COMPLEX IMITATION OF GESTURES IN SCHOOL-AGED CHILDREN WITH LEARNING DIFFICULTIES

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Abstract:

Developmental Coordination Disorder (DCD) has often been overlooked both in school practice and in everyday work with children. DCD is one or all of the heterogeneous range of development disorders affecting the initiation, organization, and performance of action. The aim of this article, therefore, was to draw attention to this problem and prove how teachers of different subjects can easily recognize pupils with DCD. Prompt recognition enables fast intervention, resulting in progress in the movement abilities of pupils with DCD. Our research has shown that we can discriminate between pupils with learning difficulties and those without them on the basis of 20 *tasks of the Bergès-Lézine's Test of Imitation of Gestures*. In particular, we wish to emphasize three tasks (*12*, *17*, and *20*) in which pupils had to cross the vertical midline of the body. Individuals with DCD face problems in spatial orientation and in complex imitation of gestures. Pupils can be classified into two groups (with and without motor coordination and learning difficulties) based on differences found in tasks requiring them to cross the vertical midline of the body and rotate their hands. Learning difficulties can be predicted by pupils' performance doing such specific tasks. School teachers, especially physical education teachers, can recognize pupils with motor coordination difficulties in informal tasks, and organize appropriate psychomotor activities for them.

Key words: *Developmental Coordination Disorder, learning difficulties, constructional dyspraxia*

Introduction

The domains of development (social, emotional, motor, cognitive, and language) are tightly interrelated. The development and transformation of a single domain influences the formation and development of others. For this reason, movement is very important during a child's development. It shapes the body scheme, the sense of time and space, and the ability to plan and adapt. It promotes self-esteem, self-confidence, and an individual's motor skills. Movement also advances motor learning, sense of cooperation, respect, and diversity (Cermak, Gubbay, & Larkin, 2002).

Motor function relies upon gesture skills. Skilful movement should be precise, planned, and executed in the shortest possible time with the least possible expenditure of energy (Vaivre-Douret, 2002a).

Occasionally something can go wrong during the course of a child's motor development, and this dysfunction can be recognized by parents and/or by teachers, especially teachers of physical education. Children demonstrating such motor dysfunction may have Developmental Coordination Disorder (DCD), also known as Developmental Dyspraxia (DD) (Kirby, 2005). Dyspraxia is often described interchangeably or synonymously by terms such as clumsiness, sensorimotor dysfunction, or developmental coordination disorder. As a result, different types of developmental motor disorders have not been well defined or consistently described (Cermak, Costers & Drake, 1980; Cermak, 1985; Henderson, 1987; Denckla & Roeltgen, 1992). In some cases, motor deficits are just one component of a general picture of delayed or retarded development. In others, motor deficits are not accompanied by a delay in intellectual development but by various academic problems (Henderson, 1987). Finally, some children may show evidence of developmental motor deficits only (Gubbay, 1979). In addition to motor deficits, children with DCD have also been found to demonstrate language and speech problems. Few studies, however, have investigated the specific language deficits of children who exhibit both language and other types of motor deficits (Crary, 1984; Crary & Towne, 1984; Crary, Landness, & Towne, 1984; Dodd, Leahy, & Hambly, 1989; Le Normand, 1993; Lyytinen & Ahonen, 1988; Schwartz & Regan, 1996; Le Normand, Vaivre-Douret, Payan, & Cohen, 2000).

DCD/DD is mentioned in the ICD-10 categorization of disorders, chapter V - *Mental and behavioural disorders* (F00-F99), *Disorders of psychological development* with codes F82 and F83 (WHO, 2007). The code F82 is referred to as specific developmental disorder of motor function. It is a disorder in which the main feature is a serious impairment in the development of motor coordination that is not explicable in terms of general intellectual retardation or any specific congenital or acquired neurological disorder. Nevertheless, in most cases a careful clinical examination shows marked neurodevelopmental immaturities such as choreiform movements of unsupported limbs or mirror movements and other associated motor features, as well as signs of impaired fine and gross motor coordination. Specific developmental disorder of motor function includes: clumsy child syndrome, developmental coordination disorder, and developmental dyspraxia. The code F83 is referred to as a residual category for disorders in which there is some admixture of specific developmental disorders of speech and language, scholastic skills, and motor function, but in which none predominates sufficiently to constitute the prime diagnosis. This mixed category should be used only when there is a major overlap between each of these specific developmental disorders. The disorders are usually, but not always, associated with some degree of general impairment of cognitive functions.

The American Psychiatric Association defines DCD/DD as a status that can be recognized among children who experience movement difficulties that are out of sync with their general development. Children with such disorders also have no known medical condition or identifiable neurological disease (American Psychiatric Association, 2000). The specific manifestations of the disorder are varied and pervasive, including both gross and fine motor skills (Visser, 2003). These problems make the child's day-to-day activities (such as dressing/undressing, tying shoelaces, buttoning, and writing), as well as sports activities (such as skipping and ball dribbling) extremely difficult. Therefore, in comparison with other children without DCD/DD, the lack of different movement abilities can easily be observed. These characteristics may be recognized as motor immaturity. Often these problems are associated with others, such as dropping objects, frequent falls, and fine motor skill problems, as well as sensory integration, visual perception, and reading and writing difficulties. Gross motor skill problems occur when an overflow of energy is spent for such basic skills as standing upright. Problems also occur in jumping, roller-skating, accurate throwing of different objects, and especially in simultaneous coordination of hands with different or identical motor patterns. Even more problems appear with the timing of movement. Children experience a lack of balance, rhythm, and spatial orientation, as well as a fear of height and climbing.

Both execution and/or planning of the complex imitation of gestures can be problematic for children with DCD/DD. According to Ayres (1972a), DD is not a singular syndrome because the sensory integration theory makes a distinction between execution and planning problems (Ayres, 1972a, 1972b; Dewey & Kaplan, 1994).

Early recognition and intervention of DCD is very important. As explained in Filipčič and Ozbič (2008) study, a quicker prognosis of DCD can lead to faster intervention resulting in the progress of children with DCD in their movement abilities. On the basis of complex imitation of movement tasks a teacher can predict which children have some learning difficulties and which do not. The results highlight three tasks where children had to cross the vertical midline of their bodies. These tasks involve bilateral coordination.

Cermak (1985) also noted that therapists in clinical practice distinguished between children who showed motor planning deficits and those with deficits in the coordination or execution of motor tasks. The former appeared to have a general problem in organizing and planning their approach to tasks (i.e., primary planning apraxia), whereas the latter appeared to know how to plan their approach to a particular task, but experienced difficulty in executing the task (i.e., executive apraxia) (Le Normand, et al., 2000).

Deconinck and colleagues (2006) divided the underlying causes of the motor impairment into two main lines. The first line focuses on the sensory information process prior to and during the motor response, while the second focuses on the motor component itself. Visuospatial processing (Wilson & McKenzie, 1998), kinaesthetic perception (Smyth & Mason, 1997), and cross-modal perception were found to contribute to the motor coordination impairments in children with DCD.

By definition, children with DCD demonstrate delays on norm-referenced motor tests (BOTMP - Bruininks, 1987; Movement ABC - Henderson & Sugden, 1992). It is worth mentioning that these tests measure the outcome of the movement rather than how the movement is performed. Motor problems are usually associated with a lack of satisfaction in movement. It is not surprising, therefore, that children with DCD tend to participate in fewer social activities than do other children (Chen & Chon, 2003), especially when the task is motor praxical in nature. This reluctance to participate demonstrates how the environment plays an important role.

In some cases, no major problems with simple gestures are observed during the preschool period. Difficulties in reading and writing, complex motor tasks, or motor coordination can be observed later, during the school period. The first two people who can recognize a child with DCD at his/her school are the classroom teacher and the physical education teacher. They observe a child in his/her complex motion involving difficult coordination as well as time and space-oriented tasks. They also observe the child's sense of rhythm and his/her coordination when playing and manipulating with different sports equipment. Both the classroom and physical education teacher encourage the child to participate in various sports activities.

Unlike other conditions, such as muscular dystrophy or cerebral palsy, DCD is often not recognized by parents or primary school teachers as a condition requiring intervention or special assessment. Children with DCD are often observed as clumsy, unmotivated, and lazy. Their problems are often assumed to be the result of other conditions such as attention deficit disorder or a learning disability. Cairney, Hay, Faught, Corna, and Flouris (2006) called children with DCD the "hidden cohort", and suggested that they are at risk for social exclusion. Unfortunately, DCD is often overlooked in school. Consequently, it could be very efficient and useful to screen pupils during physical education classes in the first or second grade of elementary school to detect coordination and praxis problems that can cause learning difficulties.

It has been estimated that between 5% and 9% of all school-aged children meet the diagnostic criteria for DCD (Henderson & Hall, 1992; Sugden & Wright, 1998), with some authors suggesting that up to 22% meet the criteria (Cermak, Gubbay, & Larkin, 2002). It was also found that more boys than girls have DCD. Different problems can occur during physical education classes: body scheme problems, lack of balance and coordination, difficulties with time and spatial orientation, problems with timing, etc. Some children with DCD often have difficulties with reading, writing, and mathematical reasoning. Primary school teachers explain school failure with lack of learning and effort, as well as with desultoriness, etc.; thus creating an important factor determining the success in school. Therefore, physical education and other teachers can be the first ones who observe different learning difficulties (LD) and other problems in school. In the ICD-10 classification of disorders (WHO, 2007), LD are mentioned in chapter V as F06.7 - *Mild cognitive disorder* (a disorder characterised by impairment of memory, learning difficulties, and reduced ability to concentrate on a task for more than brief periods) and as F81 - *Specific developmental disorders of scholastic skills* (disorders in which the normal patterns of skill acquisition are disturbed from the early stages of development: specific reading disorder, specific spelling disorder, specific disorder of arithmetical skills, mixed disorder of scholastic skills, other developmental disorders of scholastic skills, developmental disorder of scholastic skills).

Several researchers examined the possible interrelation between praxis and school success: Ayres (1972b), Deuel (1992), Elbert (1999), Erhardt, McKinlay and Bradley (1987), Haines, Brown, Grantham, Rajagopalan and Sutcliffe (1985), Keogh (1982), Lyytinen and Ahonen (1989), Miyahara, and co-workers (1997), O'Hare and Brown (1989), Polatajko (1999), Wilson and McKenzie (1998), Vaivre-Douret (2002a, b), Filipčič and Ozbič (2008).

From Vaivre-Douret's (2007) point of view, dyspraxia is a non-verbal neuropsychological dysfunction still unrecognized. Vaivre-Douret (2007) researched the impact of dyspraxia on school success and found that it can generate learning and behavioural difficulties. It can influence graphic efficiency (motor difficulties, dysgraphia, difficulties in the imitation of gestures, difficulties in spatial orientation on paper), arithmetic (dyscalculia, including difficulties in counting and calculating, solving problems, and understanding texts), geometry (disregard of direction and spatial relations, and problems in describing and analysing geometric figures due to lack in mental representation), and reading (sometimes it is halting, slow; confusion between letters occurs because of fixation). Problems with understanding may appear, whether in the context of written instructions or in answering on the basis of written text, figures, or schemes. Orthographic problems may also occur (i.e., writing or copying individual letters, reading, or learning from a written text). The latter may concern the child's orientation within the text itself or his/her difficulties with the meaning of symbols, motion of lines, etc. The most frequent difficulties with dyspraxia are problems of intentional movement and motor control, postural tonus, lateralization (unhomogeneous or undefined), problems of general motor coordination (level of the basal ganglia), bimanual coordination (interhemispheric dysfunction, level of the corpus callosum), written language (dyslexia, dysortographia, discalculia), speech-language production (expressive dysphasia), problems of attention, hyperactivity and impulsiveness, problems of the executive functions (impulsiveness, problems of planning), associated psychopathology, and neurovisual problems (nystagmus) (Vaivre-Douret, 2007).

Due to the frequent comorbidity between DCD and other developmental disorders, Kaplan, Wilson, Dewey, and Crawford (1998) suggest that DCD may not be a discrete disorder (Cermak, Gubbay, & Larkin, 2002, p. 22). Longitudinal studies indicate that the presence of motor problems in middle childhood is associated with academic, cognitive, and behavioural problems at later ages (Gillberg, & Gillberg, 1989).

The correlations between LD and DCD, as well as between LD and motor impairment, have been studied by a number of researchers. Strang and Rourke (1985) identified a subtype of LD that they called "non-verbal perceptual-organizational--output disability – NPOOD". Children with this disorder exhibit bilateral psychomotor impairment, difficulties with complex movement skills, and difficulties in perception, analysis, organization and synthesis of non-verbal information.

Gubbay (1975) reported that 50% of children with problems in motor coordination had difficulty with schoolwork, a slightly higher prevalence than the 41% reported by Sprinkle and Hammond (1997). Drillien and Drummond (1983) reported that 32% of children with motor impairments had moderate problems in school, while 32% had severe problems.

Dellen, Vaessen and Schoemaker (1990) reported that one third of their sample of 31 children identified as clumsy repeated a grade, compared to one child in the control group. All of these studies indicate that many children with problems in motor coordination also show school-related problems (Cermak, Gubbay, & Larkin, 2002, p. 21). A high number of children with LD have also been identified as having poor motor coordination and visual-motor skills. It is recognized, however, that DCD is not predictive for LD, and that not all children with LD have problems with motor coordination.

Miller, Anzalone, Lane, Cermak, and Osten (2007) explained DCD/DD, specifically focusing on the difficulties in bilateral manual coordination as a sensory integration dysfunction (SID), or sensory processing disorder. It is a neurological disorder that causes difficulties with processing information from the five classic senses (sight, hearing, smell, taste, and touch), the sense of movement (vestibular system), and/or the positional sense (proprioception). Sensory information is sensed normally, but perceived abnormally. The difficulty occurs because the information is processed by the brain in an unusual way that may cause distress or confusion. SID is a diagnosis of its own, but it can also be linked to other conditions, including attention deficit disorder, dyslexia, developmental dyspraxia, and speech delays, among many others.

The corpus callosum, the main structure subserving hemispheric collaboration, is necessary for efficient cognitive functioning (Njiokiktjien, 1994). Njiokiktjien (1994) reported that children with specific LD (i.e., dysphasia/dyslexia), or with several degrees of general LD, had corpus callosum that varied in size. The size of the corpus callosum did not vary significantly according to the severity of LD, although it tended to be smaller in severe LD. Despite a multitude of factors influencing the size of corpus callosum, this study suggests that the callosal size, supposedly linked to interhemispheric function, may contribute to the pathophysiological mechanisms that increase the chances of developing LD (Njiokiktjien, 1994).

Stančák, Cohen, Seidler, Duong, and Kim (2003) analysed the effects of the size of the corpus callosum on cortical activations evaluated during motor tasks: unilateral finger movements and bilateral movements either with or without a temporal delay between left and right fingers. They found that the activation over the lateral cortex was sparse and occurred only in bimanual movements. The results suggest that the corpus callosum modulates the activity of the supplementary motor and cingulate cortical areas, depending on the temporal complexity of bimanual movements. The corpus callosum represents the major cerebral commissure connecting the homotopic and heterotopic cortical regions of both hemispheres (Pandya & Seltzer, 1986; Lent & Schmidt, 1993). Lesions of the corpus callosum are accompanied by apraxia (Geschwind, 1965) and a diminished temporal (Preilowski, 1972; Kennerly, Diedrichsen, Hazeltine, Semjen, & Ivry, 2002) and spatial (Zaidel & Sperry, 1977; Degos, et al., 1987; Eliassen, Bayness, & Gazzaniga, 1999) coordination of bimanual movements. The callosal connections with the primary motor area are sparse (Gould, Cusick, Pons, & Kaas, 1986; Rouiller, et al., 1994). In contrast, the callosal connections between the left and right supplementary motor area are dense (Rouiller, et al., 1994), and contribute to bimanual coordination (Brinkman, 1980). Thus, it is expected that the size of the corpus callosum is an important factor for bilateral motor control. The correlations between cerebral activation and the size of the corpus callosum point to the activation of commissural pathways during motor tasks. The results should apply to all tasks requiring interhemispheric communication. This could include bimanual movements, unimanual movements (due to ipsilateral cortex activation), and possibly tasks such as a left-handed response to a stimulus presented in the right visual field (Stančák, et al., 2003).

Leslie, Davidson and Batey (1985) examined the differences between dyslexics and controls in the unimanual and bimanual conditions of the peg placement section of the *Purdue Pegboard Test*. Due to differences in unimanual and bimanual conditions in the control and experimental group, the authors affirm that the data are consistent with the theories arguing for left hemispheric dysfunction in dyslexics (Gordon, 1980, Rudel, 1993) and with the models proposing interhemispheric transfer deficits (Obrzut, M., Obrzut, A., Hynd, & Pirozzola, 1981).

According to the cited studies that point to the possible interrelation between learning difficulties and DCD/DD and the prediction of learning difficulties based on praxical tasks, the purpose of this research was to suggest and present a relatively simple way of screening for LD in children with DCD/DD. Results suggest that tasks based on the *Bergès-*

Lézine's Test of Imitation of Gestures (1972) can be used by primary school teachers in order to recognize pupils with learning difficulties. Based on simple imitation, the tasks can help to identify pupils with specific problems such as dyslexia, dyscalculia, and dysortographia, as well as those without these problems. Prompt recognition thereof enables fast intervention and progress in the development of children with DCD.

The aim of this research was to discriminate between pupils observed by their teachers to be exhibiting coordination and learning difficulties and those without teacher-reported difficulties of this kind. The second part of the *Bergès-Lézine's Test* was used to find discriminant variables in the test of imitation of gestures for unsuccessful and successful pupils.

The following hypothesis was tested. Based upon some variables of the complex imitation of gestures of the *Bergès-Lézine's Test* (1972) - i.e., its second part - it is possible to classify pupils with and without LD including DCD.

Methods

Subjects

Pupils from the first five grades of primary school participated in this research. In total, 46 pupils (aged 6 to 11 years) were tested (25 boys and 21 girls). They were 8.96 years old on average (SD=1.52). Pupils with intellectual disabilities were excluded from the research. Group 1 presented 11 pupils (8 boys and 3 girls) aged 6 to 11 years, their average age being 8.27 years (SD=1.48). Subjects were identified by the teachers who observed and reported their learning difficulties. Group 2 presented 35 pupils (17 boys and 18 girls) aged 6 to 11 years, with an average age of 9.17 (SD=1.48). No coordination problems and learning difficulties were observed beforehand in this group. There were no statistically significant differences in the age (p=.05) between Group 1 and Group 2. In addition, there were no statistically significant differences observed in the praxic performance between older and younger pupils in both groups (p=.05).

Procedures

The second part of the *Bergès-Lézine's Test of Imitation of Gestures* (Bergès & Lézine, 1972) was used in our procedure. The first part of the test consisted of simple gestures to be imitated. The second part of the test measured the organization of body scheme and fine motor skills (i.e., complex imitation of gestures). It included 20 different tasks suitable for children aged 6 to 10 years:

- tasks number 1, 2, 3, 4, 5, 6, 7 and 9 examined recognition of fingers maturity of fine motor skills;
- tasks number 5, 8, 10, 12, 14, 17, 19 and 20 examined spatial coordination, control of particular body parts ability of asymmetric use of hands;
- tasks number 11, 13, 15, 16 and 18 examined recognition of fingers as a base of global model where cognitive presentation is needed.

Each pupil was assessed individually by the *Bergés–Lézine's Test of Imitation of Gestures* during a physical education class. Assessment took place in a small, quiet room and was conducted by the same researcher. Parental consent was obtained and parents were informed about the research according to the Declaration of Helsinki. The order of the tasks was performed according to the *Bergès-Lézine's Test* (its second part) (Bergès & Lézine, 1972). No time limit was imposed for the execution of a task. Each gesture was retained in view until the child had finished imitating it. The overall test took approximately 15 minutes per child.

Each successfully executed task scored one point if the proposed gesture was correctly imitated. Failure to imitate the gesture scored zero points.

The Kolmogorov-Smirnov normal distribution test and the stepwise discriminant analysis were applied. Data were processed with the statistical programme SPSS for Windows (release 13.0).

Results

Cronbach's alpha coefficient showed relatively reliable internal consistency of the test (.76). The stepwise discriminant analysis was used to analyse differences between the two groups. Fourteen variables of the complex gestures imitation were included (tasks 1, 2, 3, 4, 7, 14, with SD =.00, were excluded from the analysis) (Table 1). Three variables entered the discriminant analysis: task 12, task 17, and task 20 (p<.01) (shown in Table 2). These variables were significant discriminant variables.

The variables included in the analysis showed diminishing tolerance and lower value of Wilks' Lambda (Table 3), thus indicating the significance of discrimination. The variables in the third step showed Wilks' Lambda values of .63, .66 and .55. The value of Wilks' Lambda gives information on the differences between the groups - low value of Wilks' Lambda means great differences, and high value of Wilks' Lambda means little differences. In the third step (three variables: 12, 17, 20), the value of Wilks' Lambda was .50 (Table 4).

Table 5 shows one discriminant function, which explains 100% of variance. Canonical correlation was high (.71) with the eigenvalue of .99 (close to 1.00). In the third phase, all three variables were chosen and the value of Wilks' Lambda was .50, Chi-square=29.34, df=3 and p<.01. The percentage of total variance was 50.1%. Due to sufficiently low value of Wilks' Lambda and sufficiently high

Table 1. Descriptive statistics (N, Mean, SD, Min, Max) of the second part of the Bergès-Lézine's Test's variables in Groups 1 and 2

Task	Group	N	Mean	SD	Min.	Max.	Task	Group	N	Mean	SD	Min.	Max.
Task 1	**Group 1**	11	1.00	.00	1	1	**Task 11**	**Group 1**	11	.45	.52	0	1
	Group 2	35	1.00	.00	1	1		**Group 2**	35	.89	.32	0	1
Task 2	**Group 1**	11	1.00	.00	1	1	**Task 12**	**Group 1**	11	.45	.52	0	1
	Group 2	35	1.00	.00	1	1		**Group 2**	35	.94	.24	0	1
Task 3	**Group 1**	11	1.00	.00	1	1	**Task 13**	**Group 1**	11	.45	.52	0	1
	Group 2	35	1.00	.00	1	1		**Group 2**	35	.86	.35	0	1
Task 4	**Group 1**	11	.91	.30	0	1	**Task 14**	**Group 1**	11	1.00	.00	1	1
	Group 2	35	1.00	.00	1	1		**Group 2**	35	1.00	.00	1	1
Task 5	**Group 1**	11	.91	.30	0	1	**Task 15**	**Group 1**	11	.82	.41	0	1
	Group 2	35	.94	.24	0	1		**Group 2**	35	.97	.17	0	1
Task 6	**Group 1**	11	.91	.30	0	1	**Task 16**	**Group 1**	11	.64	.51	0	1
	Group 2	35	1.00	.00	1	1		**Group 2**	35	.97	.17	0	1
Task 7	**Group 1**	11	1.00	.00	1	1	**Task 17**	**Group 1**	11	.36	.51	0	1
	Group 2	35	1.00	.00	1	1		**Group 2**	35	.89	.32	0	1
Task 8	**Group 1**	11	.64	.51	0	1	**Task 18**	**Group 1**	11	.36	.51	0	1
	Group 2	35	.94	.24	0	1		**Group 2**	35	.66	.48	0	1
Task 9	**Group 1**	11	1.00	.00	1	1	**Task 19**	**Group 1**	11	.82	.41	0	1
	Group 2	35	.97	.17	0	1		**Group 2**	35	.91	.28	0	1
Task 10	**Group 1**	11	.27	.47	0	1	**Task 20**	**Group 1**	11	.73	.47	0	1
	Group 2	35	.77	.43	0	1		**Group 2**	35	.94	.24	0	1

Legend: N-number of subjects, Mean-arithmetic mean, SD-standard deviation, Min.-minimum, Max.-maximum

Table 2. Stepwise statistics of the discriminant analysis of the variables of the Bergès–Lézine's Test, second part, between Group 1 and Group 2 – children with LD and without LD

Step	Variable	Wilks' Lambda							
		Statistics	df 1	df 2	df 3	Exact F			
						Statistics	df 1	df 2	p
1	**Task 12**	.70	1	1	44.00	19.04	1	44	.000
2	**Task 17**	.55	2	1	44.00	17.51	2	43	.000
3	**Task 20**	.50	3	1	44.00	13.92	3	42	.000

Table 3. Variables of the second part of Bergès-Lézine's Test, entered in the discriminant analysis of Group 1 and Group 2 – children with LD and without LD

Step	Variable	Tolerance	F to remove	Wilks' Lambda
1	**Task 12**	1.00	19.04	
2	**Task 12**	1.00	13.76	.73
	Task 17	1.00	11.46	.70
3	**Task 12**	1.00	10.76	.63
	Task 17	.95	13.60	.66
	Task 20	.95	4.17	.55

correlation (.71), it can be concluded that the two groups were in fact different. The significance of Wilks' Lambda value was checked by Chi-square test (Chi-square=29.34). It has been established that at p<.01 the two groups differed in variables *task 12*, *task 17* and *task 20*.

Table 4. Wilks' Lambda in the discriminant analysis of the Bergès-Lézine's Test, second part, between Group 1 and Group 2 – children with LD and without LD

Step	Number of variables	Wilks' Lambda	df 1	df 2	df 3	Exact F			
						Statistics	df 1	df 2	p
1	1	.70	1	1	44	19.04	1	44	.000
2	2	.55	2	1	44	17.51	2	43	.000
3	3	.50	3	1	44	13.92	3	42	.000

Table 5. Summary of the canonical discriminant function (eigenvalue and Wilks' Lambda) in the discriminant analysis of the tasks from the Bergès-Lézine's Test, second part, between Group 1 and Group 2 – children with LD and without LD

Function	Eigenvalue	% Variance	Cumulative %	Canonical correlation	Test of the function	Wilks' Lambda	Chi-square	df	p
1	.99	100.00	100.00	.71	1	.50	29.34	3	.000

The data in Table 6 confirm that the two groups of pupils differed. The variable *task 17* had the highest standardized canonical correlation coefficient in the discriminant function (.72). The variables *task 12* and *task 20* had standardized canonical correlation coefficients of .64 and .44, respectively. In the structure matrix (Table 6) the variable *task 12* had the highest correlation (.66). In addition, the variable *task 17* as well as the variable *task 20* had positive values (.61 and .31).

82.6% of originally grouped cases (38/46 of cases) were correctly classified (9 of 11 in group 1 and 29 of 35 in group 2), which means that less than 20% of pupils were incorrectly classified. 76.1% of cross-validated grouped cases were correctly classified. Classification results in Table 7 show that 81.8% of pupils from Group 1 were correctly classified into Group 1 (after validation, 72.7%), while 82.9% of pupils from Group 2 were correctly classified into Group 2 (after validation, 77.1%).

Table 6. Discriminant function analysis between Group 1 and Group 2 – children with LD and without LD: standardized canonical discriminant functions coefficient and structure matrix of the classification variables from the Bergès-Lézine's Test, second part

Standardized canonical discriminant functions coefficient		Structure matrix	
Variables	Function 1	Variables	Function 1
TASK 12	.64	TASK 12	.66
TASK 17	.72	TASK 17	.61
TASK 20	.44	TASK 20	.31

Table 7. Classification results: successfulness of the classification in Group 1 and 2 on the basis of three tasks from the Bergès-Lézine's Test, second part

		Group	Predicted group membership		Total
			Group 1	Group 2	
Original	Count	Group 1	9	2	11
		Group 2	6	29	35
	%	Group 1	81.8	18.2	100.0
		Group 2	17.1	82.9	100.0
Cross-validated	Count	Group 1	8	3	11
		Group 2	8	27	35
	%	Group 1	72.7	27.3	100.0
		Group 2	22.9	77.1	100.0

Discussion and conclusions

For sufficient quality of discrimination of DCD, three variables used in the discriminant analysis (stepwise method) of the second part of the *Bergès-Lézine's Test* were significant: *task 12*, *task 17* and *task 20* (presented in Figure 1). All three variables represented tasks where hands needed to be crossed; in tasks 12 and 17 intertwining of fingers was demanded, while in task 20 hand rotation was needed. All three tasks represented a complex structure where crossing the vertical midline of the body was involved. These tasks are interrelated with bilateral coordination (i.e., coordinated activities of the left and right side of the brain), where the corpus callosum plays a very important role, according to Vaivre-Douret (2007). The discriminant function can be explained by different tasks (crossing hands, intertwining fingers and hand rotation), which means that there was lack of cognitive involvement. It can be concluded that the discriminating tasks are those where the pupil had to cross the vertical midline of the body. A function that requires crossing the vertical midline of the body can be called a *discriminant function of the complex gesture structure and interhemispheric connection*.

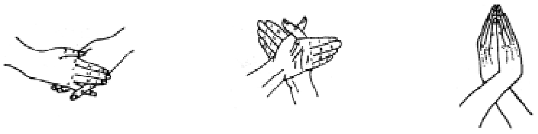

Figure 1. Discriminating tasks 12, 17 and 20 (Bergès-Lézine, 1972).

The ability to coordinate the right and left side of the body and to cross the midline of the body is an indication that both sides of the brain are working well together and sharing information efficiently.

Coordination of the two body sides is an important foundation for the development of many gross and fine motor skills. This is essential for the development of the cerebral specialization of the skilled use of a dominant hand. A child with poor coordination of the two body sides may adjust his/her body to avoid crossing the midline. He/she may not be able to coordinate one hand's movement while the other is acting as an assistant to ease the effort. A child may switch hands when performing a fine motor task because he/she is experiencing frustration. In this case, skilful use of both hands simultaneously is needed.

This has also been confirmed by Filipčič and Ozbič's study (2008) in which three variables proved to be significant for a sufficient and quality prediction ($p<.001$) of school success. It is worth noting that the present research complements the results of the previously mentioned study with more controlled groups (classified by age and praxical achievements among children of different age). It has been found that in both studies, using different samples and statistical methods, the same tasks were important, namely, the ones demanding planned goal-oriented and intended gestures. All of the three variables represented tasks where hands needed to be crossed; in tasks 12 and 17 intertwining of fingers was demanded, while in task 20 palm rotation was needed. In sum, the imitation of gestures is a good predictor and discriminator of school failure.

Good coordination of the two body sides is an important foundation for writing with pencils and cutting with scissors. Children learn to coordinate their body sides when they play with toys (for example, threading beads, assembling Lego cubes, skipping rope, and playing rhythmic games over a rope) or ride a bicycle as suggested in Chen and Cohn (2003).

The biggest problem was observed in pupils' cognitive involvement and consequently in their motor performance. Pupils therefore faced problems with their body scheme and coordination, as well as with spatial perception. Learning difficulties can occur as a result of these problems. Children with DCD face problems in spatial orientation and complex imitation of gestures.

The results presented in Table 7 show that two pupils from Group 1 (exhibiting learning difficulties) were classified into Group 2 (pupils without learning difficulties), and six pupils from Group 2 were classified into Group 1. The results showed that not all of the pupils with DCD had LD, and that those with LD did not all have DCD.

Based upon the results of the complex imitation of gestures of the *Bergès-Lézine's Test*, the classification of pupils with and without DCD and LD was possible. With systematic screening of pupils with the *Bergès-Lézine's Test*, problems with visual perception, spatial organization, motor planning, and cognitive reasoning could be recognized. On the basis of differences found in tasks where pupils had to cross the vertical midline of their body and rotate their hands, children could be classified into two groups (with LD and without LD).

The results of this research have practical value: teachers can recognize pupils with DCD before they start reading and writing activities. Teachers can organize appropriate psychomotor activities for such pupils: bimanual and bilateral coordination of arms and body; unilateral, homolateral, monomanual and bimanual activities (swimming, yoga, etc.); activities where coordination of upper and lower limbs is required; activities with hand rotation; activities for kinaesthetic and vestibular stimulation (restraining and accelerating riding on a handcart, cycling, swinging, rotating, etc.). Such activities are also suitable for children in the preschool period. Children with DCD/DD should be assessed by occupational therapists, speech and language therapists, and psychomotor experts/psychomotricians. They should also be involved in sports activities that promote sensory integration and bilateral coordination.

It is necessary to enlarge the sample of participants and to apply regression and deeper discriminant analysis in future research. It would also be interesting to explore probable differences between boys and girls. For practical value it would be necessary to implement motor activity programmes that stimulate planning of simple and complex consecutive movements in stable and moving environments.

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IMITIRANJE SLOŽENIH POKRETA KOD ŠKOLSKE DJECE S POTEŠKOĆAMA U UČENJU

Razvojni koordinacijski poremećaj (DCD) je često zanemaren i u radu sa školskom djecom i u svakodnevnom radu s djecom. DCD podrazumijeva jedan ili cijeli heterogeni spektar razvojnih poremećaja koji utječu na inicijaciju, organizaciju i izvedbu nekog pokreta. Cilj ovog članka bio je privući pažnju na ovaj problem i dokazati da nastavnici različitih predmeta mogu vrlo lako prepoznati učenike s razvojnim koordinacijskim poremećajem. Brzo prepoznavanje omogućuje brzu intervenciju koja rezultira napretkom u razvoju kretnih sposobnosti kod učenika s DCD-om. Ovo je istraživanje pokazalo kako je moguće razlikovati učenike s poteškoćama u učenju od ostalih učenika primjenom 20 zadataka okupljenih u Bergès-Lézineovom testu imitiranja pokreta.

Ključne riječi: *razvojni koordinacijski poremećaj, poteškoće u učenju, konstrukcijska dispraksija*