a note from David Dossetor...

Moving to Learn, Learning to Move: *the importance of motor development in mental health and intellectual disability*

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Introduction

The recent excitement of the Olympics emphasises how much value we put on superlative motor performance. The finest motor and visuo spatial skills are honed with thousands of hours of practice, training and education. There is superlative planning, organisation, and anticipation as well as repetition and recall of experience that is part of the development of such skills. Team work and competition also integrates these with complex empathy skills. Can we call this gifted "motor intelligence"? Motor skills certainly are recognised as one of Gardner's 8 types of intelligence. Gardner is a Psychologist who has challenged the debate that intelligence is single concept or attribute of general intelligence or "g" (1999). Gardner established there are a number of reliable and validated distinct skill sets which are only loosely correlated with each other. They are:

- Spatial
- Linguistic
- Logical-mathematical
- Bodily-kinesthetic
- Musical
- Interpersonal
- Intrapersonal
- Naturalistic

Gardner articulated several criteria for a behaviour to be an intelligence and these included: potential for brain isolation by brain damage, place in evolutionary history, presence of core operations, susceptibility to encoding (symbolic expression), a distinct developmental progression, the existence of savants, prodigies and other exceptional people, and support from experimental psychology and psychometric findings. The first 3 intelligences are the most fluid abilities and therefore most linked with the notion of an underlying general intelligence. My interest as a clinician is more about the clinical implications when one or more of these intelligences are specifically delayed, and I think they may provide explanations for different developmental disorders. Some other developmental disorders might be clumsiness, language problems and associated reading problems, intellectual disability, Autistic Spectrum, dyscalculia and ADHD.

I have generally felt that the contribution of motor skills to development are not sufficiently considered in mental health and special education. Maybe this is a dualist habit, separating the wellbeing of the mind from the wellbeing of the body. The justification for this may be the lack of evidence-based practice to demonstrate the secondary benefit to other domains of development and wellbeing through improving motor skills and performance. However, many physiotherapists will contend that promoting physical development contributes to other areas of developmental competence and emotional well-being, it is just that these influences need to be supported by empirical research. Yet there is so little research in this area.

In the study of general health and longevity, the importance of fitness and regular activity have more recently been recognised, (as well as diet and genetic risk factors and too much screen time), eg in the epidemics of obesity and cardiovascular disease. Exercise is also shown to be good for mental health and is the best universal community intervention for depression. However, the longer the hours we work and the less activity, the more we increase our mortality (Bauman *et al*, 2012).

When one looks at the developmental profile of many with intellectual disability, motor development is often an area of protected or better development. Maybe this is because in evolutionary terms, motor development was established and refined before the other skill domains of communication such as logico-deduction and emotional/social intelligence. Perhaps it is more "hardwired" and less vulnerable to problems of development. The public image of cerebral palsy and primary motor development problems, such as through the Special Olympics, is that they are otherwise "normal".

Professor Amanda Kirby is an academic and general practitioner who has made this an area of special study and she has been closely associated with establishment of the Dyscovery Centre in Cardiff. She was the keynote speaker at the Children's Hospital Educational Research Institute (CHERI) in 2010 (www.cheri.com.au) and argued that problems of motor development are a central part of specific learning disorders. I have drawn broadly from her presentations and ideas.

> "The contribution of motor skills to development are not sufficiently considered in mental health and special education..."

Definition

Developmental Coordination Disorder (DCD) is defined in DSMIV by:
A. Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (e.g., walking, crawling, and sitting), dropping things, "clumsiness", poor performance in sports, or poor handwriting.
B. The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living.
C. The disturbance is not due to a general medical condition (e.g., cerebral palsy, hemiplegia, or muscular dystrophy) and does not meet criteria for a Pervasive Developmental Disorder.

D. If Mental Retardation is present, the motor difficulties are in excess of those usually associated with it.
(The ICD10 equivalent of Specific Development Disorder of Motor Function (WHO, 1993) has an exclusion criteria of intellectual disability, so I shall not refer to it further because of the explicit prejudice).

DCD has a long history but over the years has been called various names: the *"Awkward"* child, Minimal Brain Dysfunction (1949), minimal cerebral palsy, perceptual-motor dysfunction, visuo-spatial disability, the clumsy child syndrome, developmental apraxia and most recently developmental dyspraxia. Developmental dyspraxia is described as *an impairment or immaturity of the organisation of movement*. It is an *immaturity in the way that the brain processes information*, which results in messages not being properly or fully transmitted. The term dyspraxia comes from the word praxis, which means 'doing, acting'. Dyspraxia affects the planning of what to do and how to do it. It is associated with problems of perception, language and thought. The term dyspraxic has been used for motor problems not due to documented basic motor impairment such as cerebral palsy (Dewey, 1995).

Brief outline of Stages of Motor Development
eg as described in the Bailey Scales
0-2 years: Normal development involves loss of primitive reflexes-e.g. selected-sucking, palmar grasp, Babinski, walking; developing spontaneous movements-e.g. supine kicking, increased postural control, locomotion and manual control.
At **one month** may hold up head momentarily. **Two months** lifts head when placed on stomach, hold up head briefly when held in a seated or standing position.
Three months holds head and shoulders up when placed on stomach. Puts weight on forearms. **Four months** holds head up well in sitting position, can lift head to a 90 -degree angle when placed stomach, may start to roll over. **Five months** has full head control, when pulled by hands to a sitting position, the head stays in line with body. **Six months** rolls over (front to back first), bears a large percentage of body weight when held in a standing position.
Seven months can stand with support, may sit without support for short periods, pushes upper part of body up while on stomach. **Eight months** stands while holding onto furniture, sits well unsupported, gets up on hands and knees, and may start to crawl backwards.
Nine months crawls first by pulling body forward with hands, may move around a room by rolling.
Ten months pulls up to standing, is very steady while sitting, moves from sitting to crawling position and back, crawls well.
Eleven months "cruises," walking while hanging onto furniture, walks with two hands held. **Twelve months** walks with one hand held, may walk with hands and feet, stands unsupported for longer periods of time.
12 and 15 months: Pincer grip —the ability to hold objects between thumb and index finger.
Fifteen months walks without help, crawls up stairs, gets into a standing position without support.
Eighteen months seldom falls while walking, can walk and pull toy, runs, climbs stairs holding railing, may walk backward.
2-7 years: progresses on to developing and improving: body control, walking, running, jumping, hopping, throwing, balancing and catching. Fine motor skills include manual skills, such as self-help skills, drawing and writing, and growing spatial and temporal accuracy.
Two years kicks a ball, walks up and down stairs two feet per step.
Two and a half years jumps with both feet, jumps off step, can walk on tiptoe.
Three years goes upstairs one foot per step, stands on one foot briefly, rides tricycle, runs well.
Four years skips on one foot, throws ball well overhand, jumps a short distance from standing position.
Five years hops and skips, good balance, can skate or ride scooter.
Between 7 and puberty: it is essential that fundamental skills are in place. During this period children start to: refine skills, play with skills in different situations, combine them and integrate them in social and recreational play. Maximum performance and gender differences start to play a part. Spatial and temporal accuracy starts to play a major part and during this period it is one area that improves significantly in terms of prediction and performance.

Recognition of DCD:
By 4-6 years this may be manifest by: unable to throw ball with direction, unable to catch ball, not exploring playground equipment, not alternating steps on descent of stairs, can't do up zips, can't cut along a line, difficulty sitting at table & chair, immature pencil grip.
By 7-8 years: writing, participating in ball sports, cannot ride a bike, messy eater - can't cut meat, cannot tie shoes, self-care tasks- dressing, cleaning teeth/wiping bottom still difficult.
By 9-10 years: Academic grades are impacted by written work, social isolation, decreased fitness level/weight gain, frustration with writing/ homework, victimisation/bullying.
By 11-12: Writing at speed, self-organisation, organisation of work, still slow getting dressed/shoes, emotional and social interaction with peers mismatch, problems with mathematics associated.

These descriptions imply connections between motor development and independence skills, fine motor eg writing, reduced activity and low self-esteem. Other related challenges include peer relationship problems, internalising mental health problems such as anxiety and depression, problems of executive function of organisation, planning, attention and academic achievement.

Objective Measurement of Motor Development
There are a number of objective measures of Motor Development which enable objective measurement of the extent of delay such as the Lincoln-Oseretsky Motor Development Scale which assesses the development of motor skills in children and adults. Areas covered include fine and gross motor skills, finger dexterity and speed, and hand-eye coordination. The test consists of 36 tasks arranged in order of increasing difficulty. These include walking backwards, standing on one foot, touching one's nose, jumping over a rope, throwing and catching a ball, putting coins in a box, jumping and clapping, balancing on tiptoe while opening and closing one's hands, and balancing a rod vertically.

Norms for each part of the test are provided for children aged 6-14 with percentiles. Alternatively, the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) or the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) may be used to assess fine and gross movement skill development in individuals with mild to moderate motor coordination deficits. The test is suitable for individuals aged 4 to 21 years. The complete BOT-2 features 53 items and is divided into 8 subtests: fine motor precision (7 items), fine motor integration (8 items), manual dexterity (5 items), bilateral coordination (7 items), balance (9 items), running speed and agility (5 items), upper limb coordination (7 items), strength (5 items). The items in every subtest become progressively more difficult. A short form of the BOT-2 can be used as a screening tool to achieve rapid and easy scoring reflecting overall motor proficiency. The BOT-2 Short Form comprises a subset of 14 items of the BOT-2 Complete Form.

Subtyping DCD
DCD can be divided into Verbal Dyspraxia,

Fine Motor Dyspraxia or Whole body coordination Problems.

- **Developmental verbal dyspraxia or articulatory dyspraxia** (also called childhood apraxia of speech in the USA) is sometimes described as a specific condition with problems of motor development of speech and causes linguistic or phonological impairment. Problems include: difficulties controlling speech organs, with difficulties making speech sounds, or difficulties sequencing sounds within a word or sentence, difficulty controlling breathing and phonation, slow language development and associated difficulty feeding.
- **Fine Motor Problems** lead to problems with handwriting which may be due to movement recognition and coordination difficulties, problems with the correct pencil grip and hand ache with writing. It can also cause difficulty with using a knife and fork, doing buttons and shoelaces, brushing teeth, doing hair or make-up, and a range of other daily activities.
- **Whole body movement, coordination and body image problems** can affect gross motor activities including walking, running, climbing and jumping. It can also involve poor timing, poor balance including tripping over one's feet, problems of combining movements into controlled sequences and remembering the sequences, problems with spatial awareness or proprioception, problems picking up objects and holding them eg pencils due to poor muscle tone, clumsiness, knocking things over or bumping into people, problems with laterality, determining left versus right, ambidexterity, problems chewing foods, problems with judging distance such as of moving objects.

These problems can be associated with memory problems, especially short term, and especially for instructions, difficulty organising time and remembering deadlines, increased propensity to lose things, problems with tasks that include sequences such as cooking. People with DCD may have sensory processing problems with abnormal over or under sensitivity to physical stimuli such as touch, light, sound and smell.

Difficulty doing physical tasks may need extra energy and lead to fatigue, often associated with low muscle strength and endurance. Hypotonia may be associated with increase soreness and fatigue and increase balance problems.

The consequences of a diagnosis of DCD:

prognosis and co-morbidity
Of those who have DCD, 50-80% of people have persisting problems of DCD into adulthood affecting: learning to drive, independent living skills, organisation of self and time, handwriting, anxiety and depression (eg Rasmussen and Gillberg, 2000). The broader message is that DCD doesn't come on its own but is associated with social and communication skills, executive functioning skills, literacy and numeracy difficulties. There is also a huge secondary impact with bullying, weight gain (Cairney *et al*, 2005), Self-esteem (Skinner and Piek, 2001), less peer-peer

> "The broader message is that DCD doesn't come on its own.. "

interaction with stigmatisation (Segal *et al,* 2002), internalisation (Sigurdsson *et al*, 2002) and anxiety and depression

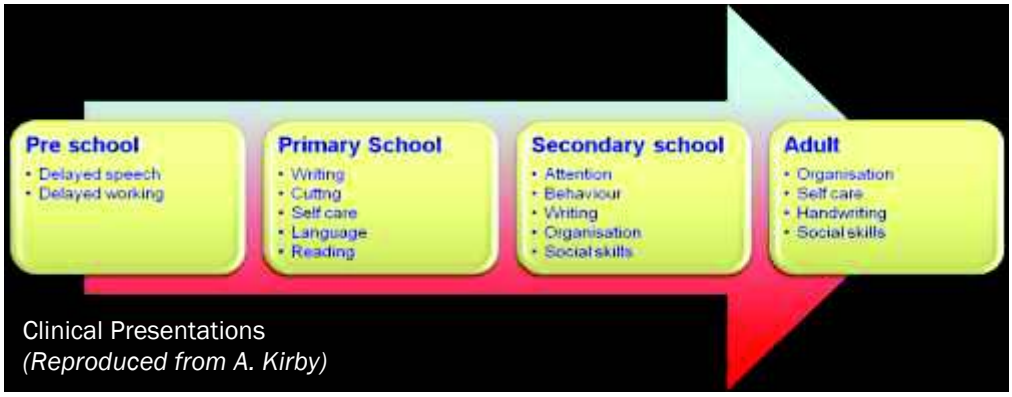
Different Clinical Presentations
There are a number of ways that children with DCD present, which varies according to age and to different services: Children may present in various ways: delayed speech, fidgety, withdrawn, refusing to write, avoiding reading, delayed walking, failing at school, 'odd gait', parent who has DCD, poor organisation and time management. A different bias can lead to a different route into services: reading and spelling to special education; motor delay, problems of self-care and writing problems to physiotherapy; problems of social communication to the speech therapist, attention problems and negative behaviour to paediatricians or CAMHS teams.

My fundamental clinical rules of Development:

- Behaviour and emotions should always be considered in a developmental context.
- Development needs to be considered in the different domains of development: Motor, Sensory, Independence Skills, Expressive and Receptive Communication Skills and most importantly Social Development Skills and Imagination.
- If there is intellectual delay, then it is likely to be uneven across the different developmental domains.
- If one domain is delayed, then there is an increased risk of another domain of development being delayed.

Accordingly the rule of developmental disorders is: Where there is one developmental disorder, there is more likely to be a second, or even a third.

High risks of comorbidity:
The rules of development arise from clinical experience, but are demonstrated by the high risks of co-morbidity of developmental disorders. Although DCD and ADHD each occur at 7% in the community, they co-occur in 50% (Gillberg & Gillberg, 1998). What is more, in their study the ADHD/DCD group had a much worse psychosocial outcome 15 years later at 22 years than either on its own. In the ADHD/DCD group 58% had a poor outcome compared with 13% in the comparison group ($p < .001$). Remaining symptoms of ADHD, antisocial personality disorder, alcohol abuse, criminal offending, reading disorders, and low educational level were overrepresented in the ADHD/DCD groups. The combination of ADHD and DCD appeared to carry a particularly gloomy outlook. The Swedes have even given this combination a separate diagnosis of DAMP (Disorder of Attention, Motor control and Perception). Kirby and Salmon (2007) suggested the overlap was between 21-40%. DAMP is associated with Autistic Spectrum traits in 36% and Aspergers Syndrome in 21% (Fitzgerald). Kaplan and colleagues (1997) found that out of those with DCD 25% had ADHD and dyslexia, 22% had dyslexia on its own and 10% had ADHD.



Clinical Presentations
(Reproduced from A. Kirby)

Early development speech problems are associated with DCD in 60% (Missiuna *et al*, 2007). DCD is also associated with language problems (verbal dyspraxia), specific reading retardation, spelling problems, dyscalculia, dysgraphia, ASD, and problems of executive function, in particular in working or short term memory.

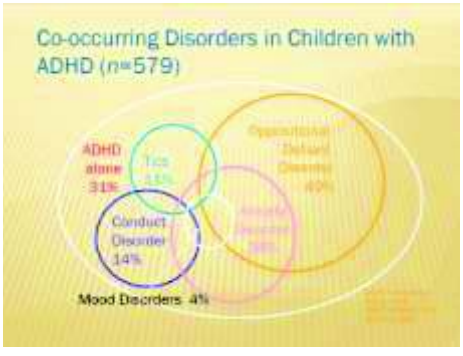
Kirby has a neat clinical breakdown of **executive function skills**.

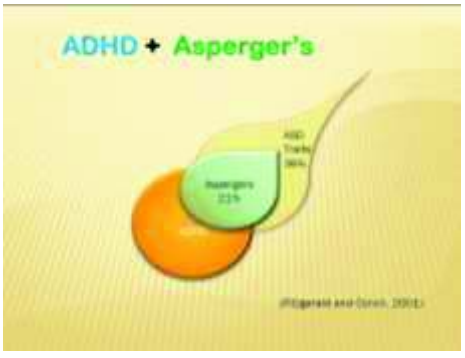
- **Activation skills**: the ability to organise and prioritise (not procrastinate).
- **Focus**: sustaining and shifting attention (not reading the same paragraph over and over).
- **Effort:** the regulation of effort (can't shut off energy).
- **Emotions**: keeping things in perspective.
- **Memory**: what was said and what was the sequence.
- **Action**: monitoring and regulating self (not impulsive, without considering the context, can't adjust pace).

Executive Function Deficits are found in ADHD, ASD, DCD, Dyslexia and Dyscalculia. DCD often causes problems of anxiety, low self-esteem and depression. It is a common cause of being bullied.

Paradoxically others young people with DCD may have specific strengths in areas such as reading, numeracy or memory.

Mood lability in the context of DCD with or without other neurodevelopmental disorders, I feel is a cause for prognostic caution. This is not the same as Bipolar Disorder, but it certainly is a vulnerability to disorder behaviour and emotional problems and can benefit from treatment with mood stabilisers. Kirby takes pains to explain how other developmental disorders overlap in similar ways, or the overlap between ADHD and ASD/Aspergers (see below)





Brain connectivity and genetics

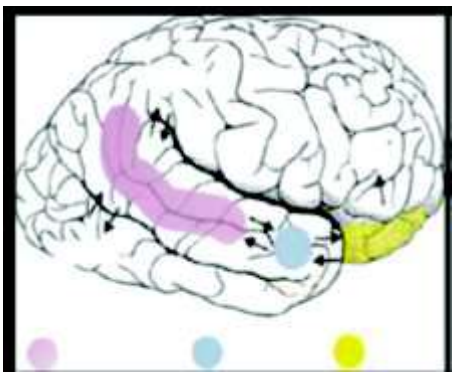
A conference at University of NSW called "networks and neuroscience: the connected brain" was held on the 7th of September 2012 which shone a light on the latest technologies that are providing new insights into the imaging and functioning of the brain. The way different parts of the brain grow and shrink at different ages and in different conditions can be shown. For example frontal lobe growth and connectivity clearly continues to grow into the 20s which in turn explains why teenagers are risk takers and challenge the boundaries before the last stages of executive function is laid down.

Jay Giedd from the National Institute of Mental Health, Bethesda, described in evolutionary terms, the growth of brain size in hominids was associated with rate of climate change, not whether the climate was hot or cold, indicating that Homo Sapiens brain size is associated with skills in adaptability. The duration and extent of skills development in Homo Sapiens is dependent on a prolonged duration of protective parenting. Tribal Homo sapiens only protect their offspring till 10 years old, and thus teenage attributes give survival skills that they use to work as a group in a challenging environment. MRI spectroscopy can show which parts of the brain work together in different activities.

New mathematics called Graph Theory can be used to help describe the complex relationships between the relative strengths of connection between different parts of the brain and the strength of connections within an area of the brain, and functional MRI Spectroscopy can identify sub-skills within these localised nodes. Using MRI Spectroscopy Eddie Harman Jones demonstrated that the left frontal lobe activation is associated with approach emotions (including anger) and the right frontal lobe is associated with withdrawal. This activity is affected by posture (leaning forwards or back) and can be altered by trans cranial magnetic stimulation (a low strength electrical pulse on the skin). Alex Fornito presented on the US$40 million study of MRI imaging of "the connectome" i.e. the comprehensive map of brain connections and how these are affected in different diagnoses, for example the reduced fronto-to-temporal-posterior network in schizophrenia and the associated loss of network efficiency in schizophrenia.

The relevance of this expose is the importance of brain connectivity to a whole range of conditions. There is growing understanding on how genetics influence the strength of connection between different brain areas.

Autism is now understood as a disorder of under-connectivity of the social brain: Superior Temporal Sulcus, Amygdala, Orbital Frontal Cortex & Fusiform Gyrus (Pelphrey *et al*, 2011). So although the research on the connectivity of DCD has not yet happened, conceptually one can see that developmental disorders are all about developing connectivity between different functional parts of the brain. Not only is this connectivity affected by genetics, but there is also evidence that environmental stimulation is critical in determining connections and even enhancing (weak) connections and in turn leading to epigenetic and brain metabolic change (ie environment influences brain function and even the genetic control processes). For example Skye Mac-



donald from the school of psychology UNSW described how one can retrain skills like emotional recognition when it is lost in traumatic brain injury.
The Queensland Brain Institute is pursuing a study of gene-protein interaction of the 700 genes associated with Schizophrenia, Autism, ADHD and Intellectual Disability. They report there are huge overlaps and interactions between the genes and proteins involved in these disorders. This cross correlative study, of what they have termed the 'Cognitive Neurone', finds interactions of problems of synaptic transmission, cell adhesion, signal transduction and vesicular transport are interconnected in these disorders and these correlations lead to the implication of 4000 genes in these disorders (which are still distinct from those used in other parts of the brain and body) (Claudianas, personal communication, 2012). These models are starting to look at the importance of cerebral

location and the life span variation of gene activity. It is of interest to note that the genetics of the single gene studies is passé, as no single gene deficit or neurotransmitter deficiency replicates any psychiatric disorders. Valsa Eapen, Professor of Child Psychiatry at Liverpool Hospital in Sydney, has pointed out how vulnerability genes influence the risk of several developmental disorders rather than being disorder specific. In a further article she describes the neuropathogenetic model that links a number of proteins involved in "trans-synaptic complexes" can explain the overlap between Tourettes Syndrome, ADHD and Autism, illustrating that in complex systems any one of several metabolic pathways can affect a number of different processes or outcomes (Clarke *et al*, 2012).

The range of this research explains the overlap and connection between different developmental disorders and the complexity of the interacting processes. While it does not explain what is happening in an individual child it does explains why a clinician should look at the whole child, and not be looking for a single disorder.

Another personal longstanding clinical developmental disorder dictum: evidence indicates that developmental disorders are genetically associated and the developmental sequence of skill development is due to mathematical complexity of neural connection, not a particular lesion in a particular brain location. It seems that these novel approaches to research are in the process of describing how this might be so, and why developmental disorders are so interconnected. As Amanda Kirby concludes: don't diagnose a single developmental disorder without looking at the whole child in context and see what else in going on in a child's development. In this context, adequate motor development would seem to be an important precursor for all other developmental disorders and indeed psychiatric disorders.

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Recommended Reading:

Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, 5th ed. and Child Development Institute, http://www.childdevelopmentinfo.com.

Gross Motor Skills - symptoms, average, Definition, Description, Common problems http://www.healthofchildren.com/G-H/Gross-Motor-Skills.html#ixzz22laRUj00

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