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Toward an Understanding
of Developmental Coordination Disorder

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Toward an Understanding of Developmental Coordination Disorder

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We consider three issues concerning unexpected difficulty in the acquisition of motor skills: terminology, diagnosis, and intervention. Our preference for the label Developmental Coordination Disorder (DCD) receives justification. Problems in diagnosis are discussed, especially in relation to the aetiology-dominated medical model. The high degree of overlap between DCD and other childhood disorders appears to militate against its acceptance as a distinct syndrome. In this context, we emphasize the need to determine whether incoordination takes different forms when it occurs alone is combined with general developmental delay or with other specific disorders in children of normal intelligence. Studies of intervention have mostly shown positive effects but do not, as yet, allow adjudication between different sorts of content. We suggest that the study of DCD and its remediation would benefit greatly from the employment of the simple but rich paradigms developed for the experimental analysis of fully formed adult movement skills.

Prefatory Note

The form and style of this paper were determined by its initial presentation as an invited lecture, delivered by SEH to an audience with a wide range of interests, few of whom spoke Scottish. In responding to the Editor’s request for a version to be published in APAQ, we have tried to preserve the informality of the spoken version while adding a few references and some technical material where we judged it appropriate. The paper states a personal view rather than a detailed and scholarly argument. In two respects, the written version is impoverished. The lecture was accompanied by videos that illustrate the difficulties of children with a developmental disorder of coordinated movement more vividly than any marks on a
page can do. Thanks to our Viennese hosts, the paper was presented as a rococco sandwich, between two delectable pieces of Mozart, played by the Opus 4 string quartet.

It has been recognized for a long time that severe and persistent difficulties in spoken language, reading and writing, attention, and motor coordination not infrequently occur in children of normal general intelligence without any obvious neurological disorder, who come from an unremarkable family background, and who have apparently adequate schooling and other educational experiences. (Rutter, 1998, p. ix)

In this paper, our concern is with unaccountable failure to acquire adequate motor skills. Motor skills are not generally as dependent on formal tuition as, say, mathematics or reading. Many of the actions we perform in every day life have been learned informally and can be performed without close attention. Indeed, under normal circumstances, we only become aware of the intricacy of our movements when suddenly deprived of our skill, as in the attempt to fasten buttons with icy fingers or the coordination of actions of hands and feet when learning to drive. A similar reminder of the movement skills we take for granted is furnished by the child who cannot acquire even the simplest motor skill without help. Being unable to fasten buttons, use a knife and fork, or ride a bike to school may seem trivial in some regards, but such failures can have far reaching consequences on the educational progress of children, their social relationships, and self-esteem.

Figure 1 shows some examples of deficient graphic skills in children above the age of 9 with normal IQ, who speak fluently and clearly and read well above

![Examples of defective graphic skills drawn from three children with general movement problems, all over 8 years of age, with IQ above normal.](image-url)
their age levels. These children come from supportive home backgrounds and go
to caring schools. Their parents and teachers are concerned about how these diffi-
culties might affect the children’s progress in school, but pediatricians can offer
neither an explanation of nor a solution to their problems. Of course, display of the
product of the child’s activity is no substitute for watching on video the child’s
struggle to generate that product.

Although awareness of children with difficulties of this sort has greatly in-
creased over the last quarter century, there is still much to be learned. While a fully
comprehensive review of the area might have started with the question of aetiol-
ogy and concluded with an examination of the growing experimental literature on
the possible deficits underlying the condition, in the space available, we have elected
to focus on three issues that continue to generate debate among theoreticians and
practitioners: terminology, diagnosis, and intervention. In their different ways, we
hope that all three sections will contribute to an interest in and understanding of
this condition.

**Part I: Terminology**

Debate about the appropriate label for a disorder might seem to be of purely “aca-
demic” interest. However, the choice of terms has important implications, both
theoretically and practically. In research, for example, terminological ambiguities
create difficulties in the definition and comparison of samples. In the realm of the
practical, a condition defined by society in one way may confer special entitle-
ment to benefits and services, while the same condition defined in another may
not. Labels, moreover, tend to be adhesive and may be difficult to shed, even when
the child has changed for the better. Such issues have been addressed in an admir-
ably succinct series of editorials in the journal Developmental Medicine and Child
Neurology (e.g., Bax, 1999; Davies, 1994; Gardner-Medwin, 1995; Hart, 1999;
MacKeith, 1968).

It is not surprising to find, therefore, that recent reviews of the labeling of
the disorder of concern to us here have concluded that terminology continues to
present a problem (Henderson & Barnett, 1998; Polatajko, 1998). To some extent,
the variations in usage are systematic, differing characteristically from country to
country, from profession to profession, and even according to the theoretical bias
of the individual. Surveys by Missiuna and Polatajko (1995), Miyahara and Regis-
ter (2000), and Peters, Barnett, and Henderson (2001) have shown that some pro-
fessionals view the competing labels as interchangeable, while others choose
different labels for slightly different groups of children. In Sweden, these children
are nearly always assigned the label Disorder of Attention and Motor Performance
(DAMP; e.g., Gillberg, 1992; Gillberg & Gillberg, 1989; Gillberg, Gillberg, &
Groth, 1989). Transported to Italy, they become Dyspraxic (Zoia, 2000), whereas
in Holland most now have DCD (Geuze, Jongmans, Schoemaker, & Smits-
Engleman, 2001). Many Australian practitioners, indifferent to fashion, still use
the term Minimal Neurological Dysfunction (Larkin, personal communication).
In New Zealand, Developmental Dyspraxia is more common (Miyahara & Regis-
ter, 2000). In Canada, 6 years after the ironically named “London (Ontario) Con-
sensus Statement” (Polatajko, Fox & Missiuna, 1995), the term physical
awkwardness remains popular in some circles. In the USA, too, different profes-
sionals employ labels of their own, but for parents seeking private services, insurance
companies recognize DCD (Diagnostic and Statistical Manual of Mental Disorders IV; American Psychiatric Association, 1994), opening their coffers only when the DSM IV diagnostic criteria are fully met. The situation in the UK is unresolved, with some therapists and teachers devoted to the term dyspraxic and others beginning to use the term DCD (Peters et al., 2001). However, our National Health Service (NHS, 1999) has recently decreed that all hospital recording systems will employ the World Health Organization classification scheme, the result being that such children shall henceforth bear the label, Specific Developmental Disorder of Motor Function (SDD-MF; ICD 10, World Health Organization, 1992).

DCD and Its Rivals – A Component Analysis

At an important interdisciplinary meeting held in London, Ontario, now known as the Consensus Forum, researchers and practitioners agreed on the recommendation that the term DCD be universally adopted (Polatajko et al., 1995). In what follows, we come to the same conclusion via a detailed comparison of the components of the DCD label with those of its principal rivals, SDD-MF and (Developmental) Dyspraxia. While DCD and SDD-MF have a relatively formal status due to their APA and WHO provenance, dyspraxia seems to have been chosen either by misguided analogy with certain neurological acquired disorders of action or for essentially political reasons because of its medical resonance. Neither the APA nor WHO attempt to justify their choice of term. Instead, both organizations assert, somewhat gnomically, that (a) the classification scheme adopted and the terminology used is not based on theory but on clinical expertise, (b) terms derived from controversial theories have been avoided, and (c) the current state of knowledge of childhood disorders rules out reference to aetiology or pathophysiology. If only this agreement on strategy had yielded an agreed label.

Why not Dyspraxia? Let us dispose of this possibility without further ado. The over-riding reasons for declining to adopt the term dyspraxia to encompass movement disorders in children are (a) longstanding confusion about the meaning of the term apraxia in the literature on acquired disorders and (b) the questionable relevance of this literature to the developmental disorder.

In adult neurology, it is not difficult to find patients who when asked, “show me how you wave goodbye” are unable to do so but then do so spontaneously and competently as they depart. In the past, the prevailing uncertainty about the nature of this disorder was evident from an unhealthy proliferation of labels, such as ideational, ideomotor, and constructional apraxia, or dressing, gaze, and limb apraxia, etc. Perhaps in reaction to this, the literature on the apraxias has recently tended to become much more empirical and locationalist, attempting to tie detailed neuropsychological description of impaired function to the patho-anatomy (e.g., Square, Roy, & Martin, 1997). These objectives, however worthy, are unlikely to commend the program to those primarily concerned with developmental matters. Moreover, attempts to define apraxia continue to generate confusion, ranging from the overinclusive (e.g., Rothi & Heilman, 1997, p. 3), “a neurological disorder of learned purposive movement skill that is not explained by deficits of elemental [sic] motor or sensory systems,” to excessively narrow formulations that assert, for example, that apraxia is a disorder of gesture.

It does not appear that apraxic difficulties, whatever their nature, involve a disturbance in the coordination of movement (but see Poizner, Merians, Clark, Rothi & Heilman, 1997). Instead, it is widely agreed that the disorder is located at
a higher level in the hierarchy of action control in which the planning or retrieval of action plans has become unduly context-dependent (the patient can only perform the act of waving good-bye spontaneously in “natural” circumstances).

Those who continue to advocate adoption of the label developmental dyspraxia as an umbrella term, despite its evident inappropriateness for the vast majority of developmental cases, may, as with parent groups in the UK, be motivated by political rather than scientific considerations. Others may have been seduced by the medical resonance of the term praxis into believing that neurological studies of the acquired disorder, however different, will somehow nurture understanding of the developmental condition (e.g., Ayres, Mailloux, & Wendler, 1987; Denckla, 1984; Dewey, 1995). Finally, a complaint that might seem pedantic is that the distinction between the prefix dys- meaning a disturbance of and the prefix a- signifying absence of has somehow become entangled with the distinction between developmental and acquired disorders.

Until recently, the labels used by the APA and WHO for the entire set of developmental disorders included the term specific. However, DSM IV (1994) departs from this usage, abandoning the whole notion of specificity. Readers of APAQ will be familiar with the broader issue, in which learning difficulties are held to be specific only if the child’s achievements fall below what might have been expected on the basis of his or her general aptitude. The underlying assumption is that specific disorders differ in nature from more global, developmental retardation. Over the last decade, this idea has been refuted in many domains, particularly language impairment and dyslexia (see Bishop, 1998; Dowdney & Scott, 1998; Rispens, Van Yperen, & Yule, 1998 for penetrating reviews). However, it remains almost untested in the motor domain.

During his lifetime, Larry Rarick provided us with one of the most detailed descriptions of the motor problems experienced by children then described as mentally retarded (e.g., Rarick, Dobbins, & Broadhead, 1976). Others among us have attempted to do the same for children of normal IQ with movement problems. Unfortunately, a quarter of a century after Rarick’s seminal work, no direct comparison between these two groups has yet been published, so it remains to be determined whether, and if so how, the nature of their motor deficiencies differs.

So, how are we to proceed? Pragmatism suggests that from a research standpoint, we should continue to employ a discrepancy criterion to select participants, if only to avoid dipping deeply into the murky etiological soup of profound retardation. However, we need to be clear that this is not a principled adoption of the specificity notion nor an endorsement of IQ as a divine basis for the calculation of discrepancies (see also Geuze et al., 2001). We are learning from other domains, such as reading, that discrepancy probably has little role to play in deciding who should receive intervention and what the nature of that intervention should be (see, for example, Stanovitch, 1998). As Bishop has observed of the language domain, “there seems little justification for continuing to place heavy reliance on IQ - language discrepancies in determining who should receive extra help at school” (1998, p. 146).

Both manuals (DSM-IV & ICD-10) include the term developmental. In addition to reminding us of the longitudinal perspective, this term encompasses “... not only the roots of behaviour in prior maturation, in physical influences (both internal and external), and in the residues of earlier experiences, but also the modulations of that behaviour by the circumstances of the present” (Rutter, 1980, p. 1).
It is now well established that the notion that most children with movement difficulties will spontaneously outgrow them is ill-founded (e.g., Cantell, Smyth, & Ahonen, 1994; Geuze & Borger, 1993; Henderson, 1993; Losse et al., 1991). Without intervention, the educational, social, and psychiatric consequences can be substantial (e.g., Hellgren, Gillberg, & Gillberg, 1994; Hellgren, Gillberg, Bagenholm, & Gillberg, 1994; Hellgren, Gillberg, Gillberg, & Enerskog, 1993; Skinner & Piek, 2001). However, we cannot predict with any degree of accuracy regarding which child will grow out of the problem or which will become seriously depressed. Only further research will help us disentangle the complex interactions between organic and environmental factors that might affect the course of DCD.

If one crucial aspect of the term developmental is reference to the interplay of biological with personal and social factors in the child’s progressive mastery of its environment, another must surely be the contrast between developmental disorders, on one hand, with an implied failure of learning and acquired disorders, on the other hand, where a once-learned skill has been traumatically lost. Among the children with whom we are concerned, the most basic of skills such as reaching, grasping, standing, and walking may be intact, but more complicated acts such as cutting with scissors, using a knife and fork, or catching a ball represent entirely novel learning tasks that are often acquired with only the utmost difficulty.

A disorder of . . . what? We have already disposed of the idea of a disorder of praxis. Whereas DSM IV considers the answer to this question to be motor coordination, ICD-10 speaks of a disorder of motor function. Function is elucidated by the Oxford English Dictionary (OED) as “activity (or) action in general, whether mental or physical.” In the present context, therefore, the child who has a disorder of motor function might be deemed to be one who fails to perform motor acts effectively. A possible disadvantage of the term, however, is that it leaves wide open the possibility that a child has poor motor function for reasons unrelated to his/her ability to control the motor system. For example, some children with ADHD appear clumsy because they are inattentive rather than actually incapable of performing the required actions. Physical weakness, consequent on a muscle-wasting disease, may also impair motor function without being a primary disorder of motor control.

In contrast to the term function, the term coordination seems to refer more directly to the heart of the problem while at the same time remaining fairly neutral as to detailed causality. Collins English Dictionary defines the verb, to coordinate as “to organize or integrate diverse elements in a harmonious operation” and the noun, coordination as “balanced and effective interaction of movement.” The OED entry, on the other hand, emphasizes the sequential nature of the movement elements of which most actions are composed: “consisting of a number of actions or processes properly combined for one purpose.”

Within the scientific literature on motor control, definitions of coordination vary considerably in their level of discourse. For Schmidt (1988), coordination occurs at a level involving individual joints and muscles. Thus, he defines coordination as “behaviour of two or more joints and muscles in relation to each other to produce skilled activity” (p. 265). Gallistel, in his monumental treatise The Organization of Action (1980), takes a broader perspective (see especially Chapter 8), quoting Weiss (1941) on coordination at some length. Gallistel’s main preoccupation in this work was to delineate the principal functional units that contribute to sustained purposive action. He discusses three types of unit (reflexes, oscillators, and servomechanisms) and considers how they may interact to produce a larger vocabulary of actions. Then in a key passage, he argues, “These diverse modes of
interaction do not, however, by themselves ensure the coherence of coordinated action.” He continues, “The coherence and purposefulness of sustained action depends upon a hierarchical structuring of the units. By means of this hierarchical structure, the highest levels of neural integration impose an overall direction on behaviour” (p. 210). For Gallistel, coordination is a feature of skilled, fluent action that takes place at various levels in the hierarchy of action control. To produce movement of a limb, opposing muscles must be activated or inhibited. This parallel coordination must be modulated over time as in oscillator-driven movement, requiring coordination of temporal patterns. Such patterns must in turn be selected or deselected by a higher level decision-making system, in the light of environmental data, and so on up the hierarchy. We can quite properly speak of coordination at each hierarchical level. As we ascend the hierarchy, information from the environment becomes increasingly important so that not only do the components of the movement have to be coordinated, actions have to fit the coordinates of the environment. The grasping hand has to be shaped to achieve a fit with the arriving ball. At each new level, coordination will exhibit new properties of fluency, appropriateness, and expertise.

In sum, four attractive features emerge from our examination of the term coordination. First, the notion of intentionality is embraced. Second, our attention is drawn to the spatial and temporal organization of actions. Third, we are reminded that most actions involve the sequencing of movement elements. Fourth, we are also reminded that actions have to be appropriately calibrated to environmental coordinates. Given our implacable hostility to the association of the developmental disorder with those acquired disorders referred to as apraxias, our approval of the term coordination as a descriptor of the processing demands of movement control at various hierarchical levels and the eschewal of the problematic notion of specificity, we have no alternative but to endorse the label “DCD.”

Part II: Diagnosis

In DSM IV, a disorder is conceptualized as a clinically significant behavioral or psychological syndrome that is associated with impairment in one or more important areas of functioning. A syndrome may, in turn, be regarded as a set of co-occurring signs and symptoms indicative of a particular disease or disorder.

In medicine, diseases are diagnosed in terms of a pattern of abnormal signs and symptoms that are sometimes assigned different weights and not all of which may be present in a given case. In well-understood diseases, the aetiology is known and this defines the disease and specifies any underlying pathophysiology. An effective therapy stems from understanding the aetiology, while failure of this therapy constitutes a prima facie reason for doubting the diagnosis.

Thus, in congenital hypothyroidism, for example, which is a genetic condition resulting in a hormonal deficit, doctors have available to them a proactive screening program, which leads to early diagnosis and in turn a rapidly instituted treatment. If instigated early enough, the catastrophic effects on cognitive and on motor development are averted (see Figure 2).

I mention the admirably clear medical disease model precisely because it tells us so little about the diagnosis of DCD. In this, my inspiration might have been that of Artemus Ward’s celebrated lecture, of which the author remarked that its principal virtue was that “... it contains so many things that don’t have anything to do with it” (Browne, 1865).
Consider the diagnostic guidelines for DCD offered in DSM IV. Four criteria are applied. Two are inclusive (the criteria must be satisfied if the diagnosis is to be assigned), and two are exclusive (meeting the criteria entails rejection of the diagnosis). As shown below, Criterion A states that a child’s performance in daily activities that require motor coordination is substantially below that expected given his or her chronological age and IQ. “Substantially” is often operationalized as meaning a score on a standardized test of motor performance lying more than 2 standard deviations below the age norm. According to Geuze et al. (2001), the Movement Assessment Battery for Children (ABC; Henderson & Sugden, 1992) is now the test most widely cited in the literature for this purpose. Criterion B is much more difficult to operationalize, requiring the assessor to judge whether the deficit interferes to a significant extent with academic achievements or the activities of daily living (e.g., Watkinson et al., 2001). Criterion C states that the deficit must not be ascribable to a medical condition such as cerebral palsy and must not satisfy the diagnostic requirements of the generally debilitating group of disorders known as pervasive developmental disorders (which include autism). Finally, Criterion D states that if mental retardation is present, the motor difficulties must be greater than those to be expected on that basis alone (for extensive reviews of these criteria and their application, see Henderson & Barnett, 1998; Dewey & Wilson, 2001; Geuze et al., 2001).

The Four DSM IV Diagnostic Criteria for Developmental Coordination Disorder

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, 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 the criteria for a Pervasive Developmental disorder.

D. If mental retardation is present the motor difficulties are in excess of those usually associated with it.

Deviations of DCD From the Medical Model

How does this kind of diagnostic protocol deviate from the classic medical model?

In acquired disorders of movement such as Parkinson’s disease, the cardinal symptoms of the disease include positive features such as resting tremor and “cogwheel” rigidity, which are present in patients but not in healthy individuals, as well as negative features such as abnormal slowness of movement, where the patient lacks the speed of movement available to the healthy individual. In contrast, the performance features specified in DSM for DCD are not pathological and can only be said to be abnormal in a statistical sense.

Positive features are not, however, the preserve of acquired disorders. The obsessional interests and stereotyped actions of autism and the hyperactivity of children with ADHD seem to have discriminable positive aspects. If positive symptoms could be said to characterize DCD, then they might comprise an awkward or influent style of performance, an aspect of performance we can all observe and agree on but which is difficult to assess with any objectivity. Another very interesting possibility is that in DCD, difficulties with motor control might exert demands on attentional resources and working memory that are not present in children whose development is normal. However, the lack of agreed positive features means that diagnosis has to be based on norm-referenced test items that yield a continuous measure of performance, such as time spent balancing on one leg, for which we can derive statistically determined cut-off points.

If the signs and symptoms of DCD do not comprise a distinct set of pathognomic features, we may still inquire whether they form a cohesive pattern at a functional level. Like schizophrenia, DCD is of unknown aetiology and lacks a biological marker. However, the symptoms of schizophrenia do seem to form two distinct clusters. A set of positive symptoms (abnormal by their presence), such as hallucinations and delusions, consists of features in which reality testing has broken down in a manner unknown to normal individuals. In contrast, the negative signs (abnormal by their absence) of schizophrenia are characterized by the lack of attributes like motivation or expressions of emotion, which are present in normal individuals. Crude though it be, this distinction has been a fertile source of further hypotheses about the action of neuroleptic medication, the chronic effects of institutionalization, and the possibility of subtypes.

Within the literature on DCD, there are a number of studies that have attempted to define subtypes of the disorder (e.g., Dewey & Kaplan, 1994; Hoare, 1994; Jongmans, 1993; Macnab, Miller, & Polatajko, 2001). However, in our view, none of the subtypes proposed have been properly validated and there is, as yet, no really persuasive evidence to suggest that the motor features form cohesive and contrasting clusters. One problem is the lack of general theories in the motor domain.
that delineate important distinctions between tasks, in terms of their processing requirements. In the construction of most standardized tests, some attempt has been made to include a range of items that straddle an intuitive taxonomy of everyday actions; these different types of test item cannot be said to reflect theoretically-motivated distinctions of a similar status, say, to that drawn in reading research between printed words whose pronunciation can be assembled by phonographic rule (d/o/g = “dawg”) and those requiring lexical retrieval (two = “tooh”).

Another problem is the lack of conclusive evidence that the features of DCD, as a whole, comprise a set that is clearly distinguishable from the features of other developmental disorders. The notion of separable syndromes implies that each disorder constitutes a discrete clinical entity. This issue is sometimes expressed in the question whether coordination difficulties amount to a syndrome or are merely a symptom.

In this regard, concern with what sort of creature DCD is reflects wider doubts about the whole idea of specific developmental disorders as distinct and independent clinical entities. These doubts are nicely captured by two quotations from the recent literature that have a remarkable consonance:

Those with highly specific deficits are the exception rather than the rule. (Hill, Bishop, and Nimmo-Smith, 1998, p. 656)
Co-morbidity is the rule, rather than the exception. (Kaplan, Wilson, Dewey, & Crawford, 1998, p. 484)

In the limited space available, just two studies will be mentioned that address these issues in relation to DCD, in rather different ways. The first surveys a substantial portion of the territory of co-morbidity; the second concentrates on the nature and extent of motor difficulties in children with DCD and in a quite different disorder, Asperger’s syndrome.

In 1998, Kaplan and colleagues examined over 200 children in Canada who had been referred to their clinic for either attention problems or learning difficulties. All were tested “blind” on measures of cognitive ability, literacy, attention, and motor performance, and strict criteria were adopted for each of three specific learning difficulties. Only children with IQs over 75 were included. This was not an epidemiological study, and it is not entirely clear to what population it can be generalized. Nevertheless, its results are very thought provoking.

As Figure 3 shows, 115 children met the criteria for at least one of the three developmental disorders. Of these, only a minority (46%) were “pure” cases. One in five actually met the criteria for all three diagnostic categories. Of special interest to us here is that the proportion of children exhibiting comorbidity was particularly high for children with motor coordination problems. Of a total of 81 children exhibiting coordination difficulties, over two thirds (68%) were diagnosed with multiple disorders.

From these data, Kaplan et al. concluded that it was likely that a variety of learning disabilities could occur when the early development of the brain was disrupted. However, the specific pattern of the deficits that resulted would depend on the site and the extent of the damaged neural substrate.

Before abandoning the notion of syndromes entirely, however, it seems worth inquiring whether the motor difficulties experienced by these various groups of children are really identical in nature and extent or whether the difficulties take a
discernibly different form when combined with another disorder. Were this to be the case, knowledge of the precise nature of these differences might enhance our ability to differentiate between different developmental disorders.

This very question is posed in a more narrowly circumscribed domain by an investigation in which one of us has recently been involved. Essentially, the work is directed toward a comparison between two developmental disorders that appear to share a component of motor impairment but are very different in other respects (Green, 1997; Green, Baird, Barnett, Huber, & Henderson, in press). One of these groups comprised children assigned a diagnosis of Asperger’s syndrome by very experienced pediatricians using ICD-10 criteria. The other group had been assigned the diagnosis DCD, also by appropriately qualified and experienced professionals. While the clinical literature on Asperger’s syndrome abounds with descriptions of movement difficulties, it is important to note that these played no role in the formal diagnosis.

We aimed to compare the severity of the movement deficit experienced by these two groups and to explore the possibility that the nature of the deficit might differ in the two groups. To this end, we examined the profiles of the children on the Movement ABC and various aspects of their performance on a gesture test. Because Asperger’s syndrome is thought to involve defective socialization, we also sought to detect any differential effect of social pressure on motor learning and performance in the two groups. So far, we have found no evidence that clumsiness was more severe or took a systematically different form in DCD where it was not accompanied by the features of Asperger’s syndrome than when it was.

Part III: Intervention

It is often difficult for practitioners to appreciate why researchers spend so much time debating issues of the type we have just discussed. If we can describe a child’s difficulties clearly, then we are ready to intervene. So, what do labels matter? However, resources for children with special needs are limited. Governments want to know how many children of a particular type there are in the system, what is the
best (or cheapest) way of identifying them, and what is the most effective (or cheapest) way of helping them to realize their potential. Rigorous evaluations of intervention are essential both for theoretical and practical reasons.

Over a quarter of a century ago, Rarick and Broadhead (1968) conducted a large-scale assessment of intervention that had its origins in work by Rarick in the 1950s. Their objective was to determine the effects of a school-based, physical activity program on the development of children whom they described as educationally disabled. A total of 481 children between the ages of 6 and 13 were involved, subdivided into those categorized as educable mentally retarded (EMR), with IQs in the 40-70 range, and those described as having “minimal brain injury” (MBI) whom one presumes to have had IQs above 70. These two sets of children were allocated to four treatment groups. Two received a remedial physical education (PE) program – one in a group setting, the other in a one-to-one setting. A third group (acting as “Hawthorne” controls), engaged in an art program, and the fourth acted as a “passive” control group, continuing with regular classes. The intervention of 35 min daily lasted for 20 weeks. Motor, cognitive, and social/emotional measures were monitored using standardized assessment by staff not involved in the intervention. We have attempted to recast these design features within a general framework, which is shown in Figure 4.

Being in the special programs, whether PE or art, had a positive effect on the children in all the domains measured. Especially when the program was individualized, PE exerted a greater beneficial effect on motor performance than the art program. Moreover, all these effects were greater for the children with higher IQs.

Rarick and Broadhead’s (1968) design was sophisticated for its time and the outcome is correspondingly interesting. The remainder of this paper employs the framework used to describe Rarick’s study as a means of examining some of the more important issues in the design of intervention studies for the 21st century, dealing first with the selection and description of participants.

Figure 4 — Schema for encoding Rarick’s intervention design. Two groups of subjects, termed educable mentally retarded (EMR) and minimal brain injury (MBI) were randomly allocated in equal numbers to one of four treatment groups (PE = Physical Education). Motor, cognitive, and social/emotional measures were employed before and after training.
The one aspect of Rarick’s study that clearly fails to meet contemporary standards is the description of his participants. Should we regard minimal brain injury as an archaism, to be translated simply as DCD? Or might the MBI group be divisible into ADHD, Asperger syndrome, and DCD? Since the London Consensus meeting, a number of researchers in the field have discussed the possibility of agreeing upon a minimum data set requirement for all published studies of DCD, comparable to that prescribed by the UK Medical Research Council for studies of schizophrenia. Ideally, this would include demographic data, data on the child’s motor difficulties, data on IQ, and data on comorbidity. Since some professionals are not qualified to administer IQ tests and others are refused access to existing data, we realize that the provision of IQ data might be problematic. Nevertheless, the presentation of such data is extremely desirable whenever possible. Recall that Rarick and his colleagues found that the PE programs they investigated were more effective for the children with higher IQs. Yet, few subsequent studies have systematically manipulated IQ as a factor.

For the motor difficulties, Criterion A and (possibly B) of DSM IV provide the basis for a descriptive requirement, but it must be acknowledged that the standardized tests currently available vary considerably in content. This means, of course, that we cannot simply assume that identical scores on two different tests are directly comparable (Crawford, Wilson, & Dewey, 2001; Dewey & Wilson, 2001; Geuze et al., 2001; Tan, Parker, & Larkin, 2001). In addition, there is also the problem of what cut-off point to use. Although for certain experimental studies, a laxer criterion might be best, for intervention studies, our own view is that the 5th percentile is not only an appropriate cut point for Criterion A but is also likely to be politically acceptable to those charged with resource provision. Just as important as a global estimate of ability, however, is the presentation of a profile of the child’s performance across the motor domain. (This requirement would incidentally militate against the use of standardized tests that draw upon an excessively narrow range of skills.) Such profiles, together with a requirement that published studies present full data sets on individual children, would give great impetus to the search for consistent subtypes.

With regard to data on comorbidity, the real problem is where to stop. As noted in our discussion of diagnosis, we do not yet know whether motor difficulties that occur in isolation take the same form as motor difficulties that occur in conjunction with reading difficulties, language impairment, or attentional disorders. Even if the motor difficulties do turn out to be the same, it is yet another matter whether the methods used to treat those that occur in isolation are equally appropriate to the treatment of those same difficulties in a child with ADHD or Asperger syndrome. Given our belief that the incidence of both of these conjunctions is likely to be high, this issue is not inconsequential.

A rather different issue from the foregoing is what should be included as outcome measures (see Figure 5). Our follow-up studies offer us a wealth of information on the long-term consequences of DCD that goes untreated. They report problems of self-esteem, peer relationships, loneliness, depression, and educational attainment that is far below what would be predicted from the child’s IQ. Although the idea that improving a child’s motor difficulties would inevitably have a positive effect on IQ was dispelled a long time ago, the notion that such programs might serve to raise a child’s self-esteem and confidence is very much to the fore.

When discussing the data we need to provide on participants, we identified the question of the compass of the measures taken, in motor and nonmotor do-
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space constraints now dictate that we concentrate on issues in the motor domain. The first of these issues concerns the relationship between the content of the measurement instrument and the content of the intervention program. The second concerns the assessment of generalization (see Figure 5; also see Mandich, Polatajko, Macnab, & Miller, 2001).

Figure 5 — Issues concerning measures. The type of measure is an important decision. Where a test is repeatedly administered, its susceptibility to practice effects should be known. Test content should not be too close to the content of training. Any generalization of training effects, whether immediate or delayed, should be determined. The persistence of training effects should be tested. N.B. Rarick’s design lacked follow-up measures. Individual subject data should be included.

Regardless of the content of the intervention, however, the demonstration of generalization represents a major issue. In the past, it was thought that the beneficial impact of a motor intervention would automatically spread to a child’s reading ability or, more precisely, to the child’s readiness to read. While the issue has not been entirely resolved, this particular generalization premise is much less likely to receive unqualified assent. Moreover, the focus of debate has become
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more refined. Consider that Adapted PE programs frequently lack any fine motor activities. Should we expect such a program to improve a child’s handwriting? Currently, available data on the specificity of skill would seem to suggest that no such effect would be obtained. Should we, therefore, confine our tests of generalization to conditions involving a distinct shift in the performance context, for example, evaluating handwriting training in the form of coloring, shape matching, copying, drawing, etc., by means of examination of the child’s essay writing in the classroom?

There is also the question of what epoch we should consider. Maybe it takes time for a child to adapt to a newly learned skill so that using it in a new context only emerges later. Once again, we return to the need to be more explicit about the pattern of impairment shown by individual children and the individual’s response to intervention. We need not be despondent about showing that one child responds to a particular approach and another does not—this is the way forward!

Sugden and Chambers (1998) concluded from a recent review of intervention studies that there was cause for optimism. “Intervention has been shown to be effective,” they proclaimed (p. 146), speaking of “overwhelming evidence that demonstrates that most approaches work” (p. 145). What has not been shown, according to Sugden and Chambers, are “identifiable and consistently different effects of the different approaches” (p. 145). We do not entirely share Sugden and Chamber’s optimism. As practitioners, it may be mildly reassuring to be told that most approaches work, at least to the extent that the intervention can be statistically discriminated from no intervention at all. However, from a research point of view, the absence of any persuasive evidence favoring one kind of intervention over another is profoundly depressing (a melancholy view apparently also taken by Mandich et al., 2001).

What kind of intervention works? Most reviews draw a broad distinction between process-oriented approaches and task-oriented approaches to intervention. In a recent meta-analysis, Pless and Carlsson (2000) agreed with Sugden and Chambers in finding that the evidence for efficacy is less persuasive in the case of the process view than in the task-oriented view. However, the utility of making general pronouncements about process-oriented interventions is worth questioning since it obliges us to lump together hugely diverse approaches. For example, under this heading, we find interventions designed to remedy deficits ranging from a narrowly conceived kinesthetic one (proposed by Laszlo & Bairstow, 1983; Laszlow, Bairstow, & Bartrip, 1988; Laszlo & Sainsbury, 1993) to one involving the integration of information across all sense modalities (e.g., Ayres, 1972). Moreover, no process-oriented approach of which we are aware presents anything approaching a comprehensive theory, tying the supposedly defective processes to the many interacting variables that underlie even the most simple of everyday tasks. In Laszlo’s reports of the efficacy of her approach, for example, nothing is said about the precise nature of the deficit, nor about how exactly simply exercising kinesthetic judgment “fixes” it. Most importantly, nothing is said about how fixing the putative deficit leads to the acquisition of normal skilled action. Fortunately, all of this may not matter, since our group and others have failed to find any evidence in support of this approach (Sims, Henderson, Hulme, & Morton, 1998a; Sims, Henderson, Moron, & Hulme, 1998b; Polatajko et al., 1995).

Another consideration in relation to intervention is that in the wider universe of deficits, some are simply not fixable. A corollary of this would be that in such cases, our interventions should not focus on the problem itself but on strategies for finding a way around it.
If our current approaches to understanding and helping children with DCD are inadequate, how should we proceed? Progress in our understanding of skilled action has come through the development of rich and detailed paradigms for the experimental analysis of particular components of action, such as walking or reaching and grasping. Consider, for a moment, the apparently simple sequence of actions involved in walking up to a table, picking up a pen, and beginning to write. Entire symposia have been devoted to components of this action sequence. The oculomotor subsystem uses saccadic search to locate the pencil. The locomotor system transports the agent to the vicinity of the pencil. Visually guided reaching extends the hand toward the object. This displaces the agent’s center of gravity so that the postural control system must make postural corrections. Overlapping with extension of the hand, theprehension system adjusts grasp to the dimensions of the pencil. The necessary unimanual adjustments are then made to the pen grip to ensure that the ideal, dynamic tripod grip can be adopted and writing can commence.

Very little of this rich and often elegant work has informed or illuminated the investigation of DCD—far less the content of interventions. At present, the gulf between experimental studies of normal performance and studies of developmental coordination difficulties seems wide and deep. Bridging it will take time. Moreover, we cannot be sure that experimentally derived insight will furnish us automatically with improved means of intervention. However, we find it difficult to believe that the greater understanding mentioned in the title of this paper will be unaccompanied by any practical application.

Meanwhile, what is the therapist or the student of intervention to do while the chasm of which we spoke is slowly being filled with grant applications, PhD theses, and other academic building materials? The content of presently available interventions needs to be considered more carefully. Above all, we require many more comparisons of treatment A with treatment B and not simply of A versus a control condition (see Figure 6). Taking account of comorbidity, adding follow-up...
measures to determine the persistence of training effects and their potential to become generalized and using cross-over designs as an orthogonal means of replication and a way of controlling for therapist efficacy means much bigger and resource demanding studies of intervention. These should keep us all in work for most of the new century.

References


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