Towards a Dynamic Systems Model of Developmental Coordination Disorder

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ABSTRACT

Dynamic systems models have been applied to the study of human physical performance, including the nature of human skill. The term Developmental Coordination Disorder (DCD) was coined to describe a condition that previously had a variety of labels, such as clumsiness, motor dysfunction or dyspraxia. This paper examines the application of a dynamic systems framework to the nature and characteristics of DCD in children. In particular how it could contribute to the identification and remediation of the condition. It is concluded that a dynamic systems model can be a useful tool in understanding DCD, as it provides a comprehensive framework that analyses more effectively the nature of the condition.

1. Introduction

Motor control problems experienced by these children are not well understood. Systematic research into DCD is in the developing stages. For some the problem may lie in the integration of sensory and motor functions, for others it could be the central motor or more peripheral neuromuscular apparatus. In suggesting that “fundamental movement patterns of these children have not been established” (p. 160), Larkin and Hoare (1991) pointed to the status of research that may enhance the understanding of the child with DCD, indicating its developing nature. The study of children with movement difficulties is far behind that of the study of other childhood disorders. However, many notional theories have been suggested to explain motor clumsiness over the years, some based on clinical observation and others on studies that have produced only conflicting explanations. The research to date does not explain fully all aspects of the child with DCD (Geuze, 2001). This paper proposes that a dynamic systems model of human physical performance can be used to describe the nature and characteristics of children who experience movement difficulties. It is organised into two main sections. The first of these describes the nature of DCD and the second describes dynamic systems theory and how this may be applied to this condition.

2. Developmental Coordination Disorder

The causes of motor difficulties are varied, the nature of the condition is multi-faceted and the population more heterogeneous than a single classification would suggest (Sugden & Wright, 1998). These causes can be viewed in the model presented in Figure 1. In this model, the view is taken that all causes stem from the nature of the individuals and their reactions with the environment. This is a liberal philosophical viewpoint in relation to the traditional theories of human development, i.e., those that argue either nature or nurture having the principal effect on development (Newell & Scully, 1987). However, it is a view that is consistent with the holistic view of DCD, which considers the heterogeneity of the condition and espouses an integrative multi-disciplinary approach (Lockman & Thelen, 1993).

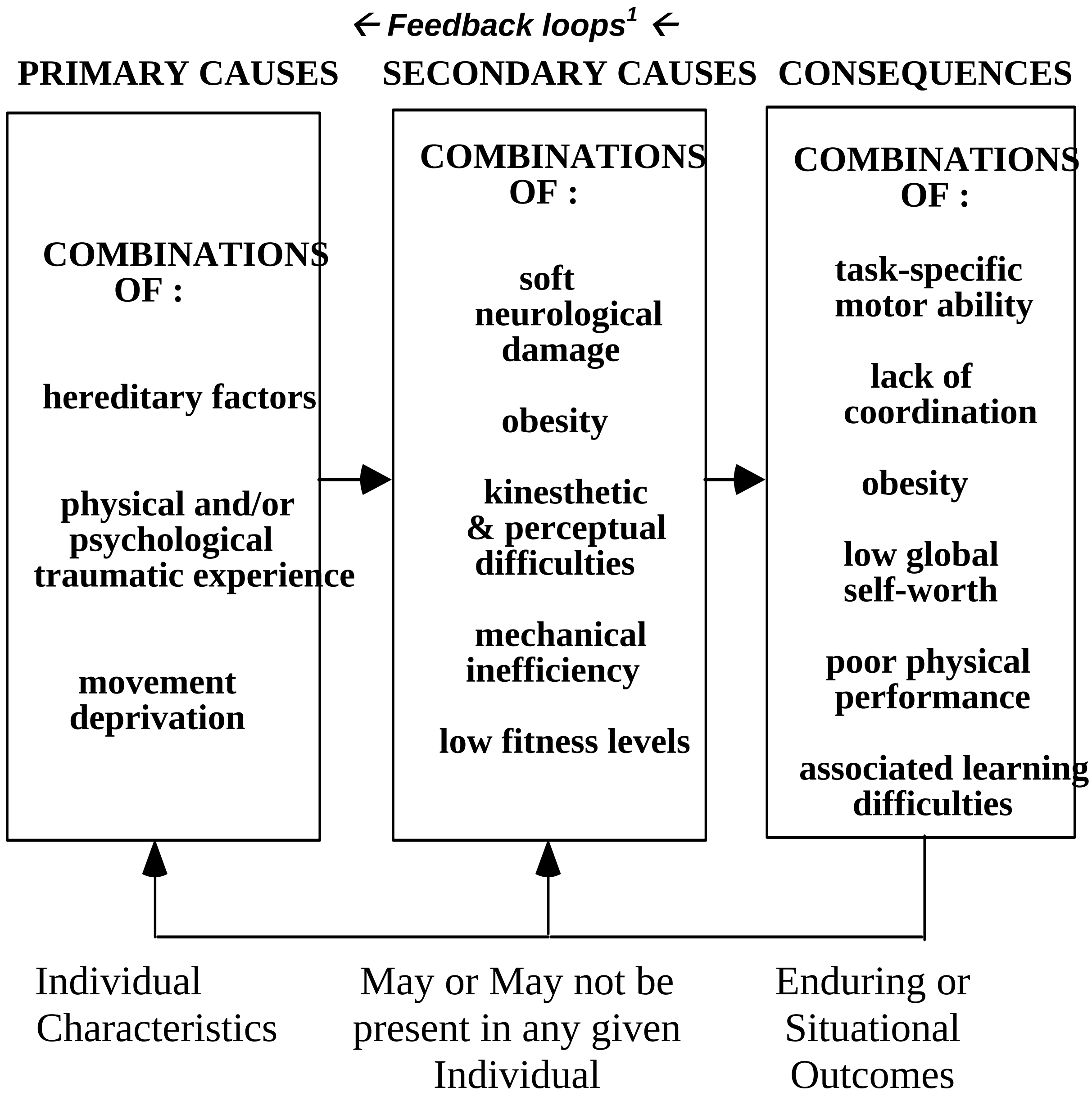

Figure 1: The Relationship Between Causes and Consequences of Motor Difficulties in Children

Even in presenting a model that confirms the notion of the heterogeneity of DCD, the relatively large number of causes and possible computations point to a condition, which is not simple to delineate. The picture that this model cannot portray, is one that depicts a more dynamic

[1] circular effect of some causes & consequences

interrelationship between causes, layers of causality and consequence. However, the model does provide an opportunity to distinguish between primary and secondary causes and the difference between cause and consequence (or symptoms).

2.1 Primary Causes Discussed

In presenting the antecedents of DCD in Figure 1, three major groupings of causality emerge, from which secondary causes or consequences are seen to flow. Firstly, it can be argued that hereditary factors would have as much of an effect on the movement ability of children as they would on other abilities. It would seem reasonable, then, to assume that movement inability could be predetermined in some cases and conclude that DCD can be genetically inherited at least for some individuals (Hoare, 1991; Magill, 1993; Walkley, et al. 1993; Cratty, 1994).

Secondly, damage through overt physical or psychological trauma to the growing child could result in serious and identifiable impairment. However, children affected in this manner would not meet the criteria used to define DCD. Therefore, the discussion is limited to the more covert, less obvious traumatic causes of movement difficulties. The most reported single traumatic event given as a cause of DCD is difficulty at birth. There is evidence to suggest a high incidence of difficulties with the birth process in children with DCD (Jongmans et. al., 1997). These difficulties could be linked to neural dysfunction and a consequent contribution to movement problems. Some comment linking psychological problems with coordination problems regard psychological difficulties as a consequence of poor coordination (Johnston et. al., 1987; Kalverboer et. al., 1990). Although association between DCD and self-worth are often reported, it is not established that psychological difficulties are a root cause of DCD, rather that most studies infer the link to be that DCD is the cause of psychological or social problems.

Thirdly, Movement Deprivation occurs when the child's opportunity for movement has been limited by environmental factors, illness or injury (Hoare & Larkin, 1991). Attainment of a mature form of fundamental movement patterns may not eventuate unless sufficient practice takes place and movement deprivation denies this. Children who have experienced a lack of opportunity for movement development are under-achievers, rather than children with DCD, and they respond well to remedial programs. However, the deprivation is sometimes severe and without proper attention there is a danger that their full potential will not be attained if early intervention is not forthcoming.

3. Dynamic Systems

The previous section indicated the heterogeneous nature and multiplicity of causes that characterise motor difficulties. Indicators evident in the model presented suggest that children with DCD do not exhibit normal patterns of motor development and may experience other associated difficulties. Although the true nature of the condition is clouded by different interpretations and definitions, it is possible to identify a number of causes and consequences of DCD. Environmental factors interact with many other casual factors and a resulting circular self-serving effect can ensue. Difficulty in learning to move, with its concomitant lack of success, leads to withdrawal from demanding situations which in turn leads to a deprived environment. It must be noted though, that a deprived environment is responsive to intervention. Therefore, working towards a model that might better reflect these interactive circular effects of the condition, may prove more useful in understanding the difficulties these children experience.

Figure 1 gave a somewhat hierarchical neuro-developmental approach to understanding motor development and coordination of movement, providing a neat compartmental framework through which to analyse human movement. However, this can be regarded by some as a rather simplified or reductionist view and recently a more holistic or ecological approach to understanding aspects of movement has been adopted. Any model of the development of motor coordination in humans should stress its "dynamic, relational and multileveled nature" (Fentress, 1986, p. 101), as the processes involved are highly complex and interrelated. For instance, there is a strong link between neurological development and the growth of the musculoskeletal system (Metzer, 1997). This emphasises that changes to the control mechanisms must also have a biomechanical context (Sporns & Edeleman, 1993). Although the traditional approaches to analysing motor development have been useful because they isolate certain functions and reduce variability, they do not fully explain the mechanisms that underlie change in coordinated movement.

A dynamic systems view provides a new framework for motor development, learning and control. Instead of the concept of predetermined and/or prescribed patterns in the Central Nervous System dictating motor behaviour, this perspective envisages a motor action emerging from a dynamic fusing of collaborating subsystems in a task-specific context. These subsystems tend to self-organise to produce movement independent of a hierarchically organised nervous system (Heriza, 1991). Based upon the work of Kelso and associates (Kelso, 1995; Jirsa & Kelso, 2004) and adapting a model of performance suggested by Hughes and Bartlett (2002), a model which moves us towards a dynamic systems view of DCD is proposed (see Figure 2). This model incorporates all of the many facets of DCD whilst attempting to illustrate the complexity and interactivity of human movement, under stress, in a dynamic form (Thelen & Smith, 1994)

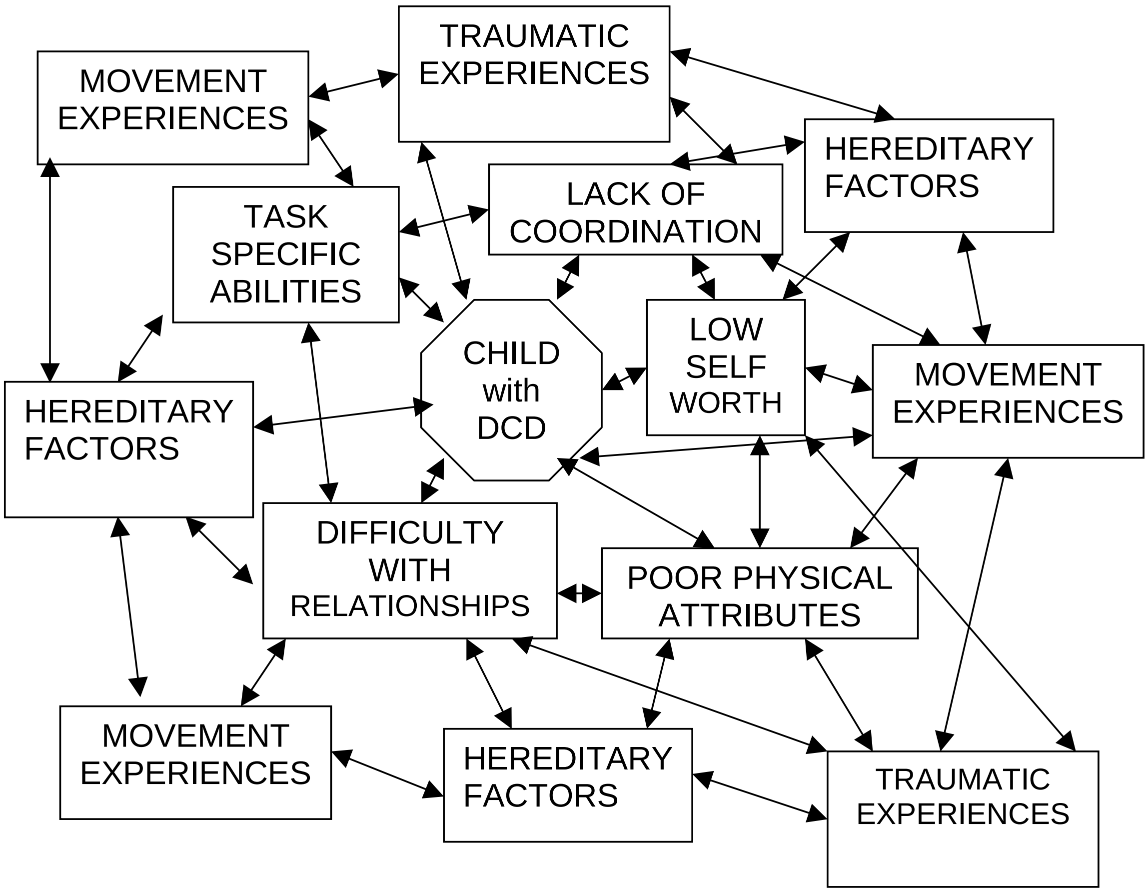

Figure 2: A Dynamic Systems Model of DCD

There are four elements of the dynamic systems approach that can be identified as distinctive features. Firstly, that developing systems are multi-dimensional and motor actions emerge from a focussing of the immense variability of the contributing entity (Davids & Button, 2004). Secondly, these motor actions occur in a self-organised way as a function of the cooperation of the subsystems in a task-specific context (Davids et. al., 2003). Thirdly, motor patterns are not necessarily requisite, occupying areas of their specific state and space at the time but often depending on the organisms predilections (Heriza, 1991). Finally, new forms of performance emerge in development in progressive segmental changes (van Rooij et. al., 2002). The dynamic systems model of DCD, seen in Figure 2, is designed to encompass these features when considering any given child with the condition. Often models are too geometrical to properly depict the dynamic nature of human performance. Therefore, this model is deliberately non-symmetrical, chaotic, repetitive, using shapes and arrows of different sizes to suggest that not all factors are contributing equally to the formation of movement patterns. Unfortunately, in a two-dimensional medium the non-linearity of dynamic systems cannot be diagrammatically represented, so readers are asked to envisage this concept in abstract form. Even a three-dimensional model would be somewhat lacking in this area.

4. Conclusion

The importance of the dynamic systems approach is that it determines that the context for understanding motor development issues is holistic and interrelated. This does not exclude segmental assessment of discrete facets of the multi-dimensional system necessarily, as depicted by the model presented. This dynamic approach is based on certain assumptions. In any performance or learning of a motor action there is a complex and collaborative interaction between the various systems of the body. There is scope for the self-organisation of muscle groups, not necessarily dependent on hierarchical neuro-physiological processes. Development is not necessarily continuous, i.e. new movement patterns may replace established movement patterns rather than develop out of the established ones. This is particularly relevant to movement pattern formation in children experiencing motor difficulties, given the task-specific nature of DCD.

A dynamic systems framework provides an alternative to the traditional neuro-developmental approach. It accommodates the heterogeneous nature of motor difficulties. This paper has pointed to the beginning of developing a model of DCD, which can better explain DCD and more importantly to move towards a guide to improved strategies for dealing with children who experience difficulties in learning everyday motor skills.

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