Profectum’s Introductory Course Lecture Series:
A Comprehensive Overview of the
DIR® Approach

Understanding the Child’s Individual Profile:
Motor Development

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Action:
MOTOR
CONTROL

Arousal
Sensory Modulation

Attention
What is Motor Control?

Motor control is defined as the ability to regulate or direct the mechanisms essential to movement.

- How does the central nervous system organize the many individual muscles and joints into functional coordinated movement?
- How is sensory information from the environment and the body used to select and control movement?
- How do our perceptions of ourselves, the tasks we perform, and the environment in which we are moving influence our movement behavior?

(Shumway, Cooke and Woolacott, 2007)

HOW DOES AFFECTIVE INTERACTIONS WITH OTHERS INFLUENCE MOTOR DEVELOPMENT, MOTOR CONTROL AND MOVEMENT?

Ari – 8 months
In Pursuit of the World
THEORIES OF MOTOR CONTROL

  • Sensory input for any motor output

  • The inhibition of primitive reflexes with the development of higher cortical structures

  • The physiology of movement with central motor programs (e.g., Pattern for writing same on paper, air or board)

  • The contribution of the nervous system but also the contribution of the musculoskeletal system - inertia. (Movement repertoire is like a sentences - The letters within a word are the muscles, the words synergies, and the sentences are the actions themselves)

  • A principle of "self organization". (example a horse that walks, trots, gallops, canters)
  • Thelen - The music infants create as they learn to move and explore would be best considered as a whole pattern of interactive elements rather than a sequence of individual notes.

  • Environment and perceptions to guide actions

Theories of Developing Postural Control

- Classic Theories (reflex hierarchy substrate)
  • Posture and movement control is dependent on appearance and subsequent integration of reflexes.

- More recent theories (systems, ecological, & dynamic actions theories)
  • Postural control emerges from a complex interaction of musculoskeletal and neural systems - postural control system with organization of elements determined by task and environment with reflexes being only one of the many influences on posture and movement.
REFLEX, RIGHTING, EQUILIBRIUM

POSTURAL REFLEXES or perhaps more accurately described as responses are transient and non obligatory in the course of infant development. Their presence is more overt when an individual is posturally stressed and working to achieve postural organization.

RIGHTING REACTIONS produce orientation of the head in space and orientation of the body in relationship to the head and the ground.

EQUILIBRIUM REACTIONS emerges in association with sequentially organized balance reactions. Equilibrium reactions serve to maintain or regain balance once the center of gravity has been displaced.
Role of Reflexes

- Controversial

- Some researchers believe that reflexes are the substrates for motor control.
  - For example: The ATNR is the basis for eye hand co-ordination while others disagree.
  - For example: Righting reactions are the basis for rolling in infants.

... or should the reflexes be considered a component of more complex postural patterns that develop with the increase of parallel processing, sensory association and inter-connectivity within the CNS.

... as postural control develops movement patterns reflect the response of the developing infant to the sensory, affective, regulation as it influences the infant’s intentional movement?

LET US CONTINUE TO QUESTION...

HOW DOES AFFECTIVE INTERACTIONS WITH OTHERS INFLUENCE MOTOR DEVELOPMENT, MOTOR CONTROL AND MOVEMENT?
Systems Theory

- Interaction of the child with the environment
  - Changes in the musculoskeletal system.
  - Balance of neuromuscular structures.
  - Development of sensory systems.
  - Integration of sensory systems.
  - Internal representations -> mapping of perceptions to action. Considered essential for comparisons, interpret self motion and calibrate motor actions.
  - Adaptive and anticipatory mechanisms -> child modifies the way they sense and move.

**........ thus the path from sensation to motor actions proceeds via an internal representation structure or body schema (Gurfinkel & Levik, 1978; Hirschfield, 1992)**
Postural Control & Development

- Gesell, 1946 described movement development over the first few years
  - Proximal to distal control
  - Spiraling Hierarchy
  - Characterized by alternating advancement and regression in the ability to perform skills

- Amiel, Tison and Grenier, 1980; note that when an infant is provided with stability in the head and neck movements seen in more mature infants emerge.

- Research on early development has shown that simultaneous development of the postural, loco-motor, and manipulative system is essential to the emergence and refinement of skills in all areas.

Postural Control & Development


- This Model Combines Elements Of All The Theories
  - Movement arises in the interaction of multiple processes, including those that are related to perception, cognition and action.
    - Motor action implies understanding motor output from the nervous system to the muscles for coordinated functional movement.
    - Perception is the integration of sensory impressions into psychologically meaningful information.
    - Cognitive control (attention, motivation, and emotional aspects of motor control) underlie establishment of intent or goals.

It is critical to recognize that movement emerges from an interaction between the individual, the task, and the environment in which the task is carried out.

"Motor Control Translating Research into Clinical Practice" Shumway, Cooke & Woollacott
Do infants all over the world have the same trajectory in motor development?

- Does an infant in mountains of Peru, Papua New Guinea, or aboriginals of Australia in missions and settlements have the same pattern as is anticipated in western society?
  - Think about the ground and the potential of parasites – how does that influence motor experiences of the infant.
  - Think about carrying patterns, and first movements.
- Does the infant in western society who is in a car seat for safety in the car but also for carrying purposes. Is their motor development different from the infant who is carried by their parent whenever they are up and out of the car?
- Is there a difference in motor development since the US Pediatric Association recommended “back to sleep?”
- Is there a difference in motor development for children who are placed in walkers at an early age?
Classification of Movement – Shared Attributes

TASK – ENVIRONMENT - INDIVIDUAL

- **Function:**
  - Directed – There is a function for the movement influencing the movement itself.
  - Non-Directed – There is no function for the movement.

- **Critical Attributes:**
  - Discrete – Movement has a beginning and an end (kick a ball)
  - Continuous – Movement continues with the end not inherent to the task but decided arbitrarily by performer.

- **Base of Support:**
  - Stable - Stability with non moving base of support, remaining in a position. These are less demanding of attention (standing or sitting).
  - Moving - Moving over the base of support. These require increased attentional resources (walking, running).

- **Movement Variability:**
  - Open Movement - Requires adapting behavior within a constantly changing and unpredictable environment (tennis, soccer.)
  - Closed Movement - Relatively stereotyped with little variation (sitting, standing, walk in open space.)

- **Environmental Constraints:**
  - Regulatory - Specific aspects of environment that shape movement - Size, shape, weight of object to be handled, surface supporting objects and self.
  - Non Regulatory - May affect performance but movement does not have to conform to features - Ambient stimulation such as background noise, visual background. May enhance movement, such as rhythmic sounds or hinder, such as a visually stimulating mall or classroom.

Is “IT” More than Acquisition of Motor Milestones?

- Is movement and the acquisition of motor milestones solely the result of the infant integrating primitive reflexes, responding to their sensory systems and the sensory environment and gaining strength in their musculoskeletal system?
  - OR
- Is the infant and developing child motor development equally influenced by the responsive, affective interaction of the caregiver?
Attention

Arousal

Sensory Affective Modulation

Action: PRAXIS

Attention
PRAXIS

- Praxis means “action based on will”
- Word of Greek origin meaning “doing, acting, deed, practice” (Safire, 1989)
- Praxis pertains to the planning of a motor act.
- It is a process that requires knowledge of actions and of objects, motivation and intention on the part of the person.

PRAXIS

- Action
- Motor Planning
  - Organizing and sequencing prior to action
  - Interconnectivity, sensory association – body scheme in relation to visual spatial, auditory spatial and emotional texture.
  - Intent to act, “will to act” either from child’s ideas or in response to others actions
PRAXIS

Praxis is a uniquely human skill that enables us to interact effectively with the physical world. (Ayres, 1985)

Praxis is the basis for dealing with the physical world in an adaptive way. (Ayres, 1985)

Praxis is not a strictly neuromotor function but it uses neuromotor system for execution of practic acts (Ayres, 1985)

Praxis and motor function are not synonymous (Ayres, 1985).

Ayres believed that the ability to process and integrate sensation formed the basis for the development of body scheme, sometimes referred to a body percept. This, in turn, provided a foundation for the conceptualizations needed for motor planning.

Kaplan (1977) considered praxis to be an acquired system of coordinated and intentional movement, the development of which begins during the Piagetian sensorimotor stage, suggesting mature praxis occurs when we demonstrate the ability to use gestural representation. Thus, in Kaplan’s view, praxis is more that a motor skill as well.
PRAXIS CONTRIBUTES TO THE ORGANIZATION OF SELF IN INTERACTIONS WITH OBJECTS AND PEOPLE IN THE CONTEXT OF AN AFFECTIVE INTERACTION

Praxis means “action based on will”

- The first action based on will is the intent to interact.
- The foundation for intent is affect driven.
- Intent is the foundation for purposeful movement
- Movement taught without embracing the child’s intent is not purposeful and will not readily generalize to other movement pattern.
PRAXIS
Non-Verbal Gestures & Communication

- Affect Cueing Can Be Understood As “The First Expression Of Praxis”
- An extension of affect cuing involves the development and organization of predictable and repeatable gestures, either through direct actions or across space.
- 85% of communication is non-verbal including gesture, tone of voice, facial expression, pacing. The affective tone of the non-verbal communication that contributes to meaning.

Tal Baz & Rosemary White, 2012
Neurobiology of Praxis

- Depends on intact prefrontal cortex, motor cortex including the basal ganglia, sensory cortices and sensory association areas, limbic system and cerebellum.

- Functionally praxis depends on
  - mirror neurons,
  - interconnectivity and cross modal integration,
  - efficient sensory processing and reactivity,
  - efficient motor control in the flow of shared attention, prediction, anticipation and the ability to adapt.

Mirror Neurons (Monkey See Monkey Do)

- Mirror Neurons, discovered by (Rizollatti et al., 1994), have a unique characteristic. These neurons found in the motor cortex are active both when we execute movements (e.g. grasping a cup of coffee) and when we passively observe other people executing those same movements.

- Mirror Neurons connect with other areas of the CNS with input coming into and out of the motor cortex from areas such as the parietal lobe (somatosensory cortex – homonculus or body map cortex), the temporal lobe (auditory cortex), occipital lobe (visual cortex).

- Mirror Neurons also connect to the Limbic system via the insula and influence our emotive response to others physical experiences and also physically expressed emotions.

- Mirror Neurons reflect the amazing influence of interconnectivity on our physical and emotional development as we interact with others.
Mirror Neurons and Shared Attention

As the parent shares attention in the intimacy of early interaction the parent observes the infant’s actions, and the parent’s mirror neurons fire and then in the flow of the interaction the parent then “mirrors/imitates the infant’s action. For example, “blowing raspberries when changing and infants diaper. Have you ever blown a raspberry back?”

When an infant is fussy a parent’s facial expression will have “matched mirroring”, not quite as intense as the infant, to communicate I feel your pain and together we will recover. Mirror neurons and the limbic system in action in an affective interaction. (Fonagy, Peter; 2009, Lecture)

Mirror Neurons and Praxis

Mirror neuron system is proposed to be a foundation for imitation.

Bringing this back to the affective interaction between the caregiver and the infant, when the pacing and affective cues are in synchrony with the infant to support arousal, alerting and attention the infant and later the toddler and developing child can take in the sights and sounds of the world to see the sequence of actions that make up a motor plan with a beginning, middle and end. The beauty of the mirror neurons is that they fire when a motor pattern has the physical attributes of an action that the individual has experienced. For example the mirror neurons will fire when an individual grasps an apple or an orange, the firing is dependent on the grasp pattern not the object handled.

In the richness of an affective interaction that is sensitive to the child, they can “feel” the parts of a sequence prior to doing it and this then builds the foundation for them imitating and then mastery of a motor plan.
Ideation

- The process of thinking, “knowing what to do”.
- Ideation is a cognitive process - Your ideas have come from prior experiences, from observations, and from your ability to adapt both earlier experience and observation of the situation at hand.
- Ideation is an initial step in the motor planning process, and it is a cognitive process - you figure out your goal and devise several ideas, or thoughts, as to how the goal might be reached.
- Ideation contributes to our ability to be creative and playful as we interact with the environment and is thought of as a contributor to imagination.

Affect Diathesis Hypothesis

- ….within a sensitive, yet rich, co-regulated affective interaction with an available caregiver the child develops the ability to connect affect that support their ideas, motor planning and sequencing capabilities as well as symbol formation.
Motor Planning

- This comes from knowing how the body is designed and how it functions mechanically.
- This information comes, in part, from the tactile, proprioceptive and vestibular systems.
- Furthermore, Ayres suggested that visual perception and praxis were closely aligned.

“*A conceptual system common to praxis also appears to serve visual perception.*”

(SIPT Manual, 1989)

Motor Planning

- Planning is a cognitive process involving putting together steps needed in order to achieve a goal or end product.

- Organization is paramount since the steps must not only be devised, they must be sequenced and transitions must be made from one step to the next.

- Planning is the organizing of a series of behaviors, both old and new, into a logical sequence, and it involves the ability to *anticipate* each step in the process (Ayres, 1985)
PRAXIS – Ideation and Planning

**Ideational praxis** - flow of ideas to form a plan to
- Use objects and tools in a correct way (bake a cake choosing the right ingredients)
- Order (using the mixer with the correct wisk in the correct socket)
- **Ideomotor praxis** - choosing the correct sequence of the steps to achieve the end goal (blending the butter and the sugar first)
Execution

- Movement depends on information traveling from various brain areas - relying on a continuous flow of sensory information before and during task performance (Kendal, 2000)
  -> description of the environment, the position and orientation of the body and extremities, mechanical information.
The cerebellum has a major role in execution of coordinated movement (Kiennan, 1998), though it is not direct and more in the integration of movement and feedback.

- The cerebellum is a comparator sending information to the brainstem and cortex which then send information to the spinal cord.
- The cerebellum regulates postural control, and guides movements of the eyes, head, body and limbs (Cohen, 1999).
- As an act is practiced repeatedly so that it can be done with greater proficiency and less conscious attention, the cerebellum transfers motor tactics from the conscious to the unconscious (Kingsley, 2000) - (Purkinge cells).

The basal ganglia receives input from the SMA & via the thalamus, project back to the SMA.

- Initiation of movement
- Dependent on context when movements are complex enough to require sequencing
- Active with onset of movement but also increase after movement initiation thus important with completion of movement sequences (Zigmond, 1999)
- Ventral area of basal ganglia receives input from the limbic system which may subserve motivation and emotion important to praxis and may be a part of the evaluator system (Graybiel and Kimura, 1995; Zigmond, 1999).
Ayres defined body schema as a neuronal model of the mechanical self, or a sensorimotor awareness of body parts, the movement of the body parts and their relationship with one another.

Nash (1970), defined schema as a diagram of the body in the brain critical for performance of coordinated movements.

Head (1920), maintained that body schema were derived from experience and acted as internal standards for recognition of movement.
Foundations for Praxis

Schema is not conscious, but developed out of feedback from our bodies and input or feedback from the environment.

Sensory, affective interaction that is sensitive to the child is an essential part of this process.

Sirigu (1995) discussed four representations that contribute to “body knowledge processing”

- Verbal information that gives names to body parts and their purposes;
- Visual spatial information about our own body and bodies in general;
- Dynamic body image (body position relative to other body parts and in relation to external world);
- Motor representation contribute to this knowledge.

Foundations for Praxis

Heilman and Rothi (1985), suggested that motor planning involves visuokinesthetic engrams, stored in the parietal lobe, which can then activate areas of the brain involved in planning and programming movement.
Foundations for Praxis

- **Tactile System**
  - Spatial and temporal characteristics of touch;
- **Proprioception**
  - Speed, rate, timing, sequencing and force; modify body image;
- **Vestibular System**
  - With muscle based proprioception, vestibular input contributes to posture and the maintenance of a stable visual field (Brodal, 1998; Horak, 1985; Shumway & Cook, 1987)
  - Important with proprioception in “how a specific movement feels” and also planning anticipatory movements or projected action sequences.

Foundations for Praxis

**Visual System**, in concert with the other sensory systems serves

- Learning about objects; maintaining posture, and informing about position in space (Fox, 1999);
- Recognition of where we are in relation to other objects thus enhancing our ability to approach or avoid objects.
- Vision influences cognition and plays a role in adaptation to the environment (Kosselyn and Koenig, 1992; Zoltan, 1996) and thus influences praxis.
Foundations for Praxis

Auditory System

- Auditory processing may contribute to organization of movement because it is responsible for providing information regarding spatial location of objects and events.

- Research linking the auditory system to praxis is virtually non-existent but some studies suggest that the auditory system may enhance movement.
  - It may be useful to examine the role of auditory enrichment. Pacing, or cueing to enhance the timing and sequencing of movement.
PRAXIS

Efficient praxis contributes to the child’s ability to:
- take in the sights, sounds and action in the environment and develop ideas about what to do (intentions)
- organize the body relative to their ideas (mirror, imitate, organize)
- sequence purposeful gestures and actions,
- execute actions to convey ideas and obtain desires,
- master physical skills and problem solve physical actions to lead to independence (body power, play skills and self help)
- seek help when the child realizes that they cannot solve the problem
- adapt a plan when the environment changes or in response to another’s actions and words

“thinking, planning, sequencing and organization prior to action is more than the physical action itself”

PRAXIS

When there is a challenge in praxis we have to determine the contributing area or areas of difficulty and address them in an affective thinking relationship that is sensitive to the individual child.
ACTION

Intent to act, "will to act" either from child’s intent or in response to others actions Or adapting to feedback

Interconnectivity, sensory association – body scheme in relation to visual spatial, auditory spatial and emotional texture.

Cerebellum – the comparator
Feed-forward (motor plan) is compared to Feedback from the body

Motor Planning
Organizing and sequencing prior to action

SENSORY AFFECTIVE INTERACTION

Action
Arousal:
- Deep sleep
- Light sleep
- Drowsy
- Quiet alert
- Active alert
- Crying

Attention:
- Alert
- Orientation
- Shared attention
- Joint attention
- Attention shifts

Sensory Affective Modulation
REGULATION OF BEHAVIOR

Arousal  Attention

Sensory - Affective Modulation

Action
Sensory - Affective Modulation supporting Attention and Action; A long term process, unfolding throughout development.