
Carl Gabbard
Department of Health & Kinesiology, Texas A&M University, College Station, TX, USA

This commentary reflects on the discussions of Whitall et al.’s paper “Motor Development Research: II. The First Two Decades of the 21st Century Shaping Our Future.” Comments focus on (a) the emergence and importance of the Developmental Systems approach to motor development, (b) the perceived ambiguity between Dynamic and Developmental Systems approaches, and (c) a case for the evolution of Developmental Motor Neuroscience from the field of Developmental Cognitive Neuroscience.

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First, I wish to express how proud I am of my colleagues’ paper, “Motor Development Research: II. The First Two Decades of the 21st Century Shaping Our Future” (Whitall et al., 2020), and the insight it brings to our understanding of how motor development research perspectives have evolved in the 21st century. The authors propose that approaches to the study of motor development have changed from a focus on Dynamic Systems (from the 1980s spearheaded by Esther Thelen’s work) to the current day Developmental Systems approach. The authors also suggest that that approach has evolved into the field of Developmental Motor Neuroscience using innovative brain imaging and measurement techniques which allow insight into the neural basis of how coordinated movement develops. I agree wholeheartedly with that proposition, especially the emergence of the Developmental Systems approach and its value in helping us better understand how motor development evolves and is influenced by several complex interacting systems.

This commentary intends to expand the relevance of the Developmental Systems approach, talk about the ambiguity between dynamic and developmental systems, and finally, add a note to Whitall and colleagues’ suggestion for a new field titled Developmental Motor Neuroscience.

Address author correspondence to c-gabbard@tamu.edu, https://orcid.org/0000-0003-2841-5833.
The Developmental Systems Perspective

Whereas there are several interpretations of Developmental Systems used in a variety of scientific fields, one of the most prominent that has direct application to motor development is one proposed by Richard Lerner (Lerner, 2002, 2012). This approach advocates the notion that human development is the product of changing relations between the developing person and his or her changing multilevel environmental contexts. That is, a person is a dynamic, self-organizing unit consisting of several systems (e.g., neurological, muscular, skeletal, and cognitive) with multiple levels within each system. Included in these interactions are ecological contexts (systems): home, school, culture, and social influences within (e.g., family, peers, and coaches). This “general” approach emphasizes the reciprocal interactions between our biological characteristics and the environment. This approach aligns nicely with the contemporary notion of epigenesis; development results from an ongoing, bidirectional interchange between one’s biological characteristics (including heredity) and the environment.

As Whitall and colleagues note, this approach complements Thelen’s (2000) idea that the study of motor development should involve the exploration of the multiple and interacting “systems” of the brain and body. An important step further has been the addition of considering possible environmental effects in our quest to understand underlying influences.

One of the most prominent researchers of contemporary motor development, Karen Adolph, adds to the Developmental Systems idea with the Adolph and Hoch paper (2019) proposing that development is: embodied (opportunities for action depend on the biological status of the body), embedded (environmental contexts create and constrain action), enculturated (social and cultural effects), and development is enabling (new skills create new opportunities for action; that is, enable a developmental cascade). This proposition clearly emphasizes the interacting agents of the body (biological) and one’s environment. In an earlier paper, Adolph and Robinson (2013) stated, “This unified ‘developmental systems’ view of neurobehavioral development emphasizes the multiple resources underlying development and provides a framework for addressing more specific questions” (p. 427).

Other motor development researchers have also described their work under of premise Developmental Systems (e.g., Adolph & Robinson, 2015; Spencer et al., 2009; Withagen & van der Kamp, 2010). For example, in the Spencer and colleagues’ paper, the authors highlight what the Developmental Systems perspective offers researchers in the 21st century. That treatise included five insights from Developmental Systems theory: (a) processes live at multiple levels from culture to genes; (b) there are cascading, nonlinear, and often nonobvious interactions among levels; (c) no one (level) is in control; (d) these nested interactions propagate over multiple time scales; and (e) nested interactions can lead to the emergence of new patterns of organization in context. It is interesting (and enlightening) how these propositions complement Lerner’s ideas and those of Adolph and Hoch. The authors concluded by stating “Putting all these critical insights together results in a theoretical approach that focuses on the developmental process ‘all the way down’—from neighborhoods to neurons—and at all time scales from milliseconds to minutes to days to years to eons” (p. 104).
In 2018, Golenia et al. (2018) provided additional support for the Developmental Systems approach. Their initial intent was to address the lack of using ideas from the Developmental Systems perspective on the study of reaching development during mid-childhood. The researchers note the importance of examining each component of the system and how each one changes on its own time scale. That is, the Developmental Systems approach views changes in actions not as a reflection of changes in a single process or component, but as resulting from the interaction of multiple changing components acting on different levels of the system. They go further to interpret that “Automatically, this means that the environment and the task are equally important parts of the system” (p. 3). An important note here, which will be discussed in a subsequent section, is that the authors considered the plan of studying “systems” to include information gathered in the environment via the perception–action cycle. Arguably, as used in many studies using the Dynamic Systems approach.

After an extensive review of the literature on the early development of attentional biases in infants, Reynolds and Roth (2018) interpreted their findings under the framework of Developmental Systems Theory. The researchers emphasized the influences of several systems including biological (e.g., arousal, neural development) and environmental (e.g., early social experience). Underlying their theoretical approach to interpretation was the idea that “phenotypic outcomes are the product of reciprocal and bidirectional interactions of multiple factors both internal and external to the developing organism.” The review considered behavioral measures and the measurement of neural correlates of infant multimodal perceptual processing. The researchers concluded that the Developmental Systems approach provides an ideal framework for interpreting the development of attentional biases in infancy.

**Ambiguity Between Dynamic and Developmental Systems**

If one were to review motor development research over the last 20 years some would perceive a distinction between discussions of Dynamic and Developmental Systems, while others would find the terms indistinctive and interchangeable. As noted earlier and illustrated in select studies, Developmental Systems are a general approach that considers biological and environmental factors (aka systems). On the other hand, most studies that note the use of the Dynamic Systems approach, especially in motor behavior, appear to focus primarily on biological systems. More contemporary work illustrates this. For example, Niklasson et al. (2018) note that the Dynamic Systems perspective on motor development stipulates that novel motor behavior emerges as a result of interactions between different subsystems (assuming biological subsystems). Similarly, van Geert and van Dijk (2021), in their review of the literature on individual variability, note that the research is based on the theory of complex Dynamic Systems. Whitall and Clark (2018), in their paper discussing the perception–action approach to understanding typical and atypical motor development, begin by describing the Dynamical Systems perspective.

Interestingly, in their review of theoretical approaches to studying infant behavior (including motor development), Darrah and Kembhavi (2022) described...

So, there would appear to be what may be described as the ambiguity between the approaches. One could argue that the Developmental Systems approach is more of a “general framework” that includes biological and environmental influences and the changing relations between the two. The use of Dynamic Systems theory appears to be more specific to biological systems associated with perception to action. However, a closer look at some of the Dynamic Systems research (e.g., reaching and walking) includes in varying degrees influences of environmental constraints (e.g., the task, types of affordances, family characteristics, parental support, movement space, cultural practices); therefore, aligning with the Developmental Systems model.

In conclusion, whereas some researchers may wish to keep the two system approaches separate, there is a good argument that Dynamic Systems is within the general framework of the more comprehensive Developmental Systems approach. Ideally, as that approach posits, to truly understand the multicomplex nature of change in development, biological, and environmental factors and their interactive properties should be considered. And some is the daunting task of the motor developmentalist.

**Developmental Motor (Cognitive) Neuroscience**

Following Whitall et al.’s proposition that Dynamic Systems has evolved to the Developmental Systems approach, I posit that there is an argument that Developmental Motor Neuroscience has evolved from Developmental Cognitive Neuroscience, which still needs our attention. The authors characterize Developmental Motor Neuroscience as a new approach that “unites the study of motor development with the advanced technical methodologies and models of neuroscience” (p. 5). More specifically, as the authors well illustrate, a look into the changing brain and its association with behavior. Whereas this excellent idea places focus on our motor agenda, a closer tie to developmental psychology, where most of our prominent journals are, is the emerging field of Developmental Cognitive Neuroscience (DCN). This scientific “field” has emerged in recent years as one of the more promising for the study of change in motor behavior. Furthermore, it shows promise in shedding light on classic developmental questions related to the mechanisms subserving developmental change. For our intent, this field addresses the question: What are the interrelations between developmental changes in the brain and behavior associated with the perception to action processes. As noted, with the promise of Developmental Motor Neuroscience, DCN offers a means to study both associations and dissociations using both behavioral and contemporary brain imaging (e.g., fMRI, PET) and measurement (e.g., EEG, MEG) techniques. According to Adele Diamond (2016), a prominent researcher with ties to motor development, DCN is an interdisciplinary field devoted to understanding how children’s minds change as they grow up, the interrelations between that, and how the brain is changing, and environmental and biological influences on that. DCN is an interdisciplinary scientific field situated at the boundaries of neuroscience, cognitive science, genetics, psychology, and movement sciences.
In 2007, a special issue of *Developmental Review* was published in recognition of this field’s emerging potential (see articles by Luciana, 2007; Pennington et al., 2007). After that publication, other prominent scientific journals devoted space to acknowledge this promising field (e.g., *Developmental Psychobiology; Astle & Scerif, 2009*), and *Developmental Cognitive Neuroscience* was introduced in 2011 (impact factor 6.46).

I strongly recommend viewing the initial and insightful article by Whitall et al., (2020), which provides more research examples and future directions for the field.

**References**


