If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.

This handout is for reference only. Non-essential images have been removed for your convenience. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.
Motor Behavior in Infants and Toddlers: A Developmental Systems Perspective

Tricia Catalino, PT, DSc
Board-Certified Clinical Specialist in Pediatric Physical Therapy

Tricia.Catalino@tun.touro.edu

Objectives -
As a result of this course, participants will be able to:

- Describe at least 3 theories leading to the developmental systems perspective of infant motor behavior.
- Identify at least 3 factors that relate to how emerging motor behaviors in infants and toddlers bring opportunities for learning, leading to more opportunities for moving and doing.
- Describe at least 3 examples of the interaction of the infant and their physical, social, and temporal environments.
- Identify at least 3 results of research describing the development of postural control, locomotion, manual actions, and movements of the face and neck in infants.
Choose the BEST representation of typical gross motor development in infants:

A. Development progresses cephalocaudally and proximally to distally.
B. Developmental sequence varies from child to child.
C. Postural control stability is present before mobility in newborns.
D. Creeping on hands and knees is universal to all infants.

**Universality**

FIG. 3.1 Developmental timeline for several gross and fine motor milestones.
Variability

Developmental Theories

- Neuro-maturationist
- Cognitive – behavioral
- Cognitive – Piagetian
- Motor Learning
- Cognitive Theory
- Dynamical Systems
Neuro-maturationist

- Development is dependent on the maturation of the nervous system.
- The nervous system alone “drives the developmental bus”
- Primitive reflexes and how the nervous system responds stereotypically to a stimulus.

(Harbourne & Dusing, 2017)

Cognitive - Behavioral

- Development occurs through interaction of the individual with the environment.
- Operant Conditioning >>
  - Positive reinforcement leads to seeing a behavior MORE often.
  - Negative reinforcement leads to seeing a behavior LESS often.

(Harbourne & Dusing, 2017)
Cognitive - Piagetian

- Development occurs through interaction between cognitive-neural structures and environmental opportunities for action.
- First actions using reflexes and later from voluntary actions.

(Harbourne & Dusing, 2017)

Motor Learning Cognitive Theory

- Trial and error practice leads to the development of motor programs.
- General motor programs, recall schemas, and recognitions schemas are the building blocks that contribute to development.

(Harbourne & Dusing, 2017)
Dynamical Systems Theory

Apparent stages of development are actually states of relative stability arising from the self-organizing, emergent properties of a multitude of systems, each developing at its own continuous rate;

Harbourne & Dusing, 2017

Dynamical Systems Theory

The individual develops as the organism recognizes the affordances of the environment and selects (self-organizes) the most appropriate available responses to tasks;

Harbourne & Dusing, 2017
Dynamical Systems Theory

Multiple cooperating systems with individual rates of development and self-motivated exploration of the environment.

Harbourne & Dusing, 2017

Dynamical Systems Theory

Neuronal Group Selection Theory
Embodied Mind Concept
Perception Action Theory
Ecological Theory
Neuronal Group Selection Theory

- “Neural Darwinism”
- Explains the relationship of the brain to behavior.
- Three basic tenets describing:
  - How the anatomy of the brain develops
  - How experience strengthens patterns of response from certain structures
  - How individual behavior functions can be mapped to the brain.

Harbourne & Dusing, 2017

Embodied Mind Concept

- Because the brain is plastic and responds to experience and information gained through movement, the viewpoint that the mind is built via the physical activities of the body within the environment >>> defined as embodiment.
- Evidence from infant studies suggests that the mind is embodied, meaning that a strong linkage exists between what we know and what our bodies can do.

Harbourne & Dusing, 2017
Perception Action Theory

- We must act to perceive AND perceive to act.
- Considers the relationship between self-generated movement and the child’s understanding of properties of the environment in a cyclical pattern that builds skills.
- Therefore, movement plays a central role in what we know and can perceive.

Harbourne & Dusing, 2017
Environmental Features

Social Environment

Interactions and Relationships
- family members
- peers
- caregivers
- extended family members
- other adults

Child’s Natural Environment!
Physical Environment

Structural Conditions
- Space
- Equipment
- Material Resources

Safety and Access!

Temporal Environment

- Scheduling or sequencing of daily routines and activities in children’s natural environments with attention to elements relating to time (e.g., transitions, length of activities).
- Evolution of humans over generations.
- Family life cycle.
What does this chart represent to you?

Is it an accurate representation of motor development?
“Development, then, can be envisioned as a changing landscape of preferred, but not obligatory, behavioral states with varying degrees of stability and instability, rather than as a prescribed series of structurally invariant stages leading to progressive improvement.”

Esther Thelen, p 77, Mind as Motion, 1995
<table>
<thead>
<tr>
<th>Blumberg, Spencer, &amp; Schenk (2016)</th>
</tr>
</thead>
</table>

“… developmental systems perspective provides a broad framework for thinking about individual development at multiple levels (molecular, neural, and behavioral) and timescales.”

“No specific entity—genetic or otherwise—controls the process.

Instead, development is emergent, like a flock of birds in which each individual bird, following simple rules and without instruction from a leader, contributes to the organized behavior of the group.”

Blumberg, Spencer, & Schenk (2016)
Blumberg, Spencer, & Schenk (2016)

“... systems framework for individual development extrapolates over evolutionary time.

Rather than imagining individuals as being ‘shaped’ by their environments, the animal and its environment evolve together as a codependent system.”
Adolph & Franchak (2016)

"New motor behaviors can emerge from a mix of interacting factors, some so pervasive that we mistakenly take them for granted, and some so subtle or nonobvious that we fail to recognize the link.

Developmental changes in one domain can have cascading effects on development in other domains, sometimes far afield from the original accomplishment.
“New motor behaviors can emerge from a mix of interacting factors, some so pervasive that we mistakenly take them for granted, and some so subtle or nonobvious that we fail to recognize the link.

Developmental changes in one domain can have cascading effects on development in other domains, sometimes far afield from the original accomplishment.

Moreover, the context in which behavior develops can be very different for individual children, resulting in developmental pathways that sometimes converge at the same outcome and sometimes veer off in unique directions”.

“… context in which behavior develops can be very different for individual children … “

Factors External to the Nervous System
“… context in which behavior develops can be very different for individual children … “

**Factors External to the Nervous System**

- Anthropometrics, body mass, nutrition
- Musculoskeletal system factors
- Cultural differences
- Task demands
- Environment

**Factors Intrinsic to the Nervous System**

??
“… context in which behavior develops can be very different for individual children … ”

Factors Intrinsic to the Nervous System

- Cognitive & behavioral factors
- Sensory factors –
  - Vision
  - Hearing
  - Vestibular
  - Somatosensory
Which of the following components are necessary for any motor behavior?

A. Vision  
B. Postural Control  
C. Age

Adolph & Franchak (2016)

- Postural Control
- Locomotion
- Manual Actions
- Movements of the Face & Neck
Overcoming gravity

Basis for action
Postural Control

Dynamic
postural control

**Posture**
(Adolph & Franchak, 2016)

Posture is the core ingredient of motor skill.
Posture is the core ingredient of motor skill.

With no postural control, most motor behaviors are impossible.

Postural control emerges from the interaction of a growing body dealing with the constraints of the physical environment—gravity, air, the properties of the support surface, and so on.
Posture is the core ingredient of motor skill.

With no postural control, most motor behaviors are impossible.

Postural control emerges from the interaction of a growing body dealing with the constraints of the physical environment—gravity, air, the properties of the support surface, and so on.

Cascade of new skills and opens up new possibilities for looking, social interactions, manual actions, and locomotion.

Partly a perceptual accomplishment - even while sitting and standing, body always slightly swaying and perception plays a key role in keeping the body inside the base of support.
Posture (Adolph & Franchak, 2016)

Caregiving practices can speed up or delay postural control and the cascade of new skills that follow.

Partly a perceptual accomplishment - even while sitting and standing, body always slightly swaying and perception plays a key role in keeping the body inside the base of support.

Postural control emerges from the interaction of a growing body dealing with the constraints of the physical environment — gravity, air, the properties of the support surface, and so on.

Cascade of new skills and opens up new possibilities for looking, social interactions, manual actions, and locomotion.
True of False?

The stepping reflex is necessary for children to learn to walk.

True=Yes
False=No
“Precursory locomotor movements are exhibited during fetal and neonatal periods, but locomotion is not reflexive or hardwired.

Rather, locomotion is creative and infants must learn to control locomotion adaptively.

Locomotion improves with practice, and practice can lead to extraordinary performance”.
(Adolph & Franchak, 2016)
Figuring it out!

(a) Crawl Sit Prone Backing

(b) Hunchback Windsurfing Mountain-climbing Drunk

FIGURE 4 (a) Some of the strategies infants use to descend slopes: squatting down in a sitting position, crawling on hands and knees, developing head-first while pressing, and turning their bodies to back down first first. (b) Some of the strategies infants use to cross bridges holding a stabilizing handrail for support. Infants employ a "hunchback" strategy by pushing down on the wall to make it easier to walk sideways while leaning back to make it easier to "windsurf," walking forward and pulling back on the rail as if "mountain climbing," and "drunkly" leaning against the wall as they staggered forward. (Reprinted with permission from Bell et al. Copyright 1987 American Psychological Association (APA) and Reprinted with permission from Bell et al. Copyright 2005 Wiley.)

Learning to Walk!

Requires sufficient strength and balance to support the body on one leg as the other leg swings forward.

(Adolph et al., 2010)
Experience standing, stepping, and moving upright facilitates gains in strength and balance and accelerates the onset of walking. (Adolph et al., 2010)

A few minutes of daily practice with upright stepping causes infants to begin walking weeks earlier than infants who receive only passive exercise. (Zelazo, 1983)
In 1 hour of free play, the average toddler takes about 2400 steps, travels the length of about 8 U.S. football fields, and falls 17 times. (Adolph et al., 2012)

Navigating obstacles

“Perception-action coupling makes locomotion functional. To navigate the everyday cluttered environment, children must select the appropriate movements and modify them accordingly, whether crawling, walking, or riding a bicycle”. (Adolph & Franchak, 2016)
Navigating obstacles

“Perception-action coupling makes locomotion functional.

To navigate the everyday cluttered environment, children must select the appropriate movements and modify them accordingly, whether crawling, walking, or riding a bicycle”.

(Adolph & Franchak, 2016)

Fetuses and neonates can produce leg and arm movements that grossly resemble locomotion, but locomotion is not hardwired or reflexive”.

(Adolph & Franchak, 2016)
“Locomotor development is plastic and responsive to caregiving practices”.

“Locomotion is wildly creative”.
“Every infant discovers a unique solution for their first crawling, walking, bum shuffling, or rolling ‘steps.’”

“Must then learn to generate information for perception and cognition to find the right solution to suit the local constraints of the cluttered, obstacle strewn everyday environment.”
True or False?

In infants, reaching occurs before grasping.

True=Yes
False=No
Manual Action

Spontaneous Motility
Reaching & Grasping
Exploring Objects
Using Tools

Manual actions appear prenatally.

Perception-Action already! Infants open their mouths in anticipation of, not in reaction to, the arrival of their thumb, for example.

Spontaneous arm and hand movements continue after birth.
As in locomotion, the contextual influences of infants’ bodies, physical environment, and social/cultural environment affect the development of manual skills.

Some flap their arms and randomly “succeed”

Some “aim” for a target.

All are unsuccessful at first!

Reaching and Grasping


“Reaching precedes grasping because control of the arms precedes control of the hands.”

Reaching and Grasping

Exploring Objects

Holding object’s creates new opportunities for visual, manual, and oral exploration, and with increasing skill, object exploration becomes more complex.

“At first, infants use their hands only to bring objects up to the face for looking and mouthing. Increased grip strength allows infants to alternate between looking and mouthing, providing multimodal information about object properties.”
“Tool use requires infants to perceive that a goal is beyond their abilities, recognize that an object can serve as a means to augment their abilities, and execute the necessary movements to use the tool.”

To do this – infants must acquire the skills in development. For example, perceiving when an object is out of reach as a very young infant and then using hooks, canes, and rakes to acquire the out-of-reach object, months later.
“Beginning prenatally, manual actions are perceptually guided and serve exploratory functions.”

| Many of infants’ spontaneous arm and hand movements are co-opted for goal-directed manual actions and tool use. |
| Infants use vision to locate the target of a reach and to preshape their hand for grasping, but they do not require sight of their hand to get it to a target. |
| “Exploring objects is a multimodal activity involving eyes, hands, fingers, and mouth.” |
| “Boosting up manual skills can jump start the cascade of opportunities for learning.” |

**Manual Action**

“Many of infants’ spontaneous arm and hand movements are co-opted for goal-directed manual actions and tool use.”

“Infants use vision to locate the target of a reach and to pre-shape their hand for grasping, but they do not require sight of their hand to get it to a target.”
“Beginning prenatally, manual actions are perceptually guided and serve exploratory functions.”

“Many of infants’ spontaneous arm and hand movements are co-opted for goal-directed manual actions and tool use.”

“Infants use vision to locate the target of a reach and to preshape their hand for grasping, but they do not require sight of their hand to get it to a target.”

“Exploring objects is a multimodal activity involving eyes, hands, fingers, and mouth”.

“Boosting up manual skills can jump start the cascade of opportunities for learning”.

Manual Action

Which of the following statements about the development of movement of the face and neck is true?

A. Infants adapt their jaw movements and biting force based on the type of food they are eating.
B. Fetuses make sucking, breathing, and swallowing movements that are coordinated.
C. Facial expressions and vocalizations appear long before infants can convey feelings and communicate ideas.
D. Postural control is not related to the function of looking with the eyes.
Movement of the face & neck appear prenatally – however, because they do not breathe air or eat, the movements are not coordinated.
Swallowing, Sucking, & Chewing
Adolph & Franchak, 2016; Jones, 2016

Newborns nurse without choking by coordinating their tongue, jaw, and lips.

Swallowing, Sucking, & Chewing
Adolph & Franchak, 2016; Jones, 2016

Chewing solid food is more complicated! Infants rely on lateral jaw movements (and use them regardless of the type of food) as opposed to rotary movements in older children & adults.
Facial Gestures & Speech
Adolph & Franchak, 2016; Jones, 2016

“Facial expressions and vocalizations appear long before infants can convey feelings and communicate ideas.”

Again, prenatally, fetuses produce motor actions that resemble adult-like expressions (smiling, grimacing, etc.)

“Perhaps because they are so critical for social interaction, facial expressions are highly redundant so that muscles distributed throughout the face work in concert; eyebrows can convey basic facial expressions as effectively as the mouth.”
Facial Gestures & Speech
Adolph & Franchak, 2016; Jones, 2016

To produce speech, children must learn to use the most complex movements.

“The jaws, lips, and tongue must be precisely positioned to shape each sound as air travels through the oral and nasal cavities. Both speed and accuracy are major challenges in speech development.”

Looking
Adolph & Franchak, 2016; Jones, 2016

- Involves coordinating the body, head, and eyes.
- Newborns simply look at whatever is in front of them.
- Infants still usually look at what is in front of them even as their posture improves.
Looking

Adolph & Franchak, 2016; Jones, 2016

- “Like other motor actions, looking is more functional and adaptive when eye, head, and body movements are controlled prospectively.”
  (Tracking is easier when it is predictable)
- As in the case of walking, infants amass tremendous amounts of experience while learning to look.

Facial Actions – Summary

- “Facial actions include many of our most prized and basic social skills—talking, facial gestures, eating and drinking, and looking at others and at the environment.”
- “And each of these skills sets off a new cascade of interactions.”
- “Infants’ solutions for moving the various parts of their face often differ from those of adults, but they get the job done in that developmental niche.”

Adolph & Franchak, 2016
Tricia Catalino, PT, DSc  
Board-Certified Clinical Specialist in Pediatric Physical Therapy  
Tricia.Catalino@tun.touro.edu

References