Sensory-motor deficits in children with Developmental Coordination Disorder, Attention

Deficit Hyperactivity Disorder and Autistic Disorder

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Abstract

Children who have been diagnosed with any one developmental disorder are very likely to meet diagnostic criteria for some other developmental disorder. Although comorbidity has long been acknowledged in childhood disorders, little is understood about the mechanisms that are responsible for the high level of comorbidity. In a series of studies, we have investigated the link between sensory-motor deficits and developmental disorders. Poor sensory-motor integration has long been implicated as a cause of motor problems in developmental disorders such as Developmental Coordination Disorder (DCD), and our recent research has also investigated sensory-motor deficits in children with Attention Deficit Hyperactivity Disorder (ADHD) and Autistic Disorder. Based on a critical examination of relevant literature and some of our recent research findings, we argue that the importance of poor sensory-motor functioning in discriminating children with different disorders has been underestimated. Poor sensory-motor coordination appears to be linked to DCD, but not ADHD. Also, sensory-motor deficits in children with DCD and Autistic Disorder may provide insight into some of the social difficulties found in these groups of children. This research will increase our understanding of why children with one developmental disorder typically also have problems in other areas.

Keywords: Developmental Coordination Disorder, Attention Deficit Hyperactivity Disorder, visual-spatial perception, Autistic disorder.

PsychInfo Classification: 2330; 3250

Introduction

The term 'developmental disorder' is used to describe a disorder that appears early in an individual's life, specifically in infancy, childhood or early adolescence (American Psychiatric Association, 1994). Developmental disorders are generally defined in terms of patterns of poor or deviant development in particular behaviours or constructs. For example, children with Developmental Coordination Disorder (DCD) have poor motor control, whereas children with Attention Deficit Hyperactivity Disorder (ADHD) have behavioural difficulties defined by symptoms of inattention and/or hyperactivity and impulsivity. Although these two disorders seem quite distinct in terms of their description, our recent research (e.g., Dyck, Hay, Anderson, Smith, Piek & Hallmayer, 2004; Piek, Dyck, Nieman, Anderson, Hay, Smith, McCoy & Hallmayer, in press) has indicated that these different types of problems are related. For example, Piek et al. noted that inattention was related to poor motor ability, particularly fine motor ability. Dyck et al. investigated five ability constructs, namely IQ, language ability, motor ability, empathic ability and attentional control in a representative sample of 390 children. All five constructs were significantly correlated with each other (except language and attention). Also, children with low ability scores (more than one standard deviation below the mean) on one measure were also likely to obtain significantly lower scores on other ability measures. Therefore, it is not surprising that most disorders are comorbid given they are generally defined by one or more of these ability constructs. Nonetheless, most research on developmental disorders has appeared to assume that the disorders are discrete phenomena with specific aetiologies.

Comorbidity has long been recognized in children with developmental disorders such as Autistic Disorder, ADHD, DCD and Language Disorders (e.g., Gillberg, 1995; Watson, Baranek & DiLavore, 2003). Gillberg described a neurodevelopmental dysfunction syndrome, called Deficits in Attention, Motor control and Perception (DAMP). Primarily a syndrome that includes children with DCD and ADHD, Gillberg also noted that these children often have empathy deficits associated with Pervasive Developmental Disorders such as Autistic Disorder. Other researchers, such as Kaplan and colleagues (Kaplan, Wilson, Dewey & Crawford, 1998), also noted comorbidity between developmental disorders, but have suggested a generalized neurodevelopmental explanation which reflects some underlying neurological abnormality. They argued that discrete syndromes were the exception to the rule. Hill (2001) also suggested that the overlap between specific language impairment and DCD could be due to a neuromaturational delay.

The fact that developmental disorders are typically comorbid implies: (a) that disorders have overlapping causes, or (b) that the direct causes of one disorder affect the mechanisms that cause some other disorder. However, little research has investigated underlying causes of these comorbidities. Rutter and Sroufe (2000) outline several reasons why such research is important. Without knowledge of the different mechanisms affected in comorbid conditions, research results may be confounded if these mechanisms are quite distinct for different disorders. Also, mechanisms must be understood in order to develop appropriate intervention programs. In this paper, we address this important issue by reviewing past literature and current research in order to investigate underlying mechanisms in several developmental disorders, namely DCD, ADHD and Autistic

Disorder. In particular, we investigate the link between visual-spatial organisation and motor control in order to determine whether sensory-motor dysfunction can distinguish one disorder from another.

2. Sensory-motor deficits and DCD

DCD is diagnosed when a child's motor ability is significantly lower than would be expected given the child's age and intellectual ability (American Psychiatric Association, 1994). Children who have DCD may display a wide range of motor problems including delays in achieving motor milestones such as walking and sitting, dropping things, and poor performance in sports or poor handwriting. For children to be diagnosed with DCD, their motor impairment needs to be "sufficient to produce functional performance deficits not explicable by the child's [chronological] age or intellect, or by other diagnosable neurological or psychiatric disorders" (Polatajko, Fox, & Missiuna, 1995, p. 5). Research has suggested that around 6% of children aged 5 to 11 years old will have motor problems that can be diagnosed as DCD (American Psychiatric Association, 1994).

The primary sensory systems associated with movement control are the visual, vestibular and kinaesthetic systems. Two of these systems, vision and kinaesthesis, have been extensively investigated in children with DCD, and perceptual deficits in each of these systems have been identified in these children. In 1982, Hulme, Biggerstaff, Moran and McKinlay examined visual, kinaesthetic and cross-modal (visual-kinaesthetic) linkages in children with and without poor motor coordination. They found evidence to suggest perceptual problems that were linked to the visual modality rather than

kinaesthesis, a finding supported by their later studies (e.g., Lord & Hulme, 1987). In contrast, other researchers identified difficulties with kinaesthetic perception in children with coordination problems (e.g., Laszlo & Bairstow, 1983; Piek & Coleman-Carman, 1995).

Wilson and McKenzie (1998) carried out a meta-analysis to examine which information processing measures are more important in distinguishing differences between children with DCD and control children. They included 50 studies involving a total of 983 children with DCD and 987 control children between the ages of 5 and 16 years. The information processing categories investigated were visual processing, other perceptual processing (kinaesthetic and cross-modal perception), and spatiotemporal parameters of movement planning and execution (e.g., reaction time, movement time, accuracy and variability). The main deficits associated with DCD were found to be visual spatial processing, kinaesthetic perception and cross-modal integration. Regardless of whether a motor response was required or not, children with DCD had difficulties with visuospatial processing (Wilson & McKenzie, 1998). These included tasks such as length discrimination (e.g., Hulme, Biggerstaff, Moran, & McKinlay, 1982), and complex visuospatial tasks such as Block Design and Object Assembly from the WISC-III (Wechsler 1992) (e.g., Piek & Coleman-Carman, 1995).

Wilson and McKenzie's examination of kinaesthetic perception revealed a significant difference between children with and without DCD with a combined effect size in the moderate to high range. The effect size was found to be higher for those studies that involved active movement (e.g., Hulme et al., 1982) than passive movement (e.g., Laszlo & Bairstow, 1983, 1985). This supported our earlier findings (Piek &

Coleman-Carman, 1995) using the kinaesthetic sensitivity test (KST: Laszlo & Bairstow, 1985) to measure kinaesthetic acuity in children with and without DCD. We used both a passive condition and active condition and found that only the latter condition differentiated the two groups. It was argued that the active condition improves kinaesthetic precision by increasing the stimulation to intramuscular receptors as a result of voluntary tension of the muscles (Paillard & Brouchon, 1968).

The third and final factor that was found to have a moderate effect size in differentiating the two groups was cross-modal perception. Wilson and McKenzie (1998) suggested that this supported the early work of Ayres (1975) who argued that children with motor coordination problems had difficulty integrating vestibular, proprioceptive and tactile information. Poor cross-modal integration cannot be ruled out in a number of studies that have examined kinaesthetic sensitivity as it has been acknowledged that measuring pure kinaesthetic ability is difficult. For example, Laszlo and Bairstow (1985) developed the KST, which includes two subtests, one measuring kinaesthetic acuity and the other measuring kinaesthetic perception and memory. As the latter requires a memory of the target shape being negotiated, it has been argued that this memory would be visual in nature, and the test is therefore more a measure of cross-modal integration (Hulme & Lord, 1986) than a measure of kinaesthetic perception and memory.

Recently, we examined perceptual processing in children with and without DCD aged between 4 and 6 years (Coleman, Piek & Livesey, 2001). Few studies have investigated DCD in children this young, and studies with children in this age range were not included in the meta-analysis carried out by Wilson and McKenzie (1998). Complex visuospatial processing was investigated using the subtests of Block Design, Object

Assembly and Geometric Design from the Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R: Wechsler, 1989). In addition, kinaesthetic acuity was tested using the Kinaesthetic Acuity Test (KAT: Livesey & Parkes, 1995). This involves passive movement of the child's hand in the horizontal plane from the centre of a circle to one of 16 equally spaced targets (animal stickers). The child's arm and hand is hidden from view, but the child sees duplicates of the stickers on a platform directly above those to which the hand is directed. As the children need to identify which animal sticker their hand visited, it has been suggested that kinaesthetic-visual integration is required in this task. Hence, it may be more a measure of cross-modal integration than pure kinaesthetic acuity.

In support of Wilson and McKenzie's (1998) meta-analysis findings, children with DCD performed more poorly on all three Performance IQ subtests than did age, gender and verbal IQ matched control children. Furthermore, children with DCD produced more errors on the KAT task than their matched controls at age 4 to 5 years and also one year later. However, it should be noted that both groups improved their performance on the KAT when tested a year later, suggesting that children's kinaesthetic acuity undergoes significant development at this early age. As there were no significant differences between the DCD and control groups on any of the scales of the Child Behavior Checklist (CBCL: Achenbach & Edelbrock, 1983), and a screening questionnaire did not identify any children with ADHD, this group was considered as a DCD group which appeared to have little comorbidity. This is unique, as most studies that have investigated underlying processes in DCD have not accounted for comorbidity.

3. Can sensory-motor deficits distinguish ADHD from DCD?

Children with ADHD are characterised by persistent symptoms of inattention and/or hyperactivity-impulsivity that are not consistent with their developmental level and are maladaptive (American Psychiatric Association, 1994). Three subtypes of ADHD have been identified by the DSM-IV, namely ADHD-Predominantly Inattentive type (ADHD-PI), ADHD-Predominantly Hyperactive-Impulsive (ADHD-HI), and ADHD-Combined type (ADHD-C) (i.e., combined inattentive and hyperactive/impulsive symptoms).

An examination of sensory-motor deficits in children with ADHD has produced inconsistent results. Only two studies appear to have examined kinaesthetic acuity, and they have provided contrary results. Using the KAT (Livesey & Parkes, 1995), Whitmont and Clark (1996) found significantly poorer kinaesthetic acuity and poorer fine motor control in children with ADHD compared with control children. In contrast, we found no significant differences in kinaesthetic acuity between children with either ADHD-PI or ADHD-C and control children (Piek, Pitcher & Hay, 1999). However, a different measure, the Kinaesthetic Sensitivity Test (Laszlo & Bairstow, 1985), was used. Also, Whitmont and Clark did not identify sub-types of children, although they reported that none of the ADHD groups would have fulfilled the criteria for ADHD-PI. Neither study separated the ADHD groups into those with or without DCD. This makes it unclear whether the different findings can be explained in terms of the presence or absence of an underlying motor disorder in the two different samples of children with ADHD.

Several studies have failed to find any significant visual-motor deficits in children with ADHD, such as the study by Carlson, Lahey and Neeper (1986) who used the Beery

Visual-Motor Integration test (1967). Pitcher (2001) examined all three sub-types of

ADHD in separate groups, and found no significant differences between these groups and

a control group when using the subtests of the WISC-III that assess perceptual

organization (i.e., picture completion, picture arrangement, block design and object

assembly). In contrast, several studies have found visual-motor deficits in children with

ADHD compared with control children (e.g., Moffitt & Silva, 1988; Oie & Rund, 1999;

Raggio, 1999). Raggio (1999) used the Bender-Gestalt test (Bender, 1983), whereas Oie

et al. (1999) used the Trail Making Test (Reitan & Wolfson, 1993) and WISC-R Digit

Symbol subtest (Wechsler, 1974). However, according to Groth-Marnat (1997) these

latter two tests are more reflective of difficulties with attention and speed of information

processing rather than perceptual organisation. Slower processing speed in children with

ADHD is a consistent finding (e.g., Mayes, Calhoun, & Crowell, 1998; Pennington &

Ozonoff, 1996; Pitcher, 2001; Schwean & Saklofske, 1998).

Motor deficits in children with ADHD are well recognized throughout the ADHD

literature (e.g., Barkley, 1990; Doyle, Wallen & Whitmont, 1995; Lerer, Lerer & Artner,

1977; McMahon & Greenburg, 1977; Parry, 1996; Piek et al., 1999; Shaywitz &

Shaywitz, 1984; Stewart, Pitts, Craig & Dieruf, 1966; Szatmari, Offord & Boyle, 1989;

Whitmont & Clark, 1996). Recently, Pitcher, Piek and Hay (2003) found a high

percentage of movement problems in all three subtypes, with 58% of ADHD-PI, 49% of

ADHD-HI and 47% of ADHD-C children with motor performance in the lower 15th

percentile of a standard movement assessment battery.

Despite this, comorbidity between DCD and ADHD is poorly recognised in the

DSM-IV (APA,1994). Within the differential diagnosis section for DCD, the motor skill

problems of children with ADHD are regarded as being "usually due to distractibility and impulsiveness, rather than to motor impairment" (p. 54), although a dual diagnosis for both disorders may be given. That is, children with ADHD do not necessarily have a comorbid diagnosis of DCD, but the poor performance on motor problems in ADHD children are a direct result of the inattentive or hyperactive/impulsive symptoms. Therefore, if children have the same level of symptomatology, one would expect similar problems with their motor performance. We tested this recently using the purdue peg-board (Pitcher et al., 2003), a measure of fine motor performance. Despite having the same symptomatology (both inattentive and hyperactive/impulsive), children who were diagnosed with both ADHD and DCD performed significantly more poorly on the purdue peg board than children diagnosed with only ADHD. This group did not differ significantly from the control children with no diagnosis.

These findings suggest that there may be distinct processing deficits associated with ADHD and DCD. Although a strong link has been found between DCD and visual-spatial deficits, the findings for ADHD children have not been as clear, and have been confounded by the possible comorbidity of DCD which has generally not been controlled. An exception to this is a recent study where we divided our sample into children with ADHD and those with and without comorbid DCD (Piek & Pitcher, in press; Pitcher, 2001). Using the WISC-III subscales that examine perceptual organization, we found that children with a dual diagnosis of ADHD and DCD (n=55) were significantly poorer on these tasks than children in the control group (n=31) or children with a single diagnosis of ADHD (n=49). Furthermore, there were also 8 children identified with a single diagnosis of DCD. Although this number was

considerably smaller than in the other groups, a significant difference was found for these children compared with the control group, with the DCD children having the poorer performance. It appears that poor visual-spatial organisation is associated with children who have DCD (regardless of whether they have ADHD), but is not linked to children with ADHD unless they have comorbid DCD.

A meta-analysis carried out by Pennington and Ozonoff (1996) also supports this finding. They identified studies that had 19 measures of visual-spatial organization, but found that children with ADHD performed poorly on only four of these. In the same study, they identified 60 executive functioning tasks that examined working memory, response inhibition and the ability to plan action sequences. In contrast to the visual-spatial tasks, children with ADHD performed more poorly on 40 of these. Executive functioning, and not visual-spatial organization, appears to be a mechanism linked to poor functioning in children with ADHD. Although executive functioning is not a topic of this paper, it is worth noting that recent findings suggest that poor executive functioning is not a process that is affected in children with DCD (Piek et al., in press). That is, this may be a distinct mechanism associated with ADHD and not DCD.

4. Can sensory-motor deficits distinguish Autistic Disorder from DCD

A child is diagnosed with Autistic Disorder on the basis of qualitative impairments in social interaction skills, communication skills, and repetitive or restricted behavior and/or interests (American Psychiatric Association, 1994, p. 65). Autistic Disorder is also associated with quantitative underachievement in language (Eisenmajer, Prior, Leekam, et al., 1998; Howlin, 2003), motor coordination (Ghaziuddin & Butler,

1998; Szatmari, Tuff, Kinlayson & Bartolucci, 1990), empathic abilities (Baron-Cohen, Leslie, & Frith, 1985; Dyck, Ferguson & Shochet, 2001), and executive functions (Ozonoff & McEvoy, 1994; Pennington & Ozonoff, 1996). DSM-IV differential diagnosis rules imply that underachievement in two of these domains, language and motor coordination, are intrinsic to the disorder and therefore, communication and motor skills disorders are not diagnosed in persons with a pervasive developmental disorder. That is, there cannot be a dual diagnosis of DCD and Autism. This implies that the motor difficulties found in DCD and Autism may have the same origin or underlying mechanisms.

Recent research on children with Autistic Disorder suggests that their motor skills deficits exceed their other ability deficits. We (Dyck, Piek, Anderson, Hallmayer, Hay, McCoy & Smith, submitted for publication) assessed the intelligence, language ability, empathic ability and motor coordination of children with Autistic Disorder. For each measure, ability quotients were devised based on normative data obtained from a single representative sample (cf. Dyck et al., 2004), which made possible a comparison of relative ability across the ability domains. Results indicated that children with Autistic Disorder obtain their lowest scores on measures of gross and fine motor coordination, and gross motor coordination was significantly lower (paired t-tests) than fine motor coordination, performance and verbal IQ, receptive and expressive language, theory of mind, emotion recognition, and emotion understanding ability. Gross and fine motor coordination scores (and receptive language ability) were uniquely related to an index of qualitative impairments in social interaction (but not to impairments in communication or to repetitive behavior/interests). It is clear that deficits in motor coordination are as

fundamental to Autistic Disorder as they are to DCD. However, it is important to consider that the underlying deficits or neural substrate that produces the deficits may not be the same for each disorder. If this is the case, perhaps dual diagnosis is important.

In children with Autistic Disorder, motor coordination is negatively correlated with qualitative impairments in social interaction, but other autism symptoms are negatively related to the discrepancy between performance IQ and empathic ability (theory of mind, emotion recognition, emotion understanding) measures: the greater the discrepancy, the lower the level of impairment (Dyck et al., submitted). Performance IQ in this study was estimated using the subtests of block design and picture completion, both measures of visual-spatial organization (Groth-Marnat, 1997). This result suggests that perceptual organization ability acts as a buffer to limit the impact of other ability deficits. When both motor coordination and perceptual organization are severely impaired, symptoms are most severe.

There are several links between what is observed in Autistic Disorder and what is observed in DCD. Motor coordination measures are positively related to empathic ability measures in typically developing children, and we (Cummins, Piek & Dyck, submitted) have shown that emotion recognition tasks in particular, but also emotion understanding, and advanced theory of mind tasks, are related to measures of fine and gross motor coordination among children with and without motor coordination problems. Children selected on the basis of low motor coordination scores and normal verbal IQ have significantly lower scores than comparison children only on measures of the ability to recognize facial expressions of emotion (Cummins et al., submitted), a task requiring visual-spatial organisation. In just over a quarter of cases (12 of 45), scores on the

emotion recognition and other empathic ability measures were under 85 (IQ-equivalent score), a value that has been associated with significant elevations on parent-rated behavioral problems (Dyck et al., 2004). This association between motor coordination and empathic abilities may account for Gillberg's (1992) inclusion of disorders of attention, motor control, and perception among the empathy disorders.

What appears to distinguish children with autistic disorder from children with DCD is that in autism, perceptual organization appears to be a buffering rather than a disabling process. The implication is that the processes underlying perceptual organization need not be impaired in each case where motor coordination is impaired. Children with DCD differ from those with ADHD in performing more poorly on perceptual organization tasks, and it may be the case that what is pathognomonic of DCD is underachievement on both motor coordination and perceptual organization tasks.

What are the implications of these findings for children with DCD? Children with DCD have been identified with social problems such as perceiving lower self worth and less social support than control children (e.g., Skinner & Piek, 1999). They also tend to withdraw from physical play with other children (O'Beirne, Larkin & Cable, 1994), are asked to play with other children less often and have fewer playmates than control children (Schoemaker & Kalverboer, 1994). An important aspect of social interaction is the child's empathic ability, which we have shown to be poorer in children with poor motor abilities (Cummins et al., submitted). Social interaction requires accurate detection, coding and processing of perceptual information in order for the child to understand the emotional information provided by other children (Lemerise & Arsenio, 2000). Given that children with DCD have poor visual-spatial organisation, this may impact on their

ability to accurately perceive the emotional cues (facial expressions and body language) provided by their peers. That is, there may be a link between poor visual-spatial organization and poor social skills in children with DCD.

5. Neural basis of comorbidity

Recent developments in brain imaging techniques have provided clues to the brain structures that are disrupted in developmental disorders. Considerable research has been carried out on children with ADHD and Autism, although there are limited studies on children with DCD.

Several studies have used cranial ultrasound scans at birth to identify haemorrhages or periventricular densities in preterm infants, and then assessed these children at age 6 years (Jongmans, Henderson & Dubowitz, 1993; Jongmans, Mercuri, Dubowitz & Henderson, 1998; Miyahara, Jongmans, Mercuri, deVries, Henderson & Henderson, 2003). These children would normally meet the diagnosis for DCD, although the fact that they had previously been identified with a brain abnormality would suggest that the diagnosis is inappropriate (cf. Jongmans et al. (1998) for discussion on this). These studies have identified a high proportion of children with perceptual-motor problems as measured by the Movement Assessment Battery for Children (Henderson & Sugden, 1992) and the Developmental Test of Visual-Motor Integration (Beery, 1982). However, locating particular brain areas that may be disrupted is difficult. A recent study using structural MRI to examine adults who were born with a birthweight below 1500g found diffuse abnormalities of both the gray and white matter (Allin et al., 2004). The diverse nature of these abnormalities may be a result of the interaction between the

perinatal brain lesions that occur in preterm infants and the normal developmental processes that occur throughout life. Other behavioural studies have implicated the cerebellum and basal ganglia as possible sites for motor dysfunction in children with DCD. Difficulty in force control has been linked in the past to basal ganglia damage (Ivry, Keele & Diener, 1988; Lundy-Ekman, Ivry, Keele & Woollacott, 1991), whereas timing problems in children with DCD have been associated with cerebellar function (e.g., Lundy-Ekman et al., 1992).

There have been considerable studies that have investigated the neuroanatomical substrate of ADHD. However, Bradshaw (2001) points out that these are "noteworthy for their contradictory findings" (p. 103). A common finding is a reduction in brain volume, particularly in the frontal regions of the right hemisphere, the corpus callosum and the cerebellum. Although there has been considerable evidence that the deficits are primarily in the frontostriatal areas, recent evidence suggests they may be more global affecting all cerebral lobes (Castellanos et al., 2002). However, Durston and colleagues (2004) argue that the reduced cerebral volume may be a familial or genetic trait as unaffected siblings shared some of the abnormalities of their brother with ADHD. Their MRI study identified reduced cerebellar volume in boys with ADHD compared with their unaffected siblings.

Like ADHD, structural brain imaging on children with Autism has not implicated a specific brain region. In contrast with ADHD, there is evidence for an increase in brain volume in the first year of life which may be considered as a marker for abnormal connectivity linked with a lack of pruning in the early months of life (Courchesne, Carper & Akshoomoff, 2003). A common view held for children with Autism is that there is a lack of connectivity between brain regions which then leads to problems with integration

of functions. This view demonstrates a very different aetiology to both DCD and ADHD,
supporting the view that different mechanisms may be responsible for the motor
difficulties found for different disorders. However, a common link is the involvement of
the cerebellum. Cerebellar abnormalities have been identified in children with Autism
(e.g., Allen & Courchesne, 2003), although the level of impairment appears to be an
important factor (e.g., Manes et al., 1999). Given the behavioural link found by us
between level of impairment and perceptual organization (Dyck et al., submitted), this
needs to be investigated further. Poor cerebellar function may play an integral role in the
comorbidity found in developmental disorders such as DCD, ADHD and Autism.

6. Conclusions

Poor visual-spatial organisation appears to be a distinct mechanism associated
with children with DCD, impacting on their motor ability and also with potential
consequences for their social interaction. It is therefore important to identify DCD in
children with comorbid disorders such as ADHD and Autistic Disorder. This is
particularly important for children with Autistic Disorder, as symptoms are more severe
when perceptual organisation is also disrupted. We need to consider whether children
with Autistic Disorder who have visual-spatial deficits should be diagnosed with
comorbid DCD, and whether these visual-spatial deficits can be linked to a deficit in
cerebellar functioning not associated with less severe symptoms of Autism.

The findings also have important implications in terms of the descriptions of
developmental disorders and their comorbid conditions within the DSM-IV (American
Psychiatric Association, 1994). For example, given that poor motor coordination in

children with ADHD may be an additional problem to the inattentive or hyperactive/impulsive symptomatology, there is a need to recognise that ADHD and DCD are comorbid conditions with distinct problems that must considered in intervention. However, the research investigating the exact nature of these underlying processes is still in its infancy and considerable research is still required to address this.

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