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Developmental coordination disorder and its cause: The road less travelled

Michael G. Wade *, Makinzee Kazeck

School of Kinesiology, University of Minnesota, Minneapolis, MN 55455, USA

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ABSTRACT

We critically review the research literature that seeks to focus on the possible cause of children diagnosed with developmental coordination disorder (DCD). In so doing we contrast the traditional information processing (IP) approach as a model to explain the causal factors that account for the motor deficits present in children with DCD, with a dynamical systems (DS) account which argues that coordination deficits in children with DCD is less to do with problems of poor internal models (a cornerstone of IP theory) and more with a degrading of perception-action coupling. We review and comment on the extant empirical data and conclusions of both approaches. We conclude that the data for an IP explanation is weak and a reconsideration of DCD is in order with respect to the underlying cause of this issue.

Two roads diverged in a wood, and I,
I took the road less travelled by,
And that has made all the difference.

[Robert Frost]

1. Introduction

Developmental Coordination Disorder (DCD) is the internationally accepted term for developmental dyspraxia. It has been the preferred term for the American Psychiatric Association (APA< 1987, DSM III), culminating in the most recent edition DSM V (APA, 2013). DCD has also been the subject of 12 international conferences starting in London in 1993 and including the next, (DCD 12), in Freemantle Australia in 2017. In the present contribution, we consider theoretical accounts that have been proposed to explain DCD. We argue that the standard and most accepted explanatory framework is grounded on the traditional assumptions about mental "mechanisms", and the "processing" of information. We offer an alternative framework—the road less travelled—that is derived from an ecological treatment of behavior and cognitive function. We suggest that it is more useful to understand DCD as a deficit in the perception-action relationship, in the context of both task demands and the individuals understanding of his or her own action capabilities.

* Corresponding author.
E-mail address: mwade@umn.edu (M.G. Wade).

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The overarching concept of this perspective is the notion of embodied cognition, while not unique to the interpretation proposed here, the fields of movement science, cognitive psychology, robotics and neuroscience all recognize, in one form or another the principle of embodied cognition (EC). We should note here that EC is a concept that can be embraced both by constructionist (IP) perspective, and by a more "radical" perspective (Chemero, 2009), which incorporates Gibson's (1979) theory of direct perception. Here we promote Chemero's (2009) view that from an overarching EC perspective the proposed deficits in perception-action coupling by children diagnosed with DCD serves to minimize the necessity for internal representations by replacing the 'sense-think-act' cycle with the notion that coordination is central to the perception-action cycle, the central premise of the ecological psychology of James Gibson. Gibson (1979) argued that cognition arises from the coupling of perception and action and this can advance our understanding of motor control and coordination in both typically developing children (TDC) and children diagnosed with DCD.

Our reference to poet Robert Frost depicts the two diverging roads. One, the traditional constructionist, or IP view that DCD arises from deficits in unconscious inference; the other view, derived from the Ecological Approach to Perception and Action, proposes that the cause of DCD is a deficit in the relationship between perception and action. For an earlier commentary of this latter perspective, see Wade, Johnson, and Mally (2005).

Over the past 30 years progress has been made in both the clinical description and assessment of children diagnosed with DCD. The quest for causal explanations has been hampered by the fact that the prevalence of DCD is approximately 5% of the population (APA estimate; Lingam, Hunt, Golding, Jongmans, & Emond, 2009), with boys at greater risk than girls. DCD often presents with co-morbidities, such as Attention Deficit Hyperactivity Disorder (ADHD), or Autistic Spectrum Disorder (ASD); (Sugden & Wade, 2013). There is disagreement about the nature of the disorder that underlies DCD: Is it a neurological problem? The National Institute of Neurological Disorders and Stroke (NINDS) refers to DCD as a "brain-based" disorder, and Hadders-Algra (2013a) argued that DCD arises from an as-yet-undetermined "minimal brain disorder". By contrast, the Diagnostic Statistic Manual (DSM-5 2013) states that DCD occurs in children of normal intelligence with no known neurological disorders.

The theoretical orientation and much of the related empirical research that drives the empirical effort to explain the underlying cause of DCD adheres to the standard information processing theory. This view has dominated both motor learning research and experimental psychology for the past half century, and remains current in its more contemporary form, cognitive neuroscience. The main assumption of the information processing approach is a constructionist view that assumes a collection of brain based representations that engage both perception and action based programs. The fundamental assumptions align with the Cartesian philosophy that requires the brain to construct meaning from the meaningless inputs present in the environment. Seeking a cause for DCD within this theoretical framework has generated a research focus on an array of 'in the head' devices such as executive function (the most recent), memory systems, visual-spatial processing, open loop responding, and similar representational models. It should be noted that a diagnosis of DCD represents essentially 5% of a population of children with a different set of resources, yet who appear on the same developmental spectrum as all children. The fundamental character of conventional cognitive science is the 'sense-think-act' cycle: Environmental information is "received" (*sense*); this information is processed (*think*) and action is then taken (*act*). This is a fundamental assumption that an ecological interpretation of EC considers to be flawed as such an approach minimizes the necessity for internal representations by replacing the 'sense-think-act' cycle with the assumption that coordination is central to the perception-action cycle, a central premise of Gibson's (1979) ecological psychology who argued that cognition emanates and develops from the coupling of perception and action (Brooks, 1999). The concept of EC can advance our understanding of motor control and coordination in both typically developing children (TDC), and those at risk for DCD. Wilson (2002) has described "Six views of embodied cognition", we (Wade & Chen, 2015) highlighted four of these as they might relate to children with DCD namely: Situated cognition; Cognition for action; Real time constraints; and Perception-Action coupling. While all may have implications for studying children with DCD, we focus here on the latter, Perception-Action coupling.

1.1. Perception-action coupling

An EC perspective contends that cognition develops as a consequence of the *perception-action coupling* system, emerging from the interactions between the organism and its environment. The animal and environment are mutual and reciprocal; the existence and influence of animal on environment, and the existence of and influence of environment on animal are both equivalent and complementary. Thus the organism and its environment is the appropriate unit of analysis for studying and understanding behavior (Chemero & Turvey, 2007). A good example of this is the stepping reflex in new born infants which typically disappears by 4 months of age. The traditional explanation for this disappearance was suppression of the 'primitive reflex' within the cortex. Central nervous system (CNS) maturation and/or an increase of information-computing capacity of the brain, was the accepted explanation. However, Thelen, Fisher, and Ridley-Johnson (1984) demonstrated the dramatic "reappearance" of infant stepping behavior, implying that the interaction between animal and environment systems (in this case pure physics!) was a critical factor when investigating the development of motor control and movement coordination in newborns.

Rather than relying on a series of internal processes to both interpret and construct motor responses in a machine–like manner, living systems have the capacity to self-organize an approach that has spawned dynamic systems theory. This idea of the system self- organizing addresses Bernstein's (1967) degrees of freedom problem, present in the musculoskeletal linkages of humans (and animals), that must be either frozen or freed, in order to execute a wide range of motor skill behaviors.