tilt, hip & LLI, with atlas displacement; LLI, atlas repositioning and increased blood flow; blood volume or blood pressure in posture or limbs; ATNR and blood flow; eye muscle movement and blood flow; regional cerebral blood flow and oxygen, with increased exercise on learning; and additional influences of neck and postural muscles. LLI overlapped disciplines, as well; perhaps providing a bridge over research silos.

The current project investigated whether teachers might find value from a handbook describing broader multidisciplinary views on the atypical neurological influence of LLI, as an additional indicator to other significant attributes for atypical movement development, possibly extending the considerations made by educators for utilizing protocols to identify individual neurological developmental needs for students, and engaging in a physical rehabilitative approach for elementary school instruction. The handbook was specifically designed to provide educators with a foundation of empirically sound concepts, assessments, and activities to possibly influence the progression of neurological movement development for learning, including for reading, by complimenting the instructional process. The three research questions involved asking content and social validity experts to review the handbook and complete an open-ended survey of five questions. Similarities, differences, especially on relevance and usefulness and generalizations on developmental movement instruction among the two groups of experts (national and educators), were analyzed and illustrated in tables.

Completing the methods for this project progressed in a relatively orderly manner. Eventually, there was a good balance of national expert and educator participant expertise to incorporate. Communicating by electronic e-mail allowed distributing the participation requests and responses, and the surveys and survey responses to be available in a timely manner. The models for the experimental design, and data analysis easily related to the outcomes of the project. The survey responses were calculable.

Feedback from survey data will be incorporated into future revisions of the handbook. No participant answered nor showed interest for the LLI survey on the last page of the handbook, so the survey will be placed in a more prominent location to attract attention with future revisions. Outside of the project participants, there have been opportunities for me to share the handbook resources with professionals in the fields of APE research, and with local school principals and teachers from surrounding communities. Additionally, during the 2012 NAFAPA conference, I was able to obtain contact information for a researcher in the field of neurology, locomotion, and rehabilitation who I am eager to contact regarding sharing resources from this project.

A limitation to the research for this study might have been that there was a small amount of participants to evaluate the handbook. Another limitation might have been that this handbook possibly presented non-traditional or novel neuroanatomical material that some participants did not expect when they accepted the offer to review, so the time-frame was not adequate for the participants to assimilate the new material, and to adequately evaluate or distinguish the usefulness of this information.

As a significant consideration, interdisciplinary study might contribute to the overall literature base for identifying learning, and reading difficulties. Perhaps, a new discipline might be created called, "Developmental Neurological Education." The rehabilitative nature of developmental neurology has an unleashed potential for researchers and child support teams to explore the influences of physical sensory neurology on the learning processes for each individual student. The handbook's multidisciplinary collaborative perspectives might help transform school systems!

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APPENDICES

APPENDIX A

Neurological Evaluation

APPENDICES

Appendix A—Neurological Evaluation

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The examination begins with observation of the general appearance, attitude, affect, and spontaneous activity of the child together with observations of his attention span, distractibility, impulsiveness, and ability to adapt to the examination and to the examiner. It is important to observe not only what tests the child accomplishes but how he accomplishes them.

A standard neurological examination is performed in which the following functions are evaluated: Cranial nerves I through XII; motor system—tone and strength; sensation-vibration, position, touch, pin; cerebellar testing; and reflexes—stretch and cutaneous.

Comments on Special Procedures

1. Inattention, distractibility, and failure of eye-head coordination can be elicited by double simultaneous stimulation of the peripheral visual field. By 5 years, the patient should be able to indicate by pointing that both the examiner's fingers are moving. Abnormal testing occurs when the patient persistently looks to either or both sides as soon as the examiner's fingers move.

2. Eye movements.

(*a*) Extraocular movements during visual pursuit of a 6-centimeter disc are smooth after 18 months of age. Horizontal jerking or saccadic extraocular movements are abnormal if persisting after this time. Visual pursuit associated with persistent head following is abnormal after 5 years of age.

(*b*) Opticokinetic nystagmus (OK nystagmus)—OK nystagmus is elicitable at any age. Normally the patient follows in the direction of motion of the moving figures with quick eye jerks occurring rhythmically in the opposite direction. The speed of the jerks varies with ability to sustain attention, and with increasing age, becomes faster. Abnormality occurs when the OK nystagmus is absent or when there is a persistent asymmetry of rate when response to movement of the targets towards one side is compared with response of movement toward the opposite side.

3. Facial apraxia: Blowing out of cheeks can be performed uniformly and alternately after 9 years of age. Facial apraxia is present if the patient is unable to perform this test over the age of 9 years.[1]

4. Hearing: Weber and Rinne tests are performed using a 1024 and air conduction is tested with a 4096 cycle per second tuning fork.

5. Pronunciation: Labials, linguals, and gutterals should be well performed by 3 to 4 years. Inability suggests a lingual apraxia.

6. Simultanagnosia: Double simultaneous stimulation testing is performed with the patient's eyes closed and stimulation with the examiner's finger four times on the following sites in variable order: Hand-hand, right hand-left face, left hand-right face. By 5 to 6 years, the normal patient makes no more than one error out of 12 stimuli.[2]

7. Performance of repetitive motions.

(*a*) Serial apposition of thumb and fingers, alternating pronation and supination of the hands, and repetitive heel-shin tapping are normally done slowly and with little or no rhythm at 3 years of age, but deliberately and with slow rhythm by 5 years of age. Abnormal performance is slow, not rhythmical and a quality to note is the persistence of avoiding response predominating over the developing flexion ability as the patient performs the test.[1]

(*b*) Clumsiness, tremor, and ataxia can be elicited in patients at 3 years by having the child place marbles in a cylinder, the diameter of which is slightly larger than the marbles. A smooth, fairly rapid performance is normal by 3 years of age.

(*c*) Synkinesiae.

(i) With finger tapping, serial apposition of fingers, and alternating supination and pronation in one hand, similar but less marked motions occur in the opposite hand up to 9 years. Such synkinesias persisting after 9 years are abnormal.[1]

(ii) Heel tapping on opposite shin associated with persistent motion of the tapped leg of variable degrees occurs normally until 8 years.[1]

8. Posture and gait.

(*a*) Posture.

(i) Resting, supine: When a child automatically assumes the infantile posture of bilateral symmetrical abduction of the shoulders, partial flexion of arms and forearms, this is abnormal after 2 years of age.

(ii) Sitting.

a. Persistent tilt of the head is abnormal at any age.

b. When asked to extend the arms and hands before them, a tendency to pronation of the arms and spooning of the fingers all exaggerated by contact stimulation of the ulnar side of the hand is abnormal over 5 years, although this activity may persist to a mild degree in the nonpreferred hand for many years.[1]

(*b*) Gait.

(i) The examiner should watch and listen to the patient's gait noting the symmetry of step, symmetry and quantity of associated movements of both arms, and listen to the sound of each foot-fall. Asymmetry suggesting minimal hemiparesis can be documented.

(ii) Toe walking: When the child walks on his toes for a minute or more, one can bring out sagging of one heel, a sign of weakness not easily elicitable otherwise in younger children. Asymmetry of arm swinging, persistent flexion of arm and forearm, or accentuated extension of arms is abnormal at any age.

(iii) Heel walking: This not only brings out weakness of dorsiflection of the foot but clumsiness and associated movements consisting of shoulder abduction, arm and forearm flection and spooning of the fingers. These postures are abnormal after 5 years, or if exaggerated are abnormal before this time.[1]

9. Visual-motor skills: The patient is asked to copy the following figures and should do so normally by the stated time.[2 3]

Scribble—18 to 24 months of age.

Circle—24 to 36 months of age.

Cross straight line, vertical, and horizontal—3 years of age.

Square with rounded corners—3½ to 4 years of age.

Square—5 years of age.

Triangle—5 to 6 years of age.

Diamond—7 to 8 years of age.

10. Conception of spatial relationships.

(*a*) Three-dimensional square, circle, triangle (2½" x 2½" x ⅜") are placed on heavy, black-lined tracings made on three separate, standard-sized papers. The normal performance consists of the following: Stacks all figures on one paper after one demonstration, 21 to 28 months; places any form on any figure, 24 to 30 months; places forms on appropriate figures after one demonstration, 30 to 36 months.

(*b*) French curve (dimensions 3½" x 6" x ⅜") is to be placed on a heavy black-line tracing of the curve on paper. The traced outline of the curve is presented sequentially in three different positions of orientation, and after each presentation the subject is to place the curve appropriately on the outline. Normal performance consists of the following—after verbal instruction and without prior demonstration: One correct trial of three trials, 48 to 52 months; three correct trials of three trials, 54 to 60 months.[4]

11. Right-left orientation: The child can name his right and left eye, ear, hand and foot by 7 to 8 years of age.[2]

12. Auditory and visual word association and language use. Picture naming: test pictures consist of house, cup, leaf, dog, flag, star, basket, clock, shoe, and book. Normal performance: 18 months—names or points to one picture; 24 months—names three, points five; 30 months—names five, points seven; 36 months—names eight; 40 months—names 10.[3]

13. Finger agnosia.

(*a*) In-between test: With the patient's eyes closed, one touches the distal phalanges of two fingers of one hand simultaneously and asks how many fingers are in between those touched. A visual demonstration is given first and five trials are made on each hand.

(*b*) Two-point test: One touches with two fingers two points simultaneously on either one or separate fingers of one hand. Following a visual demonstration, the subject is to identify whether one or two fingers have been touched. Five trials are made on each hand. Normal standards: 50 percent of children make no errors by 5¾ years, 95 percent make no errors by age 7½ years.[6]

14. Reading ability: This may be roughly assessed by samples from the Gray Oral Reading or Gates Primary Reading Test. Reading performance one or more years below the grade placement should be referred for psychological testing.[7]

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APPENDIX B

Vestibular, Tactile, Proprioceptive, Auditory, and Visual System Disorders, including Difficulty Integrating Both Sides of the Body

Vestibular System Disorders

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1) *Atypical muscle tone.* **Muscle tone** *refers to the elasticity of the muscles and fluidity of associated movements.* Some individuals with a disability demonstrate **hypertonicity** (overly tight tone) and others **hypotonicity** (overly flaccid tone). If hypertonicity dominates, the individual tends to have limited range of motion, the muscles appear to be stretched (tight), and the movements appear to be jerky and awkward….if hypotonicity exists, the muscles tend to be flaccid (floppy), with extreme flexibility around the joints. The movements appear labored and lacking precision.

2) *Poor balance and equilibrium responses*

3) *Poor cocontraction.* Poor cocontraction is demonstrated by the inability simultaneously to contract antagonist muscle groups or to "fixate" two or more body parts around a joint (e.g., the inability to hold one's out stretched arms in a steady position with the addition of weight or force on the arms).

4) *Postural insecurity.* Postural insecurity is demonstrated by an adverse reaction to sudden movements (e.g., flailing arms upon sudden movement of the body).

5) *Poor eye pursuits.* The inability to track visually the movement of an object, when this can negatively affect motor performance (e.g., catching a ball), demonstrates poor eye pursuits.

6) Disorders in arousal state (e.g., excitability, lethargy). Atypical responses to auditory stimuli (e.g., aversive reaction to sound) and visual stimuli may also appear.

7) *Short attention span and distractibility.*

8) *Avoidance of or seeking out swinging, spinning, or twirling activities.* These might include

spinning one's body or twirling one's fingers in front of the eyes or active avoidance of these activities (e.g., avoiding merry-go-rounds and swings).

Note: From Seaman, at al. (2007, pp. 79-80).

Tactile System Disorders

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1) *Tactile defensiveness*—demonstrating a negative response to touch or defending oneself from tactile stimuli

2) *Tactile-seeking behaviors*—a strong desire to touch and feel anything and everything

3) *Tactile processing difficulties*—a complete lack of response to touch, the inability to discriminate between different tactile sensations, the inability to locate where one has been touched, or the inability to perceive stimuli simultaneously

4) *Hyperactivity or distractibility*

5) *Difficulty in motor planning*—difficulty in planning and executing nonhabitual, purposeful movement

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Note: From Seaman, at al. (2007, p. 80).

Proprioceptive System Disorders

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1) *Atypical muscle tone*. [See prior definition.]

2) *Inadequate muscle contraction for maintenance of posture.* [See prior definition.]

3) *Poor cocontraction*. [See prior definition.]

4) *Lack of body awareness.* Body awareness is demonstrated through the ability to "know"

where one's own body parts are based upon internal stimuli (without vision). With a lack of body awareness, one's ability to use body parts for movement is limited.

5) *Difficulty in coordinating movement efficiently and effectively.*
6) *Difficulty in moving through space, especially around objects.*

Note: From Seaman, at al. (2007, p. 79).

Auditory System Disorders

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1) Difficulty grasping the meaning of words
2) Difficulty using language creatively by conceptualizing the message, associating the appropriate language symbols for use, and sequencing the motor response (expressive language)
3) Inability to recall and use language structures
4) Difficulty discriminating sounds from one another
5) Difficulty detecting variations in sound, including pitch, volume, direction and rhythm

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Note: From Seaman, at al. (2007, p. 82).

Visual System Disorders

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1) Limited ability to attend to visual stimuli
2) Difficulty following a visual sequence or fixating on a moving object
3) Difficulty discriminating visual objects in the field of vision
4) Difficulty maintaining spatial orientation either at rest or while in motion

5) Difficulty recalling visual sequences, spatial relations, forms, or other visual features

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Note: From Seaman, at al. (2007, pp. 80-81).

Difficulty Integrating Both Sides of the Body

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1) Difficulty jumping with both feet simultaneously

2) Unequal stance

3) Difficulty crossing the midline of the body (e.g., a child who hesitates as he or she moves a hand to the opposite side of the body or whose eye movements become "jerky" while visually tracking an objet across the midline of the body)

4) Poor performance in rhythmic activities

5) Poor coordination of both sides of the body during symmetrical and asymmetrical movements (difficulty buttoning a shirt blouse [symmetrical], skipping or galloping [asymmetrical], or jumping up and down)

6) Difficulty isolating body parts for use (e.g., a child who is attempting a task with one hand, whose other hand is moving in response)

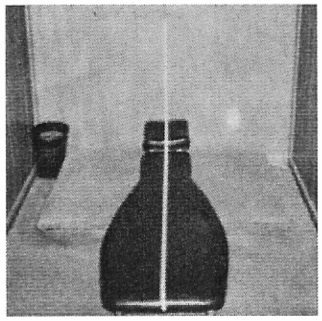
7) Slow balance reactions

Note: From Seaman, at al. (2007, p. 84).

APPENDIX C

NUCCA/UCRF Supine Leg Check

SLC Procedure



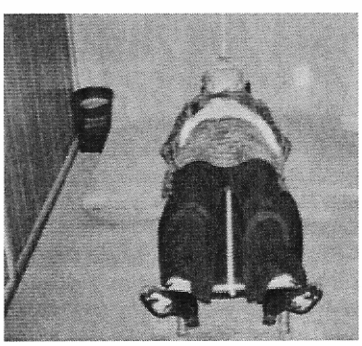
Example of Table centered on a perpendicular line on wall via center marked UC side posture side posture adjusting table 12 inches in height, rear feet placed on 6 inch platform

PATIENT/PRACTITIONER ALIGNMENT

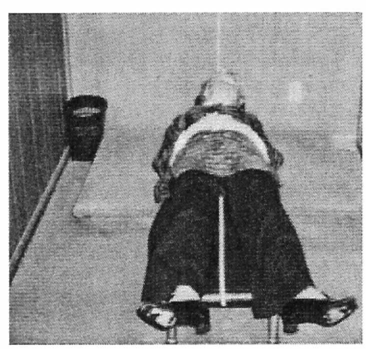
1. Remove all objects from the back pockets of patient's pants, slacks, etc.
   Rationale: Objects in back pockets will cause turning of patient's pelvis into transverse plane, shortening leg.

2. Seat the patient on the body end of the adjusting table, facing away from the headpiece.

3. Guide patient onto his/her back, sliding the body toward the headpiece ,aligning the center of the pelvis, the spinal column, and center of the head to a pre-marked line which divides the table into two equal halves.



Proper Positioning



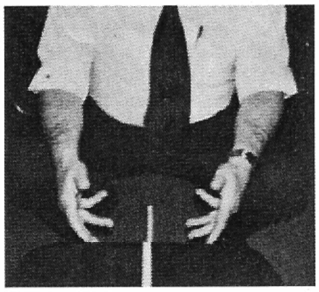
Improper positioning

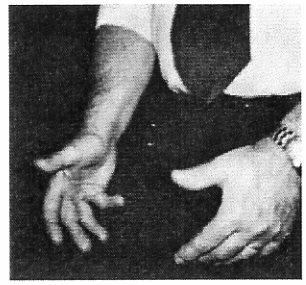
4. Practitioner checks patient's position while standing at the patient's feet. The glabella, center of chin, episternal notch, and pubic center should lie directly above the table's center or dividing line.

5. The examiner holds and cups the feet in the following manner sling like manner known as

the Arciform.

THE ARCIFORM





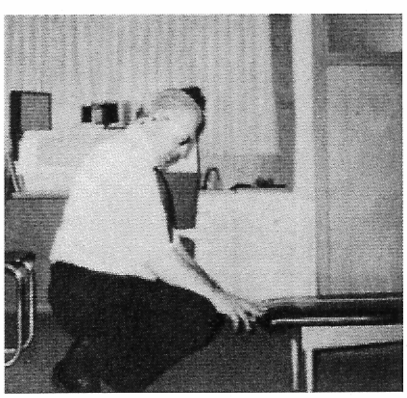
Position of Hands Grasping Heels for SLC, The Arciform

The practitioner forms his hands in an arc or bow-like shape, called the Arciform, to hold the patient's shoes. The backstay, or part of the shoe just above the heel, rests in the palm of the hand. The little finger is placed under the heel so that sufficient pressure can be exerted to keep the shoe against the patient's heel. The thumb rests gently along the outside of the shoe and patient's ankle, paralleling the patient's leg and permitting control in squaring the patient's shoes to the baseline of the triangle. Care should be taken that no downward pressure is placed on the patient's shoes; neither should they be lifted but rest, relaxed, on the table.

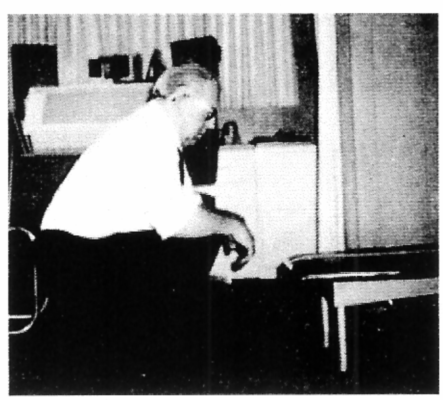
6. Practitioner aligns his sagittal plane to the patient's sagittal plane.

   Rationale: If practitioner's body is not aligned, the lateral displacement will produce greater pressure on patient's shoe on the side of the displacement.

Examiners Position



Proper Position



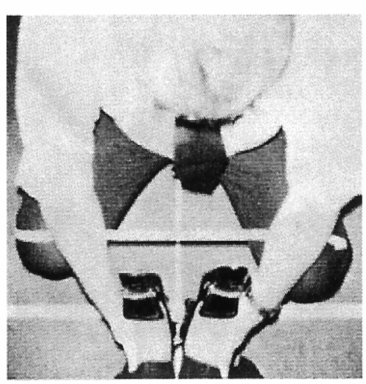
Improper Position

7. Bending his knees, the practitioner settles down by following his knees forward in the same plane as his feet. The knees flex more rapidly than the hips; the lumbar spine is kept straight. The body weight should be sufficiently forward so that the practitioner cannot maintain his position without holding the table. His hip sockets should be slightly higher than his knees. This position permits the necessary forward pressure of about five pounds against the patient's shoes. In this position, the practitioner can control the pressure against the patient's shoes by bringing his body forward and downward. The practitioner's position should not be too close or too far from' the patient's feet. A triangle is formed by the practitioner when he assumes the above position. The apex is at the practitioner's pelvic center and the sides are formed by his thighs. A line (imaginary) across the practitioner's knees forms the base line.

Rationale: The triangle aligns the practitioner further: The base line parallels a line across the patient's heels and the apex lies directly over the mid-center line between his feet, indicating that the practitioner's body is not rotated. The base line, of the triangle is used as a guide and the patient's feet should approximate the base line, being about two or three inches in front of the base line.

Note: The imaginary line bisecting the table should be extended between practitioner's feet and pass directly beneath the center of his pelvis. The practitioner's feet should be equidistant from this line and pointing outward at a 45 degree angle. The width between the feet should approximate the width of the pelvis of the patient.

Examiner alignment



Note: Slight rotation of the examiner that can effect the leg check

8. Positioned in the checking posture, the practitioner again checks his sagittal plane

alignment to the patient's sagittal plane, verifies that the base line of the triangle is parallel to the line across the patient's heels and confirms that an equal distance exists from the center of each of his knees to the line across the patient's heels. He then places his fore-arms, elbows slightly outward, across his thighs at about a 45° angle. Forming his hands in the arciform position, he secures the patient's shoes, squares them, and pushes downward with his knees to exert a slight pressure equally against the patient's shoes. He then brings his knees together to close any distance that may separate the patient's shoes and compares them.

9. The practitioner raises the patient's legs, one at a time, about two inches from the table top and place each leg in parallel alignment to the table's center line.

(Do not drag the legs across the table top)

> Rationale: Dragging the legs will pull on the muscular structure at the posterior of the leg, causing false shortening.

The practitioner checks for leg resistances by exerting about a ten pound pressure with his hands against the heel of each patient's shoe, pushing straight up the leg. Inequality to the resistance exerted indicates spastic contracture. A slight weakening of the resistance signals an incipient misalignment.

10. The patient's shoes are compared to each other at that point where the heel of each shoe attaches to the backstay of the shoe. Shoe heels and soles are frequently unequally worn or warped and unsuitable for checking other than where the heel attaches to the backstay. Inequality or equality is then noted and distance estimated to be recorded at the end of the procedure.

11. If the patient's legs are equal in length, his/her head should be rotated as a check against an impending Atlas misalignment. The patient is asked to rotate their head from center to the right, back to center and to the left and any disparity in leg length is noted. An Atlas misalignment that is just forming and is not sufficiently active to cause leg disparity, will register a contractured or short leg when the head is rotated to one side.

If Atlas misalignment does not exist, rotating the head will not cause a leg deficiency

APPENDIX D

North American Federation for Adapted Physical Activity

Conference Abstract, Fall 2012

A Comprehensive Literature Review: Adapted Physical Education and Related Disciplines, in Neurological Development and Reading

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This project examined usually distinct academic fields, crossing disciplinary boundaries, to create a holistic approach for children who have difficulty learning to read. **PURPOSE:** Atypical readers are at a disadvantage, and although there has been substantial multidisciplinary investigation outlining neurological symptoms for individuals with learning disabilities, including reading problems (Brodney & Kehoe, 2006; Decker, 2008; Habib, 2000; Menghini, et al. 2010; Nicholson & Fawcett, 2009; Punt, et al., 2010), further efforts are necessary to bridge the silos that have been growing for decades through research specialization (Ysseldyke, 2001). Developing appropriate diagnostic and evaluation tools is essential. Literature reviews were conducted and similar themes were identified in: Special Education; Neuroscience (Neurological Cognitive Research, Psychology, Biology, Physiology, Auditory and Vision); Kinesiology and Motor Development Science (Adapted Physical Education, Occupational Therapy and Physiotherapy, and Physical Therapy); Osteopathy and Surgery, Orthopaedics and Pediatric Orthopaedics; Neuro-Developmental Medicine (Rehabilitation); Behavioral Science; and Upper Cervical Research. **METHODS:** Sources were used if 1) procedures and data-based results were published between 1896 - 2012, and 2) topics were relevant to connecting the concepts of atypical movement development, head tilt, leg length disparity, and dyslexia; related to reading instruction. Systematic searches for specific articles/book chapters were conducted through computerized databases: Science Direct-Elsevier; Academic Press; Academic Search Elite (Ebsco); CINAHL; PsychARTICLES; PsychINFO; Hotwire Press; Google; JSTOR Retrospective Journals; Sage Journals; Science Direct-Elsevier; SpringerLink; and Wiley Interscience Journal Backfiles. Key words used: 1) primary reflex persistence; 2) postural instability; 3) eye saccades; 4) atlas subluxation; 5) leg length inequality; and 6) dyslexia. Descriptors were used alone or in word combinations. Some articles were referenced from *Council for Exceptional Children* publications, and many textbooks were examined. Personal communications: P. Aufsesser, R. Croce, K. DePauw, M. Horvat, and J. Rimmer. **RESULTS:** Predominant themes included 1) atypical motor development and muscle strength; 2) atypical neurological blood/oxygen flow; 3) eye muscle weakness; 4) auditory dysfunction; 5) balance deficits; 6) persistent asymmetrical tonic neck reflex, influencing functional leg length inequality; and 7) inconsistency for criteria to identify, and provide services to children with reading disabilities. **CONCLUSIONS:** This review supports that interdisciplinary study might contribute to the overall literature base identifying reading difficulties. This might create a new discipline "Developmental Neurological Education," so child support teams might further examine the influence of physical neurology on the learning process.

APPENDIX E

Survey for National Experts

Survey for National Experts

by Lisa Kline

1) Are there any specific areas in the handbook that are not of sufficient importance or relevance for elementary educators? If so, please list, and explain.

2) List possible modifications to the content of the handbook.

3) Is there enough empirical evidence in this handbook a) to support the connection for an atlas displacement to reading ability; b) to support the need to assess for LLI in relation to reading disability? Why, or why not?

4) Would you share the Research References, and Developmental Movement Education Assessment, Classroom Interventions & Activities References (on pages 60-71) with colleagues?

5) List possible multidisciplinary audiences, and the format for how they should receive this information.

APPENDIX F

Survey for Elementary Educators

Survey for Elementary Educators

By Lisa Kline

1) Are there any specific areas in the handbook that are not of sufficient importance or relevance for elementary educators? If so, please list, and explain.

2) List possible modifications to the content of the handbook.

3) Please describe the strengths of the handbook?

4) Would you share the Research References, and Developmental Movement Education Assessment, Classroom Interventions & Activities References (on pages 60-71) with colleagues?

5) On a scale of 1 (least) to 5 (most), how comfortable would you be using this handbook of resources and activities to teach P.E.?

APPENDIX G

A Handbook for an Introduction to the Neurodevelopmental Framework

for Elementary Educators

A Handbook for an Introduction to the Neuro-Developmental Framework for Elementary Educators

By Lisa B. Kline

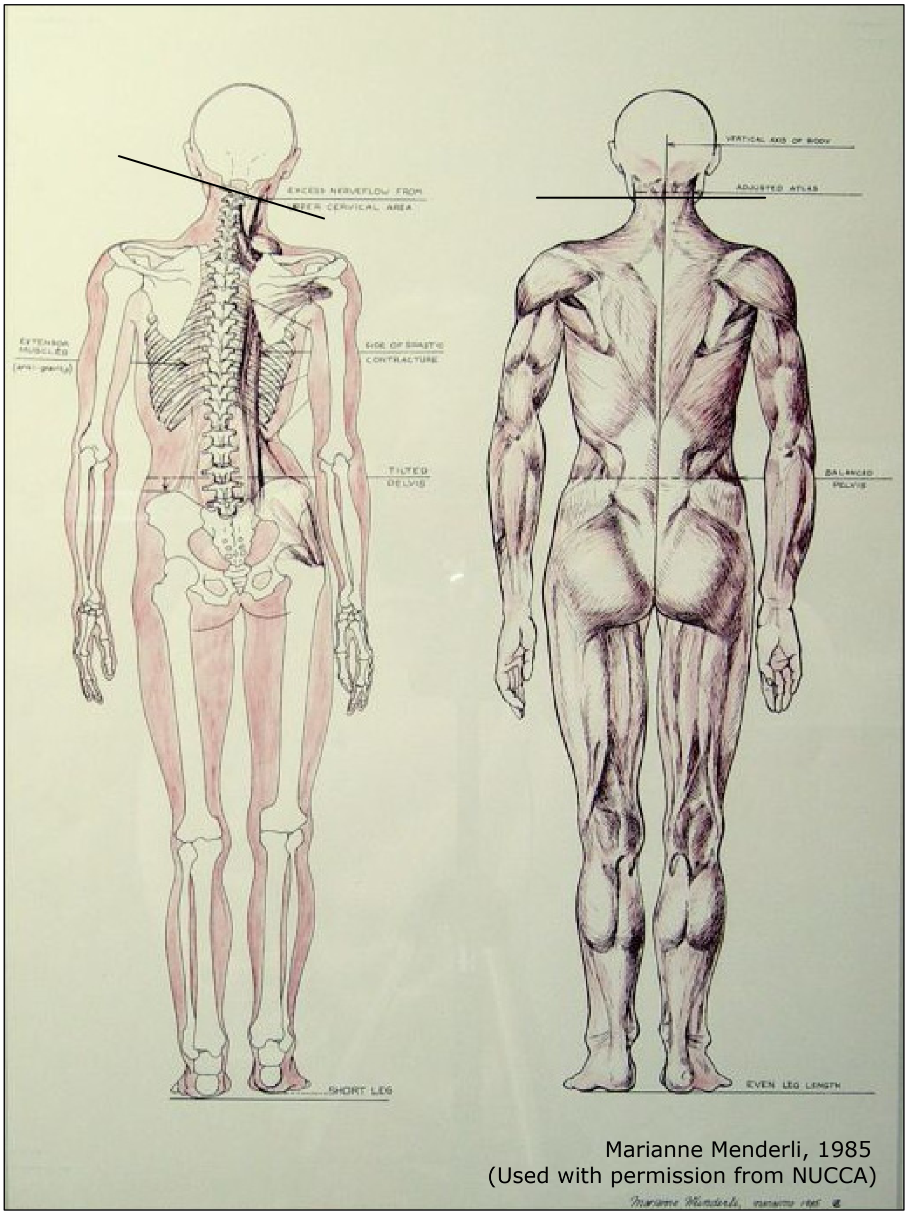
Although medical and educational diagnoses for
"conditions seem to indicate different levels and types of disability,
the motor development issues among them are similar."

Cheatum & Hammond, 2000, p. 3

The College of Professional Studies School of Education
California State University, Monterey Bay

What is different about these two figures?

Can this condition affect children's reading ability?



*DIFFERENCES IN FIGURES: Head tilt, shoulder imbalance, hip imbalance, functional **L**eg **L**ength **I**nequality, and reduced cerebral blood flow*

ATLAS SUBLUXATION = A treatable condition…

then, increasing blood flow, lengthening eye muscle fibers, and possibly influencing stronger eye muscles for reading…

The special education field today is recognizing the multifactorial deficits of students with dyslexia and learning difficulties, and is investigating meeting students' *individual* needs with habilitative approaches along the developmental continuum; now with advances in science and medicine.

Table of Contents

Introduction

In the educational arena, the focus toward good health most often gears lessons around food intake. The impact of *exercise* on health is frequently mentioned secondarily, or as an after-thought…the add-on requirement for good health. Federal law has been enacted with the emphasis on obtaining higher language and math test scores; often physical education programs have been minimized or eliminated.

An expanded neurodevelopmental perspective can assist teachers to become familiar with the evolutionary framework for movement. Being informed of how the brain anticipates and requires movement for good health is *essential* for overall learning.

Educational research now has the ability to rely on brain imaging techniques, and results from multimodal assessments have contributed to a multifactorial hypothesis for students with learning disabilities; developmental movement disparities are at the forefront. In addition, reliability of the categorical model for identifying students at risk for reading, and for special education services, has continuously been controversial.

Presently, there is an emphasis to investigate possible physical causes for individuals with learning challenges. Perhaps, with a broader neuro-developmental view, student referral team members would have better knowledge base for their collaborative decisions.

In order to have [sensory] integration,
information must reach a specific neuron so integration can occur.
'Convergent neurons' is where information comes together.

Feedback is always happening, and is always being used. Movement is a powerful organizer of sensory input; it is planned, meaningful, purposeful, and can be very integrative. We pay attention and organize it.

Feed forward.

Dr. Marcia R. Karwas, 2007

Linking Atlas Displacement to Eye Muscle Vulnerability

* The majority of sensory processing takes place in the brain stem (Fiorentino, 1981); the ***atlas*** (the most freely moveable **1st cervical vertebra**) encircles the spinal cord under the medulla, the lowest part of the brain stem (Martin, 1996), with the skull balancing on the atlas. The atlas can become misaligned, so the weight of the skull *tilts* and compresses the brain stem.

⇩

* Since the 1940s, clinical evidence has shown that an atlas misalignment is diagnosed with a supine **leg length inequality** check (for a functional leg length inequality, not anatomical leg length inequality). Repositioning the atlas to the central axis point on the skull typically results in balancing the skull on the atlas; minimizing pressure on the brain stem (Bakris, Dickholtz, Meyer, Kravitz, Avery, Miller,…& Bell, 2007).

⇩

* Typically, students with learning difficulties have demonstrated atypical neurological movement development, and balance deficits, due to the *persistence* of primal brain stem reflexes that are typically incorporated into more sophisticated sequential movement patterns, and no longer are necessary at the appropriate stages of physical movement development (Horvat, Kalakian, Croce & Dahlstrom, 2011). The asymmetrical tonic neck reflex is one of these reflexes; typically inhibited around 6 months of age, and if not, most-likely interferes with developmental motor learning.

⇩

* An asymmetrical tonic neck reflex occurs when the head is rotated or turned (tilted) to one side while in a supine position, as the arm and leg on the chin-side straighten and *the arm and leg on the back-of-the-head side contract*. The asymmetrical tonic neck reflex is closely related to eye muscle coordination development during the first half year of life; possibly assuring that an object can be reached when close-up vision is forming. A persistent asymmetrical tonic neck reflex is associated with poor eye muscle coordination (Seaman, DePauw, Morton, & Omoto, 2007).

⇩

* Clinical evidence, using X-ray analysis, has shown that re-positioning the atlas to the central orientation of the skull typically results in relaxing tightened lateral trunk muscles, so leg length inequality is reduced, or eliminated; possibly affecting the lessening of an asymmetrical tonic neck reflex response (Knutson & Owens, 2005).

⇩

* Some individuals with dyslexia have demonstrated eye muscle vulnerabilities, including difficulty in the peripheral vision area. Repositioning the atlas with the skull has shown evidence for increased blood flow (Bakris, et al., 2007). Increased cerebral blood flow would lengthen eye muscle fibers (Edwards, Dallas, Poole, Milligan, Yanagawa, Szabo,…& Deuchars, 2007), so perhaps longer eye muscle fibers would provide additional eye muscle, balance coordination for individuals with dyslexia.

Overlapping Reference Categories Connecting Movement Development to Reading Ability

(1) Postural Control, Balance & Visual Performance

(2) Atypical Neurology

(3) Postural Instability, Atypical Balance & Motor Development

(4) Atypical Postural Control, Balance, Gait & Dyslexia

(5) Persistent Asymmetrical Tonic Neck Reflex, Postural Instability & Poor Eye Muscle Coordination

(6) Poor Eye Muscle Coordination & Dyslexia

(7) Auditory Brain Stem Processing Deficits & Dyslexia

(8) Persistent Asymmetrical Tonic Neck Reflex, Reading & Learning Difficulties

(9) Vertebral Subluxation, Speech & Dyslexia

(10) Head Tilt, Body Asymmetry, Hip & Leg Length Inequality

(11) Head Tilt, Hip & Leg Length Inequality, with Atlas Displacement

(12) Leg Length Inequality, Atlas Repositioning & Increased Blood Flow

(13) Blood Volume or Blood Pressure in Posture or Limbs

(14) Asymmetrical Tonic Neck Reflex & Blood Flow

(15) Eye Muscle Movement & Blood Flow

(16) Regional Cerebral Blood Flow & Oxygen; Increased Exercise on Learning

(17) Some Additional Influences of Neck & Postural Muscles

(18) Education

Challenges to Fitness Development Faced by Individuals with Disabilities

Horvat and Croce (1995) and Winnick and Short (2000)
As cited in: Horvat, M., Kalakian, L., Croce, R. & Dahlstrom, V. (2011). *Developmental/Adapted Physical Education: Making Ability Count* (5th ed.). San Francisco, CA: Pearson, p. 101.

* Architectural barriers may require an inordinate amount of energy expenditure and impede independent movement.

* Many people with disabilities are overprotected, fostering an inactive lifestyle and the potential for obesity and other health concerns.

* Inefficient movement patterns and poor body alignment increase energy expenditure required to perform everyday tasks. Fatigue occurs easily, reducing job efficiency and the desire to participate in leisure activities.

* Restricted sensory input, abnormal reflex activity, spasticity, and/or paralysis reduces mechanical efficiency and functioning, which in turn fosters inactivity.

* To use prosthetic and orthotic devises contributes to a loss of functional muscle mass, reduces neuromuscular efficiency, and contributes to excessive fatigue.

* Depression or anger often results from an accident, disease, or acquired disability, often leading to reduced participation in physical activities.

* Individuals with cognitive or attention deficits require behavior intervention and prompting to sustain a sufficient level of fitness.

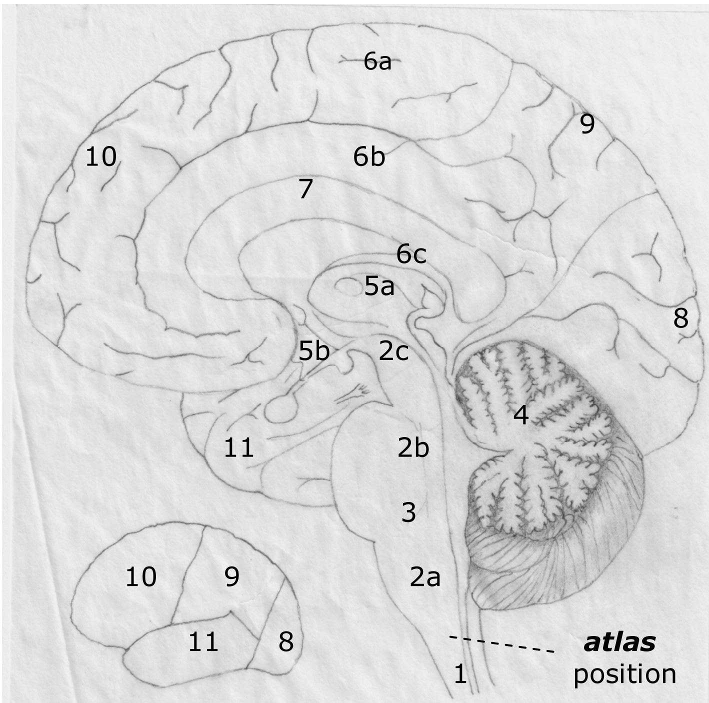
* Motivation to complete a task or sustain an effort to induce a training effect is often lacking.

* Children with disabilities often do not develop age appropriate play skills, which further decreases their physical functioning and social interaction.

* Attitudinal barriers often focus on what the individual cannot do instead of what the individual can accomplish.

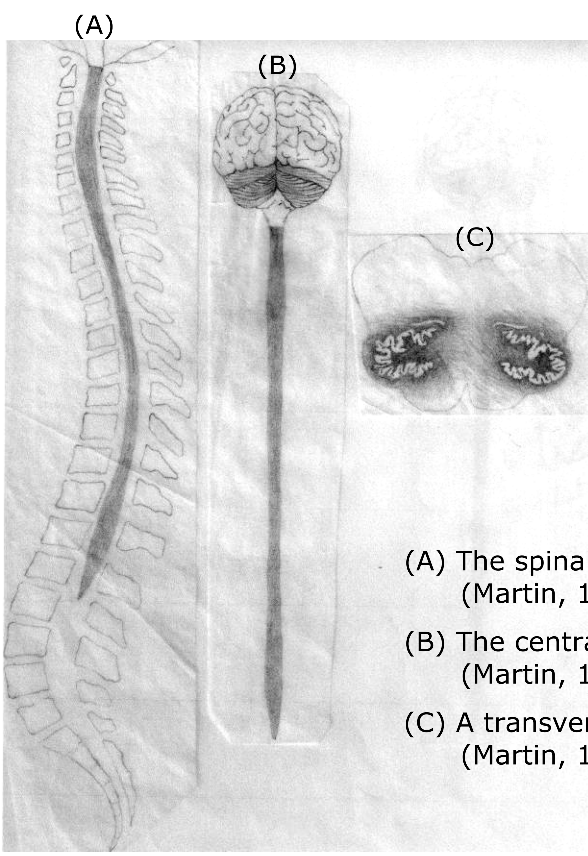
Neuro-Anatomical Reference Points

Adapted from: **Martin (1996). *Neuroanatomy: Text and Atlas* (2nd ed.). Stamford, CT: Appleton & Lange.**



1 spinal cord (p. 15)
2 brain stem (p. 5)
 a medulla (p. 15)
 b pons (p. 15)
 c midbrain (p.15)
3 reticular formation (p. 131)
4 cerebellum (p. 15)
5 diencephalon (p. 15)
 a thalamus (p.15)
 b hypothalamus (p. 15)
6 telencephalon (p. 36)
 a cerebral cortex (p. 52)
 b limbic lobe (p. 449)
 c basal ganglia (p. 110)
7 corpus collosum (p.15)
INSET:
8 occipital lobe (p. 14)
9 parietal lobe (p. 14)
10 frontal lobe (p. 14)
11 temporal lobe (p. 14)

The ***atlas*** (1st cervical vertebra) encircles the spinal cord under the medulla, the lowest part of the brain stem (Martin, 1996).



(A) The spinal cord and vertebral column, a lateral view. (Martin, 1996, p. 67.)

(B) The central nervous system, a dorsal view. (Martin, 1996, p. 67.)

(C) A transverse section of the medulla; the vertebral arteries. (Martin, 1996, p. 400.)

Literature Review Highlights

Multifactorial Hypothesis

Researchers have been addressing varying symptoms for individuals with reading deficiencies, and by now there have been studies to support previous findings relating to multifaceted deficits for dyslexia (Habib, 2000; Nicolson & Fawcett, 2009). Kibby, et al. (2009) found correlations between the shape and length of the pars triangularis brain region relating to the function of language, including for children with Attention-Deficit Hyperactivity Disorder. Within the search to understand Autism Spectrum Disorder, children have demonstrated considerable deficits associated with those for Attention-Deficit Hyperactivity Disorder (Allen & Courchesne, 2001; Corbett & Constantine, 2006). Evidence has shown children with dyslexia suffer both phonological coding and visual deficits (Eden, Stein, & Wood, 1993; Valdois, Bosse, & Tainturier, 2004), when tested for nonsense words (Lovegrove, Martin, & Slaghuis, 1986). Menghini, et al. (2010) recognized wider implications, beyond the linguistic brain area, for defining and treating Developmental Dyslexia (DD):

> [Developmental Dyslexia is] a composite disorder in which other competencies besides linguistic ones are compromised…a diagnostic system that collects only linguistic symptoms of dyslexics is not sufficient for understanding their reading difficulties, making a correct diagnosis and, consequently, developing a consistent program of treatment. (p. 870)

Students with reading difficulty have gained additional support with further evidence of a specific working memory deficit (Beneventi, Tonnessen, Ersland, & Hugdahl, 2010). Wolf, et al. (2010) identified specific brain regions showing the working memory deficit for Developmental Dyslexia:

> Within an "executive" neural network, dyslexics exhibited decreased connectivity in key regions associated with executive function during working memory…, but also increased functional connectivity in parietal, hippocampal and thalamic regions. The relationship between task accuracy at high load levels of manipulation demand and connectivity indices in parietal and hippocampal areas suggests the presence of alternative neural pathways in dyslexics in order to compensate for deficient executive neural processing. (p. 317)

DeLuca, Borrelli, Judica, Spinelli, and Zoccolotti (2002) demonstrated a close relationship between motor and cognitive development, and the cerebellar and pre-frontal cortex. To better understand the importance of recognizing specific brain regions relating to dyslexia, it is necessary to have a basic knowledge of neurological functions relating to movement.

Neurological Foundations for Human Movement

Seaman, et al., (2007) described the basic foundation of the central nervous system, starting with the neuron (the body and processes of the cell), made of axons (pathways from the cell) and dendrites (branchlike receptors transferring stimuli to the cell). Seaman, et al., (2007) described the process for central nervous system growth and development:

> maturation depends on several factors: axonal growth, maturation of neuronal dendritic systems, maturation of the synapses, and myelination. The maturation of the synapses is interdependent on axonal growth and the functioning of the dendritic systems. Myelination occurs as a separate process and is considered a measure of the maturity of the individual cell and its ability to transmit impulses efficiently. Not all nerve cells become myelinated, nor does all myelination occur at the same time. In general, myelination begins before birth and continues for nearly 30 years of life. (p. 45)

Seaman, et al. (2007) explained the structure and function of the central nervous system as "hierarchical" (p. 45), although it is important to also recognize and understand the central nervous system functioning "as a whole" (p. 44). Seaman, et al. specified the comparison between the "old" and "new":

> The evolutionary older structures are found at the anatomically lowest level (i.e., spinal cord) and are the least functionally complex…the newer structures are found in the highest anatomical position (i.e., telencephalon or cerebral cortex) and have the most complex functions. For optimum functioning, the higher levels of the brain depend on adequate lower-level function. The following general concepts apply:
>
> 1. Growth, development, and maturation begin in the spinal cord and end in the cortex.
> 2. Hierarchy of control and complexity of function increase with higher CNS [central nervous system] structures.
> 3. Inhibitory centers tend to predominate over excitatory centers.
> 4. Reflexes and feedback loops become progressively more complex with higher structures. (p. 45)
>
> The spinal cord is at the lowest anatomical level and is structurally and functionally the simplest in the CNS [central nervous system]…Its importance lies in its mediation of spinal cord reflexes and conduction of neural impulses. Located anatomically higher, the brain stem receives sensory input from many sources, handles significant and massive integration, and has widespread influence over the rest of the brain…(p. 45)

> Within the brain stem is housed, at least in part, the **reticular formation**, considered to be *the master control mechanism in the CNS* [central nervous system]*.* The reticular formation serves a general arousal and alerting function, as well as a central integrative role (e.g., inhibition, facilitation, augmentation, synthesis). It is also a selective network that decides which information is to be perceived and focused on. (p. 46)

Seaman, et al. (2007) defined the **cerebellum** as "*a huge integration center, the primary functions of which are integration and regulation*...its function has been linked most frequently to motor output, smoothing and coordinating action and influencing muscle tone" (p. 46). The cerebellum coordinate motor function, influence long-term memory, spatial perception, impulse control, attention, and cognitive function (Sousa, 2006).

The higher brain centers are more diverse, and numerable than the lower ones. Seaman, et al. (2007) identified some of the higher brain centers:

> The diencephalon and telencephalon, respectively, are the next to highest and highest levels of the CNS [central nervous system]. Their functions are more complex. The **diencephalon** (thalamus, hypothalamus, and other structures) serves as *a relay station for sensation and movement.* The **telencephalon** includes the basal ganglia, limbic lobe system, and the cerebral cortex. The basal ganglia assist with the initiation and execution of purposeful movement. The **limbic lobe system**, or "old cortex," is *the primary memory storage area of the brain*. (p. 46)
>
> The **cortex** consists of *two hemispheres (right and left) and five lobes (two temporals, occipital, parietal, and frontal)*. The two hemispheres are connected through a bundle of fibers known as the corpus collosum, which transmits impulses between hemispheres. These higher centers organize sensory activity at their respective levels and influence integration at the lower levels. (p. 46)
>
> Processing at the cortical (cortex) level depends on subcortical (levels below the cortex) processes. As the level of function increases, behavior becomes less stereotyped and more individualized. As the level of sensory organization decreases, more emphasis is placed on sensorimotor integration. (p. 46)

Appropriate central nervous system development relies on essential sensory and environmental factors, regardless of innate potential (Haywood & Getchell, 2009; Seaman, et al., 2007). Seaman, et al. (2007) emphasized that the *strength* of the higher central nervous system relies on the lower central nervous system:

> Sensory input (e.g., tactile, vestibular, proprioceptive, visual, and auditory) continually impinges upon the human organism, placing demands that help foster the

> growth of the nervous system…The process begins with enhancing development in the lower, less complex levels of structure and response that, in turn, enables the individual to become more competent at the higher, more complex levels. (p. 46)

Seaman, et al. (2007) summarized the process of sensory input to sensory motor output response (e.g., movement, writing, speaking). Furthermore, Seaman, et al. included the importance of the feedback loop for refining future motor responses or movement:

> In order for a person to move, sensory stimuli must be received (reception) and attended to (selective attention). Following neurological arousal and attention, the sensory information is available to be modulated, analyzed and integrated. The result is the perception or image of the desired and appropriate motor response. This is matched with memory and then translated into the motor program. The actual motor response is influenced by selected motor control mechanisms of the brain (e.g., basal ganglia, cerebellum). Once neural impulses are sent to the muscles, the motor response occurs.
>
> The functioning of each phase depends on the processing of the previous phase. Breakdowns, which can occur in the system, can influence the processing of the next phase and ultimately adversely affect motor response. (pp. 49 - 50)

Sensory Motor Development from Earlier- to Later-Maturing Systems

The growth process takes place according to particular physical directions of development. Horvat, et al. (2011) explained the process of growth and motor development:

> Motor skills develop in a predictable sequence from basic to more complex movement patterns beginning at the head and proceeding to the feet [cephalo-caudal], and beginning from the midline of the body and proceeding to the extremities [proximo-distal]. The head develops initially and has the greatest degree of control in the upper extremities. During the process of maturation, the arms will develop in mass and control before the lower extremities. Similarly, control of the large muscles of the trunk and shoulder girdle develops before control of the hands and fingers…the sequence of motor development and postural control is orderly, although not all abilities will be mastered at a specific age. (Horvat, et al., 2011, p. 69; bracketed material from Pyfer, 1983, p. 155, and Roach & Kephart, 1966, p. 5)

In the developmental model "it is generally accepted that each developmental step depends on a certain degree of maturation at previous steps…early developmental stages serve as building blocks for later stages" (Seaman, et al., 2007, p. 58). The developmental pyramid model (Figure 1) demonstrates the progression of development for the three lower systems; initially, for the innate neural capacity or reflexes; secondly, for the earlier-maturing systems, including the tactile, vestibular, and proprioceptive; *then*, for the later-maturing systems, the visual and auditory systems (Seaman, et al., 2007, p. 59; M. Karwas, personal communication, 2006, 2007). The development of movement sequences within each of the later stages of motor-sensory responses, motor patterns, and motor skills are dependent on the sophistication of the previous stages. The sensory systems are designed to interrelate. The most refined movements are at the top of the pyramid.

> The astonishing accuracy with which normal human subjects can estimate their straight ahead body orientation under normal conditions argues for a stable body-centred [*sic*] reference frame for the evaluation of body orientation in space and further shows that under normal conditions the sensory systems [visual, vestibular, and proprioceptive] tested act together in a very precise manner, supplying us with a close to optimal estimate of body orientation. (Karnath, Sievering, & Fetter, 1994, p. 145)

Figure 1 *Developmental Pyramid for Motor Development*

Motor Skills – **culturally determined**

running while bouncing balls, walking on the balance beam, dancing

Motor Patterns – **common to all humans**

rolling over, hand raising, walking, running, creeping, crawling, sliding, throwing, jumping, hopping, skipping (combination of hopping and walking), leaping, kicking, striking, galloping

Motor-Sensory Responses – **planning and executing purposeful movement**

twisting, bending, lifting head, eye-hand coordination, eye-foot coordination; ability to use both sides of the body independently from each other, isolate one body part, cross midline, and maintain balance

Functioning of Later-Maturing System – **visual, auditory**

hand-eye and eye-hand coordination; most closely linked to the vestibular

Functioning of Early-Maturing System – **vestibular, tactile, proprioceptive**

understanding right from left, memory playing an important role; the same anatomic age

Innate Neural Capacity − **reflexes**; according to **survival behavior**; gene pool

---

Note: Adapted from Seaman et al. (2007, p. 59) by Karwas (2006, 2007), used with permission (M. Karwas, personal communication, August 14, 2012) [below].

Seaman, et al. (2007) indicated, "reflex development and inhibition occur along a continuum rather than an 'all or nothing' manner" (p. 54). Horvat, et al. (2011) explained the function of reflexes that are typically present to assist infants:

> Reflexes are automatic responses of the nervous system that are present at birth and controlled by the primitive regions of the nervous system, spinal cord, labyrinth of the inner ear, and brain stem. They are responsible for changes in muscle tone and movement and gradually become integrated into voluntary movements as the higher center of the brain develops. Reflexes also aid children in assuming postures and controlling movement. During infancy reflexes will dominate movement until 6 months of age. (p. 207)

The following represents a glimpse of the individual sensory systems. Each system, intricate on its own, typically integrates with the others.

Spoor, Wood, and Zonneveld (1994) examined the dimensions of the inner ear's bony labyrinth vestibular system, the oldest evolutionary and developmental sense, among hominid fossils as "a major component of the mechanism for the unconscious perception of movement" (p. 645). The study explored the question of why "the upright posture and obligatory bipedalism of modern humans are unique among living primates" (Spoor, et al., p. 645). "Among the fossil hominids investigated, the earliest species to demonstrate the modern human semicircular canal morphology is *Homo erectus*" (Spoor, et al., p. 647). An advantage to studying the bony labyrinth is that it develops to its "adult shape and size long before birth" (Spoor, et al., p. 648).

The vestibular sense regulates sensory processing by coordinating the visual, auditory, proprioceptive, and tactile senses (Ayres, 2005; Cheatum & Hammond, 2000), with neuroplasticity (Ayres, 2005; Sousa, 2006). Seaman, et al. (2007) described the vestibular:

> It functions to maintain equilibrium, muscle tone, position of the head in space, and an awareness of motion. It exerts widespread influence throughout the CNS [central nervous system] and contributes to the coordination and timing of all sensory input for the enhancement of perception…and chiefly acts through the vestibular-spinal tracts and the vestibular-oculomotor pathways, sending impulses to the rest of the CNS [central nervous system]…via the cerebellum. (p. 52)

Grasso, et al. (2011) investigated the responses of the vestibular system according to leg rotation and head position. Grasso, et al. found evidence that the labyrinthine apparatus responds to positions of the legs and the entire body:

> In particular, within the cerebellar cortex, the direction of animal tilt giving rise to the best response of the neurons tend to rotate by the same angle and in the same

> direction as the body under the head, so that labyrinthine responses become dependent on the direction of body displacement, rather than head displacement (p. 312)
>
> We postulate that the cerebellum integrates somatosensory information from the whole body and adapts the voluntary and reflex movements to the orientation assumed by the body in space and to the relative position of the different body segments…(p. 312)
>
> The results of the present experiments support the hypothesis that somatosensory signals related to leg rotation and/or copies of the corresponding voluntary motor commands modify the pattern of VS [vestibulospinal] reflexes and, thus, maintain this postural response appropriate to counteract body sway in the direction inferred by labyrinthine signals. (p. 312)

The tactile system receptors respond to touch, pressure, temperature and pain, and are located in layers of the skin; most sensitive in the mouth, lips, tongue, fingers, and hands (Cheatum & Hammond, 2000, pp. 223, 225). Seaman, et al. (2007) stated, "Touch refers to the primary sense, characterized by the reception of nondiscriminating, nonlocalized, and generalized information...tactile is the later-developing sense able to discriminate among and localize tactile information" (p. 53). "Spaces in the sensory cortex created by impulses [from the fingers, thumbs and lips] are larger than the combined space reserved for impulses for all the other body parts" (Cheatum & Hammond, pp. 226 - 227). "One of the most important functions of the tactile system is to enable the brain to suppress or ignore a vast amount of information it receives through the skin" (Cheatum & Hammond, p. 230).

Body schema coordination understands how body parts are in relation to each other, including the concept of laterality or lateral preferences for favoring one eye, hand, or foot, and movements crossing the midline, so directional discrimination can be learned (Cheatum & Hammond, 2000). Cheatum and Hammond explained that proprioceptive receptors detect:

> relationships of the body parts and joints to each other in both stationary (static) and moving (dynamic) positions...at any time, the proprioceptive system sends information to the brain concerning the (a) location of the joints and body parts; (b) movement of the joints and muscles; (c) pressure on the skin and underlying tissue; (d) pain [or relief from pain] felt in the joints, tissue, or muscles; and (e) temperature (p. 187).

Seaman, et al. (2007) stated, developmentally, the proprioceptive sense has three main objectives: "1) it helps to maintain normal muscle contraction; 2) it influences muscle tone; and (3) it aides in space perception…regarding size and shape of the environment" (p. 52).

The auditory system detects vibration that creates sounds. Seaman, et al. (2007) described the auditory system as:

> a very intricate and complex system. The stimuli enter at the ear and are routed bilaterally almost as soon as they enter. As input passes through the nervous system, it makes many different connections and travels directly or indirectly to the cortex. The direct path leads through brain structures that contribute to the general arousal and inhibition of the CNS [central nervous system] at the cerebellar level. As impulses travel through integrative brain structures, the auditory system becomes closely associated with the visual system. The auditory system also has a close association with the vestibular system because the receptors are in proximity to one another in the inner ear and share the same cranial nerve. (p. 53)

"The visual system is the most complex of all the sensory systems. The auditory nerve contains about 30,000 fibers, but the optic nerve contains one million, more than all the dorsal root fibers entering the entire spinal cord!" (Mason & Kendel, 1991, p. 420). According to Porter, Porter, Baker, Ragusa, and Brueckner (1995) "Eye muscles can execute pursuit and vergence movements to maintain fixation upon smoothly moving targets at velocities at which motion is barely perceptible, yet also are capable of saccadic peak velocities of as high as 600 [degrees]/second" (p. 454). Regarding oxidative capacity, the extra-ocular eye muscle fiber "[is likely] the most fatigue resistant mammalian skeletal muscle fiber type" (Porter, et al., p. 459). In humans, "extraocular muscle blood flow, and thus potential oxidative capacity, is the highest of any skeletal muscle" (Porter, et al., p. 466). "The eye movement reflexes, vestibulo-ocular and optokinetic, represent phylogenetically old systems that provide a baseline ocular stability that is vital for clear vision and thereby provide a platform from which to execute voluntary movements" (Porter, et al., pp. 453 - 454).

Muri (2006) found evidence that eye movement control or oculomotor processes and visuospatial attention are closely integrated in a common neural network. Cheatum and Hammond (2000) stated that the visual system is composed of "several visual skills: binocular vision, accommodation (convergence and divergence) fixation, visual pursuit (pursuit fixation), depth perception (stereopsis), visual memory, and visual sequential memory" (p. 267). Ocular motor control is described as "the ability…to use the six eye muscles…[to] allow the eyes to move in all directions for tracking" (Cheatum & Hammond, p. 269). Stoffregen, Pagulayan, Bardy, Hettinger, and Hettinger (2000) explained how eyes typically move together, "binocular convergence…is controlled by rotating the eyes relative to one another" (p. 208). Kirkby, Webster, Blythe, and Liversedge, (2008) described functional binocular control, as each eye adjusts its position to the other:

> An important implication of this conclusion is that the traditional description of the human binocular system in which the two lines of sight adhere to a tight, rigid trigonometric, angular arrangement in relation to the fixated stimulus is untrue. This description is frequently depicted in undergraduate text books, and it may be time to revise it. The two eyes are coordinated such that each eye fixates within a degree of proximity to the other in order to allow fusion to occur. Thus, the oculomotor control system subserves a visual system that is efficient in constructing a clear and unified perceptual representation from retinal inputs that can differ to a substantial degree. Arguably, this may be the most important implication to emerge from our review. (p. 759)

Kulkarni, Chandy, and Babu (2001) studied human fetuses, post-mortem from stillborn, to find a very high muscle spindle (sensory receptors) content in the suboccipital muscle triangle, compared to other muscles, and encouraged further investigation of these small muscles acting as sensors in the craniovertebral joints. Kulkarni, et al. indicated the importance of the cervical muscles for postural and eye movement control, and the authors found evidence that suboccipital muscles move according to length changes, instead of muscle contractions. Kulkarni, et al. described:

> The convergence of proprioceptive afferents from these [neck] muscles with vestibular and ocular inputs at various levels of neuroaxis is well recognized. The complex integrative mechanisms involved in head-eye coordination probably demands complex proprioceptive inputs from the neck muscles which probably is the reason for their high spindle content (p. 358)…sub-occipital muscles studied here, are very small (mean weight 0.2-0.5 gm, in human foetuses [*sic*], and seem incapable of bringing about any significant head rotation. Moreover, they are inserted very close to the craniovertebral joints and are at obvious mechanical disadvantage, as compared to the large powerful rotators of the head, like trapezius and splenius muscles, which are multisegmental and inserted laterally. Thus, the role of these muscles as the rotators or extensors of the head seems doubtful. Their closeness and diagonal arrangement around the joints…and their very high proprioceptive content make them ideal candidates as sensors of joint position and movements of craniovertebral joints (pp. 358 - 359)…the presence of such a high spindle content but paucity of tendon organs in these muscles, suggests that these muscles are functionally incapable of sensing contractile tensions but sense length

> changes and thus the movement…kinesthetic information from the suboccipital muscles may be handled in more complex ways, as evidenced by convergence of vestibular, oculomotor, visual and neck proprioceptive inputs at various levels of neuroaxis. (p. 359)

Edwards, et al. (2007) stated that increased blood flow would influence the cervico-sympathetic reflex for suboccipital muscles. Additional blood flow "would result in altering the length of fibers in the suboccipital muscle group" (Edwards, et al., p. 8331).

Bringing together the senses, internal and external neurological feedback shapes an individual's motor planning while motor skills are learned through repetition, via hypo- and hyper-sensory input responses, as they avoid and seek stimuli toward a balanced homeostasis (Cheatum & Hammond, 2000; Horvat, et al., 2011; M. Karwas, personal communication, 2006, 2007; Seaman, et al., 2007) (Figure 2).

"An unknown amount of sensory input, unique to each individual, is necessary for adequate functioning" (Seaman, et al., 2007, p. 59). "A process disorder of responsivity may manifest itself in one of three ways: hyperresonsivity, hyporesponsivity, or vacillating responsivity" (Seaman, et al., p. 74). Integrating the concepts of the developmental pyramid with those of the responsivity continuum result in combinations of sensory responses (e.g., hypo/hyper vestibular, hypo/hyper tactile, hypo/hyper proprioceptive, hypo/hyper auditory, and hypo/hyper visual) (Cheatum & Hammond, 2000; Karwas, 2006, 2007). Seaman, et al. described compensating behaviors according to sensory system responses for the vestibular, tactile, proprioceptive, auditory, visual, including integrating lateral sides of the body (Appendix A). Horvat, et al. (2011) stated the importance of addressing individualized movement development:

> programming for special needs must be implemented at the appropriate functioning level, with age providing a general guideline of expected skill development. If children can overcome or compensate for deficiencies, they will attain similar levels of functional ability. For children with movement disorders, the more completely we understand the stages of development and underlying mechanisms of disease or injury, the more likely we can develop an instructional program based on individual needs. (p. 69)

Figure 2 *The Responsivity Continuum*

Hypo(--**X**--)Hyper

gets little/seeks stimulation **HOMEOSTASIS** gets too much/stays away

Note: Adapted from Seaman, et al. (2007, p. 74) by Karwas (2006, 2007), used with permission (M. Karwas, personal communication, August 14, 2012).

Visual Deficits and Reading

As early as 1896, visual deficits were examined for individuals learning to read; comparing the recognition of whole words and smaller components of letters comprising words (Hinshelwood, 1896). "Inappropriate use of vision only adds to the child's literacy problems; he is likely to keep losing his place and to scan poorly" (Baker, 1981, p. 360). Children with reading disability have performed significantly worse than children without disabilities on several eye-movement and visual tasks, in addition to testing poorly with verbal indicators (Eden, 1995, p. 272). Investigators studying dyslexia have suggested the presence of a serious spatial orientation problem or a visual-spatial deficit resulting in taking longer to read than normal readers, by using additional longer fixations, poor saccadic control due to shorter or increased saccades (Prado, DuBois, & Valdols, 2007), and more regressions (Biscaldi, et al., 1998; Miles & Segel, 1929; Rayner, 1998). A reduction in saccadic eye movement frequency relates to gaining better control over fixation and tracking (Ayres, 2005; Cheatum & Hammond, 2000; McPhillips, Hepper, & Mulhern, 2000). Scores have been significantly lower on tracking, binocular depth perception, and focusing difficulty for students who were academically and behaviorally at-risk (Johnson, Nottingham, Stratton, & Zaba, 1996). Pavlidis (1981) documented an ocular motor disability for individuals with Developmental Dyslexia regarding inability to follow a sequentially illuminated light, and proposed using the light as a pre-reading diagnostic tool.

Facoetti, et al. (2000) investigated abilities for focusing and orienting visual attention using a simple detection task, and found a visuospacial automatic attention deficit while orienting the peripheral vision, with slower eye movement planning for children with Developmental Dyslexia. Facoetti, et al. suggested that dyslexia might be an ocular fixation disorder, where laterally-distracting information is not ignored, so is distracting to the reading process.

Lateral visual disparities have been evident for Developmental Dyslexia. "Without visual information, human subjects are not able to maintain displacement in a straight line" (Boyadjian, Marin, & Danion, 1999, p. 21). The results from Boyadjian, et al. suggested that "veering was the result of a peripheral mechanism linked to an imbalance between the two sides of the body" (p. 23). For Developmental Dyslexia, Facoetti, Turatto, Lorusso, and Mascetti (2001) found "significantly slower reaction times in the left visual field than in the right visual field…[possibly] due to an asymmetric control of visual spatial attention" (p. 46).

It is critical to better understand interrelated neurological processes necessary for following the physical reading process. Brenner and Gillman (1966) stated, of the children surveyed, that visuomotor and visuospatial deficiency is associated with behavior disorders, and “clumsiness either in gait or movement, or in fine motor control, or both” (p. 700). Dare and Gordon (1970) emphasized, “children with visuo-motor disabilities are often in need of special help…and are often classified as having minimal cerebral dysfunction, minimal brain damage” (p. 178).

Posture, Ocular Motor Control, and Balance

The majority of sensory integration takes place in the brain stem where primitive postural reflexes change the effects of muscle tone in the entire body (Fiorentino, 1981). Horvat, et al. (2011) stated that the righting reflexes emerge from the brain stem, through the input of sensory information into the vestibular apparatus, for posture and vision. “Tilting (equilibrium) reactions…righting reactions and primitive reflexes are considered evoked responses” (Stuberg, Dehne, Miedaner, & Romero, 2010, p. 2). “Sensory information is…sent to the brain stem, which controls contraction of the appropriate postural muscles necessary to obtain upright posture. The brain stem also controls the visual muscles that fixate eyes while the head is moving” (Horvat, et al., 2011, p. 70). Horizontal eye movements are controlled by nerves in the brain stem (Martin, 1996). Results from Karnath, Reich, Rorden, Fetter, and Driver (2002) showed that when determining the “subjective straight ahead” some visual memory integrates with proprioceptive inputs, “and that this integration is sensitive to the delay over which the visual memory must be held” (p. 357). Stoffregen, Bardy, Bonnet, Hove, and Oullier (2007) explained the relationship between posture and the visual, “overall results are not consistent with the view that eye movements and postural control compete for limited central processing resources. The results are consistent with the thesis of a functional integration of postural control with visual performance” (p. 86).

Reflex-based coordination assists infants at first with hand-eye coordination, and then develops later with eye-hand coordination (Seaman, et al., 2007, p. 61), to facilitate reaching toward and ultimately touching an object they can see (Holt, 1991). The asymmetrical tonic neck reflex is closely connected to the early balancing system (Ayres, 2005; Cheatum & Hammond, 2000; McPhillips & Jordan-Black, 2007), with visuomotor responses for close-up vision occurring around the same developmental time. Horvat, et al. (2011) described the asymmetrical tonic neck reflex: “in a supine position [the asymmetrical tonic neck reflex] is elicited by rotation or lateral flexion (tilt) of the head leading to increased extension of the limbs on the chin side with accompanying flexion of limbs on the head side” (p. 73). The asymmetrical tonic neck reflex is typically inhibited, or incorporated into more sophisticated movement patterns by the second half year of life (Peiper, 1963).

In the developmental progression of muscle growth for the proximo-distal manner, or "from the center of the body outward" (Seaman, et al., 2007, p. 55), later-developing "distal muscles are generally used to produce finer gradations of force and are more difficult to control; thus, the use of distal muscle activity to regulate balance may represent a more refined and effective level of motor control" (Williams & Castro, 1997, p. 48). The postural control system for children with normal motor development in Williams and Castro (1997) demonstrated both proximal and distal leg muscle force activated when balance was perturbed, but distal muscles responded with additional force. Furthermore, the effects of vision influenced the order of muscle activation: "when the sensory framework for postural control is modified by removing vision….[then] children with normal motor development continue to maintain a pattern of disto-proximal muscle activation" (Williams & Castro, p. 50).

The erector spinae act to stabilize the trunk against gravity (Floyd & Silver, 1951). Comparing sitting and standing, Clair, Okuma, Misiaszek, and Collins (2009) examined the erector spinae muscles for regulating posture, and found connections between the "ES [erector spinae] muscles of the lower back evoked by the activation of sensory receptors in the lower leg….These reflex pathways between the legs and lower back may play a role in the neural control of posture and balance" (p. 226).

The neck is critical for considering the strength of the postural and balancing systems, including for vision. Haywood and Getchell (2009) described balance as "characterized by refined control of degrees of freedom of movement in the neck" (p. 227). Karnath, et al. (1994) found "strong experimental evidence that neck afferent activity plays an important role in maintenance of posture, in ocular motor control, and in the perception of body orientation in space" (p. 144). Stoffregen, et al. (2000) recognized the effects of posture on vision: "Postural control can be used to improve visual performance" (p. 203).

Blood flow influences posture. In rats and mice, Edwards, et al. (2007) found the first evidence of connecting neural pathways between specific neck muscle neurons associated with regulating blood flow for postural reflexes. "These data provide a novel pathway that may underlie possible reflex changes in autonomic variables after neck muscle spindle afferent activation" (Edwards, et al., 2007, p. 8324). Confirming results from their prior study, Vaitl, Mittelstaedt, and Baisch (1997), Vaitl, Mittelstaedt, Saborowski, Stark, and Baisch (2002) demonstrated that shifts in posture perception, with upward and downward shifts in head tilt, are influenced by shifts in blood volume distribution in the lower body; according to positive and negative blood pressure in the lower body traveling in and out of the thoracic cavity.

Boyd, Blincoe, and Hayner (1965) found evidence for the quadratus lumborum muscle, working in conjunction with the diaphragm, to support the breathing system. "The quadratus exerts a braking action to oppose the normal elastic recoil of the lungs during expiration" (Boyd, et al., 1965, p. 579). Chung, et al. (2004) found evidence that visuospatial performance improved with breathing additional 30% oxygen. The functional quality of the quadratus lumborum, influencing respiration, might also influence eye movement for reading.

Atypical Posture, Eye Coordination, and Movement; Body Asymmetry and Leg Length Inequality

Posture and movement influences have been examined for Developmetnal Dyslexia in relation to control groups. Pozzo, et al. (2006) identified postural and muscle tone impairment, with or without vision, for boys with Developmetnal Dyslexia. Balance deficits for children with Developmetnal Dyslexia (Moe-Nilssen, Helbostad, Talcott, & Toennessen, 2003) and adults with DD (Brookes, Tinkler, Nicolson, & Fawcett, 2010), including deficits in gait (Moe-Nilssen, et al., 2003), have been evident. Wolff (1990) found bimanual timing deficits for adolescents and young adults with Developmetnal Dyslexia, and Geuze and Kalverboer (1994) for children with Developmetnal Dyslexia and Developmental Coordination Disorder.

Interference in the brain stem reaches to structural deficiencies. "Without an appropriate balance or postural framework, any number of action patterns could be expected to deteriorate" (Williams & Woollacott, 1997, p. 9). Seaman, et al. (2007) described the "structural interdependence" of the brain stem in relation to motor performance:

> When the brain stem—the master control area for muscular activity—is performing its function adequately, performing on tasks such as moving through an obstacle course is controlled automatically, and the attention of the cortex can be directed to the planning, processing, and adapting required to complete the obstacle course successfully. If the brain stem is not doing its job, then the cortex or the conscious attention must be focused on the muscular activity rather than on planning how to get through the obstacle course, thus deterring or interfering with motor performance. (p. 155)

Integrating the function of the vestibular, tactile, proprioceptive, and visual sensory systems results in "praxis…the ability to plan and execute purposeful movement…for the necessary input and appropriate motor output" (Seaman, et al., 2007, p. 83). Seaman, et al. (2007) described that "disorders in interpretation, assimilation, organization, and transmission of sensorimotor information" can be demonstrated in some of the following characteristics of disordered praxis:

> 1) Clumsiness; 2) Messy handwriting; 3) Difficulty imitating movements; 4) Lack of body awareness; 5) Observable slow, deliberately sequenced (calculated) movements; 6) Poor fine motor coordination; 7) Poor gross motor coordination; 8) Poor eye-hand or eye-foot coordination; 9) Uneven or hesitant gait (p. 83)

Gubbay (1985) defined "clumsiness" as referring to "a child whose ability to perform skilled, purposeful movement is impaired, yet whose motor coordination is virtually normal by the standards of routine, conventional neurological assessment, and who also has normal bodily habitus, intellect, physical strength and sensory function" (p. 159). Authors have compared children with "clumsiness" to similar characteristics of Developmental Coordination Disorder (Dare & Gordon, 1970; Geuze, 2005; Gubbay, 1975; Huh, Williams, & Burke, 1998; Johnston, Burns, Brauer, & Richardson, 2002; Williams & Woollacott, 1988). Williams, Fischer, and Tritschler (1983) stated that muscular control did not show "a clearcut pattern of age-related development" for slowly developing children (p. 25). Delayed muscle timing responses for DCD have been evident (Williams & Castro, 1997; Williams, Woollacott, & Ivry, 1992). A distinguishing factor for the "clumsy child" is poor cocontraction for muscles, or "the inability to contract antagonistic muscle groups simultaneously" (Seaman, et al., 2007, p. 79). Geuze (2005) identified the most significant characteristics of poor control for Developmental Coordination Disorder as "an inconsistent timing of muscle activation sequences, co-contraction, a lack of automatization, and slowness of response" (p. 194). In contrast to children with normal development, muscle activation for children with Developmental Coordination Disorder demonstrated more frequent occurrence of a proximo-distal pattern when testing balance (Williams & Castro, 1997; Williams & Woollacott, 1997), and children with Developmental Coordination Disorder sometimes seemed "to need visual information and were unable to shift control from vision to other sources of sensory information when needed. This often resulted in postural responses that were either developmentally inappropriate or characteristics of central nervous dysfunction, or both" (Williams & Castro, 1997, p. 51).

Shoulder girdle, pelvic girdle, and trunk instabilities have been observed in "clumsy children" (Baker, 1981, p. 357). Johnston, et al. (2002) observed some conditions for muscle activation in Developmental Coordination Disorder:

> Poor upper-limb coordination is a common difficulty…One hypothesis is that deviant muscle timing in proximal muscle groups results in poor postural and movement control…significantly [taking] longer to respond to visual signals and longer to complete the goal-directed movement…shoulder muscles, except for serratus anterior, and posterior trunk muscles demonstrated early activation. Further, anterior trunk

> muscles demonstrated delayed activation…anticipatory function was not present in three of the four anterior trunk muscles. These differences support the hypothesis that in children with Developmental Coordination Disorder, altered postural muscle activity may contribute to poor proximal stability and consequently poor arm movement control when performing goal directed movement. These results have educational and functional implications for children at school and during activities of daily living and leisure activities and for clinicians assessing and treating children with Developmental Coordination Disorder. (p. 583)

The oldest evolutionary animal reflex behaviors, usually present and necessary shortly after birth, do not always integrate into motor development to allow the emergence of volitional movement against gravity (Ayres, 2005; Horvat, et al., 2011; Milani-Comparetti & Gidoni, 1967; Seaman, et al., 2007; Silver, 1952; Stuberg, et al., 2010). Seaman, et al. (2007) indicated, "reflex inhibition, not disappearance, is accomplished in stages: not discretely designated, but individually, developmentally sequenced" (p. 55). The primal brain stem reflexes that are most-likely to interfere with developmental motor learning, but if not inhibited, include: the tonic labyrinthine; asymmetrical tonic neck reflex (ATNR); and symmetric tonic neck (Cheatum & Hammond, 2000; Horvat et al., 2011; Levine & Kliebhan, 1981). Horvat, et al. (2011) described conditions for persistent righting reflexes:

> unable to run, change directions, and maintain body alignment in movement requiring proper head control. Without the persistence of these reflexes or any maturational delays, the reflex movements are replaced by equilibrium reactions. Reactions are automatic responses that proceed from reflexes as the individual's central nervous system matures. These reactions allow individuals to maintain body support and to develop posture and balance control. Problems encountered in this stage of development include the inability to establish basic stability, body positioning, and muscle tone necessary for movement. (p. 72)

Additionally, the protective extension reflex might be lacking. Lacking of the protective extension would interfere with the appropriate amount of movement development, by *avoiding* movement to be "safe," due to a child's propensity for getting hurt (Seaman, et al., 2007, p. 78).

The ATNR can persist for older children causing motor development confusion (Cheatum & Hammond, 2000; Horvat, et al., 2007; Levine & Kliebhan, 1981; Milani-Comparetti & Gidoni, 1967; Morrison, 1985; Parmenter, 1983; Seaman, et al., 2007). Poor eye movement control is associated with primary reflex persistence (Ayres, 2005; Cheatum & Hammond, 2000; Horvat, et al., 2011; McPhillips & Jordan-Black, 2007; Seaman, et al., 2007). Pyfer (1983) described effects of balancing and eye movement coordination, “inadequate or inappropriate vestibular signals could delay development of muscular control of the eyes” (p. 159). In addition, Horvat, et al. (2011) explained some of the influences of a persistent ATNR on posture and eye movement:

> Persistence of the reflex will cause difficulty in rolling, because the extended arm impedes rolling...the ATNR interferes with holding the head in the midline, resulting in visual perceptual problems commonly associated with tracking or fixating on objects. (p. 73)

Silver (1952) documented developmental postural and neck righting responses, connected to the occipital-sided arm extremity activated by left and right head rotation for children with organic brain disturbances and maturational lags. Rider (1972) studied early motor development and found a correlation between children with early primitive reflex integration deficits and poor academic achievement. Morrison (1985) observed the “extension of arm and leg on face side…and flexion of limbs on the occiput-side” (p. 49) when assessing for ATNR presence in children with Learning Disability. Overactive reflexes can interfere with refined movement needs such as reading and writing (Ayres, 2005; Cheatum & Hammond, 2000).

McPhillips and Jordan-Black (2007) compared core literacy skills in dyslexic and non-dyslexic poor readers with ATNR persistence in the general education setting from thirteen primary schools. ATNR persistence was also compared among groups of males and females, and in groups with social advantages compared to the socially disadvantaged. Results indicated that ATNR persistence was a strong predictor of reading, spelling, non-word reading, and of verbal IQ attainments, with 62% of the students showing high levels of reflex persistence in the bottom 10% of reading level. No differences were determined between students with dyslexia and poor readers. In addition, results revealed males with higher levels of persistent ATNR than females, and socially disadvantaged children exhibited higher levels of persistent ATNR than without social disadvantages.

McPhillips and Jordan-Black (2007) proposed that many students in general education settings might be influenced by a "brainstem mediated reflex system that should have been inhibited in the first year after birth" (p. 748). McPhillips and Jordan-Black suggested that the term *dyslexia* is not a specific category of poor readers based on IQ scores, but perhaps it is best to use the term *dyslexia* to describe poor readers.

Shaheen (2010) stated that persistent ATNR and apraxia tests were predictors of dyslexia. Teitelbaum, et al. (2004) found evidence to suggest that persistent ATNR evaluation can be used as an early pre-language indicator for autism.

Typically, in the ATNR response for children with cerebral palsy the arm *and leg* contract on the opposite side of the direction the head is turned (Goddard, 2002; Haywood & Getchell, 2009; Hoskins & Squires, 1973). "Some ['clumsy children'] demonstrate patterns of movement or balance responses suggestive of a minimal cerebral palsy" (Baker, 1981, p. 357). Dare and Gordon (1970) stated that the study of "'clumsy' children with visuo-motor disabilities confirms that…some may show evidence of minimal cerebral palsy, while others may present a specific disability, apparently affecting only the acquisition of skilled movement" (p. 181). Gubbay (1985) recognized mild symptoms of cerebral palsy that might influence learning:

> Although anoxic birth injury has been implicated as the fundamental aetiology in most patients with cerebral palsy, there must be many which are due alternatively to cerebral maldevelopment. Very mild degrees of cerebral palsy without overt evidence of the hallmarks of weakness, spasticity and involuntary movements may result in ungainly motor activity possible partly due to impairment of perceptual abilities. Paradoxically, the child with no conventional neurological signs of cerebral palsy may manifest defects of motor functioning of greater personal impact than cerebral palsy and which interfere more profoundly with function of learning and performance. (pp. 162 - 163)

Some researchers have concluded that balance deficiencies for "clumsy children are more related to dysfunction of the motor control system than to a delay in the development of the system" (Williams & Woollacott, 1997, p. 20). Bilateral motor coordination seemed to be evident for children with and without DCD around the age of six, although only children with DCD demonstrated balance control problems showing significant inefficiency in organizing bilateral muscular activation responses, temporal inconsistencies, and use of "different motor-control strategies" than normal children (Huh, Williams, & Burke, 1998, p. 483). Williams and Woollacott (1997) found that only *selected* deficits of neuromuscular postural responses for "clumsy children" were evident when studying leg muscle responses (p. 21). So, the authors stated that they could *not* conclude that "the motor control deficits of these children lie solely within the postural control system…[but, perhaps] could be related to a more general problem of timing of all movement sequences" (Williams & Woollacott, p. 21). Larger amounts of muscular activity for leg and trunk muscles have been evident for children with DCD attempting to hold a quiet stance, than controls (Williams, et al, 1983). In Williams (1999), as cited in Cermak & Larkin (2002), control children activated postural control in the order of: ankle, upper leg, trunk, and neck;

whereas children with DCD activated postural control in the order of: upper leg muscles, ankle muscles, trunk and neck (pp. 132 - 133).

Bove, Diverio, Pozzo, and Schieppati (2001) found that "Neck muscle vibration disrupts steering of locomotion" when human neck muscle vibration was used to examine the influences of atypical neck proprioceptive input for the organization and execution of gait (p. 581). Muscle length of erector spinae, and leg length has been investigated for analyzing and comparing gait in children to quantify physical handicap (Butler, et al., 1984). In contrast to children without DCD, children with DCD displayed varied erector spinae muscle timing when responding to visual prompts for postural muscles (Johnston, et al., 2002). There has been a comparison between leg length inequality and the endurance of the erector spinae and the quadratus lumborum (Knutson, 2005).

Head tilt, shoulder and hip imbalances, and leg length disparities have been investigated for muscle strength discrepancies (Kendall, Kendall-McCreary, Provance, Rodgers, & Romani 2005), and according to Lasko and Aufsesser (n.d.) (as cited in Horvat, Block, & Kelly, 2007), for postural instability. Horvat, et al. (2011), defined the skeletal system's influence:

> musculoskeletal limitations can lead to problems in postural control. Any limitation in strength or joint range of motion in the upper or lower extremities and trunk can have a negative impact on postural control…impairments in cognition—such as attention, memory, spatial relations, body schema, and praxis—are challenges that also can compromise postural functioning. (p. 79)

The dysfunction of leg length equality might be strongly connected to structural and postural impairment for individuals with Learning Disability. Boyadjian, Marin, and Danion (1999) studied the properties of correcting body orientation, and found, "systematic deviations occurring in two-limb displacements originate from a peripheral mechanism (slight different properties of the right and left limbs) rather than a central mechanism (systematic bias in the perceived body trajectory)" (p. 21). "The spine, pelvis, and lower extremities are all involved in the compensation of limb-length asymmetry. The symptoms associated with limb-length discrepancies are often due to the mechanisms involved in trying to equilibrate functionally the asymmetry" (Kaufman, Miller, & Sutherland, 1996, p. 149). When participants were walking blindfolded, Lund (1930) observed a correlation between the structural and functional strength of a shorter or longer leg, and the tendency to veer in the opposite direction as the shorter leg. Kaufman, et al. (1996) found a connection with leg length inequality and gait: "as the limb-length inequality increased, the degree of gait asymmetry also increased" (p. 146).

Anatomical leg length inequalities in have been addressed by orthopedic surgeons for many years (Carpenter & Kirk, 1952), and differences between anatomical and functional leg length disparities have been examined (Eichler, 1977; Gurney, 2002; McCaw & Bates, 1991; Reid & Smith, 1984). Eichler (1977) defined "Functional length" as "Leg shortening or lengthening caused by joint contractures or by axial malalignment" (p. 30). Injury or compromise to central nervous system pathways can result, as muscles on one side of the body tighten, creating leg length disparity (Bakris, et al., 2007; Knutson, 2001; Rochester, 2009); referred to as a functional, opposed to anatomical, leg length inequality (Eriksen, 2004; Thomas, 1991).

Methods for assessing leg length inequality have been investigated (McCaw & Bates, 1991; Sabharwal & Kumar, 2008). Measuring pelvic crest height alignment has been implemented for establishing leg length discrepancy (Petrone, et al., 2003), with heel comparison (Gregory, 1979). Lateral pelvic imbalances have been evident for school children to distinguish asymmetries in leg length inequality (Klein & Buckley, 1968; Pearson, 1951). "Femur head lowness, commonly termed 'leg shortness'…[was] visualized in 80 per cent of rural school children between the ages of 5 and 13" (Pearson, 1951, p. 166). According to Lasko and Aufsesser (n.d.) (as cited in Horvat, et al., 2007; P. Aufsesser, personal communication, October 4, 2010; M. Horvat, personal communication, September 28, 2010), the San Diego State University Adapted Physical Education Posture Evaluation checks a short leg according to the evenness of popliteal creases [in the back of knees] (Horvat, et al., 2007, p. 145). In Fong, Mak, Swartz, Walsh, and Delgado-Escueta (2003), brain imaging was used for differentiating body asymmetry, and found that evaluating popliteal crease levels for shorter or longer legs to be useful for examining possible origins of seizures. Reinhart, et al. (2006) examined leg length, and atypical gait patterns in children with autism:

> Spatiotemporal gait data for children with autism were compatible with findings from patients with cerebellar ataxia: specifically, greater difficulty walking along a straight line, and the coexistence of variable stride length and duration. Children with autism were also less coordinated and rated as more variable and inconsistent (i.e. reduced smoothness) relative to the comparison group. Postural abnormalities in the head and trunk suggest additional involvement of the fronto-striatal basal ganglia region. Abnormal gait features are stable across key developmental periods and are, therefore, promising for use in clinical screening for autism. (p. 819)

Esposito, Venuti, Maestro, and Muratori (2009) detected lower levels of symmetry for infants with Autism Spectrum Disorder lying in a supine position, and suggested that lower levels of symmetry might be used to define subgroups of Autism Spectrum Disorder in the early months of life. de Quirós (1976) described the usefulness for connecting symptoms for infants related to atypical vestibular function, with Learning Disability later in life:

> equal or different arm abduction, homo- or heterolateral raising of arms or legs, sternocleimastoid contraction, tonus modification, trunk position, need for visual support…can provide extremely valuable medical data. This information is particularly helpful in the diagnosis of some learning disorders, especially those in vestibular disabled children. (p. 44)

Upper Cervical; Correction

Upper cervical research has been connected to brainstem responses. Positive effects from chiropractic care for individuals with dyslexia, speech disorder, and Learning Disabilities, correcting vertebral subluxation, have suggested cognitive functioning improvement (Lerner & Lerner, 2009; Pauli, 2007).

Since the 1940s, investigators have used physics and mathematical measurements in increments of degrees to examine the upper cervical placement of the atlas bone, or 1st cervical vertebra (Eriksen, 2004). The atlas encircles the spinal cord under the medulla, the lowest part of the brain stem (Martin, 1996). The atlas, in its central position, relative to the gravitational vertical, orients the central axis, balance and weight of the skull, including the spine, shoulders, and pelvis below. The atlas relies on soft tissue for support, so it can be displaced or subluxated from its central position, as the head tilts and the brain stem becomes compressed (Bakris, et al., 2007). "Persistent tilt of the head is abnormal at any age" (Rabe, 1969, p. 70). The visceral sense is located in the brain stem for regulating blood flow (Ayres, 2005; Edwards, et al., 2007; Knutson, 2001). Martin (1996) described that "occlusion of the vertebral artery can produce discrete set of limb and sensory motor signs" (p. 401). According to Kendall, et al. (2005), "Pelvic rotation or lateral tilt will change the relationship of the pelvis to the extremities enough to make a considerable difference in measurement" (p. 438).

There are some that support the fact that contracted reflex muscles occurring on one side of the body for an atlas displacement are associated with a rotated or torqued atlas activating the ATNR (Knutson, 1997; Knutson & Owens, 2005); influencing differences in lateral awareness and reduced blood flow. Bakris, et al. (2007) stated, "Anatomical abnormalities of the cervical spine at the level of the atlas vertebra are associated with relative ischaemia of the brainstem circulation and increased blood pressure. Manual correction of this malalignment has been associated with reduced arterial pressure" (p. 1). Presently, there has been investigation showing good interexaminer reliability in discriminating leg length inequality for upper cervical structural instability (Woodfield, et. al, 2011; C. Woodfield, personal communications, October 15, October 16, November 5, November 19, November 25, November 29, 2009, January 16, October 25, November 25, and December 20, 2010).

Bakris, et al. (2007) proposed that correcting misalignment of the atlas, reduces and maintains lower blood pressure, increases blood flow, and lengthens a functional short leg; by assessing alignment of the pelvic iliac crests with a heel position comparison for leg length disparity (Gregory, 1979). Bakris, et al. examined 50 patients (26 drug naïve, and 24 with washed out systems) who were: a) between 21 and 75 years; b) positive for a preliminary screening of atlas misalignment (with comprehensive X-ray analysis determining head tilt [based on three dimensional physics and mathematical calculations relative to the center axis of the skull]) and a supine contracted leg length check (comparing heel positions when patients turned their heads to the far right and left); and c) documented with a history of Stage 1 hypertension.

The participants were manually adjusted for a difference in both a rotational and lateral central atlas positioning on a low adjusting table. For 8 weeks, patients showed the atlas holding position, and a reduction in blood pressure with no detrimental effects. The conclusion indicated that the restoration of an atlas misalignment related to substantial and ongoing reductions of blood pressure; similar to using a two-drug combination therapy (Bakris, et al., 2007).

The atlas, in its central position, relative to the gravitational vertical, typically orients the central axis, balance and weight of the skull, including the spine, shoulders, and pelvis below. McKnight and DeBoer (1988) found evidence for blood pressure changes, and Scott, Kaufman, and Dengal (2007) for blood flow, with chiropractic manipulations of the atlas. Knutson (2001) studied the effect of a vectored atlas correction affecting an abrupt drop in blood pressure, perhaps due to a cervico-sympathetic reflex stimulation, relaxing muscle tone, and the releasing of pressor reflex effects. Ahmetoğlu, et al. (2003) investigated the effects of an antihypertensive drug for extraocular muscles in patients with hypertension. "These findings suggest that blood flow in the extraocular vessels decreased due to increased peripheral resistance in hypertensive patients" (Ahmetoğlu, et al., 2003, p. 182). Relieving hypertension might coordinate peripheral vision for extraocular muscles.

Relaxing lateral muscles typically result in lengthening the shorter leg of a leg length inequality. Aligning the skeletal system might have beneficial effects by reducing brainstem compression for improved sensory organization, and increasing blood flow for strengthening the vulnerability of postural and eye movement systems for reading.

Conclusion

The U.S. civil rights history in the past fifty years was influential for upholding important basic human rights for individuals with disabilities, with the idea of addressing special needs by formulating special education law (Friend & Bursuck, 2002). The medical and educational fields were initially consulted in the beginning efforts to identify Learning Disability, and even though the medical field identified children with Learning Disability as having minimal neurological dysfunction or Minimal Brain Dysfunction, special education law was formulated according to the recommendations by educators to base identification of individuals with Learning Disability on functional educational diagnostic information, as a heterogeneous group, and without considerations regarding neurological conditions (Haring & Bateman, 1969). Visser (2003) stated, "In later years, the terminology used to describe these children changed from MBD [Minimal Brain Dysfunction] into 'Deficits in Attention, Motor Control and Perception' " (p. 486), attributable to brain dysfunction involving an "automatization deficit" (p. 489).

There has been long-standing multidisciplinary investigation outlining neurological symptoms for individuals with Learning Disability or reading difficulties (Brodney & Kehoe, 2006; Decker, 2008; de Quirós, 1976; Habib, 2000; Johnson, et al. 1996; Kephart, 1964; MBD Compendium, 1974; Menghini, et al. 2010; Miles & Segel, 1929; Morrison, 1985; Nicholson & Fawcett, 2009; Orbrzut et al., 1983; Punt, et al., 2010; Rider, 1972; Silver, 1952; Strauss, 1943). Motor coordination deficits are sometimes misinterpreted to mean that a child is not trying hard enough. "Often parents think their child is being naughty or lazy, and this increases the pressures he is already under" (Baker, 1981, p. 356).

To compound the confusion for Learning Disability, it has been demonstrated so far that there are not sufficiently reliable academic assessments to determine identification for *individuals* with Learning Disability (Reynolds & Shaywitz, 2009; Stuebing, et al., 2009). Current Learning Disability identification does not reflect the developmental continuum. By now the perspective of the medical community has been reflected into the fields of physical education and adapted physical education (Horvat, et al., 2011; Kovar, et al., 2007; Winnick, 2005). Evidence shows common physical symptoms for children with Learning Disability and Developmental Coordination Disorder according to insufficiencies occurring during atypical neurological motor development; persistent primitive reflexes and hypo- or hyper-sensory responsivity affecting balance, postural instability, and poor muscle tone (Cheatum & Hammond, 2000; Horvat, et al., 2011; Rabe, 1969; Seaman, et al., 2007).

Horvat, et al. (2011) described the importance of addressing "soft neurological signs" for children in a timely manner, so that neuroplasticity can be utilized for learning:

> The most important thing to remember about neurological dysfunction, or soft neurological signs, is that some damage has occurred to the brain. If teachers can address the specific problem area early in the child's development, other areas of the brain may take over impaired functions before the process of mylinization takes place. (p. 138)

Pearson (1951) recognized the importance of early intervention: "Problems of structural [postural] nature, serious but not producing symptoms…suggest the need for routine structural examination…during the preschool years or during the first year of school" (p. 166). Cherng (2007) emphasized that poor balance control for children with Developmental Coordination Disorder is "more likely due to a deficit in sensory organization than compromised effectiveness in individual sensory systems. It is important that such deficits be identified at an early stage in a child's development" (p. 925). Levine and Kliebhan (1981) described, "The posture and movement problems of children with neuromotor handicaps affect their social, perceptual, cognitive, verbal, linguistic, and emotional development" (p. 209).

Understanding the physiology of movement plays an important role for the outcomes of appropriate educational planning (Levine & Kliebhan, 1981). Any therapeutic program to improve balance control should implement a multisensory approach with repeated opportunities for the child to incorporate and refine vestibular and proprioceptive information (Williams & Castro, 1997). Extensive, regular, and systematic opportunities of carefully designed therapeutic activities to strengthen distal muscle control should be given to children with Developmental Coordination Disorder (Williams & Castro, 1997, p. 52; M. Karwas, personal communication, September 15, 2011), including varying "levels of force production (e.g., minimal, mild, moderate, maximal)" (Williams & Castro, 1997, p. 52). Levine and Kliebhan (1981) formulated a prescription to be used to identify developmental motor disparities, including assessing for: 1) postural tone; 2) movement patterns; and 3) primitive, postural, and abnormal qualities for reflexes and reactions (pp. 209 - 210). Levine and Kliebhan (1981) addressed the significance of recognizing persistent reflexes: "when accompanied by increases in tone and seen in an exaggerated, obligatory form… [they] are again useful for diagnosis" (p. 210).

The importance of motor function deficits are now recognized as "pervasive across diagnoses, thus, a cardinal feature of ASD [Autism Spectrum Disorder]" (Fournier, Haas, Naik, Lodha, & Cauraugh, 2010, p. 1227), being relevant for psychologists diagnosing autism (Dowd, Rinehart, & McGinley, 2010), and with the strong need for interventions

(Bhat, Landa, & Galloway, 2011). Reed (2007) suggested the importance of early detection of persistent primary reflexes for Autism Spectrum Conditions:

> If persistent Primary Reflexes [including ATNR] that predict the possible development of ASC [Autism Spectrum Conditions]-related behaviors, and ASC itself, could be inhibited by approaches that are known to help with the removal of Persistent Primary Reflexes, this might allow the development of a preventative intervention for some aspects of ASC that could be taken long before the typical point of diagnosis of ASC. That is, the potential precursors of ASC problems may be remediated long before they impede typical development. (p. 22)

It is important to acknowledge the integral learning processes of reading *with* writing (Cecil, 2003). Assessment for developmental dysgraphia has been investigated (Gubbay, 1995). Impairment to a child's fine motor control would be influenced by balance disorders and delays in gross motor development (Baker, 1981; Johnson & Williams, 1988). Baker (1981) indicated that children with gross motor disparities might have difficulty copying postures that might translate to "higher perceptual processes of space and form relationships," including poor ability for copying letters (p. 360). Cermak and Larkin (2002) recognized muscle tone and weak pencil grip for problems with handwriting for children with DCD, "despite meeting early intervention goals in foundation motor skills, most children with DCD encounter serious problems with writing" (p. 257). Johnson and Williams (1988) explained that hand use might be distracted by postural responses:

> A child with inadequate postural control may…have difficulty producing the additional muscular activity needed to maintain a stable sitting posture and also use the hands to perform a task skillfully. For such children, sitting unsupported may require conscious attention or even use of the hands to maintain balance. Thus, minimal energy may be available for controlled activity of the distal musculature. (p. 25)

Lee, Yoo, and Lee (2010) studied treatment to improve the ATNR influence on muscle weakness in dominant-hand grip strength. When evaluating head tilt detected for infants, Ocklenburg, et al. (2010) showed that "increased visual control of the hand during early childhood seems to modulate handedness" (p.447).

Much emphasis in the academic field has to do with awareness of the quality of articulating sound for the beginning reader (Shaywitz, et al., 2007). Dyslexia has been explored according to brainstem responses affecting central auditory function (Banai, et al., 2009; Banai, Nicol, Zecker, & Kraus, 2005; Billiet & Bellis, 2011). It is possible that "these findings are among the first to establish a direct relationship between subcortical sensory function and a specific cognitive skill (reading)…this cortical-subcortical link could contribute to the phonological processing deficits experienced by poor readers" (Banai, et al., 2009, p. 2699). Roth, Muchnik, Shabtai, Hildesheimer, and Henkin (2012) found first evidence of atypical auditory brainstem responses "already apparent in young children with suspected ASD [Autism Spectrum Disorder] and language delay" (p. 23). Relieving brainstem compression would be important to investigate for delayed speech-motor articulation; possibly connected to poor muscle tone.

Eye movement disparities have been the focus of research for dyslexia (Biscaldi, 1998; DeLuca, et al., 2002; Facoetti, et al., 2000; Facoetti, et al. 2001), and for autism regarding deficiencies in "broadening the spread of visual attention" (Mann & Walker, 2003). Vogel (1995) presented a review of theory, testing, therapy for eye saccades by evaluating eye-tracking for reading disabilities and academic success, with suggestions for successful eye muscle strengthening techniques. Brodney and Kehoe (2006) investigated assessing eye movement vulnerabilities with dyslexia, and showed significant potential for elementary school teachers "to identify children at-risk for related vision problems" (p. 13).

Physical fitness has been linked to the prefrontal and parietal cortices brain regions for inhibitory functioning and spatial selection (Colcombe, et al., 2004). Motor development and cognitive development have been correlated with activation of the prefrontal cortex and the cerebellum (Diamond, 2000). Some studies have investigated the possible relationship of physical exercise on cognitive thinking, but positive results have varied (Hill, et al., 2010; Hillman, et al., 2008; Reynolds & Nicolson, 2007; Tomporowski, et al., 2008; Zagrodnik & Horvat, 2009). Exercise treatments have shown gains for phonology, speech/language fluency, working memory, motor skill, and "highly significant reduction in the incidence of symptoms of inattention" related to DD (Reynolds & Nicholson, 2007, p. 78). Students with Attention-Deficit Hyperactivity Disorder and autism have seen significantly improved focusing ability by implementing movement and other intense sensory experiences (Sousa, 2006).

There have been critics regarding sensory integration through motor movement techniques for individuals with Learning Disability (Hoehn & Baumeister, 1994). Doubt exists regarding some study assessments that might be comparing items that are unrelated. "A plausible explanation for researchers' failure to detect the effects of exercise on children's intelligence is that IQ tests provide only global measures of functioning, which may not be sensitive enough to detect subtle changes in specific aspects of cognitive functioning brought about by exercise training" (Tomporowski, et al., 2008, p. 117). Additionally, there are cross-disciplinary factors for understanding cognition. "Comprehensive theories have yet to be formulated that address numerous contextual and psycho-social factors that may moderate or mediate the relation between exercise and children's cognitive function." (Tomporowski, et al., 2008, p. 126).

Zagrodnik and Horvat (2009) stated that there is a lack of research investigating exercise and cognition for students with developmental disabilities, perhaps due to the lack of control for exercise frequency, type, intensity and duration, and pre-determined heart rate level. "Developing studies where the intensity of exercise is known throughout the intervention is critical" (Zagrodnik & Horvat, p. 280). The authors addressed the concern that comorbity among populations of individuals with disabilities are "major roadblocks for the generalizability of the research findings on, not only the impact of exercise on cognition, but any investigation in these populations" (Zagrodnik & Horvat, p. 282). Zagrodnik and Horvat advocated utilizing the influences of nutrition and exercise for understanding the impact of developmental movement on cognition, and the necessity for using double blind studies in the future.

Endurance is a necessary part of learning. Yerkes and Dodson (1908) hypothesized the level of intensity for optimum physical performance as, "a stimulus whose strength is nearer to the threshold than to the point of harmful stimulation…[is] most favorable to the acquisition of a habit" (p. 481). The authors added, "an easily acquired habit…may readily be formed under strong stimulation, whereas a difficult habit may be acquired readily only under relatively weak stimulation" (Yerkes & Dodson, pp. 481 - 482). Zagrodnik and Horvat (2009) explained how learning motor control might be influenced: "Exercise may be too demanding and, therefore, too taxing for the brain to efficiently respond…or the exercise understimulates" (p. 280). It is more important for children to have fun learning to be active for a lifetime, than to risk being discouraged to move because of an emphasis for young individuals to reach high levels of competitive skills (Martens, 1996). Perhaps when children are pushed beyond their maximum threshold for attainment of developmental movement capabilities (or not pushed hard enough), their sense of inadequacy also translates to approaching their academics with learned helplessness. Butkowsky & Willows (1980) defined "learned helplessness" as, "significantly lower initial estimates of success, less persistence, attribution of failures to lack of ability and of successes to factors beyond personal control, and greater decrements in expectancy of success following failure" (p. 408). Becoming aware of physical barriers associated with leg length inequality is critical.

Although there is evidence of pediatric musculoskeletal examination to include leg length inequality (Jandial & Foster, 2007), presently, leg length inequality is not a procedural pediatric assessment (B. Bannon, personal communication, November 7, 2009; Stanford

Pediatrics, Los Gatos, California, personal communication, November, 2009), nor for occupational therapy (T. Ammon, personal communication, October 22, 2009). In physical therapy there is leg length inequality assessment measuring from the umbilicus to the medial malleoli (Kendall, et al., 2005; E. Folkins, personal communication, September 23, 2009; R. Croce, personal communications, October 8 and 12, 2010). Aligning the medial malleoli, as a marker for determining functional leg length inequality, has been investigated for the NUCCA/UCRF [National Upper Cervical Chiropractic Association/Upper Cervical Research Foundation] Supine Leg Check procedure (S.N. MacDonald, personal communications, November 12, 21, & December 21, 2009, January 18, August 8, & October 8, 2010).

There is much evidence to support that a functional leg length inequality is specifically due to an atlas displacement (Bakris, et al, 2007; Eriksen, 2004; Thomas, 1991; Woodfield, et al. 2011) possibly influencing an asymmetrical tonic neck reflex (Knutson, 1997, 2005), with clear evidence showing that brain stem responses are closely linked to eye movements (Kulkarni, et al, 2001), and eye movement strength (Ayres, 2005; Cheatum & Hammond, 2000; Horvat, et al., 2011; Seaman, et al. 2007). Presently, there is evidence that the most influential vestibular sense relies on leg position (Grasso, et al., 2011). "It may well be that somatosensory leg afferents act at the cerebellar level by tuning the neuronal responses to vestibular stimulation" (Grasso, et al., 2011, p. 312). It seems plausible that correcting leg length inequality might improve the most influential vestibular response.

Martin (1996) described investigation regarding the influence of the upper cervical nervous system pathways on the legs, and a possible influence for leg length inequality: "Animal experiments…have shown that propriospinal neurons located in the upper cervical spinal cord can transmit control signals from the medial pathways to more caudal levels… thus, pathways terminating in the cervical cord may also influence trunk and lower limbs muscles" (p. 260). Martin (1996) stated the importance of lessening the obstruction of cerebral blood flow: "occlusion of the vascular supply to the midbrain produces a complex set of neurological deficits that disrupts eye movement control, facial muscle function, and limb movements" (p. 412). Brownlee, Flatt and Miller (2004) found that "Intraocular pressure was significantly reduced, and pulsatile ocular blood flow was significantly increased, following moderately intense exercise" (p. 44). Areas of "brain blood flow abnormalities" (Burroni, et al., 2008, p. 155) have been apparent for children with autism, especially relating to language and understanding sounds and music (p. 150). The suggestion of a left-hemisphere blood flow anomaly for adults who had DD as children (Flowers, Wood, & Naylor, 1991) might be influenced by head tilt associated with an atlas displacement.

Presently, speech and language therapist services have been cut from budgets, so students are not receiving adequate time allotted for sufficient movement outcomes (retired Veteran Speech and Language Pathologist, personal communication, December 20, 2011). Currently, the educational system is not set up to assess for leg length inequality or an atlas displacement, and if a leg length inequality condition were recognized, it would be necessary to be designated on an Individual Education Plan; ultimately school districts would be responsible for treatment costs. Most likely it will be a long time into the future before X-ray technology, or a safer alternative, is incorporated into educational assessment, but in the meantime it is relevant to acknowledge the effects of head tilt, pelvic, shoulder and hip imbalances, possibly associated with an atlas displacement. Early leg length inequality screening might provide opportunities for referrals to treatment for an atlas displacement. Perhaps, if leg length inequality were incorporated into the framework for developmental educational screening assessments, classroom learning environments might ultimately reflect the importance of movement by incorporating persistent primitive reflexes into more sophisticated developmental movement patterns, and the overall affects on strengthened muscle tone and increased cerebral blood flow might become more evident. Developmental movement activities for the classroom (Cheatum & Hammond, 2000; Colvin, Markos, & Walker, 2008; Horvat, et al., 2011; Kovar, et al., 2007; Seaman, et al., 2007) might be regularly incorporated into classroom teachers' lesson plans via identifying leg length inequality.

In the future, educational support teams and parents might be trained to assess leg length inequality as a screening tool for reading success. Perhaps, collecting leg length inequality data eventually might be able to easily document and distinguish relevant neurological patterns for *individual* struggling readers, eventually resulting in *reducing* school district costs by averting more expensive and time-intensive identification processes and treatments. Addressing the importance of a sound visual system might reflect a better understanding for more immediate benefits for *all* students' reading abilities, and ultimately for their quality of a functionally independent life.

Sensory System Disorders

Adapted from:
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Vestibular System Disorders

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1) *Atypical muscle tone.* **Muscle tone** *refers to the elasticity of the muscles and fluidity of associated movements.* Some individuals with a disability demonstrate **hypertonicity** (overly tight tone) and others **hypotonicity** (overly flaccid tone). If hypertonicity dominates, the individual tends to have limited range of motion, the muscles appear to be stretched (tight), and the movements appear to be jerky and awkward….if hypotonicity exists, the muscles tend to be flaccid (floppy), with extreme flexibility around the joints. The movements appear labored and lacking precision.
2) *Poor balance and equilibrium responses*
3) *Poor cocontraction.* Poor cocontraction is demonstrated by the inability simultaneously to contract antagonist muscle groups or to "fixate" two or more body parts around a joint (e.g., the inability to hold one's out stretched arms in a steady position with the addition of weight or force on the arms).
4) *Postural insecurity.* Postural insecurity is demonstrated by an adverse reaction to sudden movements (e.g., flailing arms upon sudden movement of the body).
5) *Poor eye pursuits.* The inability to track visually the movement of an object, when this can negatively affect motor performance (e.g., catching a ball), demonstrates poor eye pursuits.
6) Disorders in arousal state (e.g., excitability, lethargy). Atypical responses to auditory stimuli (e.g., aversive reaction to sound) and visual stimuli may also appear.
7) *Short attention span and distractibility.*
8) *Avoidance of or seeking out swinging, spinning, or twirling activities.* These might include spinning one's body or twirling one's fingers in front of the eyes or active avoidance of these activities (e.g., avoiding merry-go-rounds and swings).

(Seaman, at al., 2007, pp. 79-80).

Tactile System Disorders

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1) *Tactile defensiveness*—demonstrating a negative response to touch or defending one's self from tactile stimuli
2) *Tactile-seeking behaviors*—a strong desire to touch and feel anything and everything

3) *Tactile processing difficulties*—a complete lack of response to touch, the inability to discriminate between different tactile sensations, the inability to locate where one has been touched, or the inability to perceive stimuli simultaneously

4) *Hyperactivity or distractibility*

5) *Difficulty in motor planning*—difficulty in planning and executing nonhabitual, purposeful movement

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(Seaman, at al., 2007, p. 80).

Proprioceptive System Disorders

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1) *Atypical muscle tone*. [See prior definition.]

2) *Inadequate muscle contraction for maintenance of posture.* [See prior definition.]

3) *Poor cocontraction*. [See prior definition.]

4) *Lack of body awareness.* Body awareness is demonstrated through the ability to "know" where one's own body parts are based upon internal stimuli (without vision). With a lack of body awareness, one's ability to use body parts for movement is limited.

5) *Difficulty in coordinating movement efficiently and effectively.*

6) *Difficulty in moving through space, especially around objects.*

(Seaman, at al., 2007, p. 79).

Auditory System Disorders

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1) Difficulty grasping the meaning of words

2) Difficulty using language creatively by conceptualizing the message, associating the appropriate language symbols for use, and sequencing the motor response (expressive language)

3) Inability to recall and use language structures

4) Difficulty discriminating sounds from one another

5) Difficulty detecting variations in sound, including pitch, volume, direction and rhythm

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(Seaman, at al., 2007, p. 82).

Visual System Disorders

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1) Limited ability to attend to visual stimuli

2) Difficulty following a visual sequence or fixating on a moving object

3) Difficulty discriminating visual objects in the field of vision
4) Difficulty maintaining spatial orientation either at rest or while in motion
5) Difficulty recalling visual sequences, spatial relations, forms, or other visual features

(Seaman, at al., 2007, pp. 80-81).

Difficulty Integrating Both Sides of the Body

1) Difficulty jumping with both feet simultaneously
2) Unequal stance
3) Difficulty crossing the midline of the body (e.g., a child who hesitates as he or she moves a hand to the opposite side of the body or whose eye movements become "jerky" while visually tracking an objet across the midline of the body)
4) Poor performance in rhythmic activities
5) Poor coordination of both sides of the body during symmetrical and asymmetrical movements (difficulty buttoning a shirt blouse [symmetrical], skipping or galloping [asymmetrical], or jumping up and down)
6) Difficulty isolating body parts for use (e.g., a child who is attempting a task with one hand, whose other hand is moving in response)
7) Slow balance reactions

(Seaman, at al., 2007, p. 84).

Teachers Facilitating Movement Education

"Skills attempted to be taught in advance of adequate CNS maturation, will become a source of frustration for both teacher and child. This is not necessarily because the teacher is not teaching, but because the child's CNS is not neurologically ready." *(Horvat et al., 2011, p. 318)*

"Many teachers mistakenly believe that children with motor deficiencies require practice in the motor skill in which they are having problems, and so they direct all their instructional time to teaching these skills. No single approach to teaching, however, will always eliminate the deficit. Teaching to a deficit may result in success with time and practice, but it may also result in failure for the individual who can tolerate only a minimum of stimulation. Teaching to the deficit also neglects the information available to the other sense modalities…The key is to match your instruction with the most appropriate method for the child to learn." *(Horvat, et al., 2011, p. 131)*

"Perceptual deficits that impede motor skill acquisition necessitate selecting meaningful teaching strategies to aid in distinguishing or enhancing auditory, visual, tactile, or kinesthetic cues. For example, a slight dysfunction in auditory perception may be overcome by using the hands, feet, sticks, or drums to create a rhythmic sequence used in dance activities and directing the child's attention to relevant input. Verbal cues, sounds made with implements (e.g., rattles), or recorded audio can also produce a variety of sounds, melodies, and/or pitches that may provide the appropriate auditory cues or prompts that can help children select the proper response." *(Horvat, et al., 2011, p. 133)*

"Teaching for Rhythm: Any motor skill that can be executed serially is potentially a rhythm skill. Hence, all fundamental locomotor and nonlocomotor skills have potential to become rhythmic. Even throwing becomes rhythmic if one becomes able to juggle. With skills that can be performed serially; quite generally, the more rhythmically they can be performed, the more skillful the performer…The more quickly the repetitions simultaneously follow one another, the more rapid the rhythm. While all children may not have potential to perform all motor skills rhythmically, all children should have opportunity to come close to rhythm performance in as many motor skills as possible." *(Horvat, et al., 2011, p. 338)*

Play in Motor Skills: "Children have both physiological and psychological needs for play, because play in large measure is the way children learn, physically and intellectually, about the world in which they live…children first learn to play so that they might play to learn." *(Horvat, et al., 2011, p. 338)*

The characteristics of a quality elementary physical education program include: developmentally appropriate activities; skill and fitness improvement; promotion of physical activity; facilitation of learning; maximization of active learning time; indirect competition and cooperation; inclusion of many forms; integration of academic content; ongoing student and program assessment; compliance with federal mandates; appropriate instructional time; and qualified teachers. *(Kovar, et al., 2007, pp. 168-175)*

Eight essential movement forms: Basic movement skills; basic game skills; creative rhythmic movements; body management skills and gymnastics; cooperative movement skills; fitness and wellness concepts and activities; water skills; recreational activity. *(Kovar, et al., 2007, pp. 178-180)*

"Most programs emphasize the first six movement forms. Ideally, the program would contain all movement forms, as students need to acquire a broad movement repertoire…Obviously, omitting certain forms at the K-6 level can severely limit future achievement in those movement forms unless the community has strong programs in those forms and the children traditionally participate in those programs." *(Kovar, et al., 2007, p. 180)*

Teachers, coaches and parents can turn off children's enthusiasm for physical education by: "Inappropriate teaching practices…forcing children into activities that are developmentally inappropriate, usually too advanced…allowing children into competitive sports programs before they have had the opportunity to develop adequate levels of motor skill…constantly pointing out children's lack of achievement in terms of teacher-desired levels of achievement…criticizing children for inadequate motor performance in the presence of Peers…testing fitness before students are conditioned for the rigorous tests and comparing children's fitness level in situations that publically announce their fitness scores" *(*Martens, 1996 and NASPE, 2000, as cited in *Kovar, et al., 2007, p. 267)*

To strengthen students' confidence in their motor abilities: "avoid embarrassing children; respect differences in physical ability; maximize opportunities to practice skills; use developmentally appropriate movement activities; provide task variations within lesson activities" *(Kovar, et al., 2007, p. 267)*

To define maximum participation: "Use movement skills that provide many skill repetitions for every child, because it is only through practice that children become more skilled. Thus games that eliminate players from action should not be part of the program or should be restructured to quickly allow eliminated players back into the games. Movement activities and games that have students wait in line for a turn, such as relays, should also be restructured to allow all students to actively participate." *(Kovar, et al., 2007, p. 268)*

"Provide variations of the tasks to be performed in order to adjust for children's varying levels of ability…providing only one task for all the children to practice is not likely to meet children's varying needs…the teacher must provide a number of tasks of varying levels of difficulty." *(Kovar, et al., 2007, p. 270)*

Movement is good for children, and they have every right to fully participate: Intrinsic motivators are the most influential reinforcement for students because they are "always available to the child…within the student's control" *(Kovar, et al., 2007, pp. 271-272)*

Here are six ways to build intrinsic motivation in students: "Draw attention to students' positive feelings about movement skills; plan for student success; evaluate students appropriately; praise students for their accomplishments; link effort and ability so that children feel they are in control of whether or not they succeed; and construct flow experiences for children" *(Kovar, et al., 2007, p. 272)*

"Classroom teachers should encourage students to participate in active recess play, and never withhold recess time from students…" *(Kovar, et al., 2007, p. 15)*

Teachers can help to insure that recess will be fulfilling for their students when they:
"* Provide appropriate equipment and play spaces
* Provide sufficient equipment and spaces for many groups to play simultaneously
* Challenge students to find a new game appropriate for use at recess time (using varied sources--the library, the Internet, and other people)
* Ask students who are just standing around if they would like to do one of the following activities: play a new game (and teach them a new game); select and use a piece of equipment from the traditional and innovative equipment available on a cart; walk with the student around the perimeter of the play area; join a game already in progress (help the student ask whether he or she can join the activity)
* Help groups establish and enforce fair game and sport rules
* Identify and reinforce expected recess behaviors, so students know that teasing, fighting, name-calling and the like are inappropriate behaviors that will not be allowed to occur
* Encourage playgroups to include students who ask to join the group
* Recognize whether certain students are loners, and then take steps to help them overcome whatever obstacles prevent them playing with others

* Observe what's happening on the playground (who plays what games with whom, who the activity leaders are, who's left out, who plays fairly), and use that information to improve the activity levels of the children
* Observe what games (activities) are being played, thus providing insight into what students like to do, so that additional activities of a similar nature (e.g., different tag games) can be taught" *(Kovar, et al., 2007, p. 15)*

The following questions are good to consider for determining the readiness of an activity:
"* Have students mastered prerequisite skills for the activity being planned?
* Do students appear awkward and unable to repeat a movement, or do students perform the skill with more repetition of correct movement, or do students perform the skill successfully in predictable situations?
* Does the equipment control the student, or does the student need to give complete attention to the challenge at hand, or can the student perform the skill appropriately and even combine it with other skills?" *(Kovar, et al., 2007, p. 40)*

"Neurons also have the ability to change neurological pathways…After a neurological pathway has been interrupted through injury, stroke, or disease, some connections can be reestablished or new ones created. The creation of a new pathway is referred to as *sprouting*…Sprouting, in the brain of a child, is a direct result of the demands of the *environment and the youngster's responses to these environmental demands…" (Cheatum & Hammond, 2000, p. 35)*

"Children who suffer damage to a portion of the brain can often use other parts of the brain for redeveloping or recovering the lost skills." *(Cheatum & Hammond, 2000, p. 37)*

When creating new neurological pathways, "the old neurological pathway must be abandoned…With enough repetition, the new pathway, created by connections between different neurons, is superimposed over the old pathway." *(Cheatum & Hammond, 2000, p. 35)*

"Allow children the opportunity to experiment with a new task before saying anything about their performances…Let them know that you do not expect them to do it right the first time; avoid starting the next activity session with skills that are more difficult; give children specific feedback about behavior and movements; tell them what to *do* instead of what *not to do*" *(Cheatum & Hammond, 2000, p. 47)*

Flight responses:
"I need to go to the bathroom."
"I'm sick. I need to go home."
"My mother told me I don't have to."
"I'm tired."
"I don't like to do this it's boring."
Deliberately falls down.
Daydreams.
"I forgot my gym clothes."
Destroys property.

Fight responses:
"I won't read."
Hits the nearest child.
Throws books off the desk on the way to the chalkboard.
Trips another child during physical education."
"You can't make me do it."
Throws books or homework.
Yells or screams at the parent or teacher.

(Quoted from: Cheatum & Hammond, 2000, p. 14)

A Developmental Survey of Assessment Tools

Selected Items from an Unpublished Survey Developed by Cheatum

The following referenced assessment items were either developed by Cheatum, or adapted from the original authors by Cheatum (1983; evolving over earlier and later years).

(Used with permission, B. Cheatum, personal communications, August 7–11, 2012)

1) **Roach & Kephart (1966, p. 34-36) - The Purdue Perceptual-Motor Survey**
Identification of Body Parts
The child faces you. WHEN I TOUCH A PART OF MY BODY, TOUCH THE SAME PART ON YOURSELF, AND TELL ME WHAT BODY PART IT IS. Results of YES or NO indicate how the child responds for the head, ears, eyes, nose, mouth, shoulders, elbows, hips, knees, ankles, and feet: hesitates; bilateral; unilateral; feels; crosses midline.

2) **Roach & Kephart (1966, p. 44-47) - The Purdue Perceptual-Motor Survey**
Angels in the Snow
The child moves arms and legs indicated up and down, keeping limbs in contact with mat. LIE ON YOUR BACK AND MOVE THE ARM AND LEG I POINT TOWARD. MOVE BOTH ARMS AND BOTH LEGS UP AND BACK. MOVE BOTH ARMS, NOW BACK. MOVE BOTH LEGS, NOW BACK. MOVE THIS ARM [right arm], NOW BACK. MOVE THIS ARM [left arm], NOW BACK. MOVE THIS LEG [right leg], NOW BACK. MOVE THIS LEG [left leg], NOW BACK. MOVE THIS ARM/THIS LEG [left arm, left leg], NOW BACK. MOVE THIS ARM/THIS LEG [right arm, right leg], NOW BACK. MOVE THIS ARM/THIS LEG [right arm, left leg], NOW BACK. MOVE THIS ARM/THIS LEG [left arm, right leg], NOW BACK. Records indicate: overflows; asynchronous; hesitates; bangs. Score positively when the child does *not* receive a tactile clue, and if performed with no pointing assistance or overflows (moves other body parts).

3) **Cheatum** – **SPELL- S**pecial **P**hysical **E**ducation **L**earning **L**aboratory
Right and Left Awareness
The child stands. TOUCH YOUR RIGHT HAND ON YOUR LEFT FOOT. NOW, TOUCH YOUR LEFT HAND TO YOUR RIGHT FOOT. Results of YES or NO indicate for right hand/left foot and left hand/right foot: hesitates; fails to cross midline.

4) **Roach & Kephart (1966, p. 52) - The Purdue Perceptual-Motor Survey; Cheatum**
Crossing Midline on Chalkboard
Draw two Xs on a chalk board, three feet apart. TAKE THE CHALK AND DRAW A LINE FROM RIGHT TO LEFT CONNECTING THE TWO Xs. Repeat left to right. Results of YES or NO for right to left, and left to right indicate: turns; moves; changes hands; deviates midline.

5) **Bruininks-Oseretsky (1978, p. 52-53)**
Balance on One Foot
The child is in tall standing position on one foot. Hands are on hips, and knee of non-supporting leg is at a right angle. Time stops when leg is no longer at a right angle, foot touches the floor, is hooked around the other leg, or the child shifts the supporting foot to keep balance. RAISE ONE LEG UNTIL THE LOWER LEG FORMS A RIGHT ANGLE. HOLD THIS POSITION FOR 10 SECONDS. Results of YES or NO (in seconds) indicate: shifts; non-support; regains (with eyes open and blindfolded).

6) **DeOreo-Pyfer-Strauss**
Fixation of Near Point and Far Point
Time the child for 10 seconds, and record the seconds if less than 10 seconds. Use an 8 inch ball and a pencil. I AM GOING TO HOLD A BALL 24 INCHES FROM YOUR FACE. STARE AT IT LONG AS YOU CAN. (Eyes may blink, but not excessively.) Results of YES or NO indicate (for ball held 24 inches from face; with pencil 24 inches from face; ball held 10 feet from face; pencil 10 feet from face): blinks; loses; avoids; hurts/stings; tenses; body moves; tears.

7) **Cheatum**
VISUAL INTERVIEW QUESTIONNAIRE

Where are you in the classroom?

Can you clearly see the writing on the chalkboard?

Is the writing on the chalkboard ever blurred?

Can you clearly see the printing in your textbook?

Is the printing in your textbook ever blurred?

When you are looking at something, do you see two images or one? Two One

Do you blink a lot when you are reading?

What happens when you blink your eyes?

When you catch a ball, do you have to blink?

Do your eyes ever water or get tears in them?

Do you use one eye or two when reading?

Do you lose your place a lot when reading?

How do you find your place again?

Do you read or write with your head on your desk?

Do you find it easier to read when you put your hand over one eye?

Do you rub your eyes a lot during the school day?

Do you get a headache after reading or writing tasks?

Do you get tired after reading or writing assignments?

8) **Cheatum [with reference to Roach & Kephart (1966)]**
Binocular Control
Observe whether the child is using one eye or both when performing visual tasks. If using only one eye, notice which eye is used if the child changes preference as the midline is crossed. HOW MANY PENCILS DO YOU SEE? First, hold a pencil in front of child's eyes. Ask, ARE YOU USING ONE EYE OR TWO EYES WHEN YOU LOOK AT THE PENCIL? If the answer is one eye, then ask WHICH EYE? (If the child does not know right and left, ask the child to point to the eye.) Then, move the pencil to the far right side so child cannot see pencil with left eye, and place your hand over the right eye. Ask the child if can see pencil. (Should not be able to see pencil.) Remove hand, so the child can see pencil with right eye. Move pencil slowly toward the center of face. Say, TELL ME WHEN YOU SEE TH PENCIL WITH YOUR LEFT EYE. DO YOU SEE THE PENCIL WITH ONE EYE OR BOTH? If the answer is one eye, then ask WHICH EYE? Repeat on the left side. Move the pencil back and forth in a semicircle 18 inches in front of the child's eyes. Periodically ask which eye is being used, or if both eyes are being used. Locate on bird's eye view of head the approximate place that the child shifts to using one eye. Results indicate: using right eye; left eye; both eyes.

9) **Roach & Kephart (1966, p. 60-62) - The Purdue Perceptual-Motor Survey**
Ocular Pursuit
Complete the movement in each position ***one time –*** across and back. Move a pencil slowly in a semi circle keeping it 18 inches from the face. Be sure to note problems with eyes. Ask the child to let the examiner know if eyes feel tired, sting, hurt. Results indicate movement or area that causes pain or stinging sensations. HOLD YOUR HEAD STILL AND FOLLOW THE

PENCIL WITH YOUR EYES. Results of YES or NO indicate (for horizontally left to right, horizontally right to left, diagonally lower left to upper right, diagonally lower right to upper left, vertically from bottom to top, peripheral, dominant eye, or dominance changes as crosses the midline): blinks; loses; avoids; hurts/stings; tenses; body moves; tears; head moves; blinks crossing midline.

10) **Cheatum - SPELL**
Catching Tossed Ball with One Hand
Use a 4 inch yarn ball for K-3 students, and a tennis ball for 4th-6th grade students. Toss ball, so the child catches on same side; also crosses midline. Score YES if catches ball 3 out of 5 times. Observe the use of opposite arm and leg. I AM GOING TO TOSS A BALL TO YOU. CATCH IT WITH THE HAND YOU USE TO WRITE AND TOSS IT BACK TO ME. Results of YES or NO for R/L preferred hand, and number of successful attempts indicate: avoids; straight arm; one side; associated movement (movement in another limb). By observing eyes tracking results of YES or NO indicate: avoids; blinks; or blinks/response (whether child blinks eyes as catches).

11) **Godfrey & Kephart (1969, p. 78, 163); Cheatum - SPELL**
Skipping
SKIP OVER TO THE OTHER SIDE OF THE ROOM AND BACK. Results of YES or NO indicate: galloping; one-sided step hop; legs only; asynchronous.

12) **Bruininks-Oseretsky (1978, p. 78-79)**
Catching Tossed Ball with Both Hands
Stand 7-10 feet apart using a playground ball at least 8 inches in diameter. Throw ball to different sides of the child. I AM GOING TO TOSS THE BALL TO YOU. CATCH IT WITH BOTH HANDS AND TOSS IT BACK TO ME USING BOTH HANDS. Repeat five times. Results of YES or NO for R/L preferred hand, and number of successful attempts indicate: avoids; straight arm; scoops; vice (has to use the body to help catch the ball); hand. By observing eyes tracking results of YES or NO indicate: avoids; blinks; or blinks/response.

13) **Cheatum - SPELL**
Preferred Eye
Place a paper tube in front of the child (in the central position). PICK UP THE TUBE AND LOOK THROUGH THE HOLE WITH ONE EYE. The evaluator may ask for the child to look at the evaluator, or something else. Results indicate a preferred eye or mixed dominance, according to where the tube is placed (i.e., left eye, right eye, or middle of forehead) for holding the tube in both hands, holding tube in right hand, and holding tube in left hand.

14) **Roach & Kephart (1966, p. 42-44) - Kraus-Weber**
Prone Check
The child lies prone on a mat. PLACE YOUR HANDS BEHIND YOUR HEAD AND RAISE YOUR HEAD, CHEST AND ARMS OFF THE FLOOR, AND HOLD THEM UP FOR 10 SECONDS. (If the child does not understand, say, POINT YOUR TOES. Shoulders should come off of the floor.) KEEP YOUR HEAD AND ARMS DOWN AND RAISE YOUR LEGS. HOLD THEM UP FOR 10 SECONDS. (If the child has trouble, ask the child to look up and concentrate on an object or spot on the wall.) Results of YES or NO indicate: upper body raised (in seconds); lower body raised (in seconds); tonic labyrinthine reflex (prone); phasic; head lags; asymmetrical.

15) **Kraus-Weber (1945, p. 270); Cheatum**
Supine Check
The child lies supine on a mat. RAISE BOTH LEGS AND HOLD THEM SIX TO EIGHT INCHES OFF THE FLOOR FOR 10 SECONDS. Results of YES or NO (in seconds) indicate: tonic labyrinthine reflex (supine); phasic; head lags, or asymmetrical. RAISE YOUR HEAD AND THEN RAISE YOUR ARMS AND HANDS EIGHT TO TWELVE INCHES OFF THE MAT, AND HOLD FOR 10 SECONDS. SHOULDERS SHOULD COME OFF THE FLOOR. (If the child has trouble,

ask the child to look at toes.) Results of YES or NO (in seconds) indicate: tonic labyrinthine reflex (supine); phasic; head lags; or asymmetrical.

16) **FIORENTINO (1981)**
Rolling
Observe for segmented rotation and effects of gravity. ROLL FROM YOUR BACK TO YOUR STOMACH. Results of YES or NO indicate: non-segmental rotation; throws limb; tonic labyrinthine supine present; asymmetric tonic neck present. ROLL FROM YOUR STOMACH TO YOUR BACK. Results of YES or NO indicate: non-segmental rotation; throws limb; tonic labyrinthine prone present; ***asymmetric tonic neck present***.

17) **Bruininks-Oseretsky (1978, p. 84); MBD Compendium (1974)**
Thumb and Finger Test
Hold one hand up and touch thumb to index finger, and then each of the other three fingers, without using double touches on little or index finger; do first one hand then the other. HOLD UP YOUR HAND AND TOUCH YOUR THUMB TO YOUR INDEX FINGER AND THEN ON DOWN TO YOUR LITTLE FINGER. Demonstrate. When child is doing one hand, watch the other for an associated reaction (synkinesis or mirror movements). REPEAT WITH THE OTHER HAND. REPEAT WITH BOTH HANDS. Results indicate: vision (looking while moving fingers); associated movement; asynchronous; gravity (whether the child can hold the hand up against the pull of gravity); unilateral.

18) **Ayres (1980, p. 5); MBD Compendium (1974)**
Skin Touch Tactile Awareness
The child is blindfolded in tall standing position (dressed in a short-sleeve shirt, or with sleeves rolled up). Evaluator uses a pencil tip dipped in chalk dust that leaves a mark from light pressure. I AM GOING TO TOUCH YOU. POINT TO THE SPOT I HAVE TOUCHED. Records indicate positive if the child responds within ½ inch (if over ½ inch mark the approximate distance). Results of YES or NO for left forearm, right thigh, left face, right hand, right face, left thigh, right forearm, and left hand indicate: tenses; locates area; hand covers; rubs; tactile defensive. Crosses midline or avoids midline.

19) **MBD Compendium (1974)**
Index Finger to Nose
The child stands with eyes closed, arms straight out to side. TOUCH YOUR NOSE WITH EACH HAND EIGHT TIMES IN A ROW. Results of YES or NO (for the eight options) include: head to finger; lowers arms; misses nose.

20) **PYFER (1983, p. 158)**
Heel-Toe Balance
Have the child stand on a 2 inch wide line on the floor. Place one foot in front of the other with arms at the sides for balance. Balance for 10 seconds with eyes open and closed. (Indicate which leg goes in front.) PLACE THE HEEL OF ONE FOOT IN FRONT OF THE TOE OF THE OTHER FOOT AND HOLD YOUR BALANCE FOR 10 SECONDS. REPEAT WITH OPPOSITE LEG. Results of YES or NO indicate: number of seconds; shifts; exaggerated arm posture; L/R side the child falls (with eyes open and blindfolded).

21) **Cheatum - SPELL**
Shoulder Level Arm Raise
The child raises arm forward to shoulder level five times in a row with eyes closed. The action is repeated with the non-preferred arm, and then with both arms together. It is useful for the evaluator to have a reference a marking on a wall for comparison. Demonstrate. CLOSE YOUR EYES AND THEN RAISE ONE ARM TO SHOULDER LEVEL FIVE TIMES IN A ROW. TRY TO LIFT YOUR ARM TO THE SAME PLACE EACH TIME. Repeat with the other arm, and then repeat with both arms at the same time. Results of YES or NO indicate: arm varies (high/low); associated movement; arm used first.

22) **Roach & Kephart (1966, p. 59-62)**
Accommodation/Convergence/Divergence
I WILL MOVE THE PENCIL TOWARD YOUR NOSE AND THEN BACK OUT AGAIN. FOLLOW THE PENCIL. Results of YES or NO indicate (which eye shifts with convergence or divergence): blinks; loses; avoids; hurts/stings; tenses; body moves; tears; head moves.

Ayres, A.J. (1980). *Southern California Sensory Integration Tests* (Rev. ed.). Los Angeles, CA: Western Psychological Services.

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Roach, E.G. & Kephart, N.C. (1966). *The Purdue Perceptual-Motor Survey.* Columbus, OH: Charles E. Merrill Books, Inc.

General Programming Ideas for All Sensory Modalities

List compiled, and open lecture presented by: Karwas, M. (2008). Sensory sensitivities in adopted children.
The Kinship Center, Salinas, CA., August, 2008.
(Used with permission, M. Karwas, personal communication, August 14, 2012.)

1. Offer a variety of tactile experiences for hands including different textures, burlap, velvet, sand, mud, pudding (*Ayres, 2005, p. 122)*
2. Build towers and stack objects *(Ayres, 2005, p. 122; MBD Compendium)*
3. Handle differently weighted objects (*Ayres, 2005, p. 84)*
4. Roll up in a variety of textiles (*Seaman & DePauw, 1989, p. 311)*
5. Play with sponges, soaps, wash cloths and water (*Seaman & DePauw, 1989, p. 310)*
6. Play with modeling clay (*Seaman & DePauw, 1989, p. 311)*
7. Draw shapes, numbers, or letters on a student's forehead, hand back etc…and ask them to identify them. *(MBD Compendium)*
8. Conceal a few familiar objects into a pillow case, identify without vision only using hands, progress towards more objects and less familiar (*Seaman & DePauw, 1989, p. 311)*
9. Blind folded, identify various shapes, letters, numbers cut out of various textures (*Seaman & DePauw, 1989, p. 311)*
10. All balancing activities in various positions and body parts--both static and phasic (balance with no movement, balance while moving) (*Seaman & DePauw, 1989, p. 316-317)*
11. Pushing and pulling objects, tug games *(Ayres, 2005, p. 112; Seaman & DePauw, 1989, p. 312)*
12. Climbing ropes and ladders, OVERALL use of large muscle groups (*Seaman & DePauw, 1989, p. 312)*
13. Massage by applying direct firm pressure on all body parts to enhance proprioception (*Seaman, et al., 2007, p. 421)*
14. Name various sounds with eyes closed, bouncing ball, pouring liquid… *(Seaman, et al., 2007, p. 421)*
15. Identify words with background noise present (*Seaman & DePauw, 1989, p. 313)*
16. Follow a suspended ball with eyes, eventually strike with implement or hand (*Seaman & DePauw, 1989, p. 314)*
17. Follow flash light beam in a darkened room with eyes and body, play flashlight tag to follow the leader (2 flashlights needed) (*Seaman & DePauw, 1989, p. 314)*
18. Using ropes, make letters, numbers, shapes (*Seaman & DePauw, 1989, p. 314)*
19. Make mirror images of each other, then move to opposite images (with younger kids mirroring will be easiest, [when] they can move to opposite image they have taken a quantum neurological leap) *(Seaman & DePauw, 1989, p. 314)*
20. Move to different beats of a drum; slow, fast, medium *(Seaman, et al., 2007, p. 433)*
21. Sleeping with the rough side of towel up on pillow will activate tactile stimulation.
22. Exercise three times a week, for 30 minutes each time.

Ayres, A.J. (2005). Sensory Integration and the Child: Understanding Hidden Sensory Challenges (Rev. ed.). Los Angeles, CA: Western Psychological Services.

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Seaman, J.A. & De Pauw, K.P. (1989). *The New Adapted Physical Education: A Developmental Approach* (2nd ed). Mountain View, CA: Mayfield Publishing Company.

Seaman, J.A., De Pauw, K.P., Morton, K.B., & Omoto, K. (2007). *Making Connections: From Theory to Practice in Adapted Physical Education* (2nd ed). Scottsdale, AZ: Holcomb Hathaway, Publishers.

"Activities for Enhancing Motor-Sensory Reponses
Balance and equilibrium responses.
Locomoting on an uneven surface." ***(Seaman, et al., 2007, pp. 422-423).***

CURRICULAR GUIDELINES *for Connecting to Classroom Curricula*

Physical Education Framework for California Public Schools-
Kindergarten Through Grade Twelve
Adopted by the California State Board of Education
Published by the California Department of Education, Sacramento, 2009
http://www.cde.ca.gov/ci/cr/cf/documents/peframework2009.pdf

Adapted Physical Education National Standard (2006)

Horvat, Kalakian, Croce, & Dahlstrom (2011)
***Developmental/Adapted Physical Education: Making Ability Count* (5th ed.)**
San Francisco, CA: Pearson, p. 339.

Standard #2 of the ***Adapted Physical Education National Standards, (2006*)** requires for an Adapted Physical Education teacher to have knowledge about typical motor development, and an understanding of the influence of developmental delays on this process, so the authors suggest to:

* Provide sensory integration (different objects), cognition (presenting information so the child understands), and conceptual (the big picture) components of movement.
* Provide *time to process* information and avoid overstimulating children with vast amounts of sensory stimuli.
* Practice over time to learn the skill; provide opportunities for retention.
* Practice a variety of environments (e.g., gym, field, track, court) and situations—games usually are dynamic.
* Build on success and previous learning; use progression and add "parts" to the skill when appropriate. For some children, using the entire skill may be easier than breaking the skill into sub-skills.
* Implement multi-faceted instruction: visual demonstration of skills, auditory cues (very limited-one word if possible); and kinesthetic orientation, for some children there is a need to physically assist the child to move through the motor pattern—to recognize where body parts are in relation to one another and the body's position in space.

Adapted Physical Education National Standards (2008)

From: http://www.apens.org/15standards.html
15 Standards of Specialized Knowledge

Standard 1: HUMAN DEVELOPMENT
The foundation of proposed goals and activities for individuals with disabilities is grounded in a basic understanding of human development and its applications to those with various needs. For the adapted physical education teacher, this implies familiarity with theories and practices related to human development. The emphasis within this standard focuses on knowledge and skills helpful in providing quality APE programs.

Standard 2: MOTOR BEHAVIOR
Teaching individuals with disabilities requires some knowledge of how individuals develop. In the case of APE teachers, it means having knowledge of typical physical and motor development as well as understanding the influence of developmental delays on these processes. It also means understanding how individuals learn motor skills and apply principles of motor learning during the planning and teaching of physical education to students with disabilities.

Standard 3: EXERCISE SCIENCE
As an adapted physical educator, you must understand that modifications to the scientific principles of exercise and the application of these principles may be needed when teaching individuals with disabilities to ensure that all children with disabilities enjoy similar benefits of exercise. While there is a wealth of information in the foundational sciences, the focus of this standard will be on the principles that address the physiological and biomechanical applications encountered when working with diverse populations.

Standard 4: MEASUREMENT AND EVALUATION
This standard is one of the foundation standards underscoring the background an adapted physical educator should have in order to comply with the mandates of legislation and meet the needs of students. Understanding the measurement of motor performance, to a large extent, is based on a good grasp of motor development and the acquisition of motor skills covered in other standards.

Standard 5: HISTORY AND PHILOSOPHY
This standard traces facts regarding legal and philosophical factors involved in current day practices in adapted physical education. This information is important to understand the changing contribution that physical education can make in their lives. Major components of each law that related to education and physical activity are emphasized. The review of history and philosophy related to special and general education is also covered in this area.

Standard 6: UNIQUE ATTRIBUTES OF LEARNERS
Standard 6 refers to information based on the disability areas identified in the Individuals with Disabilities Education Act (IDEA) found within school age population. Material is categorically organized in order to present the information in a systematic matter. This organization is not intended to advocate a categorical approach to teaching children with disabilities. All children should be treated as individuals and assessed to determine what needs they have.

Standard 7: CURRICULUM THEORY AND DEVELOPMENT
As you are planning to teach physical education to students with disabilities, you should recognize that certain Curriculum Theory and Development concepts, such as selecting goals based on relevant and appropriate assessments, must be understood by APE teachers. As you have no doubt discovered Curriculum Theory and Development is more then writing unit and lesson plans. Nowhere does this come into play more than when you are planning a program for a student with disability.

Standard 8: ASSESSMENT
This standard addresses the process of assessment, one that is commonly taught as part of the basic measurement and evaluation course in a physical education degree curriculum. Assessment goes beyond data gathering to include measurements for the purpose of making decisions about special services and program components for individuals with disabilities.

Standard 9: INSTRUCTIONAL DESIGN AND PLANNING
Instructional design and planning must be developed before an APE teacher can provide services to meet legal mandates, educational goals and most importantly the unique needs of individuals with disabilities. Many of the principles addressed earlier in human development, motor behavior, exercise science and curriculum theory and development are applied to this standard in order to successfully design and plan programs of physical education.

Standard 10: TEACHING
A major part of any APE position is teaching. In this standard many of the principles addressed earlier in such standard areas as human development, motor behavior, and

exercise science, are applied to this standard in order to effectively provide quality physical education to individuals with disabilities.

Standard 11: CONSULTATION AND STAFF DEVELOPMENT
As more students with disabilities are included in the general education program, teachers will provide more consultation and staff development activities for colleagues. This will require sensitivity and excellent communication skills. The dynamics of interdisciplinary cooperation in the consultation process requires knowledge of several consultative models. This standard identifies key competencies an adapted physical educator should know related to consultation and staff development.

Standard 12: STUDENT AND PROGRAM EVALUATION
Program evaluation is a process of which student assessment is only a part. It involves evaluation of the entire range of educational services. Few physical educators are formally trained for program evaluation, as national standards for programs have only recently become available. Therefore, any program evaluation that has been conducted is typically specific to the school or district, or limited to a small range of parameters such as number of students scoring at a certain level of a physical fitness test. Adapted physical education programs or outcomes for students with disabilities are almost never considered in this process.

Standard 13: CONTINUING EDUCATION
The goal of this standard is to focus on APE teachers remaining current in their field. A variety of opportunities for professional development are available. Course work at a local college or university is just one avenue. APE teachers can take advantage of workshops, seminars and presentations at conferences, conventions or in service training. Distance learning opportunities are also becoming abundant.

Standard 14: ETHICS
A fundamental premise of the Adapted Physical Education National Standards Project is that those who seek and meet the standards to be certified as adapted physical educators will strive at all times to adhere to the highest of ethical standards in providing programs and services for children and youth with disabilities. This standard has been developed to ensure that its members not only understand the importance of sound ethical practices, but also adhere to and advance such practices.

Standard 15: COMMUNICATION
In recent years, the role of the professional in APE has evolved from being a direct service provider to include communicating with families and other professionals in order to enhance program instruction for individuals with disabilities. This standard includes information regarding the APE teacher effectively communicating with families and other professionals using a team approach in order to enhance service delivery to individuals with disabilities.

(Used with permission: **Timothy D. Davis, Ph.D., CAPE, Adapted Physical Education National Standards (APENS) Chair, (607)753-4969 www.APENS.org**).

National Standards for Physical Education (2004)

National Association for Sport and Physical Education, an Association of the American Alliance for Health, Physical Education, Recreation and Dance (2004).
***Moving into the Future: National Standards for Physical Education* (2nd ed.)**

A physically educated person:

Standard 1: Demonstrates competency in motor skills and movement patterns needed to perform a variety of physical activities.

Standard 2: Demonstrates understanding of movement concepts, principles, strategies, and tactics as they apply to the learning and performance of physical activities.

Standard 3: Participates regularly in physical activity.

Standard 4: Achieves and maintains a health-enhancing level of physical fitness.

Standard 5: Exhibits responsible personal and social behavior that respects self and others in physical activity settings.

Standard 6: Values physical activity for health, enjoyment, challenge, self-expression, and/or social interaction. *(p.11)*

Standard 1: Grades K-2

Student Expectations (at the end of grade 2)
Young children are very active and enjoy learning and mastering new ways to move and be active. Students achieve mature forms in the basic locomotor skills and vary the manner in which these skills are performed in relationship to changing conditions and expectations. They demonstrate smooth transitions between sequential locomotor skills. Students show progress toward achieving mature form in the more complex manipulative skills (e.g., foot dribble) and achieve mature form in the less complex manipulative skills (e.g., underhand throw). They demonstrate control in traveling, weight bearing, and balance activities on a variety of body parts.

Sample performance outcomes (across K-2 grade range)

* Skips (or hops, gallops, slides, etc.) using mature form (e.g., step-hops, swings arm, swings knee, shows smooth and continuous motion, shows rhythmical weight transfer and use of arms).
* Performs a simple dance step in keeping with specific tempo (e.g., slow-slow, fast-fast).
* Demonstrates clear contrast between slow and fast movement when skipping (or hopping, galloping, sliding, etc.).
* Travels forward and sideways, changing directions quickly in response to a signal or obstacle using a variety of locomotor skills.
* Demonstrates a smooth transition between locomotor skills in time to music.
* Taps the ball form foot to foot, shifting weight and balancing the body on the non-dribbling foot, while in one location (i.e., not moving). (Developmentally, this is more difficult than tapping the soccer ball forward using the big-toe area of the inside of the foot. This describes what is called a “juggle” back and forth between the feet, basically a very small side-to-side leap while “pushing” the ball back and forth; it is a coordination task and serves to develop footwork in soccer.
* Drops a ball and catches it at the peak of bounce.

* Throws a ball underhand using mature form (e.g., places feet together and shoulders square to target, swings throwing arms straight back, shifts weight forward by stepping forward onto opposite foot, rolls ball off fingers, and finishes with throwing arm outstretched toward target).
* Discovers how to balance on different body parts, at different levels, becoming "like" a statue while making symmetrical and non-symmetrical shapes. *(p.16)*

Standard 1: Grades 3-5

Student Expectations (at the end of grade 5)
Older children develop maturity and versatility in the use of fundamental motor skills for more pleasurable movement experiences. Students achieve mature forms in the basic nonlocomotor and manipulative skills. They demonstrate locomotor, nonlocomotor, and manipulative skills for performance outcomes (e.g., hitting targets). They use these skills in dynamic and complex environments (e.g., formal dance to music) and I combination with each other. Students also acquire some specialized skills basic to a movement form (i.e. basketball chest pass, softball fielding with a glove).

Sample performance outcomes (across 3-5 grade range)

* Demonstrates good posture while lifting and carrying an object.
* Balances with control on a variety of objects (e.g., balance board, large apparatus, skates).
* Catches a fly ball using mature form (e.g., has eyes on ball, moves to position, reaches with hands, catches with hands only rather than trapping the bal, bends elbows to pull ball into chest to absorb force).
* Performs a basic tinikling step to ¾ time (close, tap, tap).
* Jumps vertically to a height of 9 inches and lands using mature form (e.g., stands, crouches with arms back and weight on toes, lifts off with hands high, lands on both feet).
* Throws a ball overhand and hits a target on the wall (6-foot square centered 4 feet above the ground) from a distance of 40 feet).
* Develops and refines a gymnastics sequence (or creative dance sequence) demonstrating smooth transitions.
* Dribbles then passes a basketball to a moving receiver.
* Throws a ball overhand to a partner 15 yards away using mature form (e.g., turns side to target, uses t-position [ball held close to and behind ear], rotates hips and chest toward target, twists, releases, follows through across body) after fielding a ball.
* Demonstrates correct pattern for the polka step (hop-step-together-step). *(p.17)*

Standard 2: Grades K-2

Student Expectations (at the end of grade 2)
Young children are rapidly maturing in their basic cognitive abilities. They learn and apply basic concepts such as actions, planes, and personal/general space. They identify and perform concepts of effort and relationships that vary the quality of movement. Students identify elements of correct form for fundamental skills and use them in performance. They use feedback to improve motor performance.

Sample performance outcomes (across K-2 grade range)

* Identifies correctly body planes (i.e., front, back, side).

* Identifies correctly various body parts (e.g., knee, foot, arm, palm).

* Explains that warm-up prepares the body for physical activity.

* Recognizes appropriate safety practices in general space by throwing balls only when others are not in the direct line of the throw.

* States that the best effort is shown by trying new or hard tasks.

* Repeats cue words for jumping vertically (i.e., crouch, straighten, land on both feet and bend knees) and demonstrates/explains what is meant by each.

* Corrects movement errors in response to corrective feedback (e.g., remember to twist your tummy when throwing the ball).

* States the short-term effects of physical activity on the heart and lungs.

* Explains that appropriate practice improves performance. *(p. 22)*

Standard 2: Grades 3-5

Student Expectations (at the end of grade 5)
Older children are able to comprehend more complex concepts and principles and apply them in structured settings. They use performance feedback to increase their cognitive understanding of a skill as well as to improve performance. They also use their knowledge of critical elements of form or simple biomechanical or motor development principles to provide feedback to others. As they learn more complex motor skills, they transfer concepts learned in other skills/games for performance of the new skill/game (e.g., bending the knees lowers the center of gravity and increases stability).

Sample performance outcomes (across 3-5 grade range)

* Describes how the heart rate is used to monitor exercise intensity.

* Identifies and demonstrates key elements of a proper grip when holding a racket to perform the forehand strike.

* Explains the necessity of transferring weight form the back leg to the front leg during any action that propels an object forward.

* Accurately recognizes the critical elements of a catch made by a fellow student and provides feedback to that student.

* Describes the difference in foot placement when kicking a stationary ball, a ball moving away, and a ball moving toward.

* Explains how appropriate practice improves performance.

* Designs a new game incorporating at least two motor skills, rules, and strategies.

* Identifies physical and psychological benefits that result from long-term participation in physical activity. *(p. 23)*

Standard 3: Grades K-2

Student Expectations (at the end of grade 2)
Young children participate in physical activities largely because of the pleasure they experience. They engage in nonstructured physical activities on an intermittent basis outside of the physical education class and have fun while doing so. They participate in

a wide variety of gross motor activities that involve locomotion, nonlocomotion, and manipulation of objects. Students knowingly select and participate in activities during their leisure time that are moderate to vigorous in nature and that they find enjoyable. They recognize that participation in moderate to vigorous physical activity has both temporary and lasting effects on the body and voluntarily choose to engage in activities that contribute to improved health. Students begin to utilize the skills and knowledge acquired in physical education class during their leisure-time physical activity.

Sample performance outcomes (across K-2 grade range)

* Engages in moderate to vigorous physical activity on an intermittent basis.
* Engages in a variety of locomotor activities (e.g., hopping, walking, jumping, galloping, and running) during leisure time.
* Participates in chasing and fleeing activities outside of school.
* Participates in a variety of activities that involve manipulation of objects in and outside of physical education class (e.g., tossing ball, juggling).
* Participates regularly in a variety of nonstructural and minimally organized physical activities outside of physical education class (e.g., hide and seek). *(p. 28)*

Standard 3: Grades 3-5

Student Expectations (at the end of grade 5)
Older children develop awareness of participation in physical activity as a conscious personal decision, choosing activities for both the enjoyment and the health benefits they derive. They voluntarily participate in moderate to vigorous physical activity for longer periods of time outside of physical education class. Students are able to identify and make use of opportunities at school and within the community for regular participation in physical activity. They begin to recognize and use critical elements and movement concepts to sustain their own participation in activities they enjoy. They are capable of using information from a variety of sources (internal and external) to regulate their activity and participation.

Sample performance outcomes (across 3-5 grade range)

* Consciously chooses to participate in moderate to vigorous physical activity outside of physical education class on a regular basis.
* Participates in organized sport activities provided through local community programs.
* Participates in an intramural sports program provided by the school.
* Chooses to participate in structured and purposeful activity.
* Monitors his or her physical activity by using a pedometer to count the number of steps taken or the distance travelled.
* Maintains physical activity (e.g., Activitygram) for a two- or three- day period documenting activity data (e.g., step count, time). *(p. 29)*

Standard 4: Grades K-2

Student Expectations (at the end of grade 2)
Young children engage in a variety of activities that serve to promote health-related physical fitness. They enjoy physical activities for the pleasure experienced form simply moving and may not associate the activity with the development of fitness. They participate in physical activity intermittently for short periods of time and will accumulate a relatively high volume of total activity and have fun while doing so. They recognize physiological signs associated

with participation in moderate to vigorous physical activity (e.g., sweating, fast heart rate, heavy breathing). Students at this level process basic knowledge of the components of health-related fitness (cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition).

Sample performance outcomes (across K-2 grade range)

* Demonstrates sufficient muscular strength to be able to bear body weight for climbing, hanging, and momentary body support on the hands.
* Engages in a series of locomotor activities (e.g., timed segments of hopping, walking, jumping, galloping, and running) without tiring easily.
* Participates in a variety of games that increase breathing and heart rate.
* Increases arm and shoulder strength by traveling hand-over-hand along a horizontal ladder (i.e., monkey bars).
* Sustains activity for increasingly longer periods of time while participating in various activities in physical education.
* Moves transversely along a rock wall with little teacher assistance.
* Recognizes that health-related physical fitness consists of several different components. *(p. 34)*

Standard 4: Grades 3-5

Student Expectations (at the end of grade 5)
Older children regularly participate in physical activity for the purpose of improving physical fitness. Students participate in moderate to vigorous physical activity for longer periods of time without tiring. They begin to engage in physical activities specifically related to each component of physical fitness and are capable of monitoring the physiological indicators that accompany moderate to vigorous activity and adjust their own activity accordingly. Students complete standardized fitness testing and achieve desired levels consistent with contemporary health-related recommendations. With teacher assistance, students interpret the results and understand the significance of information provided by formal measures of physical fitness.

Sample performance outcomes (across 3-5 grade range)

* Participates in selected activities that develop and maintain each component of physical fitness.
* Engages in appropriate physical activity that results in the development of cardiorespiratory endurance.
* Recognizes that physiological responses to exercise are associated with their own levels of fitness.
* Runs the equivalent of two laps around a regulation track without stopping.
* Chooses to participate in sport activities that require high levels of muscular strength.
* Explains the personal consequences of poor flexibility on ability to perform various activities.
* Maintains heart rate within the target heart rate zone for a specified length of time during an aerobic activity.
* Meets the age- and gender-specific health-related fitness standards defined by Fitnessgram.

* Identifies his or her own strength and weaknesses based on the results of Fitnessgram testing. *(p. 35)*

Standard 5: Grades K-2

Student Expectations (at the end of grade 2)
Young children discover the joy of playing with friends and experience how social interaction can make activities more fun. They know safe practices and physical education class rules and procedures, and they are able to apply them with little or no reinforcement. Children know how to utilize acceptable behaviors for physical activity settings and are building a foundation for successful interpersonal communication during group activity. By improving motor skills, children have gained a basis and appreciation for working with others in cooperative movement, sharing, working together to solve a problem, and/or tackling a challenge.

Sample performance outcomes (across K-2 grade range)

* Practices specific skills as assigned until the teacher signals the end of practice.
* Follows directions given to the class for an all-class activity.
* Shows compassion for others by helping them.
* Handles equipment safely by putting it away when not in use.
* Uses equipment and space safely and properly.
* Honestly reports the results of work.
* Works in a divers group setting without interfering with others.
* Invites a peer to take his or her own turn at a piece of apparatus before repeating a turn.
* Assists a partner by sharing observations about skill performance during practice.
* Enjoys participating alone while exploring movement tasks.
* Accepts all playmates without regard to personal differences (e.g., ethnicity, gender, disability).
* During class closure, identifies sharing with a partner as a way to cooperate.
* Displays consideration of others while participating on the playground.
* Demonstrates the elements of socially acceptable conflict resolution during class activity. *(p. 40)*

Standard 5: Grades 3-5

Student Expectations (at the end of grade 5)
Older children are active participants and learn to work independently and with small groups, enjoying diversity of those around them. Students identify the purposes for and follow activity-specific safe practices, rules procedures, and etiquette. They continue to develop cooperation and communication skills to facilitate completion of a common goal while working with a partner and/or small diverse groups. Older children work independently and productively for short as well as progressively longer periods of time. Building on the foundation laid in the earlier grades, students continue to develop cultural/ethnic self-awareness, appreciate their own heritage, and appreciate the differences in others.

Sample performance outcomes (across 3-5 grade range)

* In preparation for a kicking goal task, arranges soccer equipment safely in a manner appropriate to practice.
* Takes seriously the role of teaching an activity or skill to his or her team.
* Cooperates with all class members by taking turns and sharing equipment.
* Works productively with a partner to improve performance of a dance sequence by following a detailed diagram of the process.
* Accepts the teacher's decision regarding a personal rule infraction without displaying negative reactions toward others.
* Assess and takes responsibility for his or her own behavior problems without blaming others.
* Recognizes and appreciates similar and different activity choices of peers.
* During class discussion of various dance forms, shows respect for the views of a peer from a different cultural background.
* Demonstrates respect and caring for a wheelchair-bound peer through verbal and nonverbal encouragement and assistance.
* Regularly encourages others and refrains from put-down statements. *(p. 41)*

Standard 6: Grades K-2

Student Expectations (at the end of grade 2)
Young children are the most active segment of our population. They are physically active because they enjoy merely participating. Students like the challenge of experience in new movements and learning new skills. They feel joy as they gain competence in them. They begin to function as members of a group and to work cooperatively for brief periods of time.

Sample performance outcomes (across K-2 grade range)

* Exhibits both verbal and nonverbal indicators of enjoyment.
* Willingly tries new movements and skills.
* Continues to participate when not successful on the first try.
* Identifies several activities that are enjoyable. *(p. 46)*

Standard 6: Grades 3-5

Student Expectations (at the end of grade 5)
Older children can identify activities they consider to be fun. Enjoyment is directly related to competence in particular activity. They are challenged by learning a new skill or activity and enjoy broadening their repertoire of movement skills. Success and improvement are attributed to effort and practice. They choose an appropriate level of challenge in an activity so as to experience success and engage in activity with students of different and similar skill levels.

Sample performance outcomes (across 3-5 grade range)

* Identifies positive feelings associated with participation in physical activities.
* Chooses to participate in group physical activities.
* Explains that skill competency leads to enjoyment of movement and physical activity.

* Interacts with others by helping with their physical activity challenges.
* Selects and practices a skill on which improvement is needed.
* Develops a dance sequence (or game) that is personally interesting.
* Defends the benefits of physical activity. *(p. 47)*

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FOLLOW-UP SURVEY

"An Atlas Subluxation Complex typically demonstrates itself initially
in measurements over ¼" before the first adjustment."
(Dr. Steven MacDonald, personal communication, October 8. 2010)

"With a ¼" threshold, 'even' would be anything ¼" and below.
At ¼" there will be excellent agreement among examiners."
(Dr. Charles Woodfield, personal communication, December 20, 2010)

Please indicate your interest to participate in an eight hour training to become a certified **L**eg **L**ength **I**nequality assessor. The **U**pper **C**ervical **R**esearch **F**oundation would provide the training designed for the purpose of using the Supine Leg Check as an initial pre-treatment screening tool for educators, parents, and support providers, to possibly address the needs of students who are at-risk for reading.

INTERESTED

NOT *INTERESTED*

Please return survey to:
Lisa Kline
255 Larkin Street, #3
Monterey, California 93940
lkline@csumb.edu