Motor coordination, empathy, and social behaviour in school-aged children

Ariane Cummins BPsych MPsych, Clinical Psychologist Registrar;
Jan P Piek* BSc PhD, Associate Professor, School of Psychology, Curtin University of Technology, Perth, Western Australia;
Murray J Dyck BA MA PhD, Professor, School of Psychology, Griffith University, Gold Coast, Queensland, Australia.

**Correspondence to second author at* School of Psychology, Curtin University of Technology, GPO Box U1987, Perth 6845, Western Australia.
E-mail: j.piek@curtin.edu.au

Children with motor coordination problems are known to have emotional difficulties and poor social skills. The current study investigated whether children with poor motor ability have poor emotion recognition skills, and whether these could be linked to problems in social behaviour. It was hypothesized that difficulties in empathic ability might be related to the poor visuo-spatial processing ability identified in children with developmental coordination disorder (as defined by the American Psychiatric Association). The relationship between motor coordination, emotion recognition, and social behaviour was examined in a sample of 234 children (113 males, 121 females; mean age 9y 7mo, [SD 1y 8mo] age range 6y 8mo to 12y 11mo). From this sample two groups of 39 children each (17 females, 22 males), one group with motor difficulties (mean age 9y 11mo [SD 2y], range 6y 11mo to 12y 11mo) and the other of control children (mean age 10y [SD 1y 11mo], range 6y 11mo to 12y 11mo), matched for age and sex, were compared using a set of six emotion recognition scales that measured both verbal and perceptual aspects of empathic ability. Children with motor difficulties were found to perform more poorly on scales measuring the ability to recognize static and changing facial expressions of emotion. This difference remained even when visuo-spatial processing was controlled. When controlling for emotion recognition and visuo-spatial organization, a child's motor ability remained a significant predictor of social behaviour.

See end of paper for list of abbreviations.

Motor skills play a crucial role in a child's functioning in social and emotional domains. Studies have shown that poor motor coordination can affect children's sense of competence, their success within their peer groups, academic achievement, and even their selection of recreational activities (Losse et al. 1991, Cantell et al. 1994). The relationship between motor skills and social or emotional functioning is usually thought to be indirect. In other words, poor motor skills may result in poor performance in individual and team games/sports, which may reduce a child's sense of competence. This in turn reduces success within peer groups, may lower academic achievement (see Cantell et al. 1994), and may increase the child's experience of anxiety and depression (Schoemaker and Kalverboer 1994, Skinner and Piek 2001, Francis and Piek 2003). Alternatively, it is possible that the processes responsible for poor motor skills might affect social performance by reducing the child's ability to perceive socially relevant cues. This issue is addressed in this study.

Movement problems severe enough to interfere with children's daily living describes a disorder identified by the American Psychiatric Association (1994) as developmental coordination disorder (DCD). The motor impairment is below that expected given the child's age and intelligence, and cannot be attributed to a general medical condition. The prevalence of these motor problems has been estimated to be up to 6% of children between the ages of 5 and 11 years (American Psychiatric Association 1994).

According to Gillberg (1992), children with DCD and other disorders of attention, motor control, and perception commonly have empathic ability deficits which may account for impaired social functioning. Empathic ability is one of several generic terms that refer to the ability to 'conceptualize other people's inner worlds and to reflect on their thoughts and feelings' (Gillberg 1992, p 835). Empathy is seen from a developmental perspective as a basic building block of social interaction. It has been argued that empathic ability in children has an important role in the development of moral judgement, pro-social behaviours, and childhood social competence (Thompson 1987).

Empathic ability is functionally dependent on several basic processes, including the ability to perceive visual cues accurately within interpersonal contexts (Minter et al. 1992, Dyck et al. 2004). As a result, children's inability to perceive visual or other sensory cues accurately limits their ability to decode and label the emotional expressions of other people, a key component in the ability to understand the experience of others.

Children with DCD have a broad range of perceptual problems, including visuo-spatial processing (Lord and Hulme 1987, Coleman et al. 2001), kinaesthetic processing (Piek and Coleman-Carman 1995), and cross-modal integration (Wilson and McKenzie 1998). On the basis of the results of a meta-analysis by Wilson and McKenzie (1998), the most substantial deficits seem to be in the area of visuo-spatial processing, often measured by complex visuo-spatial tasks such as Block Design and Object Assembly subtests from the Wechsler Intelligence Scale for Children – 3rd edition (WISC-III; Wechsler 1991). This deficit has been related to impaired emotion recognition ability (Dyck et al. 2004). If Parush et al. (1998) are correct in arguing that children with DCD reproduce pictorial designs incorrectly because they fail to visually perceive them accurately, it may also be true that children with DCD will have particular difficulty in recognizing facial expressions of emotion because the expressions were inaccurately perceived and decoded.

The first aim of the current study was to assess whether children with motor coordination problems have difficulties across a range of empathic abilities. We predicted that deficits were most likely to be observed in empathic ability tasks that place greater demands on perceptual processes, and especially on visual perceptual processes. Using the Emotion Recognition Scales (ERS; Dyck et al. 2001), verbal and perceptual aspects of empathic ability can be measured separately. It was expected that tasks requiring more 'direct' perceptual processing, such as emotion recognition tasks (facial cues, vocal cues), would be more adversely affected in comparison with other tasks (comprehension and vocabulary) that have a larger verbal component; children with movement problems were expected to have lower scores than their age-matched peers in the control group. In their study, Schoemaker et al. (2001) noted that children with DCD have deficits in visual perception but also in other modalities, such as proprioceptive and tactile perception. Therefore, this study also sought to determine whether vocal cues, and hence auditory perception, are also affected. Given that poor performance on the emotion recognition tasks requiring direct perceptual processing may be linked to the poor perceptual organization of children with DCD, to investigate this, we used subtests from the WISC III Performance IQ measure that assess visuo-spatial organization as a covariate in a subsequent analysis.

We further predicted that, in a representative sample of children, there would be a significant relationship between motor coordination, visuo-spatial processing, and social behaviour. If processing deficits are primarily responsible for poor social skills, then, when perceptual organization is controlled, the impact of motor ability on social behaviour will disappear. Social problems were measured by parent report of social behaviour using the Social subscale of the Child Behavior Checklist (CBCL; Achenbach 1991).

Method

PARTICIPANTS

The participants were 234 children (113 males, 121 females; mean age 9y 7 mo [SD 1y 8mo], range 6y 8mo to 12y 11mo). Participants were recruited from 42 schools in the Perth metropolitan region, and chosen to represent the distribution of academic achievement within the state of Western Australia.

From the total sample, 39 children (17 females, 22 males) were identified as being within the range of movement ability identified for children with DCD (motor difficulty [MD] group; mean age 9y 11mo [SD 2y], range 6y 11mo to 12y 11mo). They scored at or below 80 on the McCarron Assessment of Neuromuscular Development (MAND; McCarron 1997). This cut-off is stricter than the 15th centile (score 84; Neuromuscular Development Index [NDI], Tan et al. 2001), as recommended by Geuze et al. (2001). Twenty-nine of these children had mild motor difficulties (scoring between 71 and 80), and 10 had moderate motor difficulties (scoring between 70 and 55). No child was identified with severe motor difficulties (a score of less than 55).

Another group of 39 children (17 females, 22 males; mean age 10y [SD 1y 11mo], range 6y 11mo to 12y 11mo) who scored at or above 100 on the MAND were selected for the control group. All participants were required to have a Verbal IQ of 80 or above to exclude the effect of intellectual disability on results. Mean age, Verbal IQ, Performance IQ, and MAND scores for each group are shown in Table I.

None of the 78 children had neurological or behavioural disorders that had been previously diagnosed. On the basis of the recommendations of Geuze et al. (2001), given that the children were all from mainstream schools and were in good health, there was no need to conduct a medical or neurological examination to ensure that criterion C of the diagnosis in accordance with the Diagnostic and Statistical Manual of Mental Disorders – 4th edition (DSM-IV; American Psychiatric Association 1994) was met. An examination of the scores on the CBLC identified several children who scored within the range of a diagnosis. Specifically, for the children with movement problems, one was within the range of both Internalizing and Externalizing problems, two scored highly on the Anxiety scale, two on the Attention scale, two on the Social Problems scale, and one on the Delinquency scale. For the control group, one scored high on the Delinquency scale and one on the Somatic Problems scale.

Because DCD is difficult to conduct, most studies investigating it have not measured whether poor motor ability affects academic achievement or daily living (Geuze et al. 2001). Henderson and Barnett (1998) argue against the strict adherence of this criterion (B) of the DSM-IV diagnosis of DCD because 'the inclusion of any such criterion detracts from the importance of motor competence in its own right' (p.461). Despite this criticism, we have chosen not to use the term DCD for the group of children identified here with movement difficulties (the MD group).

Table I: Motor difficulty (n=39) and control (n=39) groups' profiles for age, Verbal IQ, Performance IQ, and MAND/NDI scores

Group	*Age (y:m)*	*Prorated Verbal IQ*	*Prorated Performance IQ*	*MAND/NDI scores*
Motor difficulty				
Mean	9:11	112.0	111.4	72.71
SD	2:0	16.68	18.31	7.24
Range	6:11–12:11	83–145	79–146	55–80
Control				
Mean	10:0	113.6	117.9	112.05
SD	1:11	14.52	15.97	9.98
Range	6:11–12:11	83–151	87–155	100–155

MAND, McCarron Assessment of Neuromuscular Development (McCarron 1997); NDI, Neuromuscular Development Index (Tan et al. 2001).

MEASURES AND APPARATUS

MAND

The MAND is a standardized test of motor skills comprising 10 tasks, including five tests of gross motor skills and five tests of fine motor skills. These scaled scores are summed and then used to determine the NDI, which has a mean of 100 and a standard deviation of 15. The MAND has acceptable test–retest reliability (0.67 to 0.98), criterion validity, and concurrent validity (McCarron 1997).

WISC-III

The WISC-III (Wechsler 1991) measures general cognitive ability in children aged between 6 years and 16 years 11 months. Performance IQ was estimated with the Block Design and Picture Completion subscales, which measure the ability to 'interpret and organize visually perceived material' (Sattler and Saklofske 2001, p 232). Verbal IQ was estimated with the Vocabulary and Information subscales. The WISC-III is one of the most frequently used measures of intelligence in children, in both clinical and research populations (Sattler 2001), and has excellent internal consistency, test–retest reliability, criterion validity, and construct validity.

ERS

Participants' empathic ability was measured by using the five subscales of the ERS (Dyck et al. 2001, 2004). The ERS include measures of the ability to recognize facial (Fluid Emotions test) and vocal (Vocal Cues test) expressions of emotion. The Fluid Emotions test has two scales: (1) the Accuracy scale which measures the ability rapidly to recognize static facial expressions; (2) the Speed Given Accuracy scale measures the ability to recognize changing or changed facial expressions (which have morphed from the expressions presented as part of the Accuracy scale; see Appendix I). The ERS also include measures of emotion-understanding ability (Emotion Vocabulary test, Comprehension test, and Unexpected Outcomes test; see Appendix I).

CBLC

The CBLC (Achenbach 1991) is a standardized questionnaire designed to measure internalizing and externalizing behaviour problems in children aged 4 to 12 years. The parent form of the CBLC was used in which parents indicated the presence and degree of each of 113 child behaviours, which are grouped into eight subscales. The social subscale, consisting of eight items, was used in the current study as a measure of social problems.

PROCEDURE

This project adhered to the ethical guidelines set out by the National Health and Medical Research Council of Australia. Children in grades 2 to 7 in Perth primary schools were invited to participate in 'Project KIDS', a large-scale, long-running project in which data are collected for child-related research in school holiday periods. Data relevant to the current study were, therefore, collected along with information pertaining to other projects.

Principals were contacted by mail seeking permission to contact parents via the school to recruit children. Parents who gave permission for their child to participate returned the completed registration and consent form in the prepaid envelope. A letter confirming enrolment was then sent to parents with a CBLC form to complete and return as soon as possible in the prepaid envelope supplied.

Children were allocated to one of 20 groups, each consisting of up to 12 participants. Each group was tested on a separate day. All children completed all the tests and assessors were blind to group status. To maintain the children's interest and motivation, and to maximize their enjoyment, children were provided with a scenario at the beginning in which their job was to colonize a fictional planet. For each puzzle or game (test) completed, participants were given coloured tokens that could then be redeemed for items that could be used to colonize the planet at the end of the day. Testing was conducted in three 90-minute sessions. The first test session was followed by a 30-minute recess, and the second by a 60-minute lunch break. Testing was administered by a team of researchers conducting related studies with the data collected. The order of test administration was not uniform, with each child having his/her own schedule.

Results

MOTOR COORDINATION AND EMPATHIC ABILITY

Means (SDs) for each of the six ERS measures for the two groups are given in Table II. Multivariate analysis of variance was used to assess whether children with poor motor coordination also have empathic ability deficits. The results indicated that the two groups differed on the linear combination of variables ($\Lambda[6,71]=0.79$, $p=0.010$). Univariate tests showed that the multivariate result was due mainly to the lower scores of the MD group on the two scales measuring recognition of facial emotion cues (total static emotions correctly identified: $F[,76]=8.85$, $p=0.004$; total changing or changed emotions correctly recognized: $F[1,76]=11.30$, $p=0.001$).

Because the two groups are known to differ on the subtests of Performance IQ, we assessed whether the group differences on the empathic ability measures are attributable to the Performance IQ difference by conducting a multivariate analysis of covariance in which Block Design and Picture Completion scores were entered as covariates. The results indicated that a significant effect remained for the main between-group factor ($\Lambda[6,69]=0.74$, $p<0.002$). Univariate analyses showed that Block Design was significantly related to a measure of recognition of facial emotion cues ($F[1,74]=5.509$, $p=0.022$). When effects due to the covariates were controlled, the MD group continued to obtain significantly lower scores on the two measures of the ability to recognize facial emotion

Table II: Mean (SD) of scores on emotion recognition tasks for movement difficulty (MD) and control groups

Task	*MD group*	*Control group*	*p*
ACC-1	18.33 (3.14)	20.41 (3.02)	**0.004**
SGA	77.02 (19.82)	94.54 (25.80)	**0.001**
VCT	19.87 (5.42)	21.61 (4.42)	0.124
EVT	10.23 (4.27)	10.74 (5.11)	0.632
CT	9.36 (2.65)	10.15 (2.32)	0.163
UOT	6.23 (3.31)	7.71 (4.26)	0.090

p values in bold type are significant. ACC-1, total static emotions correctly identified; SGA, speed given accuracy; VCT, Vocal Cues test; EVT, Emotion Vocabulary test; CT, Comprehension test; UOT, Unexpected Outcomes test.

cues (ACC-1: $F[1,74]=9.973$, $p=0.002$; SGA: $F[1,74]=14.99$, $p=0.0002$), and also on one measure of emotion understanding (Unexpected Outcomes test: $F[1,74]=5.43$, $p=0.022$).

SOCIAL PROBLEMS

Hierarchical regression was used on the total sample of 234 children to investigate the relationship between social problems and motor ability, using the NDI, when Performance IQ, the six emotional recognition tasks, and other relevant variables were taken into account (Table III). Only those variables that were significantly correlated with NDI and/or social problems were included. Social problems, as measured by the CBCL and NDI, were found to be negatively correlated ($r=-0.26$, $p<0.01$). Age and Verbal IQ were found to correlate with the NDI score, and were entered into the regression equation on the first step. This was statistically significant ($R^2=0.031$). On step 2, Performance IQ plus the six ERS measures were entered and were found to have a significant effect ($R^2_{change}=0.064$). When NDI was entered in the last step, it was found to be a significant predictor of social problems once the other variables were accounted for ($R^2_{change}=0.057$).

Discussion

Although it has been established by Dyck et al. (2001) that children with other childhood disorders such as Asperger syndrome and attention-deficit–hyperactivity disorder display deficits in empathic ability, this is the first study to demonstrate that children with poor motor coordination are less competent in their ability to recognize emotions. As such, the current study provides support for Gillberg's (1992) contention that DCD should be recognized as an 'empathy disorder'. However, the fact that the delay in acquiring empathic ability was specific to recognizing facial expressions of emotions, and not to the ability to recognize vocal emotion cues or to understand emotions, suggests that to regard DCD as an empathy disorder would be an inaccurate generalization. The finding that children with poor motor coordination have more difficulty in recognizing facial cues of emotions yet display no difference in conceptually understanding emotions strongly supports Cutting and Dunn's (1999) argument that emotion recognition and understanding tasks reflect different aspects of social cognition. It should be noted that once Performance IQ was controlled for, a difference between the groups was identified for the Unexpected Outcomes test. This was a surprising outcome.

This study has shown that children with motor coordination problems are less accurate and slower in responding to facial emotion cues. This finding is clearly valuable when considered in the context of a child's social functioning within their peer group. Lemerise and Arsenio (2000) postulated a model of social information processing in which they argued that a child's perceptual ability is vital in detecting and interpreting social and affective cues from others. These findings suggest that children with DCD may be disadvantaged in the ongoing social process with their peers because they may have more difficulty in detecting the emotional states of others and using this information to guide their behaviour in social contexts.

The level of motor ability in children with MD was negatively correlated with social problems. It was argued that these problems may be related to the child's inability to process social and affective cues appropriately. However, through hierarchical regression analysis it was found that when perceptual organization and emotional recognition measures were controlled, motor ability continued to predict social problems. Therefore, although perceptual deficits may be partly responsible for poorer social functioning, such as poor peer relations, isolation, and lower self-perception (Losse et al. 1991, Cantell et al. 1994, Skinner and Piek 2001), it is clear that other unknown factors contribute to the child's inability to function in complex social situations.

Although the present study has yet to explain the exact nature of the relationship between empathic abilities and motor coordination, it has shown that children with motor coordination problems do have specific deficits in empathy. The findings related to deficits in recognition of facial emotion cues support the notion that children with DCD may be disadvantaged in the social domain, which in part might account for their established social and academic problems in childhood. These findings also have implications for selection of treatment of motor coordination problems. Mandich et al. (2001) reviewed the range of treatments available for children with DCD and they noted that the lack of an established causal mechanism to explain all motor coordination problems results in the type of treatment provided being based on differing theories of motor development and learning. Given the findings in this study, treatment options may need to include enhancing both the physical and social skills of children with DCD to improve the level of age-appropriate functioning.

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Table III: Hierarchical regression analysis examining predictors of social problems ($n=234$)

Predictors		β	R^2_{change}	F_{change}	*df*	*p*
Step 1			0.031	3.33	2.211	0.038
	Age (y)	0.080				
	VIQ	–0.149[a]				
Step 2			0.064	2.073	7.204	0.048
	Age (y)	0.327[b]				
	VIQ	0.014				
	PIQ	–0.074				
	ACC-1	0.080				
	SGA	–0.194[a]				
	VCT	–0.025				
	EVT	–0.226[a]				
	CT	0.028				
	UOT	–0.102				
Step 3			0.057	13.645	1.203	0.0001
	Age (y)	0.259[a]				
	VIQ	–0.005				
	PIQ	–0.049				
	ACC-1	0.086				
	SGA	–0.119				
	VCT	–0.001				
	EVT	–0.226[a]				
	CT	0.039				
	UOT	–0.094				
	NDI	–0.254[b]				

[a]$p<0.05$; [b]$p<0.01$. VIQ, Verbal IQ; PIQ, Performance IQ; ACC-1, total static emotions correctly identified; SGA, speed given accuracy; VCT, Vocal Cues test; EVT, Emotion Vocabulary test; CT, Comprehension test; UOT, Unexpected Outcomes test; NDI, Neuromuscular Development Index.

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List of abbreviations

CBLC	Child Behavior Checklist
DCD	Developmental Coordination Disorder
ERS	Emotion Recognition Scales
MAND	McCarron Assessment of Neuromuscular Development
MD	Movement difficulties
NDI	Neuromuscular Development Index

Appendix I

EMOTION RECOGNITION SCALES

The Fluid Emotions test (Dyck et al. 2004) measures the ability to recognize static and changed or changing facial expressions of emotion. This is a computer-presented test and items are drawn from Matsumoto and Ekman's (1995) colour slides of adults expressing one of seven emotions (e.g. anger or happiness) or a neutral expression. Each item consists of two pictures of a Japanese or Caucasian male or female expressing one of the seven emotions or a neutral expression. The participant is asked what emotion is being expressed in the first picture. After responding, the image is gradually (over 4 seconds) transformed to another person expressing a different emotion. Participants identify the second emotion as quickly as they can. Initial accuracy (ACC-1; initial emotions correct); and speed given accuracy (SGA; the speed of accurate post-morph responses) were measured. These scales are internally consistent (ACC-1, α=0.90; SGA, α=0.94), have good concurrent validity (Dyck et al. 2004) and are useful in identifying empathic ability deficits in children with autism spectrum and non-spectrum disorders (Dyck et al. 2001).

The Vocal Cues test (Dyck et al. 2004) measures the ability to recognize vocal intonations specific to different emotions. The Vocal Cues test's 'Unreal' scale consists of 43 items in which emotions are expressed using non-semantic content: numerals, letters, nonsense syllables. The emotions sampled are identical to those in the Fluid Emotions test. Responses are scored correct (1) or incorrect (0). This scale is internally consistent (α=0.93) and has good concurrent validity (Dyck et al. 2004).

The Emotion Vocabulary test measures the ability to define emotion words (e.g. what does the word 'angry' mean?). The response format of the Emotion Vocabulary test is open-ended and initial responses can be queried to resolve ambiguities in the initial response. The Emotion Vocabulary test is internally consistent (α=0.82 to 0.89), is moderately related to other ERS, and is strongly related to other measures of vocabulary (Dyck et al. 2001, 2004).

The Comprehension test measures the ability to understand the emotional consequences of exposure to an emotion-eliciting context (e.g. Susan is given a new bicycle for her birthday. What will Susan feel?). Comprehension test items sample the seven emotions in the Fluid Emotions test, 'social variants' of emotions (e.g. pride or shame) and variations in the intensity of emotions (e.g. terror versus fear). Emotion causes include 'material causes' (e.g. loss or gain of an object), 'social causes' (e.g. interpersonal rejection) and 'intrapsychic causes' (e.g. failure to achieve one's goals). The Comprehension test has acceptable reliability (α=0.64 to 0.79) and is moderately related to other ERS and to measures of intelligence (Dyck et al. 2001, 2004).

The Unexpected Outcomes test measures the ability to apply reasoning skills and knowledge of the causes of emotions to explaining apparent incongruities between an emotion-eliciting context and the emotion elicited by the context. Unexpected Outcomes test items provide information about a situation that is likely to cause an emotional response in a protagonist (e.g. 'John likes a girl called Susan, and he wants her to go to the movies with him. When he asks her, she says yes'). Items then indicate what emotion has been experienced (e.g. 'On their way to the movies, he is very angry'). In each case, the emotion differs from what is usually expected to occur in the situation. The child is asked to explain the apparent incongruity. The Unexpected Outcomes test has adequate reliability (α=0.73 to 0.81) and is moderately to strongly related to other ERS and to measures of intelligence (Dyck et al. 2001, 2004).