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Neurodevelopmental Soft Signs: Implications for Sensory Processing and Praxis Assessment—Part Two

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ABSTRACT

Occupational therapy pediatric clients with sensory integration and processing dysfunction often have co-occurring neurodevelopmental conditions, such as autism spectrum, attention deficit hyperactivity, learning, and motor planning/coordination disorders. The research evidence indicates that unique patterns of neurological/neurodevelopmental soft signs (NSS) occur frequently in these populations, and correlated central nervous system structures and processes are increasingly being identified through advances in neuroimaging and other technologies. Integrating clinical observations of NSS and advanced brain-based research expands our understanding of the sensorimotor scaffolding that leads to higher functions of behavior organization, communication, and cognition. This knowledge has the potential to enhance significantly our theory, evaluation, interpretation, and intervention strategies for children with sensory processing and integration challenges that ultimately affect occupation and participation.

LEARNING OBJECTIVES

After reading this article, you should be able to:

1. Understand the role of NSS in occupational therapy clinical practice
2. Describe how the presence of NSS relates to sensory processing and integration
3. Identify areas of overlap between NSS and clinical observations in sensory integration
4. Discuss the interpretations of different NSS in the context of sensory integration theory

NSS INVOLVING BILATERAL BODY ORGANIZATION

Bilateral body disorganization (BBO) is used here to denote neurological/neurodevelopmental soft signs (NSS) and other testing deficits that involve deficiencies in motor function of the two sides of the body in relation to each other, and to the midline of the body and head; indicators of lateral dominance agreement of hand, foot, and eye; and perception of right versus left spatial orientation.

NSS for BBO include:

- Poorly executed bilateral movements of upper and lower extremities
- Poor bilateral oculomotor pursuits and vergence
- Avoidance of approaching and/or crossing the body midline during upper extremity tasks (depending on age)
- Developmentally immature establishment of lateral preference of hand, eye, and foot
- Directional confusion of right versus left

This set of NSS seems to appear most frequently in a constellation with inadequate postural tone, righting/equilibrium and balance responses in standing/ walking, and other indicators of vestibulo-spinal influence from the gravity receptors and caudal brainstem nuclei in the vestibular system (Ayres, 1989; Lundy-Ekman, 2017).

Incoordination When Executing Bilateral Movements of Extremities

The most commonly observed NSS are during procedures requiring two extremities to work together simultaneously and/or reciprocally. Most studies of bilateral coordination of movement have used the upper extremities for measurement ("bimanual"), although the ability to move the two body sides reciprocally is acquired by all four extremities, including the eyes, by early-to-middle childhood, depending on the required speed of execution (Ayres, 1989; Huh et al., 1998). Interference with smooth bilateral coordination is produced by (1) incorrect sequencing, (2) dysrhythmia (uneven rhythm), and (3) dysmetria (incorrect timing), and it can be observed during standardized tests such as the Bilateral Coordination Test of the Sensory Integration and Praxis Tests (Ayres, 1989); Stride Jumps items on the Bruininks-Oseretsky Test of Motor Proficiency-2 (Bruininks & Bruininks, 2005); and other informal structured observations, such as "jumping jacks" (Magalhaes et al., 1989).

This deficiency is highlighted by comparing bilateral versus unilateral coordination on NSS screening tasks of (1) diadochokinesia and (2) thumb-finger serial opposition. If the child performs rapid supination-pronation or thumb-finger tap sequences smoothly with each hand individually but shows a marked decrease in quality when both hands are tested simultaneously, bilateral motor deficiency is evident. The greater effort of using both hands simultaneously is often accompanied by associated movements of the mouth and tongue, or mirror movements in the "at rest" arm/hand, while the active arm/hand is being tested.

One issue that has created a challenge for distinguishing "pure" bilateral coordination dysfunction from a motor sequencing problem (associated with dyspraxia) lies in the similarity with which the items are scored. Sequencing errors will automatically lower a bilateral motor coordination NSS score, but poor timing or rhythm will generally not affect a motor sequencing item score, as long as the movement pattern is correct. To avoid this confusion, it may be best to test motor sequencing with one extremity at a time.

Inadequate bilateral oculomotor control. If a primary neurological ocular deficit has been ruled out (e.g., strabismus), we can use NSS procedures to assess the child's capacity for executing the fundamental extraocular movements of:

- Fixation on a still object
- Smooth pursuits (or "tracking")
- Voluntary saccades (quick localization)
- Vergence (convergence and divergence)
- Suppression of the vestibulo-ocular reflex (fixation on target during head movement)

NSS may occur in the control of any of these functions (Karatekin, 2007).

Dysfunctional oculomotor movements compared with typically developing and motor-matched controls have been documented in children with developmental coordination disorders (DCD; Sumner et al., 2018), learning disorders (Fukushima et al., 2005), attention deficit hyperactivity disorder (ADHD; Mahone et al., 2009), and autism spectrum disorder (Schmitt et al., 2014; Wilkes et al., 2015). When executing smooth pursuits horizontally, soft signs may consist of problems maintaining fixation and intrusive saccades during tracking.

Quick localization of the presented target uses voluntary saccadic eye movements to different random locations in the visual field, with NSS composed of overshooting or undershooting of the target, followed by corrective attempts to locate it (Sumner et al., 2018). NSS on vergence is noted by the child struggling to converge eyes smoothly on the examiner's approaching visual target, then to diverge the eyes to fix on the examiner, alternating these adaptive eye responses as directed.

Finally, difficulty with fixation on a visual target during head movements is the oculomotor NSS that reflects integration of vestibular stimuli (head movement) with volitional eye control (fixation on target) and requires the neurologic ability to suppress the vestibulo-ocular reflex (Vercher & Gauthier, 1990–1991). Dynamic eye movement problems have been associated with poor performance in academic occupations, as well as their implications for facial scanning and social eye contact.

Absence, incomplete, or inconsistent patterns of lateral dominance of upper extremity, eye, lower extremity. NSS related to eye, hand, and foot preference have the intention of measuring the degree of motor laterality agreement established in the central nervous system for these three key "extremities." It has been proposed that lateralization of sensorimotor functions actually provides a "scaffold" for eventual cognitive specialization of higher level functions to occur between the left and right hemispheres (Gonzales et al., 2018). Higher levels of inconsistency (sometimes called "crossed laterality") may share a common denominator with problems of learning and behavior.

In NSS evaluation, different opportunities are presented to the child to engage in unilateral skills, such as moving pegs, writing or drawing, sighting with one eye through a tube, or kicking a ball multiple times, and the examiner records and tallies the extremity used (De Agostini & Dellatolas, 2001).

In terms of functional movement, incompletely established hand dominance could lead to a lag in developing fine and gross motor skills and is a marker for language lateralization in the brain (Papadatou-Pastou et al., 2008), which has potential consequences for academic performance (Mori et al., 2006). Researchers have differed, though, in the level of movement challenge presented by their measurement activities, leading to a lack of consensus in the conclusions.

Lack of consistent agreement across eye, hand, and foot has been found in the past to be associated with learning disorders, including reading and language acquisition (Satz et al., 1988). Correlation does not necessarily imply causation, though, and the direct importance of consistent laterality to developing higher cognitive or academic achievement remains mostly unsubstantiated. A meta-analysis by Ferrero and colleagues (2017) of 26 articles making this claim, covering a total population of 3,578 children aged 5 to 12, concluded that taken collectively, the results of these studies did not support the hypothesis that there is a reliable association between crossed laterality and either academic achievement or intelligence. This inconsistency in results may be because of some investigators using lateral preference as the independent variable, rather than the side with superior skill.

Immature patterns of crossing the body midline. In this NSS, Ayres (1973) emphasized that not crossing the body midline (CML) with either hand is a subtle, spontaneous tendency rather than an inability or a conscious "choice" by the child. Ayres noted that when attempts are made to evaluate CML behavior directly through imitating the examiner's demonstrations of reaching across midline, typically developing children may discern the point of the task and cognitively overcome the usually automatic inclination to use each hand in its own lateral space.

Therefore, the ideal scenario for observing spontaneous CML is during upper extremity play or fine motor tasks requiring unilateral prehension and placing of objects from either side toward a target placed at the midline (Ayres, 1973, 1989). Examples include penny- or bead-placing tasks, in which items are placed in a horizontal line or arc on the table in front of the child; or reaching to different sides of a table to pick up puzzle pieces with either hand. Coelho and colleagues' (2013) kinematic analysis in typically developing subjects found arm selection for reaching favored the dominant hand for at-midline and slightly left-of-midline targets. Thus, it would appear lateral dominance would be expected to be mostly established before midline crossing becomes proficient.

Ayres proposed that the value of CML as an NSS was not only a possible indicator of integration between the two sides of the body, but also was a reflection of inter-hemispheral communication. This reflects a somewhat theoretical intersection with the aforementioned work of Coelho and colleagues (2013), who concluded their results might have implications for theoretical models of sensorimotor asymmetries in dynamic intersegmental coordination, and hence for neural lateralization. (They further proposed that the dominant hemisphere might be in charge of organizing these postural dynamics.)

However, Ayres uniquely hypothesized this cross-midline communication takes place at the brainstem nuclei and midbrain levels (e.g., thalamus and basal ganglia), rather than solely at the level of the corpus callosum, and hence it may be under the influence of vestibular processing. It also has been noted that midline crossing appears to originate biomechanically, with rotational movements of the cervical, thoracic, and lumbar spinal segments, which are influenced by vestibular, proprioceptive, and visual inputs (Stallings-Sahler, 1998). This idea seems to be supported by Coelho and colleagues (2013) and Sainburg and colleagues (1999), who linked reaching dynamics to postural, anticipatory, and sequencing mechanisms in the central nervous system.

In summary, the relevance of examining for NSS in these areas links to how the two sides of the child's brain function to bring about skilled movement, share perceptual and cognitive information, and support the development of praxis and learning.

Right-left directional confusion or reversals. This NSS can be tricky to discern because the examiner should avoid mischaracterizing a language-labeling issue with true spatial directional confusion. By the age of 6 years, most typically developing children can rotely identify their right or left hand, but many children with a learning disability, ADHD, or autism display both directional and labeling confusion. In an older school-age child, this may manifest as inability to reverse a mirror image on another person (Corballis, 2018). The problem is more often seen in terms of spatial disorientation when relating the body to the environment and needing to turn to the left or right, or orienting the body to objects, such as clothing.

Caregivers and/or teachers will typically report observations, such as the child consistently getting their shoes on the wrong feet, confusion when donning clothing as to "front" and "back," running in the wrong direction on a sports playing field, or getting lost in the hallway at school. A reversed drawing approach and reproducing printed figures, or block designs that are constructed exactly opposite to the model presented, are other examples of directional confusion, which also have been noted to occur in children with dyslexia (Fernandes & Leite, 2017).

In summary, the basis of child challenges in bilateral integration is believed to lie in deficient processing of vestibular gravitational and proprioceptive sensations, with influence from the visual environment, as these sensations have been demonstrated to be vital to regulating postural tone and all that emanates from it.

Ayres proposed that at this level, poor inter-hemispheral integration might originate in brainstem and midbrain structures. Examining NSS at these and higher cortical levels, the relationship among inadequacies in bilateral body coordination, lateralization of motor functions, and possibly the ability to cross the body midline spontaneously have been hypothesized to be linked through neuroanatomical deficiencies in white matter integrity in parts of the corpus callosum, subcortical structures, and atypical emergence of normal cerebral asymmetry, which begins at birth (Best, 1988). Different patterns of hand preference and lateralized skill have been noted across different neurodevelopmental conditions, including autism, intellectual impairment, and learning disorders, but research results on their meaning have not reached a consensus.

Automatic Neuromotor Soft Signs. We refer to these as "automatic" because they are the least under volitional control because of a lack of normal inhibition by the cortico-spinal motor system over the extra-pyramidal system. The neurobiological origins of these NSS are still being explored.

Associated movements or synkinesis. Sometimes referred to as motor “overflow” or” mirror” movements, these are simultaneous movements of another part of the body not necessary to complete a certain motor task. Examples are holding the mouth stiffly, or protruding the tongue while attempting a skilled hand motion, or while performing diadochokinesia or finger opposition with one forearm/hand, the opposite extremity can be seen unintentionally mirroring with a similar “shadow” movement (Cox et al., 2012; Touwen, 1979).

Choreiform movements, tics, or tremors in the hands/fingers. Choreiform movements of the fingers, also called choreoathetosis, are small, jerky, and irregular movements that occur in distal muscles. We may observe them during Schilder’s arm extension procedure as the child stands with eyes closed and arms outstretched in front of the body, with fingers slightly separated. After a few seconds, fine writhing movements of the fingers appear (Ayres, 1973; Touwen, 1979). Choreiform movements have been associated with dysfunction in basal ganglia processing (Mink & Zinner, 2010), whereas hand/finger tremors and tics may originate either with cerebellar or basal ganglia dysfunction (Leisman et al., 2014; Mink & Zinner, 2010).

Dysdiadochokinesia. In a study of NSS in children with DCD, dysdiadochokinesia was found in a neurological sub-group of children (Vaivre-Douret et al., 2016), suggesting cerebellar/basal ganglia involvement. In a group of children and adults with ADHD, performance of this maneuver was found to lag behind matched typicals, significantly by several years (Kaneko et al., 2016). This impairment refers to difficulty with performing rapid alternating pronation-supination movements of the forearms, which is assessed first unilaterally with each forearm/hand, then bilaterally/simultaneously after demonstration by the examiner.

A child with this impairment may have problems with performing complete forearm rotations, using excessive humeral abduction/adduction to compensate for poor dissociation of the forearms from the upper arms. This compensation may be linked to low postural tone, causing scapulo-humeral instability. Dysmetria (poor timing) and/or dysrhythmia (impaired rhythm) may also affect smoothness of execution (Touwen, 1979).

Further, the diadochokinesia test provides an opportunity to compare unilateral versus bilateral skill. Poorer bilateral than unilateral skill may suggest dysfunction in bilateral coordination, whereas poorer unilateral than bilateral skill tends to be associated with higher-level motor planning deficits, especially in the preferred arm/hand.

Dysmetria and dysrhythmia during timed upper extremity tasks. Errors in timing and rhythm may be observed during any standardized dynamic coordination test, or clinical observations where a certain rhythm or timing has been demonstrated for the child to follow (Mutti et al., 2017). Dysmetria has historically been associated with motor ataxia, whose locus of dysfunction is in the cerebellum. However, recent research has broadened our understanding of the cerebellum’s role in the regulation of other facets of behavior—executive cognition, language, and emotions, whose loci of control are found in the posterior-lateral aspects of the cerebellum. Thus, when we observe the NSS of dysmetria in children, it would be wise to think beyond “motor” if the child presents with problems in attention, emotion, and social skill set (Schmahmann, 2019).

Ankle clonus check to rule out mild spasticity. A percentage of children diagnosed with DCD have been found to have mild spasticity on testing of the phasic stretch reflex. A quick way to rule out this upper motor neuron source of incoordination is through testing of ankle clonus. Vaivre-Douret and colleagues (2016) identified “surprising co-morbidities” in 33% of a subgroup of DCD subjects with mild neurological dysfunction, including spasticity that affected sitting tone. From six to eight “beats” of ankle clonus suggests that phasic stretch reflexes are interfering with movement beyond simple soft sign incoordination (Touwen, 1979).

Even though occupational therapists (OTs) pursue specifically tailored changes in function and participation, it will be interesting to see whether NSS in the form of clinical observations change as we move forward in the process of achieving specific activity and occupation-based outcomes. Thus, new research designs that include specific areas of occupation (e.g., academic learning, behavior) and NSS or clinical observations may prove fruitful.

NSS related to developmental dyspraxia: Problems with imitation, complex motor sequencing, and symbolic representations. This group of NSS have been identified in children diagnosed with DCD, a heterogeneous movement condition that OTs generally identify as developmental dyspraxia because of its identification as one of the main sensory-based motor disorders (Ayres, 1989; Cermak & Larkin, 2002; Miller et al., 2007).

Children diagnosed with “clumsy” movement in childhood have significantly more soft signs and problematic perinatal histories than typical comparison children (Cermak & Larkin, 2002), as well as abnormal brain imaging results.

In a pilot study of children with DCD, diffusion tensor imaging showed the axial diffusivity of the corticospinal tract and posterior thalamic radiation is lower and significantly correlated with the high degree of motor impairment in children with DCD (Zwicker et al., 2011, 2012). Because of the complex nature of dyspraxia, soft signs must be judged within the context of what would be considered typical/atypical at different ages.

Erroneous imitation of demonstrated postures/movements. Imitating the actions of another person is a basic skill acquired as early as infancy, through the activation of fronto-parietal mirror neurons (Uddin et al., 2007). Among other NSS, impairments in gestural imitation and finger praxis have been found to be salient markers for developmental dyspraxia (Ayres, 1989;

Reeves & Cermak, 2002) and "mixed" type DCD (Vaivre-Douret et al., 2016).

Imitational impairments may be found involving some body segments, but not others; or grounded in the processing of sensory input needed to create the representational map, rather than in motor control (Mostofsky et al., 2006)—all of which suggest different neurobiological origins and different subtypes of DCD. Evaluation procedures involve demonstrating static postures or dynamic movements presented by the examiner, prompting the child to imitate the same gesture. Through these procedures, the OT may examine whole-body postures, positions of the hands/fingers, and oral-facial postures and movements.

Whole-body gestures. A familiar occupational therapy example of this procedure is the Sensory Integration and Praxis–Postural Praxis subtest (Ayres, 1989). However, standardized testing as well as research methodologies differ, with some investigators limiting challenges to arms and hands, hands only, or feet only, rather than involving the central body axis.

Below-typical performance in the ability to imitate meaningless gestures has been termed *ideomotor apraxia* in the motor control literature (Vaivre-Douret et al., 2016), with the caveat that it cannot be attributed to deficient memory for action or motor control, but rather to a problem with "representation" (Mostofsky et al., 2006), "mapping self to other" (Uddin et al., 2007), or inadequate cognitive planning of the movements needed to arrive at the posture or gesture (Ayres, 1973, 1989, 2005). Significantly low scores on gestural imitation tests have been found in large sub-samples of children with DCD, dyspraxia, autism spectrum, ADHD, and learning disorders.

Hand/finger positions. Just as with whole-body imitation, replicating hand/finger gestures may be static or dynamic, meaningful or not. The examiner instructs the child to watch and do what they do. The examiner then makes their finger(s) form a shape, such as a circle or cross, or another configuration, or gives the child a command to perform a representative action with an imaginary object, such as "show me how you would stir a bowl of oatmeal with a spoon" or "Show me how you would write with a pencil."

A sub-group of clinic children who do well on whole-body imitation items and excel at gross motor sports may nevertheless perform poorly on hand/finger praxis and struggle with fine motor tasks such as handwriting, suggesting that there are different neural networks mediating "gross motor" versus "fine motor" praxis.

Oral structures. Practic skill of the mouth is elicited by challenging the child to imitate the same oral positions and movements as the examiner, such as protruding the tongue, clicking the teeth, retracting the lips with the cheek muscles and so on (Ayres, 1989). NSS impairments in the ability to imitate oral movements, termed *oral dyspraxia*, may affect speech production and oral-feeding proficiency. When impairment directly affects the child's ability to produce speech sounds, it is called *verbal dyspraxia* or *apraxia of speech* (Malmenholt et al., 2017). Oral dyspraxia has been defined as a core impairment in planning and/or programming spatiotemporal parameters of lips, tongue, and jaw movement sequences. Oral dyspraxia can further impair oral feeding skills in children at risk for food aspiration (Gisel et al., 1996) or be present in specific conditions such as fetal alcohol spectrum disorders (Terband et al., 2018). However, oral dyspraxia has not been fully explored in the mild to moderate neurodevelopmentally impaired/DCD population.

To summarize, NSS related to the different aspects of praxis—imitation involving various parts of the body, complex sequencing, and representational gestures—has over time have evolved from NSS screenings consisting of a few items to fully normed and standardized tests, which have provided greater specificity to elements of developmental motor coordination. Nevertheless, these areas should be probed in occupational therapy evaluations to help determine the presence of practic dysfunction in the child, which may be impeding the acquisition of occupational performance in self-care, play, academics, or social interaction. The global significance of praxis for neurodevelopment may lie in its unifying ability to organize many types of behavior, not simply movement, a possibility that bears further exploration.

SENSORY DISCRIMATION, COMMUNICATION, AND COGNITION

Together with higher-level praxis ability, these three areas together provide the examiner with a clinical "window" into cortically controlled functions of both hemispheres, discussed in the following sections.

Poor Sensory Discrimination and Interpretation. Historically, this area has been evaluated more completely using classical standardized perceptual testing in the major areas of visual, auditory, and somatosensory processing by occupational therapy and other professionals. However, the presence of difficulties with perceptual discrimination can be screened briefly to detect any gross deficits that bear further evaluation. For example, the evaluator may present a few key tasks that require the child to recognize, identify, match, replicate, localize in space, or integrate with another type of stimulus during a functional task (Dazzan et al., 2006; Kikkert et al., 2013; Mutti et al., 2017). Cortical maps have been identified through a functional MRI for haptic discrimination of shape, texture, and hardness, so significant impairment in this skill may suggest irregular development of these maps (Lederman et al., 2001). Proprioceptive discrimination can be assessed through the NSS strategies of Finger-to-Nose, Finger-to-(examiner's) Finger; or engaging in "ramp movements," consisting of following the examiner's abducted arms/hands as elbows flex to bring fingertips to the shoulders at varying speeds (Blanche et al., 2019). Vestibular discrimination is more challenging to discern because of its complex interdependency with proprioception and visual input. Therefore, it must be inferred from impressions of spatial awareness and topographical memory for place.

Refer to measures such as the Quick Neurological Screening Test, 3rd Edition, Revised (Mutti et al., 2017); the Miller Assessment for Preschoolers (Miller, 1982); or the First STEP Screening Test for Evaluation of Preschoolers (Miller, 1993) for more examples of screening of sensory discrimination skills.

Communication. NSS related to communication skills may be observed throughout the session by noting the child's speech and language production and quality, sample or report of written communication, and use of nonverbal strategies, any of which may signal the need for a referral for speech-language evaluation. These soft sign observations (within the context of age ranges) include (1) speech unintelligibility; (2) articulation errors, such as sound substitutions, and sound omissions in words; (3) length of sentences short for age; (4) need for repeated directions, suggesting poor receptive language; and (5) flat intonation of voice as well as echolalia and pronoun reversals (common in autism). A school-age child may have difficulty with reading or written expression of language unrelated to handwriting difficulties, signaling possible language dysfunction.

Cognition. Total NSS correlation with cognitive markers, and those reflecting attention problems, which may in turn affect cognition, were discussed earlier in this paper (Alamiri et al., 2018; Tupper, 1997). During the occupational therapy evaluation process, inadequate executive functions may be suspected if deficits are observed in (1) impulse control; (2) family/teacher report of poor preparation for future tasks (such as writing down homework assignments in calendar); and (3) disorganization of belongings and space (Mares et al., 2007). Difficulty with remembering and replicating complex movement sequences has been mentioned as a NSS in children with ADHD (Schreiber et al., 2014) and DCD (Bernardi et al., 2018), a motor memory skill that may share a common neural network underlying executive processing in the prefrontal cortex with support from subcortical structures (Leisman et al., 2014).

In debating about whether to include NSS related to language and cognition, we present a recently published hypothesis and evidence for the scaffolding of complex cognitive and language skills upon a foundation of sensory-motor processing, as articulated by Gonzales and colleagues (2018):

> "We further suggest that sensorimotor and cognitive functions are inextricably linked … Our view is that sensorimotor control serves as a loom upon which the fibers of language, executive function, spatial, and numerical processing are woven together to create the fabric of cognition" (p. 405).

CONCLUSION

Ayres (1973, 1989, 2005), Touwen (1979), Denckla (1985), and others have hypothesized that the neurobiological basis for many types of neurodevelopmental disorders might be revealed through elicitation of NSS as part of the clinical evaluation of children with ADHD, learning disorders, DCD/dyspraxia, and autism spectrum disorders. OTs constantly seek more accurate and efficient procedures in their examination of detailed aspects of childhood occupations as well as the sensory-motor processing difficulties that have the potential to prevent satisfactory participation in them. By understanding children's sensory and motor challenges, OTs can design more effective intervention strategies to assist their clients in living fuller, more productive lives.

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Neurodevelopmental Soft Signs: Implications for Sensory Processing and Praxis Assessment—Part Two

To receive CE credit, exam must be completed by October 31, 2021.

Learning Level: Intermediate to Advanced

Target Audience: Occupational Therapy Practitioners

Content Focus: Domain: Client Factors; OT Process: Occupational Therapy Evaluation and Interventions

1. Efficiency of two-sided extremity and body movements, smooth ocular pursuits and vergence, effective approach and crossing of body midline, and mature establishment of lateral dominance are neurodevelopmental capacities denoting:

- A. Postural and equilibrium abilities
- B. Bilateral body organization
- C. Hemiplegia
- D. Synkinesis

2. Research on the association between (1) poorly established lateralization of side dominance and (2) academics/intelligence has been inconclusive up to this point. A probable reason for this outcome is that:

- A. There is no validity to the hypothesis that body side-dominance is an indicator of brain lateralization and specialization of function.
- B. There is no validity to the hypothesis that lateralization of motor dominance affects academic performance or intelligence.
- C. Investigators are all using high level IQ tests to measure academic performance, which is inappropriate.
- D. Some investigators have used hand preference as the representative "hand dominance" variable, while others have used superior hand skill, causing inconsistent results.

3. Which of the following is not true concerning the condition of developmental coordination disorder (DCD)?

- A. DCD and Somatomotor dyspraxia have been determined to be the same condition.
- B. Children with DCD have significantly more neurological/neurodevelopmental soft signs (NSS) and problematic perinatal histories than typicals.
- C. Children with DCD have significantly greater occurrence of anatomical irregularities in the corticospinal tract and posterior thalamic radiations.
- D. The DCD diagnosis is heterogeneous, probably subsuming several different types of movement dysfunction, such as bilateral incoordination and the various subtypes of developmental dyspraxia.

4. Which of the following is true regarding comparisons of NSS occurrence and motor maturity between men and women, of which occupational therapists (OTs) should be aware?

- A. Boys start out "behind" on stationary balance and gait tasks but catch up by age 7.
- B. Girls and boys reach overall maturity of motor performance at about the same time.
- C. Men show greater proficiency on timed patterned tasks and better performance on spelling.
- D. Girls show fewer subtle motor signs and better performance on stationary balance and gait tasks.

5. Fine, writhing, or jerky movements of the fingers which have been associated with dysfunction in processing within the basal ganglia, are called:

- A. Tics
- B. Tremors
- C. Choreoathetosis
- D. Spasticity

6. Observation of rapid, alternating pronation-supination forearm movements also provides an opportunity to compare unilateral to bilateral skill of the upper extremities. Poorer simultaneous execution of the two hands than with one hand suggests a deficit in ______; while poorer execution with one hand than with two hands suggests greater deficiency in ______.

- A. Bilateral coordination; praxis
- B. Cerebellar control; cortical control
- C. Praxis; bilateral coordination
- D. Sequencing; timing

7. In a study of children diagnosed with DCD, Vaivre-Douret and colleagues (2016) discovered 33% of these children to have mild neurological signs, including unidentified spasticity, which affected sitting. Given this, it may be suggested for OTs to check out some of the child's:

- A. Diadochokinesia
- B. Prone extension
- C. Asymmetrical tonic neck reflex in quadruped
- D. Phasic stretch reflexes, such as ankle clonus

8. Children reported by caregivers and clinicians as having "clumsy" movements have been found through advanced brain imaging of white matter microstructure to have:

- A. Lower than normal axial diffusivity of the corticospinal tracts, and posterior thalamic radiations
- B. Higher than normal radial diffusivity of spinothalamic tracts
- C. The degree of abnormal white matter integrity not significantly correlated with the degree of motor impairment
- D. Primarily problems with ideomotor praxis

9. Which of the following is *not* a classic NSS observation for the presence of developmental dyspraxia?

- A. Representational gesture imitation ability
- B. Hand-finger postures imitational ability
- C. Using the hand and a writing tool to trace a line on top of a printed line
- D. Ability to follow a verbal direction to perform a bodily movement

10. The ability to identify shape, texture, or hardness of an object held in the hand, and for which cortical maps have been identified through functional MRI, is called:

- A. Haptic discrimination
- B. Touch localization
- C. Proprioceptive discrimination
- D. Stereognosis

11. A child who presents with poor planning for "future" events, disorganization of belongings and work space, and decreased impulse control may be showing signs of:

- A. Dyspraxia
- B. Inadequate executive functions
- C. Bilateral integration dysfunction
- D. Attention deficit-hyperactivity disorder

12. Numerous articulation errors, sound or word omissions, or pronoun reversals in a preschooler may signal the presence of:

- A. Non-verbal learning disorder
- B. Attention deficits
- C. Speech and/or language delay
- D. Oral dyspraxia

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