Developmental Coordination Disorder: From Genes to Behaviour

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Movement is something most of us take for granted.

Our first movements take place *in utero* and over the course of our life we produce millions upon millions of movements.
Movement allows us to meet our basic needs, to communicate and to learn.
For most individuals, movement develops into a automatic process that does not demand conscious effort and it is only when movement is impaired in some manner that the extreme importance of motor competency comes to the fore.
Movement difficulties are sometimes referred to as *hidden* because they are often unrecognized and children with developmental motor impairments receive limited assistance in facing their challenges.
Harry Potter star’s disability takes cloak off DCD

Daniel Radcliffe suffers from a mild version of dyspraxia, a condition that can make even the simplest daily tasks unmanageable.

BY ANNE-MARIE TORIN

When Harry Potter star Daniel Radcliffe spoke publicly about having dyspraxia recently, it was the first time many people had ever heard of the condition.

The diagnostic term used by the medical community is Developmental Coordination Disorder, and it encompasses a range of motor difficulties that can interfere with the activities of daily life.

Mr. Radcliffe’s spokesman has been quoted saying the star of the phenomenally successful Harry Potter films has a very mild condition that, at its worst, means he has bad handwriting and trouble with tying his shoelaces.

Warren Fried, executive director of Dyspraxia USA, is grateful that Mr. Radcliffe has talked openly about it.

“Finally, people are interested in what I’ve been trying to explain to them for the past 27 years,” he said in a telephone interview from Chicago.

“Ever since I was little, my parents knew there was something a bit different about me. And growing up in the States they didn’t exactly know where to put me, because I wasn’t autistic. I didn’t have cerebral palsy. I was failing every subject, and [students and] teachers were bullying me.

Mr. Fried, who describes his own case as severe, grew up in New York and Florida. But it wasn’t until he moved to England at 18 that he was told he had dyspraxia and found out there were support groups. And then my whole world opened up.

After five or six years in England, he moved back to the U.S. and settled in Chicago, and spoke and does public service announcements for radio stations.

He’s found a niche that suits his talents, but for many years he struggled.

“Something as simplistic as getting dressed in the morning was quite difficult, so I’d show up late,” he recalled. “And I remember when I was 7... I put my jeans on in the wrong direction, inside out.”

His fine motor skills are not good — it’s physically painful for him to hold a pen. He didn’t have the verbal difficulties that some kids do, but math class was troublesome.

“Imagine having problems with depth perception and trying to do geometry, or lining up numbers,” he said.

“Getting around as an adult isn’t easy. Some people with DCD can’t drive a car, and although Mr. Fried uses public transit, he can have difficulty putting his ticket into the machine.

“I can’t judge which way the arrows should go, and which way it should go in,” he explained.

Cheryl Missuma, an occupational therapist and director of the CanChild Centre at McMaster University, said an estimated 5 to 10 percent of children have DCD, but very few of them receive a formal diagnosis.

“These are not children who are just low in athletic ability,” she said from Hamilton, Ont. “They are children who are having difficulty with everyday activities like putting on shoes, brushing hair, getting dressed in the morning, learning to write, doing everyday activities.”

Dr. Missuma said it can be devastating for families when they recognize that their children are struggling, to know that the children are not going to get worse, that it’s not a degenerative condition,” she said.

“In fact, the children are going to develop some skills over time, and therefore they will seem better.”

Kids with DCD, which prior to 1994 was sometimes called clumsy child syndrome, might be labelled lazy and unmotivated when they struggle in school, she said.

“If people realize how hard it is for them to do the motor aspect of tasks, and they understand it, there’s a lot of ways around many tasks.”

Families can reduce their stress and the child’s frustration by identifying the difficulties and modifying them or adapting the environment, she added.

Dr. Missuma added a study has just been completed involving adults who were resilient and successful, who went to university and are doing well. Their families were supportive, and they found their areas of strength.

“Sometimes they use humour,” Dr. Missuma said. “You saw that probably with Daniel Radcliffe as well. He sort of jokes: ‘Why hasn’t Velcro ever taken off?’

Indeed. Mr. Fried said: “Nothing’s missing with us. We have talents, things are just a bit off.”

He said that knowing about Mr. Radcliffe’s success will help many children with dyspraxia.

“Now they have someone to look up to, who’s on the mild spectrum. They see me on the severe spectrum and getting the word out. And I function...”
“It is not the delay itself, but the extreme difficulty and distress experienced by these children in trying to master skills that differentiates them from their peers......hours spent daily unsuccessfully trying to teach buttering bread or tying shoelaces; tearful opposition to ride a bicycle or skate......despair because of failure to button jeans or fit a key in a lock.”

Fox and Lent, 1996
Developmental Coordination Disorder (DCD)

- Difficulty acquiring new motor skills
- Poorer performance in handwriting, reading, spelling
- Inaccurate goal-directed movements
- Inattentive characteristics
- Co-occurrence with ADHD and reading disability (dyslexia) (35-47%)
One child in every primary school class could have developmental coordination disorder
Consequences

- Frustration
- Low self-esteem
- Impairments in social functioning
- Limited peer interactions
- Withdrawal from existing sporting activities
- Resistance to trying various types of physical activity
- Reduced muscle tone
- Unhealthy weight
- Reduced fitness
- Deterioration in physical abilities due to lack of participation
- Complications of unhealthy weight and sedentary lifestyle – (e.g., high blood pressure; increased risk of diabetes)
DCD share similarities with other NDs

Querne at al., 2008; Prehn-Kristensen et al., 2011
Attention Deficit Hyperactivity Disorder (ADHD)

- Highly prevalent childhood disorder

- Three main subtypes
  - Primarily Inattentive
  - Primarily Hyperactive
  - Combined

- Difficulties in academic, social and emotional functioning

- Associated with poor motor functioning
Learning Disorders

- Encompass problems in input, integration, storage and output
- Reading disability (RD, Developmental Dyslexia)
- Math disability (Dyscalculia)
- Writing disorder (Dysphasia)
- Nonverbal learning disability (Non-DSM-motor, visuospatial, social)
- Auditory processing disorder
Neurodevelopmental disorders are highly prevalent in school age children

- 15-20% of all school-age children suffer from a diagnosable disorder
- Up to 50% of children with motor problems display attentional deficits and 30-40% have learning disorders
- Can lead to feelings of frustration, fear, worthlessness and problems in peer relationships
Heritability

Genes

Neurobiology

Behaviour
Where are we at?

- 316 families participating (493 children)
  - DCD
  - ADHD
  - Reading Disability
  - Typically Developing

- Data obtained
  - Detailed family histories
  - DNA samples
  - Comprehensive neuropsychological assessments
  - Assessments of academic skills
  - fMRI and DTI
  - Kinematic Analysis of Movement
  - EMG
Heritability
Developmental Disorders are highly heritable

- ADHD associated with candidate loci DAT1, MAO, and DRD4 (Chen et al., 2003; Payton et al., 2001; Langley et al., 2004)
- Children with ADHD display more motor problems than unaffected siblings (Fliers et al., 2009)
- Familiality with Conduct Disorder, ODD, and motor deficits (Mulligan, et al., 2009)
- Linkage findings in dyslexia have identified chromosome regions 1p34–p36, 6p21–p22, 15q21 and 18q11. Four candidate genes have identified in linkage region 6p21–p22
- Few studies on DCD
Do DCD, ADHD, and LD have a shared genetic etiology?

- Common co-occurrence suggests shared genetic cause
- Population prevalence = ~5-6%
- Familial aggregation
Genes
Complex traits

Susceptibility

Environment

Genes

Infectious Diseases,

ADHD, Obesity, DCD, RD

Birth Defects, Autism, Epilepsy, CP

Cystic Fibrosis, Muscular Dystrophy
5-10% of children with unexplained cognitive and or physical disabilities have pathogenic copy number variants detectable by arrays.
78 of 366 children with ADHD had large rare CNV’s. CNVs overlapped with autism and schizophrenia CNV’s!
Copy Number Variants

- Change in chromosome number: T21, T13, Turner
- Single gene conditions: CF, DMD
- Microscopic
- Molecular
Now over 1.8 million probes complementary to genetic information of interest
Neurobiology
Brain activation patterns differ in children with DCD

Querne et al., 2008

Schneider et al., 2010
GO/NOGO Task
Functional MRI analysis

• FSL-based first level analysis completed

• Second level analysis of “GONOGO” data underway
Resting State fMRI
Diffusion Tensor Imaging (DTI)

- Diffusion of water molecules
- Myelin = hydrophobic
- Fractional anisotropy (FA)
- Mean diffusivity
- Integrity
White matter abnormalities are associated with developmental disorders

- **ADHD** (Konrad et al., 2010; Helpern et al., 2010; Qiu et al., 2010; Gillam et al., 2011)

- **Learning disabilities**
  - Auditory (Schmithorst et al., 2010)
  - Reading (Klingberg et al., 2000; Deutsch et al., 2005)

- **Autism** (Barnea-Goraly et al., 2010)

- **DCD** (...?...)

http://www.pnas.org/content/105/9/3593/F1.expansion.html
DTI and Functional Connectivity

**CORPUS CALLOSUM**
- higher order prefrontal functions
- sensory and motor functions

**SLF**
- language
- attention
- memory

**CINGULATE CORTEX**
- attention
- executive functioning
Behaviour
Neuropsychological Assessments
Motor Functioning

YOU SEE —
— AT THIS AGE THEY CAN’T COPY A DIAMOND PROPERLY!
Kinematic analysis of movement

Bodies in motion
Studying motor disorders in children takes dedication, a multi-skilled team of researchers, and some high tech tools.
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