Self-Regulation of Sport Specific and Educational Problem-Solving Tasks by Children With and Without Developmental Coordination Disorder

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Abstract

The purpose was to examine the domain specificity of the self-regulatory skills of children with Developmental Coordination Disorder (DCD) compared to their peers without DCD. Participants included 10 children with DCD and 10 without. A sport specific problem-solving task (shooting at a hockey net) and an educational problem-solving task (peg solitaire) were compared. Zimmerman's (2000) social cognitive model of self-regulation was used; it has three phases (a) forethought, (b) performance or volitional control, and (c) self-reflection. Participants were taught to think aloud during both tasks to access cognitive processes (Ericsson & Simon, 1984/1993). Codes were developed under five major categories, (a) goals, (b) knowledge, (c) emotion, (d) monitoring, and (e) evaluation. Verbalizations were transcribed and coded using the NUD*IST Vivo software. Results indicated that children with DCD have decreased knowledge in the motor domain, may have general difficulties with planning and set less challenging goals. The findings also support previous research regarding their negative emotions attached to motor tasks.

Résumé

Le but fut d'examiner la spécificité du domaine de la régulation de soi des habiletés des enfants avec un Developmental Coordination Disorder (DCD) comparés avec leur pairs sans DCD. Les participants inclus 10 enfants avec DCD et 10 n'ayant pas de DCD. Une tâche de résolution de problème reliée à un sport spécifique (lancer dans un filet de hockey) et une tâche éducative de résolution de problème (peg solitaire) ont été comparées. Le modèle social et cognitive de régulation de soi de Zimmerman (2000) a été utilisé ; ce modèle a trois phases (a) prévoyance, (b) performance ou contrôle volontaire , et (c) réflexion personnelle. Les participants furent enseignés de penser à haute voix pendant les deux tâches pour avoir accès à leurs processus cognitifs (Ericsson & Simon, 1984/1993). Des codes furent développés sous cinq catégories principales, (a) buts, (b) connaissance, (c) émotion, (d) surveillance, et (e) évaluation. Les verbalisations furent transcrites et codées en utilisant le programme informatique NUD*IST Vivo. Les résultats ont indiqué que les enfants avec DCD ont une diminution de connaissance du domaine moteur, peuvent avoir des difficultés générales de planification et se fixent des buts moins élevés. Les résultats supportent également les recherches antérieures concernant leur émotions négatives reliées aux tâches moteurs.

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Chapter 1

Introduction

The ability to perform simple motor tasks is often taken for granted; some have difficulty with even elementary tasks such as buttoning a shirt or catching a ball (Dare & Gordon, 1970; Wall, 1982). Labels for these problems include *movement difficulties, Developmental Coordination Disorder, physical awkwardness, dyspraxia, developmental apraxia,* and *clumsiness* (Dare & Gordon, 1970; Henderson & Barnett, 1998; Losse et al., 1991; Wall, 1982; Wall, Reid, & Paton, 1990; Sugden & Wright, 1998). Often the descriptors are a reflection of professional interest or cultural differences. For example, medical professionals might use the term dyspraxia while education specialists might prefer physical awkwardness (Sugden & Wright, 1998). Sometimes the labels are used interchangeably, creating much confusion. Although terminology issues abound, Developmental Coordination Disorder (DCD) has emerged as the international term and DCD will be used in this research (Henderson & Henderson, 2002).

While most people develop competence in the physical domain early in life, children with DCD are physically low skilled and do not develop adequate proficiency in movement (Dare & Gordon, 1970; Gubbay, 1975; Wall, 1982; Wall et al., 1990). Anyone who attempts a new movement skill will appear clumsy at first, but with enough practice this apparent awkwardness is usually overcome (Dare & Gordon, 1970). Children with DCD have great difficulty learning new skills even with much practice, and over time are likely to avoid practicing to prevent failure experiences (Bouffard, Watkinson, & Thompson, 1996). Wall's 1982 definition of DCD is still relevant today, "physically awkward children are children without known neuromuscular problems who fail to perform culturally normative motor skills with acceptable proficiency" (p. 254). Culturally normative skills, as defined by Wall, are skills that are generally used within a culture by a large number of people, for example, hockey in Canada.

Children with DCD constitute approximately 4-5% of school aged children, and are a heterogeneous group that is difficult to identify and define (Wall et al., 1990). It is often reported that these children drop things, bump into others, fall frequently, and are generally considered clumsy. When participating in dynamic game situations involving other children, the difficulties in movement become more apparent because of increased motor demands (Wall, 1982). Difficulty might also be experienced with fine motor skills such as using a pencil, cutting with scissors, fastening buttons, or tying shoelaces. Academic performance may also be poor (Miyahara, 1994; Wall, McClements, Bouffard, Findlay, & Taylor, 1985). Children with DCD are more likely to be introverted and judge themselves to be less competent than their peers both physically and socially (Causgrove Dunn, 2000; Schoemaker & Kalverboer, 1994). Henderson and Henderson (2002) report that DCD is a lifelong condition, children will not grow out of it.

As the link between physical activity and health becomes more transparent (McKardle, Katch, & Katch, 1996), the development of proficient motor skills during childhood becomes critical. It is assumed that a physically active lifestyle requires an adequate level of motor proficiency. Proficiency in movement is not easily defined and is dependent on many factors, including physiological, psychological, and motivational variables. Children with DCD often experience failure in physical activity leading to decreased participation due to low motivation; thus making it difficult to lead a healthy physically active (Bouffard et al., 1996). Continued failure often leads to lack of confidence, poor self-concept and an eventual withdrawal, causing a vicious cycle that reinforces inactivity (Causgrove Dunn, 2000; Bouffard et al., 1996; Schoemaker & Kalverboer, 1994; Wall et al., 1985; Wall et al., 1990; Watkinson et al., 2001).

In 1985 Wall et al. proposed a knowledge-based approach to study children with DCD. They argued that DCD is a developmental problem that might be explained by a significant lack of knowledge in the motor domain. There are five components in the model: (a) declarative knowledge, (b) procedural knowledge, (c) affective knowledge, (d) metacognitive knowledge, and (e) metacognitive skill.

Declarative knowledge refers to factual knowledge about the motor skill in question, and influences the development and execution of skilled action.

Procedural knowledge underlies all aspects of an action, it is the "knowing how" to perform the skill. An aspect that must not be ignored in children with DCD is affective knowledge. Affective knowledge refers to the subjective feelings that children attach to movement (Wall et al., 1985; Wall et al., 1990). Metacognitive skills and metacognitive knowledge are integral to a person's overall knowledge about action (Glaser et al., 1987; Glaser & Chi, 1988; Wall et al., 1985). Metacognitive knowledge about action refers to the knowledge about what is known about movement. In the movement context, Wall et al. (1990) stated that the metacognitive knowledge that children develop refers to their procedural, declarative and affective knowledge of physical actions. Metacognitive skills refer to the person's ability to take control of his or her cognitive activity and the demands of the task (Wall et al., 1985).

Children with DCD have been described as having a "movement learning disability" (Keogh, 1982; Miyahara, 1994; Polatajko, 2001; Wall et al., 1982). The learning disabilities in the motor domain were considered by Keogh (1982) to be parallel to the learning disabilities some children have in the math or reading domains. Because the limited children with DCD have in the motor domain, "one can readily predict that their metacognitive skills will also be underdeveloped" (Wall et al., 1990, p. 304). Self-regulatory skills, which fall under the umbrella of metacognition, are important in developing proficiency in many academic and motor skills (Bouffard & Dunn, 1993; Glaser et al., 1987; Glaser & Chi, 1988; Wall, 2002). Self-regulation is a multidimensional event, that refers to the personal thoughts, feelings, and actions that are planned and adapted to the attainment of goals (Zimmerman, 2000). Metacognitive skills develop with maturity and they may be less developed in students with learning disabilities or performance difficulties (Bos & Vaughn, 1994; Butler, 1998; Glaser et al., 1987; Wong, 1985). Therefore, it is likely that children with DCD have problems in metacognition and specifically self-regulation, although there is no empirical evidence of these problems in DCD (Bouffard, 2002).

Zimmerman (2000) describes self-regulation as, "self-generated thoughts, feelings and actions that are planned and cyclically adapted to the attainment of personal goals" (p. 14). Zimmerman (2000) and Schunk and Zimmerman (1997) suggest that self-regulation is a dynamic interaction of processes rather than a single trait, hence it is possible to self-regulate one type of performance and not another. From a social cognitive perspective, Zimmerman (2000) has offered a cyclical model of self-regulation consisting of three stages: (a) forethought, (b) performance or volitional control, and (c) self-reflection.

The forethought phase of the model proposed by Zimmerman (2000) consists of two categories: task analysis and self-motivational beliefs. Within the task analysis category is goal setting and strategic planning. In a highly self-regulated individual, his or her goals are organized hierarchically with subgoals representing checkpoints of achievement on the path to the higher goals and accomplishments. Strategic planning is another form of task analysis; for a person to achieve a high level of expertise there must be methods for reaching those goals. In a self-regulated learner these methods assist the learner in attending to relevant cues that aid cognition, emotion control and skilled action (Zimmerman, 2000). The second category of forethought is self-motivational beliefs. Self-regulatory skills are of little use if a performer is not motivated to partake in the activity. It is important to realize that no self-regulatory strategy will work equally well for every individual nor for specific individuals in all situations. "Thus as a result of diverse and changing intrapersonal, interpersonal, and contextual conditions, self-regulated individuals must continuously adjust their goals and choice of strategies" (Zimmerman, 2000, p. 17).

The second phase is the performance or volitional control phase (Zimmerman, 2000). This phase includes two categories: self-control and self-observation. Self-control includes such processes as self-instruction, imagery, attention focusing, and task strategies. The second type of performance control involves self-observation. This refers to the learner's monitoring of performance, and the context within which the performance takes place.

The third and final stage of Zimmerman's (2000) model is the self-reflection phase. The two categories of this stage include self-judgment and self-evaluation. Self-judgment involves evaluating one's own performance and identifying causal factors. Self-evaluation refers to comparing one's performance to a standard or goal. Self-reflection links to the goal setting of the first phase of this model as it is difficult to evaluate one's progress without goals, whether or not those goals are achieved. The three phases of this model are sustained by a self-regulatory feedback loop. Self-reflective processes influence forethought about future actions such as adjusting goals, planning and self-motivational behaviour (Zimmerman, 2000).

Zimmerman's (2000) model was chosen because it can easily accommodate discrete tasks and it may explain developmental differences and difficulties in self-regulation (Zimmerman & Cleary, 2001; Kitsantas & Zimmerman, 1998). Kirschenbaum (1984/1987) proposed a model of self-regulation in the sport domain, however Zimmerman's (2000) model from the social cognitive perspective emphasizes metacognitive skills in performing motor tasks, therefore it was deemed appropriate for this study. Zimmerman's model also acknowledges that self-regulation is dependent on more than just metacognitive skill, it also is dependent on declarative knowledge, procedural knowledge and affective knowledge within a given domain which is consistent the knowledge based approach (Wall et al., 1985). Therefore, because knowledge is considered to be domain specific, it is possible to have proficient self-regulatory skills in a given domain and have underdeveloped self-regulatory skills in another domain (Schunk & Zimmerman, 1997). Children with DCD have difficulties in the motor domain therefore insight into their self-regulatory skills on sport specific problem-solving tasks is valuable. By investigating their self-regulatory skills on educational problem-solving tasks a better understanding as to the state of their global self-regulation abilities will emerge. However important, self-regulation is a difficult skill to measure and study scientifically.

Concurrent and retrospective verbal reports are methods of examining thought and action (Bainbridge & Sanderson, 1995; Ericsson & Simon, 1984/1993; Fonteyn, Kuipers, & Grobe, 1993; Payne, 1994). Verbal reports can provide information that is usually difficult to access, in particular, information about the type of knowledge used while performing a problem-solving task (Fonteyn et al., 1994; Payne, 1994). Ericsson and Simon (1984/1993) propose that verbal reports are generally an accurate representation of mental processing.

The use of verbal reports with children is increasing (Martini, 2002; McPherson & Thomas, 1989; Reid, Harvey, Lloyd, & Bouffard, 2002). Estes (1998) studied how aware children are of their own mental activity. This study found that children as young as 6 years old were able to acknowledge their own cognitive activity. Therefore it was deemed appropriate to use children 10-12 years old for the present study.

Some studies in the psychomotor domain have investigated thought processes using verbal reports. McPherson and Thomas (1989) used retrospective verbalizations to compare decision-making during tennis by child expert and non-expert players. A more recent study by Martini (2002) used a concurrent think aloud methodology during a ball-throwing task of children who were identified as being high skilled, average skilled, and having DCD. The present study also used a concurrent think aloud methodology.

Keogh (1982) described children with DCD as having a learning disability and metacognitive skills tend to be underdeveloped in those with learning disabilities (Bos & Vaughn, 1994; Glaser et al., 1987; Wong, 1985). Therefore it is expected that the self-regulatory skills of children with DCD will be underdeveloped in the motor domain and will be investigated in the present study with a hockey shot toward a net. However a study to examine the state of their self-regulatory skills in cognitive/problem-solving tasks is also warranted to gain a better understanding of their global self-regulatory skills. Therefore, an educational problem-solving task of peg-solitaire was also chosen for the current study to evaluate the domain specificity of self-regulation. Peg solitaire was chosen because success in this problem-solving game is not dependent on physical proficiency; there is no time limit, and the game is not timed. Polatajko, Mandich, Miller, and Macnab (2001) suggest researchers should investigate effective *learning* strategies that will enhance motor performance. Studying the self-regulatory skills of children with DCD will provide insight into the learning abilities of children with DCD and possibly lead to improved intervention techniques.

Purpose

The purpose of this study was to examine the domain specificity of the self-regulatory skills of children with DCD in a sport specific problem-solving task and an educational problem-solving task compared to their peers without DCD.

Hypotheses

A) Children with DCD will have fewer self-regulatory verbalizations, as compared to their peers on the sport specific problem-solving task.

B) Children with DCD will have a similar number of self-regulatory verbalizations compared to their peers on the educational problem-solving task.

Limitation

The think aloud procedure employed for this study may interfere with the execution of the sport specific task. To some extent it is unnatural to take a hockey shot or complete a problem-solving task and talk about it in detail while performing. Yet Ericsson and Simon (1984/1993) concluded that if verbal reports are collected properly, they do not interfere in the processes used to perform the task. Martini (2002) as well as Reid et al. (2002) both studied the verbalizations of children aged 10-12 with DCD while performing motor tasks and found that the participants were able to verbalize while performing tasks. Zimmerman and Cleary (2001) and Kitsantas and Zimmerman (1998) both used "think-aloud" methodology with success when studying self-regulation on sport specific tasks using Zimmerman's (2000) model.

Chapter 2

Literature Review

This chapter will consist of four major sections. The first section will define Developmental Coordination Disorder (DCD) including a discussion of diagnosis and identification, as well as heterogeneity and co-morbidity. The second section will present the major cognitive research approaches: the information processing approach, the knowledge-based approach and a problem solving approach. The third section will discuss self-regulation using theoretical models from Kirschenbaum (1984/1987) and Zimmerman (2000). The final section will address the issue of dysfunctions in self-regulation with particular emphasis on the link to children with DCD.

Developmental Coordination Disorder: Introduction

Diagnosis and Identification

The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) uses Developmental Coordination Disorder (DCD) to describe a marked impairment in motor coordination, which cannot be better explained by an intellectual disability or a known physical disorder (American Psychiatric Association, 1994). There are four criteria in the DSM-IV, two are inclusive and two are exclusive. Criterion A states that performance in daily activities that require motor coordination is substantially below that expected for chronological age and IQ. Criterion B requires the investigator to judge whether the difficulties interfere significantly with academic achievements or activities of daily living. Criterion C states that the deficit must not be better diagnosed by a different medical condition such as cerebral palsy and must not satisfy the criteria for pervasive developmental disorders. Finally, criterion D states that if an intellectual disability is present, the motor difficulties must be greater than those expected of the original disability. Developmental Coordination Disorder is currently of unknown etiology and does not have a biological marker, therefore the diagnosis occurs by observation of behaviours (Henderson & Henderson, 2002).

Children with DCD constitute a heterogeneous group that is very difficult to clinically identify and define. Several different tests have been developed to identify children with DCD, however there is no "gold standard" (Henderson & Barnett, 1998). There are theoretical and practical implications associated with identification (Henderson, 1987; Maeland, 1992; Sugden & Sugden, 1991). First, there are many variations in the developmental patterns of each individual which govern the emergence, and evolution of movement difficulties. Therefore, when is the most appropriate time to screen for DCD? Second, the wide range of movement difficulties makes it difficult for one instrument to cover areas such as locomotor skills, ball skills, self-help skills and, manipulative skills. Third, as there is a continuum of motor ability in any sample, it is difficult to determine the arbitrary point in a given motor scale below which indicates a motor problem (Henderson, 1987; Henderson & Barnett, 1998; Maeland, 1992).

The selection criteria used in previous studies with DCD from 1980-1999 were reviewed by Geuze, Jongmans, Schoemaker, and Smits-Engelsman (2001). The four most common standardized tests were, the Movement Assessment Battery for Children (Movement ABC), formerly called the Test of Motor Impairment, and the Test of Motor Imapairment-Henderson Revision; Gubbay's test; the McCarron test; and the Bruininks-Oseretsky Test of Motor Proficiency. Standardized tests never satisfy the needs of every researcher, nevertheless the research community needs a standardized test because these procedures permit replication and comparison between and within individuals (Maeland, 1992). The current standardized test recommended for research is the Movement ABC (Geuze et al., 2001; Henderson & Sugden, 1992; Maeland,1992). However, it is also recommended that in addition to administering the standardized test, investigators should acquire as much qualitative information from teachers and parents through questionnaires as well as observation of the child in a movement setting (Geuze et al., 2001; Gubbay, 1975; Wright & Sugden, 1996).

Developmental Consequences

Proficiency in movement is characterized by "purposeful, planned, accurate, and precise behaviour" (Wall, 1982, p.254). Skilled movement may fall on a spectrum of low to high, as with any other domain. Most children learn motor skills with ease while others have difficulty performing even the simplest tasks (Dare & Gordon, 1970; Gubbay, 1975; Losse et al., 1991; Wall, 1982; Wall et al., 1985 Wall et al., 1990). This latter group of children has been labeled children with *movement difficulties*, as *physically awkward* (Wall, 1982, Wall et al., 1990), children with *minimal cerebral* dysfunction (Gubbay, 1975), and clumsy *children* (Dare & Gordon, 1970; Gubbay, 1975; Henderson & Hall, 1982). Although there is great debate surrounding the most appropriate label for this population (Henderson & Henderson, 2002), Developmental Coordination Disorder (DCD) is currently used by the DSM-IV (American Psychiatric Association, 1994).

Because of the generally vague nature of what is defined and identified as DCD, it is very difficult to determine an exact prevalence figure, however an often cited range is 4-15% of the general population (Sugden & Keogh, 1990; Wall et al., 1990). It is generally reported that DCD has a ratio of 3 boys to 1 girls (Sugden & Sugden, 1991; Wall et al., 1990). These children do not show any classical neurological signs and their difficulty cannot be linked to an identifiable neurological disorder (Losse et al., 1991). Children with DCD are also described to be more introverted, judge themselves to be less competent both physically and socially, and are significantly more anxious than children without DCD (Schoemaker & Kalverboer,1994; Skinner & Piek, 2001).

Wall (1982) defined children who are physically awkward as those without known neuro-muscular problems who fail to perform culturally-normative motor skills with acceptable proficiency (p. 254). These children are often reported to drop things, bump into others, fall frequently, and are generally considered "clumsy". When participating in dynamic game situations involving other children, the difficulties usually become more apparent because of the increased motor demands of open skills (Wall, 1982). Difficulty may also be experienced with fine motor skills such as using a pencil, tying shoelaces, or using a knife and fork. Handwriting is reported to be particularly slow and illegible, additionally the self-help skills of children with DCD have been reported to be poor (Smits-Engelsman, Niemeijer, & van Galen, 2001; Sugden & Wright, 1998).

The reduced ability to adequately perform functional childhood activities may reduce participation in everyday school activities (Wright & Sugden, 1996). In North American culture, the mastery of physical skills is highly valued, especially for boys in the context of competitive sport (Schoemaker & Kalverboer, 1994; Wall 1982). It has been suggested that in cultures where sport is highly valued children with poor motor skills may end up in socially isolated positions, leading to poor self-esteem and withdrawal from physical activity to avoid failure (Bouffard et al., 1996; Cantell, Smyth & Ahonen, 1994; Keogh, 1982).

> Much of the literature on children with movement difficulties suggests that these children may refrain from participation in physical activity due to a cycle of demonstrated incompetence, lack of confidence, exclusion, and withdrawal that is based on a history of failure in the motor domain (Bouffard et al., 1996, p. 61).

Withdrawal causes a vicious cycle that reinforces inactivity, thereby decreasing opportunities to practice and improve (Cantell et al., 1994; Causgrove Dunn, 2000; Bouffard et al., 1996; Keogh, 1982; Rose, Larkin, & Berger, 1998; Schoemaker & Kalverboer, 1994; Wall, 1982; Wall et al., 1985; Wall et al., 1990; Watkinson et al., 2001). Children with DCD, on average, have lower perceived physical or athletic competence. Causgrove Dunn (2000) suggests that physical education environments should be structured in such a way to promote perceptions of a mastery climate. By enabling children with DCD to experience success, the physical educator may thereby prevent a climate of negative self-perceptions and further withdrawal from physical activity. This type of proactive approach is recommended rather than the passive approach of allowing the child to "grow out of it."

In spite of evidence to the contrary, it is often assumed that children with DCD will grow out of their awkwardness during adolescence or early adulthood; or that only those with severe movement problems will continued to experience difficulties (Cantell et al., 1994; Dewey & Wilson, 2001; Losse et al., 1991). Henderson and Hall (1982) conducted a study with 16 participants who had DCD. A follow up study 10 years later by Losse et al. (1991) demonstrated that at age 16 these same participants continued to have substantial motor difficulties as well as a variety of educational, social and emotional problems. Cantell et al. (1994) also found that 46% of their participants continued to experience movement difficulties as adolescents. It is generally accepted that children with DCD will not grow out of their difficulties (Henderson & Henderson, 2002). Therefore it is important that movement difficulties are recognized early and addressed by the physical educator and parents.

Heterogeneity and Co-morbidity

Children with DCD constitute a heterogeneous group, variation exists in both motor and academic performance (Henderson, 1987). For some the difficulty appears to be with all motor skills and for others the difficulty may be quite specific, for example not being able to use a knife and fork. Variation also exists in the development of skills over time.

Substantial heterogeneity has led researchers to investigate the possibility of sub-types within the DCD population (Henderson & Barnett, 1998; Hoare, 1994; Macnab, Miller, & Polatajko, 2001; Miyahara, 1994; Wright & Sugden, 1996). Hoare (1994) identified five possible sub-types via cluster analysis. The first sub-group was a group who had general overall deficits in gross motor skills. The second group had above average skills involving visual judgment compared to the rest of the DCD group. The third group had particular difficulty with both visual and kinesthetic tasks, suggesting a perceptual dysfunction. The fourth group had particularly good kinesthetic sense relative to the rest of the DCD group and the final group exhibited execution problems. Although this study highlights many of the difficulties within the heterogeneous population with DCD, it is not conclusive evidence that these sub-groups do in fact exist, it just reinforces the wide variety of difficulties experienced by this population. Sub-groups within DCD has been investigated by others (e.g. Henderson & Barnett, 1998; Macnab, Miller, & Polatajko, 2001; Miyahara, 1994; Wright & Sugden, 1996) and the sub-groups identified are not consistent across studies.

Comorbidity is the coexistence of two or more disorders. The problems experienced by these children are often associated with a high incidence of learning difficulties and socio-emotional and behavioural problems (Cantell et al., 1994; Gubbay, 1975; Hall, 1988; Harvey & Reid, 2003; Henderson & Henderson, 2002; Losse et al., 1991; Sugden & Sugden, 1991; Sugden & Wright, 1998). Developmental Coordination Disorder shares symptoms with other conditions such as attention-deficit/hyperactivity disorder (AD/HD), learning disabilities (LD) and other learning problems (Dewey & Wilson, 2001; Harvey & Reid, 2003; Kaplan, Wilson, Dewey, & Crawford, 1998; Wall et al., 1990).

Henderson and Hall (1982) found that 11of 16 DCD participants had past or present difficulties associated with speech, hearing or other aspects of physical development. Five participants were above average in intelligence and the movement difficulties were considered to be an isolated problem. The remaining six participants had IQs that were at the low end of the normal range, and their general academic attainment was low. However, there are some children and have DCD who do not have any concomitant problems. Some are bright well-adjusted children who have learned to cope with their movement difficulties (Hall, 1988).

Cognitive Perspectives

Several perspectives have explored the source of the movement difficulties experienced by children with DCD: the information processing approach (e.g. Lord & Hulme, 1987a; Smyth & Glencross, 1986), the knowledge based approach (e.g. Wall et al., 1985; Wall et al., 1990), and a problem solving perspective (Bouffard & Wall, 1990).

Information Processing

The information processing posits distinct phases or stages that operate between stimulus and response (Marteniuk, 1976).

> The performer's central nervous system is likened to a communication channel through which information from the environment must be processed. Thus one can conceive of the performer as a communication system, receiving information from the environment, and sending a message to the muscles so that movement can occur (Marteniuk, 1976, p. 5).

A breakdown at any of the links in the chain could theoretically result in awkward movement. When this theory is applied to DCD there is an assumption of some disruption in the perceptual and/or motor control mechanisms that underlie the disorder. The search for specific deficits has also provided support for a visual perception problem (Hulme et al., 1982; Lord & Hulme, 1987a; Schoemaker et al., 2001), and/or a kinesthetic perception problem (Hoare & Larkin, 1991; Lord & Hulme, 1987b). With respect to motor response, response selection (van Dellen & Geuze, 1988), and processing speed (Smyth & Glencross, 1986) have also been studied. Two extensively researched avenues include visual perception and kinesthetic perception.

Visual Perception. Performance on almost all motor skills entails visual perception to some extent (Hulme et al., 1982; Lord & Hulme, 1987a). Lord and Hulme (1987a) hypothesized that if the initial perceptual input was poor then correct decisions regarding the motor output could not be made. In addition, poor visual monitoring of movement would hinder the feedback, subsequently compounding the problem of poor motor performance. Hulme et al. (1982) found no significant correlation between motor ability and perceptual impairment of the participants with DCD even though they were consistently less accurate in their visual judgements of length than the comparison children of the same age and verbal intelligence.

Wilson and McKenzie (1998) conducted an extensive meta-analysis of research findings regarding information processing deficits in DCD. "The meta-analysis indicated that numerous studies support the hypothesis that children with motor impairment have difficulties with processing visual information" (Wilson & McKenzie, 1998, p. 835). However, while visual perception and motor impairment are associated, it does not follow that they are indicative of a single disorder determined by a single causal agent (Henderson, Barnett, & Henderson, 1994).

Kinesthetic Perception. Kinesthesis is the sense of body position and movement (Magill, 1998). Receptors in the joints, muscles, tendons and skin all act to contribute to the global sense of kinesthesis. As kinesthesis has been linked to proficiency in motor skills, it has been proposed that the movement difficulties could have resulted from inadequate kinaesthetic sensitivity (Hoare & Larkin, 1991). Lord and Hulme (1987b) studied the extent to which kinaesthetic sensitivity was related to the level of "clumsiness." Two tests were employed that were designed to discriminate kinaesthetic sensitivity. The results showed that the control group and the DCD group did not differ significantly on either of the two kinaesthetic tests (Lord & Hulme, 1987b). Hoare and Larkin (1991) tried to establish a clear relationship between kinaesthesitic sensitivity and clumsiness using a variety of kinaesthetic tasks. They found that children with DCD performed poorly on three of seven tasks but significant differences were not found for kinaesthetic perception or memory. However, Piek and Coleman-Carman (1995) found that participants with DCD performed significantly worse than control participants on a kinasethetic perception and memory test and a kinaesthetic active acuity test. Wilson and McKenzie (1998) suggest that due to the inconsistent results in kinesthetic research and inconsistencies in the implementation of kinesthetic interventions (Sims, Henderson, Hulme, & Morton, 1996; Sims, Henderson, Morton, & Hulme, 1996), deficits in kinesthesis may not be the only source of movement difficulties.

The information processing model has produced important information on children with DCD. There is some evidence of slow kinaesthetic (Smyth & Glencross, 1986) and inaccurate kinesthetic and visual-spatial information processing (Hulme et al., 1982; Hulme & Larkin, 1991; Lord & Hulme, 1987b). However, the findings, have not clarified the exact source of the motor deficits (Schoemaker et al., 2001).

Knowledge Based Approach

In 1985 Wall et al. proposed an approach to studying children with DCD arguing that it was a developmental problem. This knowledge-based approach built on the basic notion that DCD is a problem of knowledge acquisition. Ferrari, Pinard, Reid, and, Bouffard-Bouchard (1991) stated that novices have "poorly defined motor schemas and little knowledge of the motor skill to which general metacognitive knowledge can be applied" (p. 144). Children with DCD may have the same skill level as a novice (Thomas, French & Humphries, 1986). Although there are several anatomical and physiological factors involved with skilled movement, individuals with highly developed knowledge bases about sport are able to make better decisions regarding the most appropriate response within a game context. Highly knowledgeable performers are also able to select responses based on less information and more quickly. Quality and speed of responses are critical factors in determining success in a sport situation, therefore those with more knowledge usually perform more effectively (Thomas et al., 1986).

Wall (1982) suggested that motor development is the result of interacting genetic and experiential factors. Through experience children acquire a body of knowledge about movement. Wall and colleagues (1985) developed the knowledge-based model to support this theoretical viewpoint. There are five components to the knowledge-based approach: (a) declarative knowledge, (b) procedural knowledge, (c) affective knowledge, (d) metacognitive knowledge, and (e) metacognitive skill.

Declarative knowledge about movement refers to the factual knowledge about the motor skills. In the context of sports, knowledge about rules, player positions, and the field are considered to be declarative knowledge (Thomas et al., 1986). Declarative knowledge influences the development and execution of skilled action. Wall and his colleagues (1985) suggested that children who have DCD have a limited vocabulary about movement, which is a reflection of their limited declarative knowledge

Procedural knowledge underlies all aspects of an action, it is the "knowing how" to perform the skill. Knowledge about offensive and defensive strategies and the most appropriate times to use such strategies is considered procedural knowledge (Thomas et al., 1986). Specifically it is "the storage of action schemas that control the execution of skilled movement" (Wall et al., 1990, p. 300). The successful execution of motor skills is dependent on the procedural knowledge that has been acquired through learning and experience. Marchiori et al. (1987) stated that children with DCD are lacking in procedural knowledge by definition. As children with DCD tend to withdrawal from physical activity they have decreased opportunities to acquire procedural knowledge (Causgrove Dunn, 2000; Wall et al., 1990).

Affective knowledge refers to the subjective feelings that children attach to movement (Wall et al., 1985; Wall et al., 1990). Affective knowledge is acquired as individuals perform or attempt to perform movement skills. Children who experience success will attach positive feelings to movement and conversely, repeated failure will decrease confidence and negative feelings will be attached to movement (Wall et al., 1990). These negative feelings can lead to withdrawal from physical activity (Causgrove Dunn, 2000).

In the movement context, Wall et al. (1985) state that metacognitive knowledge refers to an awareness of the procedural, declarative and affective knowledge of physical actions that has been acquired. "Metacognitive knowledge is knowledge about what one does or doesn't know" (Wall, 1985, p. 30). Metacognitive knowledge is used in situations that are novel and which requires a problem-solving approach to be taken. If an individual has little experience in movement, such as someone with DCD, and has acquired few skills, metacognitive knowledge will typically be underdeveloped.

Metacognitive skills refer to the person's ability to take control of his or her cognitive activity and the demands of the task (Wall et al., 1985). "Metacognitive skills include both the conscious control of action as well as automatized executive control procedures related to the planing, monitoring and evaluating of learning and performance" (Wall et al., 1990). Without a strong procedural, declarative and affective knowledge base children with DCD often do not know how to approach a movement problem, analyze the task demands or plan the best approach to solve the movement problem, they appear to be unable to regulate their own learning (Wall et al., 1990).

Polatajko et al. (2001) stated that children with DCD have a "motor learning problem" (p.101). Movement difficulties have long been recognized as a secondary condition in many children with specific learning disabilities, however, Keogh (1982) and Wall (1982) suggested that DCD was a distinct type of learning disability. Children with DCD often exhibit poor academic performance, despite having average intelligence (Dewey & Wilson, 2001; Wall et al., 1985). However, the assumption that all children with learning disabilities have movement problems, or that all children with movement problems have learning disabilities is not true. Wall et al. (1985) proposed that children with DCD do not have adequate knowledge about movement.

Problem Solving Approach

Dominiowski (1998) defines problem-solving as a goal-oriented activity where the means of achieving the goal is uncertain. Movement situations are considered by Bouffard and Wall (1990) to be problems to be solved. Factors such as intelligence, physiological constraints, and knowledge can limit the number of solutions to a movement problem. Bouffard (2002) states that a problem solving approach to studying children with DCD is needed because movement can be considered a problem to be solved, and children with DCD have difficulty in movement. Therefore, deficits in problem-solving may contribute to the overall difficulties in movement. Wall et al. (1985) state that to adequately solve problems an integration of knowledge, including metacognitive knowledge, is crucial. The problem-solving model proposed by Bouffard and Wall (1990) is divided into five steps: (a) problem identification, (b) problem representation, (c) plan construction, (d) plan execution, and (e) evaluation of progress.

Problem identification is the first step in the problem solving process; if a problem is not identified it is not likely to be solved. A child with DCD who is participating in the elementary school track meet is on the relay team, but has difficulty receiving the baton while running. An accurate representation of the problem is essential to the planning process, a skill that is part of self-regulation. The child with DCD must recognize that the problem is not in his sprinting ability; it is in the exchange of the baton which is slowing him down. Time could be spent practicing sprinting but without a clean baton exchange, the race would never be won. In plan construction the performer constructs a course of action to improve the skill. A plan could be constructed where the child with DCD being the first runner therefore only one exchange would be required; the child would never have to receive the baton, only hand it off. The execution of a plan is the next step. Training sessions could now focus on handing the baton to the second runner, with enough practice the child with DCD will be ready for the big meet. Evaluation of progress can occur at any stage of the problem-solving process and involves decisions regarding the feasibility of plans, whether the problem has been solved at all or the goal has been met (Bouffard & Wall, 1990). By staging a couple of practice races in the school yard the physical education teacher and the child with DCD could evaluate how well the plan was working.

Wall and Bouffard (1990) state that difficulties solving movement problems may stem from three major areas: (a) lack of knowledge base or access to it, (b) lack of use or inappropriate use of control strategies, and (c) motivational factors. In a similar vein Henderson and Sugden (1992) advocate a cognitive-motor approach to intervention. This approach conceptualizes the acquisition of motor skills as problem-solving exercises involving the interaction of cognitive, motor and affective components. The aim of this intervention model is to increase understanding of the skill and to acquire and automatize the skill (Henderson & Sugden, 1992; Sugden & Wright, 1998). Miller, Polatajko, Missiuna, Mandich, and Macnab (2001) created a new treatment approach called the Cognitive Orientation to daily Occupatoinal Performance (CO-OP). The CO-OP approach is based on the premise that motor performance is not only a matter of maturation and practice, it is an issue of learning, and that children with DCD have difficulty *learning* motor skills (Polatajko et al., 2001). This approach is strongly embedded in a learning paradigm which teaches strategies to effect a change in performance (Polatajko et al., 2001). The CO-OP approach posits that a cognitive problem-solving approach to interventions for children with DCD is an effective means of improving their motor skills (Miller et al., 2001).

Self-Regulation

Self-regulation, which falls under the umbrella of metacognition, is important in developing proficiency in both academic and motor skills (Glaser et al., 1987; Glaser & Chi, 1988; Wall, 2002). Metacognition has been defined as a set of generalized skills for approaching problems; monitoring, predicting the outcome of performance, planning ahead, efficient time management, self reflection and self-regulation (Anderson et al., 1998; Glaser et al., 1987; Winne, 1995). Self-regulation is a multidimensional event, that refers to the personal feelings, thoughts, and actions that are planned and adapted according to the attainment of goals (Zimmerman, 2000). It follows that self-regulation is an important aspect of skilled action. To set goals, plan, monitor, and evaluate performance indicates a sophisticated knowledge structure which children with DCD may not have in the motor domain. It has been documented that children with learning disabilities have difficulty with metacognitive skills such as planning, executing and evaluation of performance, these are the basic skills of self-regulation (Butler, 1998; Glaser et al., 1987; Keogh, 1982). To the extent that DCD represents a problem of learning, it is possible that self-regulation difficulties are associated with DCD.

Kirschenbaum's Model of Self-Regulation

Self-regulation in the motor domain was first studied by Kirschenbaum (1984/1987) who defined self-regulation as "the process by which people manage their own goal-directed behaviours in the relative absence of immediate external constraints" (Kirschenbaum, 1984, p.160). In other words self-regulation is a complex exchange of cognitive factors (such as planning or evaluating), affective factors (fear or motivation), physiological factors (such as strength and speed) and environment factors (such as training conditions) (Kirschenbaum, 1984/1987; Ferrari et al., 1991). Kirschenbaum's (1984/1987) model, developed for athletes, consists of five stages: (a) problem identification, (b) commitment, (c) execution, (d) environmental management, and (e) generalization.

Problem identification involves recognizing aspects of performance that need to be improved or changed. For example, some athletes may not initiate the self-regulation process because they do not recognize that their performance has reached a plateau. The commitment stage can also be considered a self-motivation stage. The recognition that change is possible, and the individual wants to make a change is critical at this stage of the model. The execution phase involves self-monitoring and self-evaluation. The athlete must systematically respond to the feedback available in order to work towards improving the performance. The environmental management phase involves both the positive and negative aspects of the social and physical environment of the athlete and how they facilitate or debilitate the athlete. Finally, this model considers generalization to other situations.

Kirschenbaum's model of self-regulation has provided some valuable insights into the self-regulation of sport performers. However, it does not consider the importance of metacognitive knowledge, nor does it consider the strategies utilized by the performer during performance. More recently, self-regulation in the motor domain has been studied using a social-cognitive perspective (Clearly & Zimmerman, 2001; Ferrari et al., 1991; Kitsantas & Zimmerman, 1998). The social cognitive perspective views self-regulation as a domain specific skill that depends on several task-dependent processes, such as planning, strategizing, and self monitoring (Schunk & Zimmerman, 1997).

Zimmerman's Self-Regulation Model

Zimmerman (2000) describes self-regulation as, "self-generated thoughts, feelings and actions that are planned and cyclically adapted to the attainment of personal goals" (p. 14). Zimmerman (2000) and Schunk and Zimmerman (1997) suggest that self-regulation is a dynamic interaction of processes rather than a single trait and therefore it is possible to self-regulate one type of performance and not another. Thus self-regulatory skills are domain specific and dependant on the specific knowledge determined by the task (Schunk & Zimmerman, 1997; Wall et al., 1985). Self-regulation also depends on self-beliefs and affective reactions such as doubts and fears about performance (Wall, 2002). From a social cognitive perspective, self-regulation is a cyclical process consisting of three stages: (a) forethought, (b) performance or volitional control and (c) the self-reflection phase (Zimmerman, 2000).

Forethought Phase. The forethought phase consists of two categories: task analysis and self-motivational beliefs. Task analysis includes goal setting. In a highly self-regulated individual, goals are organized hierarchically with subgoals representing stepping stones to the achievement of higher-level goals. Strategic planning is another form of task analysis; for high level expertise there must be methods for reaching those goals. These methods which depend on domain specific knowledge assist in attending to relevant cues that facilitate cognition, emotional control, and directing motor skill execution (Zimmerman, 2000). Self-regulated individuals must constantly adjust their goals and strategies as a result of complex interactions of the environmental and personal factors.

The second category of forethought is self-motivational beliefs (Zimmerman, 2000). Self-motivational beliefs refer to key motivational beliefs such as, self-efficacy, outcome expectations and intrinsic interest or value of the task. Schoemaker and Kalverboer (1994) found, "that children who are DCD...judge themselves to be less competent both physically and socially" (p. 130). Highly self-regulated learners have higher self-concepts partly because they set hierarchical goals, which are attained in a progressive manner. This allows for continual feelings of satisfaction. It follows that if hierarchical goals are not set, and low self-esteem is already an issue, the individual will be more likely to maintain a low self-concept, which in turn could impede his or her self-regulatory skills from developing.

Performance of Volitional Control Phase. The second phase of Zimmerman's (2000) model is the performance or volitional control phase. This phase includes two categories: self-control and self-observation. Self-control includes such processes as self-instruction, imagery, attention focusing, and task strategies. Learners can self-regulate their learning by verbalizing instructional cues and using mental imagery to develop a cognitive representation of the skill. Wall et al. (1990) describe the understanding of relevant task variables, being able to remember key plays, and being able to critically analyze strategies and actions, as being characteristics of expert performance. Children with DCD do not have adequate procedural knowledge, which is necessary in order to use instructional cues, self-instruction and imagery. Lefebvre and Reid (1998) also state that children with DCD would benefit from learning important movement cues.

The second type of performance control involves self-observation. This refers to the learner's monitoring of his or her performance, and the context within which the performance takes place. Marchiori et al. (1987) found that even after extensive practice children with DCD did not improve their movement pattern on a hockey slap shot. It would seem that the participants were unable to monitor their performance.

Self-Reflection Phase. The third and final stage of Zimmerman's (2000) model is self-reflection. The two categories of this stage include self-judgment and self-evaluation. Self-judgment involves critically evaluating one's own performance and coming to a conclusion about what caused the results. Self-evaluation refers to comparing one's performance to a standard or goal. Marchiori et al. (1987) acknowledge that children with DCD need to practice motor skills to develop proficiency but the practice must be guided by feedback. Practice sessions must be held to a standard of proficiency and the individual must have knowledge of results and performance. This phase links to goal setting in the first phase of the model. Reflection on performance is difficult without goals that have been set and attempted, whether or not those goals are achieved.

Cleary and Zimmerman (2001) examined the differences in self-regulation between expert, non-expert and novice basketball players while performing basketball *free-throws.* This study focused on the forethought and self-reflection phases of Zimmerman's (2000) model. The expert basketball players were found to set more specific goals than non-experts and novices, and provided more specific technique-related strategies to achieve their goals than the other groups. Cleary and Zimmerman (2001) concluded that "experts appear to be at an advantage for improving and sustaining high levels of skill and motivation because their specific goals and strategies enable them to focus on the essential form components" (Cleary & Zimmerman, 2001, p. 200). This study also illustrated the value of using a microanalytic approach to studying the cognitive and behavioural aspects of motoric practice.

Kitsantas and Zimmerman (2002) also tested Zimmerman's (2000) model of self-regulation in volleyball. They studied self-regulation in expert, non-expert, and novice volleyball players. Higher levels of forethought were found in the experts, they set more specific goals and had more structure in planning their practice routines. More experts self-regulated their practices and used more specific technique strategies. Experts were also more likely to self-reflect on their performance (Kitsantas & Zimmerman, 2002). This study demonstrated self-regulatory differences among athletes in goal setting, self-observation and self-evaluation.

Dysfunctions in Self-Regulation

The importance of self-regulation is clear from the research on expertise in sport, however some people have difficulty self-regulating many different aspects of their lives. Self-regulation is not just an academic skill. For example, people who have difficulty regulating their caloric intake can either become over-weight or conversely, anorexic. Zimmerman (2000) stated that many of the dysfunctions in self-regulation stem from a reactive approach to a task rather than a proactive approach. In any domain the self-regulatory skills of novices may remain limited due to the low knowledge base, therefore a child who has limited experience in the motor domain, and a poor knowledge base will have low self-regulatory skills (Ferrari et al., 1991).

Poor self-regulators have not developed the necessary goal structure and the strategic planning when approaching a task, and therefore must try to correct themselves after they have completed the task, instead of evaluating their performance throughout. Because of the decreased ability to evaluate their own performance poor self-regulators are dependent on social comparisons. These social comparisons may, in the case of a child with DCD, result in a low self-esteem and withdrawal from physical activity in order to prevent further failure (Causgrove Dunn, 2000; Schoemaker & Kalverboer, 1994; Wall et al., 1990). "A lack of social learning experiences is the first important source of self-regulatory dysfunctions" (Zimmerman, 2000, p. 27). Eventually a vicious circle may emerge in which a child with DCD does not participate in physical activity because of the negative self-concept acquired due to continued failure. This, in turn, decreases the amount of practice in the motor domain and leads to an inability to improve upon performance and self-regulatory skills.

A second source of dysfunction in self-regulation is apathy or disinterest (Zimmerman, 2000). To acquire proficiency in any skill, attention to details, concentration, and detailed self-reflection are necessary. When a skill is not valued by the learner there is no incentive to self-regulate. A final source of dysfunction in self-regulation is the presence of a learning disability (Zimmerman, 2000).

> Learning disabled students set lower academic goals for themselves, have trouble controlling their impulses, and are less accurate in assessing their capabilities. They are also more self-critical, less self-efficacious about their performance, and tend to give up more easily than non-disabled students (Zimmerman, 2000, p. 28).

Thus, there is a theoretical expectation that self-regulatory skills in the motor domain would be underdeveloped in children with DCD; however, there is no empirical evidence to support this assumption (Wall, 1982; Wall et al., 1990).

Keogh (1982) and Wall (1982) both felt that children with DCD had a form of learning disability. Metacognition, which includes self-regulation, can be underdeveloped in children with learning disabilities (Butler, 1998; Glaser et al., 1987; Keogh, 1982). It is expected that children with DCD would have difficulty self-regulating learning in the motor domain. The question is whether or not the potential problems in self-regulation are confined to the motor domain.

Many have explored the learning characteristics of children with DCD, but there is little consensus regarding the specific difficulties (Smyth & Glencross, 1986). It appears that the poor motor performance of children with DCD is the result of many factors, and self-regulation may be one of the pieces of the puzzle. Yet, Bouffard (2002) states that very little is known about how children with DCD self-regulate their learning of movement skills. Reid, Harvey, Lloyd, and Bouffard (2002) conducted a pilot study investigating the self-regulatory skills of children with DCD while throwing a ball at a target. The findings showed that boys, with DCD and without, 10-12 years of age, are able to verbalize while performing a motor task. This study also suggested some differences in the self-regulatory skills of the participants. Differences were seen in the statements regarding the goal of the task, and in the quality of the emotional statements. The negative statements offered by the two groups differed in content. For example the control group expressed their frustration when they didn't hit the target for example, "I can't believe I keep missing." The DCD participants were more likely to comment before throwing, "I'm not going to get it, there is no way I'm going to hit the target."

Self-regulation is critical to performance in all domains, however it is also considered to be domain specific (Schunk & Zimmerman, 1997). To what degree do self-regulatory skills transfer from one domain to the other if they are so critical, yet so specific? It is necessary to study their self-regulatory skills when performing educational problem-solving tasks.

Summary.

Developmental Coordination Disorder is characterized by an inability to perform culturally normative skills proficiently. This reduced skill level can lead to withdrawal from physical activity. This population has been studied using three main cognitive perspectives, the information processing approach, the knowledge-based approach, and the problem-solving approach. Although both approaches have provided valuable insights into DCD, neither has provided definitive answers as to what causes the motor deficits. Self-regulation from a social cognitive perspective is defined as a multi-dimensional event that includes thoughts, feelings and actions that are cyclically planned and monitored in the attainment of goals. Self-regulation is important in learning and has been studied using Zimmerman's (2000) model in the sport context. Self-regulation is also considered to be underdeveloped in children with learning disabilities, and children with DCD are considered to have a movement learning disability. Little is know about the self-regulatory skills of children with DCD. It is expected that they would have decreased self-regulatory skills in the motor domain, however there is no empirical evidence to support this expectation. There is also no literature discussing the self-regulatory skills of children with DCD on educational problem-solving tasks either. This study explores the self-regulatory skills of children with DCD on a sport specific problem-solving task and on an educational problem-solving task.

Chapter 3

Methodology

This chapter consists of four major sections. The first section will describe participant identification, including a description of the Movement Assessment Battery for Children (Movement ABC). The second section will illustrate instrumentation, including both the sport specific problem-solving task (hockey shot) and the educational problem-solving task (peg solitaire). The rationale for using concurrent and retrospective reports will also be discussed. Procedures will be described in the third section, including the pilot study, familiarization tasks, and the procedures for both the hockey shots and the peg solitaire games. Finally, the last section will discuss data analysis including the statistical procedures and inter-rater reliability.

Participants

Identification of children with DCD has long plagued researchers, the heterogeneity of the population and the limited standardized tests available for assessment have compounded these difficulties (Keogh, 1982; Maeland, 1992; Sugden & Sugden, 1991). Keogh (1982) stated that children with DCD should be identified in different ways and from different perspectives. However "there is very little agreement within and across studies in identification of clumsy *(DCD)* children" (p. 247, italics added). For these reasons, a triangulated approach was adopted in the identification of the participants in this study, including (a) observation by the researcher, (b) performance on Movement ABC, and (c) teacher questionnaire.

This study is a subset of a larger project investigating the self-regulatory skills of children with DCD. The research and ethics board of McGill University granted ethical permission for both the sport specific problem-solving task and the educational problem-solving task (Appendix A). The Lester B. Pearson School Board of Montreal also granted permission for this study to be conducted in their schools. The supervisor of the large project approached physical education teachers at two schools for their cooperation. The larger study sought to identify 20 children with DCD and 20 without.

The primary researcher of this study proceeded to observe the grade five and six physical education classes at each school (seven classes in total). The purpose of the observation was to secure a comfortable relationship between the students and the researcher, and to try to identify potential participants through observation.

After five weeks of observation, informed consent documents (Appendix A) were sent home to the parent or guardian of every child in grades five and six, in each school (n = 175). Permission was obtained for 100 participants.

Since children with DCD may represent 15% of the population, identifying 20 participants with DCD was the initial challenge. The other 20 participants were age-matched peers and were readily available with the 100 volunteers. The initial observations by the researcher served to decrease the number of students it was necessary to test. The Movement Assessment Battery for Children (Movement ABC) was then administered to 52 participants. The Movement ABC is a standardized test that was developed to identify children with movement difficulties and is used frequently in research (Geuze et al., 2001; Henderson & Sugden, 1992). Because there were enough (n= 28) scores below the cut-off on the Movement ABC it was only necessary to test 52 children to identify the target of 40 participants.

The physical education teachers were then asked to complete a short questionnaire (Appendix B) rating the movement skills of the potential participants. This questionnaire was designed to prompt the teachers to use their expertise to form an opinion on whether or not each participant had difficulty in the movement context. This was considered to be an assessment of Criterion B, that is, did the movement difficulties interfere with physical education participation as an activity of daily living. The teachers were not informed of the Movement ABC scores and the names of the participants were presented in alphabetical order in an attempt to establish an objective evaluation. A total of 12 participants were eliminated because there was disagreement among the three identification methods.

In summary, the individuals were identified with or without DCD (a) observation in physical education classes, (b) performance on the Movement ABC, and (c) the results of the physical education teacher questionnaire (Appendix B).

Once the identification procedures were completed for the larger study, an additional informed consent document for the educational problem-solving task was sent to the parents and guardians of the 40 participants (Appendix A). Consent was received from 20 participants, 10 with DCD and 10 without DCD to participate in the educational problem-solving task. Thus, the same 20 participants participated in the hockey shots and the peg solitaire games. All 20 participants were boys aged 10-12 years.

Movement ABC

The Movement ABC is a standardized test that identifies the extent to which a child falls below the level of his or her age matched peers on motor performance (Henderson & Sugden, 1992). The Movement ABC has evolved directly from the Test of Motor Impairment (TOMI) and the TOMI-Henderson Revision (TOMI-H).

The reliability of the TOMI-H was examined using test-retest and inter-tester reliability. The minimum value of test-retest reliability at any age band was 0.75 and of the inter-tester at 0.70 (Henderson & Sugden, 1992). Riggen, Ulrich and Ozmun (1990) tested the reliability and the concurrent validity of the TOMI. Each participant in their study was tested three times, twice with the TOMI-H and once with the Bruninks-Oseretsky Test of Motor Proficiency –Short Form (BOT-SF). The results showed a high consistency of impaired and non-impaired decisions from the first to the second administration of the TOMI-H (Riggen et al., 1990). They also found a high degree of consistency of motor impairment decisions between the BOT-SF and the TOMI. There were five cases where the decisions were inconsistent, however it was concluded that the TOMI was consistent measure of motor performance (Riggen et al., 1990). As the Movement ABC has evolved directly from the TOMI and the TOMI-H, the validity and reliability studies of earlier editions are still relevant (Henderson & Sugden, 1992).

The Movement ABC was designed to identify children 4-12 years of age with movement difficulties, therefore the tasks were designed to be simple for the general population. To account for developmental differences it is divided into four age bands. The participants in this study were tested with age bands three (9-10 year olds), and four (11-12 year olds). Within each age band there are eight tasks which fall into three domains: (a) manual dexterity, (b) ball skills, and (c) Static and Dynamic Balance (Henderson & Sugden, 1992). The total combined score on all the eight items is interpreted in reference to established percentile norms (Henderson & Sugden, 1992). At present the Movement ABC is the standard in the research community for the identification of children with DCD (Geuze et al., 2001). A high score denotes poor performance, for example a child who scores 24 out of 40 is much less competent than a child who scores 4 out of 40. Henderson and Sugden (1992) suggest that the 15th and 5th percentile points are important standards for motor performance. A score below the 5th percentile is considered to represent a definite movement difficulty and a score between the 5th and 15th percentile is considered to be a potential problem.

Instrumentation

Sport Specific Problem-Solving Task (Hockey Shot)

The sport specific problem-solving task was a hockey shot at a net from 4m. The hockey net was made of stainless steel and was 1.34m by 1.11m. Attached to the front of the net was a canvas sheet with five holes and a figure of a goalie silk-screened on the front (Appendix C). This "shooter-tutor" is commonly used to allow a person to practice shooting at a hockey net without a goalie. The purpose is to increase shooting accuracy. The holes were located in the four corners and one smaller hole was located in the center to represent the hole between the goalie's legs. Red electrical tape was added to number each hole, with the top left hole being 1, the top right hole was 2, the bottom left hole was 3, the bottom right hole was 4 and the middle hole was 5. The labels were applied to make it easier for the participant to identify the holes, than discriminating between "top-left, bottom-right," as the participants were instructed to identify the goal of each shot.

Three different plastic hockey sticks were available for the children to use, they were identical sticks except they were three different heights 1.29m, 1.24m, and 1.21m. All the sticks had a straight plastic blade to accommodate children who shoot from the left or right side. A soft rubber puck (100g) was used for this task. A large piece of Plexiglas was placed on the floor, to simulate an ice surface and to prevent any damage to the floor.

To determine the most appropriate distance to shoot from and which of two pucks should be used, a small pilot study was conducted with three children; a boy with a movement difficulty, one without, and one girl. It was decided that shooting from 4m provided enough challenge to the skilled participants and was not beyond the capabilities of the participants with DCD. The softer puck was chosen as it was deemed to cause the least damage to the surroundings when the children missed the net, as data were collected in a vacant classroom.

Educational Problem-Solving Task (Peg Solitaire)

The game "Peg Solitaire" was used as the educational problem-solving task. This game is played on a wooden board that has a pattern of holes drilled, each hole except one contains a peg (Appendix D). The rules of the game are very simple and were explained to each participant. Jumping a peg over an adjacent peg (much like checkers) makes a move, the moves must be horizontal or vertical. The peg that has been jumped over is removed. The aim of the game is to remove all the pegs except the last, which should be left in the center of the board. The game is over when no further moves can be made.

Children with DCD may have fine-motor problems, and peg solitaire requires fine motor performance. However, peg solitaire, is not a timed task, there is also no time limit, both hands may be used, and there is no penalty for dropping pegs or the manner in which they are held. The pegs are shaped so they are easier to hold, and they fit easily into the holes on the board. The time taken to play the game is short, approximately 7 minutes, and success in the game is not dependent on physical ability. The moves are discrete, only one peg may be moved at a time, and there is a concrete outcome of each move. Like the hockey shots, this game can be broken down into discrete trials, which fits into Zimmerman's cyclical model of self-regulation (2000).

Rationale for Concurrent and Retrospective Reports

Metacognitive knowledge and skill are very difficult to empirically study. Ericsson and Simon (1984/1993) argued that verbal self-reports reflect many of the properties of nonverbal cognition. Concurrent and retrospective verbal reports have been used to examine cognitive processes and problem solving skills in reading, mathematics, and chess (Ericsson & Simon, 1984/1993; Pressley & Afflerback, 1995). Thinking aloud is a verbal report protocol in which an individual verbalizes all thoughts and cognitive processes while performing a task (Ericsson & Simon, 1984/1993; Payne, 1994; Winne & Perry, 2000). A retrospective report is an interview following a task. Concurrent reports require the participant to articulate thoughts, plans, feelings, and actions.

Concurrent verbal reports, however, are infrequently used in the motor domain (Martini, 2002; Reid et al., 2002). McPherson and Thomas (1989) studied knowledge and performance, in relation to age and expertise, in 10-13 year old male tennis players. They found that the participants were able to articulate their knowledge during situation interviews conducted immediately after performance. Martini (2002) and Reid et al. (2002) both found that boys 9-12 years, with DCD and without DCD, were able to verbalize while performing a throwing task. Martini (2002) found that the group with DCD verbalized the most, and the highly skilled group verbalized the least. Reid et al. (2002) found that the number of verbalizations for the DCD and the non-DCD group were almost equal.

In order to strengthen the reliability of the information, Ericsson and Simon (1984/1993) suggest the use of both concurrent and retrospective reports. Bainbridge and Sanderson (1995) propose that whenever possible the participant should verify transcripts of experimental sessions. However, because of the age of the participants it was decided that a more reliable verification method was to watch the taped performance immediately after to the task. While watching the tape the researcher pointed out any unclear or ambiguous statements and probed for clarity. This interview served as a member check to establish internal validity of the verbalizations (Sparkes, 1998). The interviews were facilitated by the notes the researcher took during the execution of the 25 hockey shots, and the during the two peg solitaire games. The researcher was able to quickly draw the child's attention to any unclear statements or any easily misinterpreted statements as the child watched his performance.

Procedures

All the data were collected in the respective schools in a quiet room that remained constant for all participants. Each participant was individually brought to the experimentation room for the administration of the Movement ABC, the hockey shots and the peg solitaire games. The three sessions were separated by several weeks in one academic school year (2001-2002).

Pilot Study

A pilot study was conducted with 8 participants, 4 with DCD and 4 without (Reid et al., 2002). The task for consisted of throwing a ball at an archery target 50 times. The concurrent verbal report methodology was used in conjunction with retrospective interviews. Using Zimmerman's (2000) model, this pilot study served to establish the coding categories in the analysis of self-regulatory skills of children with DCD. Reid et al. (2002) showed that the concurrent think aloud methodology is a viable method of studying the thought processes of children with DCD. Preliminary differences were found in the self-motivational strategies and goal statements between DCD and non-DCD boys. Their results warrant further study using this problem solving approach.

Familiarization Tasks

As "thinking aloud" while performing a problem-solving task is novel, and can prove to be difficult, two familiarization tasks were introduced to each participant before the hockey shot session. First, each participant was asked to describe a recent experience in physical activity. Questions focused on activities that had been engaged in during recess or lunch of that day. If these outdoor sessions proved to be inactive, the researcher asked for a description of a favourite activity in physical education class. This process served two purposes; it created a comfortable environment in front of the cameras and also initiated the participant to "talking about movement" (Crutcher, 1994; Ericsson & Simon, 1984/1993; Payne, 1994).

A second familiarization task involved four plastic, coloured discs placed on the floor. The researcher demonstrated how to talk aloud concurrently while jumping from one disc to another. The importance of verbally expressing all thoughts, feelings, plans, while executing the task was stressed. The participant then jumped through the same disc pattern while practicing the talk-aloud procedure. After the first sequence of jumps was complete, the discs were moved to make the jumping task more challenging. The participant was instructed to jump from disc to disc again while talking aloud one last time. During this trial the researcher limited the reminders and probes to "keep talking" and "what are you thinking about."

Sport Specific Problem-Solving Task (Hockey Shot)

The sport specific problem-solving task was shooting at a hockey net. Practice shots were encouraged to allow the participants to become familiar with the equipment and the task demands. Following the practice shots (approximately 3 shots) each participant shot 25 times from 4m. Any type of hockey shot could be used. The participants were instructed to verbalize which hole they were aiming for before they took their shots, in order for the researcher to know whether or not the goal of the shot had been achieved.

Only one puck was used to provide time for reflection, planning or any other verbalizations between shots (Adams, 1987; Barkley, 1997). During the 25 shots the only prompts given by the researcher were "keep talking" and "what are you thinking?" These are the same two probes employed during the familiarization task.

Two cameras were set up in the room. A digital camera was placed to the left of the Plexiglas, facing the participant. This camera recorded all actions and verbalizations. A second camera, which used VHS tapes, was placed to the right of the participant. This camera served to record the outcomes of each shot, and to record the verbalizations in the event that the first camera failed to record. This second camera allowed the researcher to pay close attention to any verbalizations that were unclear and should be clarified in the retrospective interview. The different types of camera resulted from availability rather than preference.

Educational Problem-Solving Task (Peg Solitaire)

The educational problem-solving task was the game peg solitaire. Peg solitaire is considered a fun, educational game for children where strategic problem solving and planning are developed. This game has clear goals and objectives and the outcome is evident at the end. Peg solitaire is traditionally played on a wooden board that has a pattern of drilled holes, each of which can contain a peg (Appendix D).

Data collection of the peg solitaire task occurred several weeks after the hockey shot, therefore all participants were familiar with the concurrent verbal report procedure (Ericsson & Simon, 1984/1993). Even so, each participant participated in a third familiarization task. This task involved setting up a row of 10 dominoes while "thinking aloud." The researcher also demonstrated how to play the game. Each participant was given the opportunity to play one practice game. The study did not begin until the participant verbally demonstrated understanding of the task by describing the goal and the critical features of the game. Each of the participants played two games of peg solitaire while thinking aloud.

For the peg solitaire portion of the study one camera was used. The camera faced the participant in order to record the progress of the game as well as verbalizations. The participant and the researcher sat opposite each other at a table.

Data Analysis

All verbalizations from both the hockey shot and peg solitaire tasks were transcribed verbatim. The transcripts were segmented by discrete thoughts or ideas (Bainbridge & Sanderson, 1995). Six categories of codes were developed in the pilot study (Reid et al., 2002) and served as the framework of codes for both tasks (Table 1). Operational definitions of all codes are found in Appendices E and F. Payne (1994) suggested that frameworks be simple and straightforward to reduce the inference on the part of the coder, increasing reliability. Task specific individual codes and levels were developed for both the hockey shot and the peg solitaire tasks (Tables 2 and 3). Codes were applied to the transcripts using the QSR NUD*IST Vivo (Nvivo) 4.0 Software. This software allowed the researcher to produce a computerized index of codes and manage the files.

After the verbal reports were coded a content analysis was performed at each level of codes, see appendices J and K for complete frequency tables. Content analysis involves counting the frequency of the codes (Bainbridge & Sanderson, 1995; Payne, 1994). By aggregating the data into categories and assuming that each category is equal, and one coded statement is worth the same as another, the categories can become a dependent measure (Payne, 1994; Winne & Perry, 2000).

Table 1

Coding Categories: Level I

Category*
Goals
Knowledge
Emotion
Monitoring
Evaluation
Other

*All categories are further divided into levels II-V.

Table 2

List of Codes for Sport Specific Problem-Solving Task

Category	Level II	Level III	Level IV
Goals			
	Specific Goal		
	Goal Change		
	Goal Not Intended		
	Non-Specific Goal		
	Challenge		
	Higher Level Goal		
	Goal Achieved		
Knowledge			
	Declarative Knowledge		
	Causal Relationship		
	Coach or Teacher		
	Hockey Experience		
	Personal Learning Theory		
	Action Plan		
		Incomplete	
		General	
		Self-Motivational Strategy	

(continued)

Table 2 *Continued*

Category	Level II	Level III	Level IV
		Error Correction	
		Specific	
			Chooses New Stick
			Switches Hand Orientation
			Type of Shot
			Instrument
			Body Part
			Follow Through
			Shoot
			Aim
Emotion			
	Positive Affect		
	Negative Affect		
Monitoring			
	Specific Monitoring		
	Task Relevant Attention Focus		
	Off Task Attention Focus		
	Attentional Control		
	Game Situation		

(continued)

Table 2 *Continued*

Category	Level II	Level III	Level IV
	Outcome Statement		
	Awareness of Completion		
	Error Detection		
		In the Outcome	
		In the Movement Pattern	
Evaluation			
	Specific Evaluation		
		Evaluation of Strategy	
		Evaluation of Shot	
		Task Difficulty Evaluation	
Other			
	Transition		
	Clarifying Statement		

Table 3

List of Codes for Educational Problem-Solving Task

Category	Level II	Level III	Level IV
Goal			
	Specific Goal		
	Short Term Goal		
	Goal Achieved		
Knowledge	Declarative Knowledge		
	Personal Learning Theory		
	Self-Motivational Strategy		
	Action Plan		
		Incomplete	
		Change of Plan	
		General	
		Specific	
			New Game Plan
			Old Game Plan
			Strategy
			Sectional Plan
			Planning Ahead

(Continued)

Table 3 *Continued*

Category	Level II	Level III	Level IV
Emotion			
	Positive Affect		
	Negative Affect		
Monitoring			
	Monitoring		
	Inadequate		
	Foresight Difficulty		
	Off-Task Attention Focus		
	Game Momentum		
	Awareness of Completion		
	Relax		
Evaluation			
	Specific Evaluation		
	Task Difficulty Evaluation		
Other			
	Transition		
	Help Seeking		
	Clarifying Statement		

Statistical Analysis

The use of parametric statistics for the content analysis was not warranted, as the data did not meet the basic assumptions of parametric tests, which include: (a) the population from which the sample is drawn is normally distributed on the variable of interest (b) samples have the same variances on the variable of interest, and (c) the observations are independent (Shavelson, 1996). The Mann-Whitney U is a non-parametric test that is used instead of the parametric t test for differences between two groups (Shavelson, 1996; Thomas & Nelson, 2001). The Mann-Whitney U statistical test was chosen over a chi-square test because frequencies less than 5 for any code, the chi-square is no longer a reliable measure (Nevill, Atkinson, Hughes, & Cooper, 2002). For the Mann-Whitney U test to be employed certain requirements must be met: (a) there is one independent variable with two levels, for example groups, (b) a participant may only appear in one group, and (c) the levels of the independent variable differ from one another either quantitatively or qualitatively (Shavelson, 1996). The data in this study were analyzed using Mann-Whitney U test for each category and at levels 2, 3 and 4. The significance level was set at .05.

Inter-Rater Reliability

After the coding process was complete a second researcher reviewed the coded documents for both the hockey shot and peg solitaire tasks. This individual was provided with the operational definitions of the codes (Appendices E and F) and together with the primary researcher reviewed samples of each category in the coding framework in order for the second researcher to learn the codes. Then, 25% of the hockey shot transcripts and 25% of the peg solitaire transcripts were randomly selected, with the second researcher being unaware to which group each participant belonged. Thus there were 10 transcripts, 5 from each task. The agreement for the 5 peg solitaire transcripts ranged from 79.2%-92%, and the 5 hockey transcripts ranged from 81.5%-94.5%.

Chapter 4

Results

The results are presented in four sections. The first section presents the participant characteristics including age and Movement ABC scores. The second section includes the performance on the two problem-solving tasks by each group. The third section presents the content analysis of the verbalizations during the hockey shot, and finally the last section presents the content analysis on the verbalizations during the peg solitaire games.

Participant Characteristics

The boys were between 10 and 12 years. Table 4 indicates that the groups were well matched for age. Although socio-economic data was not collected, the two elementary schools were located in similar neighborhoods.

Table 4

Age of Participants in Years

Group	N	Minimum	Maximum	Mean	Standard Deviation
DCD	10	10.75	12.50	11.50	0.55
N-DCD	10	10.75	12.66	11.50	0.55

As part of the identification process the Movement Assessment Battery for Children (Movement ABC) was administered. The descriptive statistics obtained on the Movement ABC are displayed in Table 5. An independent *t*-test demonstrated a significant difference in the Movement ABC scores of the two groups, (2,18), $t = 7.004$, $p < .05$. This finding confirms that the DCD group and the non-DCD group were distinct with respect to their motor skills.

Table 5

Performance Scores on Movement ABC

Group	N	Minimum*	Maximum	Mean	Standard Deviation
DCD	10	10.50	22.00	16.55	4.16
N-DCD	10	3.50	8.50	6.55	1.73

*Note: a lower score indicates more skilled performance

A score of 10 or above on the Movement ABC indicates a movement problem at the bottom 15 percent of the population, and a score of 13 indicates the bottom 5th percent (Henderson & Sugden, 1992). A score below 10 indicates no movement difficulty. Geuze et al. (2001) suggest that the 15th percentile or below be used for research purposes.

Performance on Problem-Solving Tasks

Sport Specific Task (Hockey Shots)

Participants were requested to articulate to which of the 5 holes they intended to shoot. The performance scores for each participant are found in Appendix L. Thirty four percent of the intended shots by the non-DCD group were on holes 1,2 and 5 and 17% of the shots by the DCD group were attempted at these holes. Holes 1, 2 and 5 were all off the ground and therefore were more challenging shots, holes number 3 and 4 were both on the ground. Fifty-two percent of the shots attempted by the non-DCD group were on holes 3 and 4 and 68% of the DCD group's shots were on 3 and 4. On 14% of the shots taken by the non-DCD group, and 15% of the shots by the DCD group, no intention was verbalized.

As might be expected, the participants were not always successful in placing the puck in the intended hole. Table 6 indicates that neither group was very successful in actually achieving the goals they articulated. To establish if there was a difference in the performance of the two groups *t*-tests were performed on the number of pucks that went in each hole. As the performance of each group on numbers 1, 2 and 5 were identical no analysis was performed. Two independent *t*-tests performed on the results of holes number 3 and 4 showed no significant differences, (2,18), *t*= 0.879, p=0.392, and (2,18), *t*= -1.251, p= 0.229 respectively.

Many of the shots did not go in the intended goal but went in another hole in the net. This was common when the participants shot at holes 1 and 2. Taking this into consideration, regardless of the intent of the shot, the non-DCD group got 31.2% of their shots and the DCD group got 28.4% of their shots (Table 6). Raw performance scores are found in Appendix I.

Table 6

Goals Achieved on Each Hole by the DCD[1] and Non-DCD Groups

Goal	Mean*		Standard Deviation	
	DCD	N-DCD	DCD	N-DCD
1	0	0	0	0
2	0	0	0	0
3	2.5	3.3	0.5	0.7
4	1.6	2.4	1.1	1.6
5	0.1	0.1	0.3	0.3

1= Developmental Coordination Disorder
* Based on 25 shots per person

Educational Task (Peg Solitaire Games)

There are 32 pegs on the peg solitaire board and the object is to have one peg left at the end of the game. Table 7 illustrates the outcomes of the first peg solitaire game. The non-DCD group performed better overall on the task with more consistent performances within the group. However, one participant in the DCD group achieved a high level of performance with only 2 pegs left and another participant in the DCD group had a performance of 24 pegs left. Raw performance scores are found in Appendix J.

Table 7

Number of Pegs Remaining on First Peg Solitaire Game

Group	N	Minimum*	Maximum	Mean	Standard Deviation
DCD	10	2	24	7.9	5.9
N-DCD	10	5	8	6.9	0.9

* Note: a lower score denotes superior performance.

A similar pattern of results was found on the second peg solitaire game. The non-DCD group had more consistent and superior overall performance. Again, the DCD group had one participant who achieved a high level of performance with 2 pegs left. The DCD group also had 3 participants who finished with 24 pegs left in the second game (Appendix J). It was not the same participant who achieved this low level of performance for the first game. Two independent *t*-tests indicated no significant difference in the performance on either game 1 or 2, (2,18) $t = 0.522$, $p = 0.603$, and (2,18) $t = 1.638$, $p = 0.119$ respectively.

Table 8

Number of Pegs Remaining on Second Peg Solitaire Game

Group	N	Minimum*	Maximum	Mean	Standard Deviation
DCD	10	2	24	11.1	9.0
N-DCD	10	4	9	6.3	1.8

* Note: a lower score denotes better performance.

Content Analysis

The total number of verbalizations for both the DCD and non-DCD groups, displayed in Table 9, was not significantly different for either the hockey shot task or the peg solitaire task. The raw data are found in Appendices G and H.

Table 9

Comparison of Total Number of Verbalizations for DCD[1] vs. Non-DCD Groups on Hockey Shot and Peg Solitaire Tasks

Task	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance ($p < .05$) *
	DCD	N-DCD	DCD	N-DCD		
Hockey Shot	150.7	161.9	63.1	50.0	43.5	0.623
Peg Solitaire	73.1	70.1	32.7	17.0	49.0	0.940

1 = Developmental Coordination Disorder

Hockey Shot Task

All the statements were coded according to the framework provided in Tables 1 and 2. The presentation of the content analysis corresponds directly to this framework. Each of the six categories were analyzed as a whole as well as at each individual coding level within the categories.

Goals. Each participant was instructed to verbalize the goal of evrey shot prior to shooting, therefore no differences were expected in total goal verbalizations, this is confirmed in Table 10.

Table 10

Comparison of Number of Goal Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance ($p < .05$) *
	DCD	N-DCD	DCD	N-DCD		
Total Goals	31.3	31.5	6.4	9.3	44.5	0.677
Specific Goals	24.4	24.3	4.5	5.4	49.5	0.970
Goal Change	0.6	1.2	0.8	1.7	45.0	0.669
Goal Not-Intended	1.4	0.9	1.8	1.1	44.0	0.630
Non-Specific Goals	1.6	1.6	1.5	1.5	49.5	0.969
Higher Level Goals	0.2	0.6	0.4	0.8	38.0	0.260
Goal Achieved	3.4	2.8	2.5	3.5	37.5	0.336

1 = Developmental Coordination Disorder

Knowledge. The content analysis under the *Knowledge* category is presented in three tables, (11,12 and 13). These tables directly correspond to the levels of *knowledge* codes presented in Table 2. A significant difference was not found in the total *Knowledge* statements, however the non-DCD group had 25% more *total knowledge* statements than the DCD group.

Table 11

Comparison of Number of Knowledge Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance ($p < .05$) *
	DCD	N-DCD	DCD	N-DCD		
Total Knowledge	57.0	76.2	45.4	41.6	35.5	0.273
Declarative Knowledge	2.3	3.6	2.6	4.6	45.5	0.727
Causal Relationship	0.0	0.2	0.0	0.4	40.0	0.146
Coach or Teacher	0.1	0.0	0.3	0.0	45.0	0.317
Hockey Experience	0.4	0.1	0.5	0.3	35.0	0.131
Personal Learning Theory	1.8	2.4	2.8	2.8	41.5	0.504

1 = Developmental Coordination Disorder

Table 12 presents the *action plan* codes. A significant difference was not found for the total *action plan* statements. However the non-DCD group had 25% more action plan statements than the DCD group. A significant difference was found in the number of statements coded with *error correction plan*. For a statement to be coded with *error correction plan* the participant must have acknowledged that a mistake had been made and how it was going to be corrected.

Table 12

Comparison of Number of Action Plan Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Action Plans	52.4	69.9	41.6	40.0	35.0	0.256
Incomplete	1.1	0.9	1.5	1.5	40.5	0.430
General	5.9	4.6	7.0	3.3	47.5	0.849
Self-Motivational Strategy	3.6	4.0	3.2	2.4	48.0	0.878
Error Correction Plan	1.5	4.1	1.7	3.9	25.0	0.055*

1 = Developmental Coordination Disorder

Table 13 presents all the *specific action plan* codes. The non-DCD group expressed 29% more total *specific action plans* but the difference was not significant. The codes t*ype of shot, instrument, body part, follow through, and aim*, are a reflection of vocabulary.

Table 13

Comparison of Number of Specific Action Plan Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Specific Action Plans	40.3	56.3	31.3	42.5	38.5	0.384
Chooses New Stick	0.0	0.2	0.0	0.6	45.0	0.317
Switches Hand Orientation	0.2	0.0	0.6	0.0	45.0	0.317
Type of Shot	4.8	9.3	5.8	13.6	45.0	0.695
Instrument	1.6	4.4	2.2	5.7	33.5	0.195
Body Part	10.1	12.9	14.3	22.2	41.0	0.490
Follow Through	1.9	3.1	5.0	5.3	41.0	0.402
Shoot	3.5	8.1	3.4	10.3	42.5	0.568
Aim	9.4	3.3	9.9	2.8	33.0	0.195

1 = Developmental Coordination Disorder

Emotion. Statements reflecting emotions and feelings were coded either as positive or negative. A significant difference was found in the total number of emotional statements between the DCD and Non-DCD participants. A comparison of negative affect statements between the two groups approached significance; the DCD group having more emotional statements overall.

Table 14

Comparison of Number of Emotional Statements for DCD[1] vs. Non-DCD groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Emotion	26.0	15.2	11.6	11.1	22.5	0.037*
Positive Affect	8.0	5.0	5.5	4.2	33.0	0.194
Negative Affect	18.0	10.2	10.9	9.1	26.0	0.069

1 = Developmental Coordination Disorder

Monitoring. The analysis of the *monitoring* category is presented in Tables 15 and 16. The two groups had very similar results for the monitoring codes except for the *error detection* codes presented in Table 16.

Table 15

Comparison of Number of Monitoring Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Monitoring	21.0	24.0	8.0	8.4	39.5	0.427
Specific Monitoring	3.0	3.4	2.4	1.8	42.0	0.539
Task Relevant Attention Focus	0.0	0.3	0.0	0.6	40.0	0.147
Off Task Attention Focus	1.1	1.0	2.5	2.4	49.0	0.926
Attention Control	0.1	0.4	0.3	0.8	44.5	0.503
Game Situation	1.4	0.2	3.0	0.6	35.5	0.149
Outcome Statement	1.3	0.5	1.7	0.7	38.5	0.338
Awareness of Completion	0.1	0.2	0.3	0.4	45.0	0.542

1 = Developmental Coordination Disorder

A significant difference was not found in the *error detection* codes, however Table 16 indicates that the non-DCD group consistently detected more errors in their performance.

Table 16

Comparison of Number of Error Detection Statements for DCD[1] vs. Non-DCD groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance ($p < .05$) *
	DCD	N-DCD	DCD	N-DCD		
Total Error Detection	14.0	18.0	5.9	7.7	31.0	0.150
Error Detection	5.3	6.3	4.1	4.8	31.0	0.150
Error Detection in the Outcome	5.8	8.4	4.8	5.6	31.5	0.159
Error Detection in the Movement Pattern	2.9	3.3	2.6	2.7	43.0	0.590

1 = Developmental Coordination Disorder

Evaluation. The evaluation statements were very similar between the two groups including *task difficulty evaluation*, which represents any statements regarding the perceived difficulty of the task. It was expected that the DCD group would find the hockey shot difficult; the *task difficulty evaluation* statements do not reflect this expectation.

Table 17

Comparison of Number of Evaluation Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Evaluation	5.6	5.7	4.8	4.3	47.5	0.848
Specific Evaluation	0.5	0.8	0.9	1.6	48.5	0.889
Evaluation of Strategy	0.3	0.7	0.6	1.8	49.5	0.957
Evaluation of Shot	0.4	1.6	0.8	1.6	47.0	0.816
Task Difficulty Evaluation	2.6	2.6	2.7	2.2	48.5	0.908

1 = Developmental Coordination Disorder

Other. The statements coded in the *other* category were not deemed to be metacognitive and as seen in Table 18 no significant differences were found.

Table 18

Comparison of Number of Other Statements for DCD[1] vs. Non-DCD Groups: Hockey Shot

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Other	6.8	7.9	4.8	2.9	34.0	0.224
Transition	4.1	4.4	3.1	2.0	44.0	0.647
Clarifying Statement	2.7	3.5	4.0	2.1	33.0	0.187

1 = Developmental Coordination Disorder

Peg Solitaire Games

All verbalizations during the peg solitaire games were coded according to the framework provided in Tables 1 and 3. The presentation of the content analysis corresponds directly to this framework. The frequencies of the codes on both games were combined for the content analysis.

Goals. The goal of the game is to have one peg remaining at the end. No significant differences were found in the total goal statements.

Table 19

Comparison of Number of Goal Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Goals	2.5	2.5	2.8	2.1	44.5	0.677
Specific Goals	0.3	0.5	0.4	0.7	43.5	0.557
Short Term Goal	2.2	1.6	2.6	1.3	49.5	0.969
Goal Achieved	0.0	0.4	0.0	0.9	40.0	0.147

1 = Developmental Coordination Disorder

Knowledge. The analysis for coded statements under the category *Knowledge* are presented in three tables (20, 21 and 22). These tables directly reflect the different levels of knowledge presented in Table 3.

No significant differences were found in total knowledge statements (Table 20). The frequencies of all other knowledge codes were very similar between the two groups.

Table 20

Comparison of Number of Knowledge Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Knowledge	42.9	42.9	16.6	15.1	49.0	0.940
Declarative Knowledge	0.3	0.3	0.4	0.9	41.5	0.357
Personal Learning Theory	0.3	0.1	0.9	0.3	49.5	0.942
Self-Motivational Strategy	0.1	0.8	0.3	1.2	34.0	0.111

1 = Developmental Coordination Disorder

Table 21 indicates that no significant differences were found for the total *action plan* codes between the two groups. The DCD group verbalized more change of plans than the non-DCD group, this number approached significance.

Table 21

Comparison of Number of Action Plans Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance ($p < .05$) *
	DCD	N-DCD	DCD	N-DCD		
Total Action Plans	42.2	41.7	16.3	15.5	35.0	0.256
Incomplete	1.2	1.4	1.3	2.0	48.0	0.873
Change of Plan	1.3	0.3	1.4	0.4	29.0	0.079
General Action Plan	28.4	26.2	12.4	15.7	41.5	0.519

1 = Developmental Coordination Disorder

Table 22 shows that in the *specific action plan* level the two groups did not differ except on the code *planning ahead.* The non-DCD group had significantly more planning ahead statements than the DCD group. When the participants verbally indicated that they were planning more than one move in advance the code *planning ahead* was used.

Table 22

Comparison of Number of Specific Action Plans Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Specific Action Plans	11.3	13.8	10.3	8.2	38.5	0.383
Specific Action Plan	5.6	4.7	6.3	4.5	49.0	0.939
New Game Plan	0.5	0.4	0.7	0.5	48.0	0.861
Old Game Plan	0.3	0.4	0.4	0.6	48.5	0.888
Strategy	0.1	0.6	0.3	0.8	48.5	0.888
Sectional Plan	3.0	2.8	4.4	2.8	43.5	0.611
Planning Ahead	1.8	4.9	2.2	3.5	24.0	0.044*

1 = Developmental Coordination Disorder

Emotion. No significant differences were found for emotional statements on the peg solitaire games. As children with DCD may have fine motor problems the peg solitaire game might have caused some frustration for this group, however the frequency of negative affect statements was similar to those of the non-DCD group.

Table 23

Comparison of Number of Emotional Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance ($p < .05$) *
	DCD	N-DCD	DCD	N-DCD		
Total Emotion	4.2	4.1	5.8	4.3	46.0	0.759
Positive Affect	2.4	2.8	3.7	3.3	43.5	0.606
Negative Affect	1.8	1.3	2.3	1.4	46.5	0.784

1 = Developmental Coordination Disorder

Monitoring. The frequency of total *monitoring* codes was higher for the DCD group as well as for the individual *monitoring*, although a significant difference was not found (Table 24).

Table 24

Comparison of Number of Monitoring Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Monitoring	13.2	11.8	8.6	5.3	49.0	0.939
Monitoring	10.1	8.6	8.3	4.2	47.5	0.849
Inadequate Monitoring	1.2	0.8	1.6	1.3	46.0	0.732
Foresight Difficulty	0.5	1.2	0.5	2.5	47.5	0.829
Off Task Attention Focus	0.1	0.1	0.3	0.3	50.0	1.000
Game Momentum	0.1	0.1	0.3	0.3	50.0	1.000
Awareness of Completion	1.2	0.9	1.1	0.9	42.5	0.548
Relax	0.0	0.1	0.0	0.3	45.0	0.317

1 = Developmental Coordination Disorder

Evaluation. The frequencies of total evaluation statements were not significantly different. Significance was also not found on any of the *evaluation* codes.

Table 25

Comparison of Number of Evaluation Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Evaluation	4.9	5.3	5.1	4.4	43.5	0.621
Evaluation	3.6	4.4	4.3	4.5	42.5	0.567
Task Difficulty Evaluation	1.3	0.9	2.2	0.7	43.5	0.601

1 = Developmental Coordination Disorder

Other. The statements coded in this category are not metacognitive. No significant differences were found in this category although the DCD group had more total *other* statements.

Table 26

Comparison of Number of Other Statements for DCD[1] vs. Non-DCD Groups: Peg Solitaire.

Code	Mean		Standard Deviation		Mann-Whitney U	Absolute Probability and Significance (p< .05) *
	DCD	N-DCD	DCD	N-DCD		
Total Other	5.4	3.5	4.0	3.4	40.0	0.446
Transition	5.2	2.9	3.7	2.9	32.0	0.170
Help Seeking	0.2	0.2	0.4	0.4	50.0	1.000
Clarifying Statement	0.0	0.4	0.0	0.6	35.0	0.068

1 = Developmental Coordination Disorder

Chapter 5

Discussion

The purpose of this study was to determine the extent to which the self-regulatory skills of children with DCD are domain specific, compared to their peers without DCD. A sport specific problem-solving task (hockey shot) and an educational problem-solving task (peg solitaire) were compared. This chapter will consist of five major sections. The use of the concurrent think aloud methodology will be discussed first, followed by the performance of the DCD and non-DCD groups on the problem-solving tasks. Third the results of the content analysis will be presented within the framework provided by Zimmerman's (2000) model in the third section. Conclusions will be drawn fourth, followed by directions for future research.

Concurrent Think Aloud Methodology

The validity of the concurrent think aloud methodology (verbal reports) has been debated but infrequently used in the psychomotor domain (Ericsson & Simon, 1984/1993; Martini, 2002; Reid et al., 2002). However, when collected properly verbal report data are considered reliable indications of cognitive processing (Bainbridge & Sanderson, 1995; Ericsson & Simon, 1984/1993; Payne, 1994). No significant differences were found in the total verbalizations between the DCD and non-DCD groups on either the sport specific or educational problem-solving task. Yun and Ulrich (2002) define validity as the plausibility of the inferences drawn from the data. Because both groups were able to verbalize during the two tasks, it can be inferred that the concurrent think aloud methodology is a valid method of investigating the self-regulatory skills of children with and without DCD.

The familiarization exercises used to initiate the participants to the concurrent think aloud procedure contributed to the success of the methodology. The familiarization tasks included practicing the think aloud procedure on a motor task (jumping patterns) prior to the 25 hockey shots, and during a similar educational task (dominoes) prior to the peg solitaire games. It likely that the opportunity to practice the think aloud procedure on similar problem-solving tasks positively influenced the ability of the participants to verbalize on the experimental tasks.

A second consideration regarding the amount of verbalizations on the peg solitaire game is the possibility of a learning effect. The peg solitaire data were collected after the hockey shot data. The order might have increased the ability of the participants to verbalize on the peg solitaire task because of previous think aloud experience on the hockey shooting task. Future studies should randomize the data collection schedule to prevent this complication.

Finally, only one puck was available during the hockey shooting task. The use of one puck created a time delay between each shot facilitating the think aloud methodology. This delay may have allowed for reflection and planning as the puck had to be retrieved before the next shot (Barkley, 1997). In conclusion, the verbal report methodology appears to be a viable means of studying the metacognitive processes of children with and without DCD.

Performance on Problem-Solving Tasks

Hockey Shot

Surprisingly, significant differences were not found between the performance of the DCD and the non-DCD groups on the hockey shooting task. This indicates that the shooting task was challenging for all participants. Holes 1, 2, and 5 were more challenging targets because they were off the ground. Although the two groups had identical performance outcomes when shooting on holes 1, 2 and 5, the non-DCD group indicated verbally that they were aiming for these more challenging targets more often (37% vs. 17%). One of the participants without DCD articulated that he wanted the challenge of shooting for the higher holes, "this time I'm giving myself a little challenge, I'm going to shoot for the 5." The non-DCD group had the same number of goals achieved on holes 3 and 4 compared to the DCD group, even though they took fewer shots on these holes. Thus, the children in the non-DCD group were more successful on the easier holes and set more challenging goals for themselves compared to the group with DCD.

It was anticipated that clearer differences in performance would emerge on the hockey shooting task. Some of the children expressed disapproval of the equipment provided. As stated previously, all the hockey sticks were plastic with straight blades to accommodate both right and left-handed shooters. Many of the non-DCD participants expressed their dissatisfaction with the type of sticks provided. For example, "I really feel like using a curved stick right now cause it is sorta hard to get the puck up in the top corner...I did everything pretty much right except I couldn't get it with a straight stick." According to the participants a curved stick allows the shooter to lift the puck more easily. Another participant in the non-DCD group expressed his dissatisfaction with the puck, "this puck is really hard to lift, so I missed, it went too low." The children in the DCD group did not express concern regarding the equipment. Thus, it is possible that the non-DCD group had less motivation to score goals because of the equipment, they may have simply given up or not tried very hard.

The similar performances on the shooting task may also be explained by the fact that the non-DCD group was not composed of "hockey players." All the participants were classmates recruited from two neighborhood schools. Some of the children in the non-DCD group did play hockey, but playing hockey was not an inclusive criterion for participation in the research. Therefore, the two groups might have been more similar than expected in hockey experience. This research project was conducted in Montreal, Canada where hockey is an integral part of the culture. Wall (1982) states that practice improves proficiency of motor skills. Therefore, the relative shooting proficiency of the participants in the DCD group might be explained by the fact they have practiced shooting at a hockey net in basements, during road hockey games or in physical education class more than expected because of cultural values.

An additional point regarding the similar performances on the shooting task is that the DCD group was recruited from an educational setting, not a clinical setting. Many studies of the DCD population have recruited participants from clinical settings who have been referred after teachers or parents realized that the child had significant movement difficulties (e.g. Hoare & Larkin, 1991;

Lord & Hulme, 1987b; Marchiori et al., 1987; Sims, Henderson, Morton, Hulme, 1996). Therefore it is conceivable that the motor deficits of the DCD group, in this study, may not be as severe as expected providing for higher performance outcomes on the hockey shot task. However, all the participants in this study did score below the 15^{th} percentile norm (Henderson & Sugden, 1992), which is recommended for research by Gueze et al. (2001). Data regarding the educational achievement of each participant (i.e. IQ or learning disability status) were not available therefore the relevance of the sample setting should be considered with caution.

Peg Solitaire

As expected, the results on the peg solitaire games were similar with no significant differences in the performance of the DCD and non-DCD groups. This game was chosen to be a novel task that would challenge both groups. The goal of the game is to have one peg remaining at the end. Any individual in either group did not achieve this therefore peg solitaire appears to have adequately challenged both groups.

Peg solitaire definitely has a fine motor component, however success on the task is not dependent on fine motor proficiency. Children with DCD are reported to have difficulty on fine motor tasks (Henderson & Henderson, 2002), however the results confirm that the fine motor component of the peg solitaire game did not inhibit the performance of the DCD group. Interestingly, two participants in the DCD group achieved the highest performance on each game. However, the individuals in the DCD group also had the poorest performance on each game. The non-DCD group had a more consistent performance within and between games.

In summary, both the sport specific and educational problem-solving tasks proved to be challenging for both groups. No significant differences were found in the performance on either the sport specific or educational problem-solving tasks. The non-DCD group set more challenging goals than the DCD group on the hockey shooting task, and achieved the same number of goals on holes 3 and 4 even though they took fewer shots at these targets.

Zimmerman's Model of Self-Regulation

Zimmerman's (2000) model involves three stages, (a) forethought, (b) performance or volitional control, and (c) self-reflection. Both problem-solving tasks involved discrete trials to which Zimmerman's model applies. No significant differences were found in the total verbalizations on either task. Not surprisingly, none of the participants verbalized during the performance phase of either tasks. Bainbridge and Sanderson (1990) point out that there are time constraints, "in problem-solving situations, many things may quickly pass through people's minds and be forgotten before there is time to report them" (p. 172). Cleary and Zimmerman, (2001) and Kitsantas and Zimmerman (2002) both studied the self-regulation of sport specific tasks using Zimmerman's (2000) model. These studies also found it difficult to access the thought processes during the performance or volitional control phase. In the current study the verbalizations before and after each trial provided information regarding the self-regulatory skills of children with and without DCD, on sport specific and educational problem-solving tasks.

Forethought

In Zimmerman's (2000) model the forethought phase is made up of two categories, (a) task analysis and (b) self-motivational beliefs. The task analysis category includes goal setting and strategic planning.

Goals. Goal setting is a very important part of skilled performance and self-regulation (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2002). For the hockey shooting task, the participants were instructed to verbalize which target they were shooting at (their goal), in order to measure if the goals achieved were intentional. The successive moves in the peg solitaire game lead to the final goal of having one peg remaining at the end of the game. It was not expected that the participants would verbalize the final goal of the game with each move. Therefore, no differences were anticipated in the *goals* category on either task. However, as noted, the non-DCD group set more challenging goals on the hockey shooting task.

Knowledge. According to Zimmerman (2000), self-regulation is dependent on domain specific knowledge. Davidson and Sternbeg (1998) also stated that the type and amount of metacognitive planning is influenced by domain specific knowledge. Children with DCD, in general, have fewer opportunities to increase their knowledge about movement because they tend to avoid participation in physical activity due to repeated failure (Bouffard et al., 1996; Causgrove Dunn, 2000; Wall et al., 1985; Wall, et al., 1990).

Although a significant difference was not found, the non-DCD group expressed 25% more mean number of *knowledge* verbalizations on the hockey shooting task (Table 11). On the peg solitaire task the mean number of *knowledge* codes were equal (Table 20). Keogh (1982) and Wall (1982) both felt that children with DCD had a movement learning disability, and according to the knowledge based approach would therefore have less knowledge in the motor domain than children without DCD.

The expectation that children with DCD would have decreased knowledge in the motor domain is clear from the literature. Although no significant differences were found in the quantity of *knowledge* utterances, the following examples illustrate differences in the quality of the verbalizations by each group. "So I have to put the puck in between my legs, take a big swing and follow through...when I'm taking a slap shot I have to transfer my weight from this leg (back leg) to this one (front leg)." This statement by a participant without DCD indicates well-developed knowledge about hockey. The following is an example of a *knowledge* statement from a participant with DCD, "so I am going to try another time to see if I, to see if I can get it in...(shoots)...I don't know exactly what I'm doing wrong because it was so close." These two examples are indicative of the quality of the *knowledge* statements made by all the participants in each group.

The culture of hockey in Canada is a pertinent point because it is conceivable that the DCD group may have had more domain specific (hockey) knowledge because of exposure to hockey culture. Even if the participants in the DCD group did not play hockey, knowledge of the game and shooting could be gained from regularly watching games on television, and following teams and players in the newspapers or magazines. In Canadian elementary schools, it is "cool" to know a lot about hockey. In short, the lack of greater differences in the knowledge domain on the hockey shooting task might be because the children with DCD actually did have more knowledge about hockey than was expected. The results regarding knowledge may have been different if shooting at a basketball net had been the sport specific problem-solving task.

Planning. Planning is essential to effective self-regulation and is dependent on knowledge and monitoring. Although a significant difference was not found in the total planning statements, the DCD group did articulate 25% fewer action plans on the hockey shot (Table 12), but an equal numbers of action plans on the peg solitaire tasks (Table 21).

The mean number of *specific action plans* verbalized by the non-DCD group on the hockey shooting task was 29% (Table 13) higher than the DCD group, although once again a significant difference was not found. The individual *specific action plan* codes are linked to vocabulary, which is a reflection of knowledge (Wall et al., 1985). The DCD group appeared not to know what to say, or just repeated the same plan without regard to performance. For example, after an unsuccessful trial a participant with DCD said, "I'm going to try to get it in again." Marchiori et al. (1987) found that even after extensive practice of a hockey slap shot the DCD participants did not demonstrate a change in motor performance, they continued to repeat the same errors. Martini (2002) also found inconsistent planning concepts verbalized by children with DCD on a ball-throwing task.

The non-DCD group articulated more detailed specific plans, for example, "bend my knees, try to sweep it, I'm going to flex my stick as I am shooting, and I'm going to get it right about where the post is." The DCD group generally did not articulate similar detail in their plans. For example, "I'm going to get my shot ready" was coded as *general action plan.* The findings regarding vocabulary are consistent with Wall et al. (1985) who stated that children with DCD have a limited vocabulary about movement. Surprisingly no significant differences were found in the number of *general action plans.* It was expected that the DCD group would have more general plans. Again this finding could be linked to the amount of hockey knowledge of each group.

A significant difference was found in two planning codes, one on each task. On the hockey shooting task, statements that identified an error, and a plan was verbalized that was intended to correct the error, were coded with *error correction plan.* The non-DCD group had significantly more *error correction plan* statements. The following is an example of how a participant with DCD attempted to correct his errors. For 3 shots the participant stated "I'm going to really bend my knees this time," but he missed all 3 shots. Finally the participant changed his mind and stated, "this time my knees aren't going to be bent." This is an example of the how the child with DCD did not have an accurate representation of the performance demands because bent knees are part of a mature shooting pattern, his bent knees were not inhibiting his performance. The following is an example of an *error correction plan* articulated by a participant in the non-DCD group, "now that didn't go where I wanted it to go. I don't think I hit it with the heal of my stick. I hit it with the middle of my stick and the middle of my stick was facing this way, and the heal was facing over there. So on every shot you have to hit it with the heal."

On the peg solitaire task, statements that indicated the participant was planning two or more moves ahead were coded with *planning ahead.* "If I move here, then I can move there and that would allow me to get that guy out in the corner, okay good, I'll do that." This is an example of a *planning ahead* statement by a non-DCD participant. The participant verbalized that he was thinking about the peg in the corner but was three moves away from removing it. The non-DCD group had significantly more planning ahead verbalizations.

Error Correction Plan and Planning Ahead codes represent a sophisticated integration of knowledge, monitoring, and planning which are important components of self-regulation. On both codes the non-DCD group had significantly more verbalizations. Children with DCD by definition have difficulty solving movement problems and have less developed knowledge in the motor domain (Bouffard & Wall, 1990; Wall, 1982; Wall et al., 1985; Wall et al., 1990). Performers with less expertise tend not to monitor performance, often have difficulty planning, and demonstrate less efficient use of strategies (Bos & Vaugn, 1994; Davidson & Sternberg, 1998; Wong, 1985). Although there is a high incidence of additional learning difficulties, socio-emotional and behaviour problems with DCD (Harvey & Reid, 2003; Henderson & Henderson, 2002; Sugden & Wright, 1998), differences in planning were not expected on the educational problem-solving task.

It has been suggested that DCD constitutes a learning disability (Keogh, 1982; Polatjko et al., 2001; Wall, 1982). There is an expectation that children with learning disabilities have difficulty with metacognitive skills such as planning, which is one of the basic skills of self-regulation (Bos & Vaughn, 1994; Butler, 1998; Davidson & Sternberg, 1998; Glaser et al., 1987; Wong 1985). Therefore the significant difference in *error correction plans* was expected on the sport specific problem-solving task. The additional significant difference in *planning ahead* verbalizations on the educational problem-solving task suggests that planning may be a more global skill, and children with DCD have general problems in planning. Thus, the differences in planning lend support to Keogh (1982) and Wall's (1982) position that DCD represents a problem of learning. Further research that targets planning on problem-solving tasks is warranted.

Self-Reflection

The final stage of Zimmerman's (2000) model is self-reflection. This phase includes (a) self-judgement and (b) self-evaluation. Surprisingly, no significant differences were found in the quantity of the monitoring and evaluation statements on either task.

The quality of the *error detection* statements within the monitoring category was different between the two groups. In perceiving an error it is inherent that the person has an accurate representation of the correct performance. The following is an example of an *error detection* statement by a participant in the non-DCD group, "that went into the middle because I didn't follow through exactly where I wanted it to go." In contrast, "and I missed again" is an example of an *error detection* statement by a participant in the DCD group.

As Zimmerman's (2000) model is cyclical, knowledge is important in all phases. The quality of the monitoring statements verbalized by the children in the DCD group reflects deficits in knowledge. Surprisingly, the mean number of evaluation statements was equal for both groups on the hockey shooting task. As previously noted, the participants DCD group may have increased knowledge about hockey. This knowledge may have positively influenced the number of evaluation statements. On the peg solitaire task significant differences in monitoring and evaluation were also not found. This was expected as self-regulation is dependent on domain specific knowledge and there was no indication of a knowledge deficit on the peg solitaire task.

In summary, no significant differences were found between the groups in *monitoring* or *evaluation* statements on the hockey shooting task. However, there were differences in the quality of the *error detection* statements. As expected, no significant differences were found on the peg solitaire monitoring or evaluation statements.

Emotion. The emotions attached to a task are present during all phases of Zimmerman's (2000) model. However during the hockey shooting task the emotional statements were most frequent after each shot. A significant difference in total emotional verbalizations was found on the hockey shot task. The DCD group expressed more emotion.

Although not significant, the DCD group had 37.5% more mean positive and 44% mean negative statements than the non-DCD group (Table 14) on the hockey shooting task. When the DCD participants scored a goal they were extremely excited, for example, "WAHOO! I got it in! I'm happy now!" Whereas when the non-DCD group scored, they generally did not express such elation or surprise, for example, "got it in, that's good."

Frustration is a potential explanation for the high number of negative statements by the non-DCD group. For example, "no good! Oh well

If I was in a real hockey game I'd be getting really mad at this point because I am not getting much." The non-DCD group expressed frustration at not being able to perform a skill arguably because of the equipment. In contrast the negative statements by the DCD group were very self-critical, for example, "Now that made me angry because I had a really bad shot this time," or "I'm not good at hockey."

The frequency of negative statements on the hockey shot task approached significance, p= 0.069. The literature suggests that children with DCD have more negative feelings attached to movement tasks (Bouffard et al., 1996; Causgrove Dunn, 2000). The results support previous research regarding the negative emotions attached to movement by children with DCD.

In summary, the results support the position that children with DCD have negative emotions attached to motor skills. A difference was not found in the mean number of negative statements during the peg solitaire games, confirming that the fine motor component of the game did not stimulate negative feelings in the DCD group.

Conclusion

The purpose of this study was to examine the domain specificity of the self-regulatory skills of children with DCD related to their peers without DCD on problem-solving tasks. Differences were not found in the total number of verbalizations on either task indicating that the concurrent think aloud procedure is a viable method for studying self-regulation in children.

It was hypothesized that on the sport specific problem-solving task the individuals in the DCD group would have fewer self-regulatory verbalizations. Significant differences were only found on emotional statements and error correction plans. There were, however, differences in the quality of the knowledge statements and the non-DCD group set more challenging goals. It was also hypothesized that the individuals in the DCD group would have a similar number of self-regulatory statements on the educational problem-solving task. This expectation was supported with the exception of planning ahead statements.

In short, children with DCD have performance difficulties in the motor domain, but not necessarily in domains where motor proficiency is not required. Wall (1982) stated that proficiency in motor skills is linked to practice, and Zimmerman (2000) stated that practice is important in the development of self-regulatory skills. The differences in emotional statements support previous research regarding negative feelings attached to movement. The differences in the quality of the knowledge statements between the DCD and non-DCD groups supports the hypothesis that children with DCD have decreased knowledge in the motor domain but not necessarily in educational problem-solving tasks. Interestingly, the significant differences in planning on each task suggest that planning may be a global skill, and regardless of domain, children with DCD may have difficulty with planning.

In conclusion, within the limitations of the current study, the results support a self-regulation deficit in children with DCD on a motor task compared to non-DCD peers. With the exception of planning, these difficulties do not appear to impact on non-motor tasks.

Directions for Future Research

To further examine the self-regulatory skills of children with DCD in the motor domain the use of a different sport specific problem-solving task is suggested. The use of a hockey shooting task with Canadian children may have impacted on their knowledge and ability to self-regulate on this particular problem-solving task.

Physical proficiency is important in a physically active lifestyle. Therefore, further research into the planning skills of children with DCD would assist in the development and implementation of intervention techniques. Intervention techniques that specifically target planning may increase physical proficiency leading to greater feelings of self-efficacy, and in turn increasing participation in physical activity.

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Appendix A

McGill Certificate of Ethics and Informed Consent Documents

RECEIVED MAY 15 2001

MCGILL UNIVERSITY
FACULTY OF EDUCATION

CERTIFICATE OF ETHICAL ACCEPTABILITY FOR FUNDED AND NON FUNDED RESEARCH INVOLVING HUMANS

The Faculty of Education Ethics Review Committee consists of 6 members appointed by the Faculty of Education Nominating Committee, an appointed member from the community and the Associate Dean (Academic Programs, Graduate Studies and Research) who is the Chair of this Ethics Review Board .

The undersigned considered the application for certification of the ethical acceptability of the project entitled:

Self-directed motor learning of children with movement problems

as proposed by:

Applicant's Name Greg Reid

Supervisor's Name ______

Applicant's Signature ______

Supervisor's Signature ______

Degree / Program / Course ______

Granting Agency SSHRC

The application is considered to be:

A Full Review ______

An Expedited Review ✓

A Renewal for an Approved Project ______

A Departmental Level Review ______
Signature of Chair / Designate

The review committee considers the research procedures and practices as explained by the applicant in this application, to be acceptable on ethical grounds.

1. Prof. ~~Evelyn Lusthaus~~ Ron Stringer
Department of Educational and Counselling Psychology
Signature / date

2. Prof. John Leide
Graduate School of Library and Information Studies
010518
Signature / date

3. Prof. René Turcotte
Department of Physical Education
May 24/01
Signature / date

4. Prof. Lise Winer
Department of Second Language Education
Signature / date

5. Prof. Claudia Mitchell
Department of Educational Studies
Signature / date

6. Prof. Kevin McDonough
Department of Culture and Values in Education
Signature / date

7. Member of the Community
Signature / date

Mary H. Maguire Ph. D.
Chair of the Faculty of Education Ethics Review Committee
Associate Dean (Academic Programs, Graduate Studies and Research)

May 29, 2001
Signature / date

(Updated January 2000)

MCGILL UNIVERSITY
FACULTY OF EDUCATION

CERTIFICATE OF ETHICAL ACCEPTABILITY FOR FUNDED AND NON FUNDED RESEARCH INVOLVING HUMANS

.ie Faculty of Education Ethics Review Committee consists of 6 members appointed by the Faculty of Education Nominating Committee, an appointed member from the community and the Associate Dean (Academic Programs, Graduate Studies and Research) who is the Chair of this Ethics Review Board .

The undersigned considered the application for certification of the ethical acceptability of the project entitled: Self-directed learning of motor and non-motor tasks by children with movement difficulties

as proposed by:

Applicant's Name Meghann Lloyd

Supervisor's Name Greg Reid

Applicant's Signature

Supervisor's Signature

Degree / Program / Course MA

Granting Agency

The application is considered to be:

A Full Review

An Expedited Review X

A Renewal for an Approved Project

A Departmental Level Review

Signature of Chair / Designate

The review committee considers the research procedures and practices as explained by the applicant in this application, to be acceptable on ethical grounds.

1. Prof. Ron Stringer
Dept. of Educational and Counselling Psychology

May 15, 2002
Signature / date

2. Prof. Ron Morris
Department of Culture & Values

May 15, 2002
Signature / date

3. Prof. René Turcotte
Department of Physical Education

May 22, 2002
Signature / date

4. Prof. Ada Sinacore
Department of Educational and Counselling Psychology

Signature / date

5. Prof. Brian Alters
Department of Educational Studies

Signature / date

6. Prof. Kevin McDonough
Department of Culture and Values in Education

Signature / date

7. Member of the Community

Signature / date

Mary H. Maguire Ph. D.
Chair of the Faculty of Education Ethics Review Committee
Associate Dean (Academic Programs, Graduate Studies and Research)

Mary Maguire May 27, 2002
Signature / date

(Updated June 2001)

November, 2001

Dear Parent or Guardian

This letter requests your permission for your son/daughter to participate in a research study to be conducted at Cedar Park. We believe it will be quite enjoyable for the participants.

We have designed the research to explore how children learn motor skills such as the hockey slap-shot. It is unique because we are actually asking the children to self-reflect during learning. We want to understand learning from their perspective. We will videotape their performance and encourage them to talk-aloud regarding their strategies and feelings during the learning process of 50 shots. We will attach a small microphone to their shirt to record their speech. The actual task, shooting a plastic puck at targets on a hockey net, is identical to activities that might be practiced in physical education.

We hope to include children who fall along the range of athletic ability. Your son/daughter has been identified by the physical education teacher as one who could be involved in our project. Prior to the 50 slap-shots, we will administer a brief standardized motor skills test involving balance, ball activities, and manual dexterity. This will require about 20 minutes.

This project, the short test and the 50 shots, will take place in the school. A graduate student from McGill will conduct the research, our plan is to administer the motor test prior to Christmas and have them perform the 50 shots in the New Year. Everything will require a maximum of 90 minutes over three days.

Even if you sign the form below, your child is free to withdraw at any point later on without question. This research has received a certificate of ethical acceptance from McGill. No child's name will be associated with any presentation or publication that might emerge from this research. Also, we will not show the videotapes to anyone after they are analyzed. Your child's identity will be secure.

Please sign the form below to indicate your willingness to have your son/daughter participate. If you have any questions, please do not hesitate to contact me at (514)- 398-4184, ext.0578. Thank you for your time and assistance.

Sincerely,

Greg Reid Ph.D.
Professor

I agree to allow my son/daughter, ___________________________ to participate in the research of Dr. Greg Reid. I understand the purpose of the research and what will be expected of my child. I am aware that he/she can stop participating at any time for any reason. I am aware that the research will be conducted on the school property and that confidentiality of my child's identity will ensured.

Date__________ Signature ________________________________

Please return this form to Mrs. Harper at the school. Many thanks.

May, 2002

Dear Parent or Guardian,

This letter requests your permission for your son/daughter to participate in a research study to be conducted in the school. We want to extend our sincere thanks for granting permission for your son/daughter to participate in the first phase of our study designed to examine how children learn motor skills, specifically the hockey slap shot. Last fall you permitted your child to participate in three separate sessions. However, after careful consideration only two sessions were necessary for the hockey slap shots. This letter requests your permission for your son/daughter to participate in the third session but with a non-motor task in lieu of the third hockey session.

There is no further time commitment for your son/daughter, only the nature of the third session has changed. We will ask the participants to play the game of Hi-Q, also known as peg solitaire. We are asking the children to self-reflect during learning in order to understand learning from their perspective. We will videotape their performance and encourage them to talk-aloud regarding their strategies and feelings while playing the game of Hi-Q.

The game of Hi-Q is a children's game which focuses on strategic problem solving and planning. It is considered to be a fun educational game for children. The same graduate student who conducted the first phase of this study will meet with your child for approximately 20 minutes. Even if you sign the form below, your child is free to withdraw at any point later on without question. This research has received a certificate of ethical acceptance from McGill University.

No child's name will be associated with any presentation or publication that might emerge from this research. Also, we will not show the videotapes to anyone after they are analyzed. Your child's identity will be secure.

Please sign the form below to indicate your willingness to have your son/daughter participate. If you have any questions, please do not hesitate to contact me at (514) 849-9556. Thank you for your time and assistance.

Sincerely,

Meghann Lloyd
McGill Graduate Student

Greg Reid Ph.D.
Graduate Student
Supervisor

I agree to allow my son/daughter__________________________ to participate in the research of Meghann Lloyd. I understand the purpose of the research and what will be expected of my child. I am aware that he/she can stop participating at any time for any reason. I am aware that the research will be conducted on the school property and that confidentiality of my child's identity will be ensured.

Date:____________________

Signature:__________________________________

Please return this form to the Physical Education teacher at the school.

Appendix B

Teacher Questionnaire

Child's Name:______________________________ **Age:**______ **Grade:**_____

School : ________________________ **Home Room:** ____________________

Please compare the physical skills of the child in question to those of his or her peers in physical education class. Circle the most appropriate answer to the following questions.

Never		**Sometimes**			**Often**	**All the time**
1	**2**	**3**	**4**	**5**	**6**	**7**

1. This child runs easily, smoothly, and stops with control.

   1 2 3 4 5 6 7

2. This child *competently* participates ball games with his or her peers.

   1 2 3 4 5 6 7

3. This child shows control and confidence in balance activities.

   1 2 3 4 5 6 7

4. This child learns new skills in physical education class easily.

   1 2 3 4 5 6 7

5. This child is *more competent* at individual activities than team activities.

   1 2 3 4 5 6 7

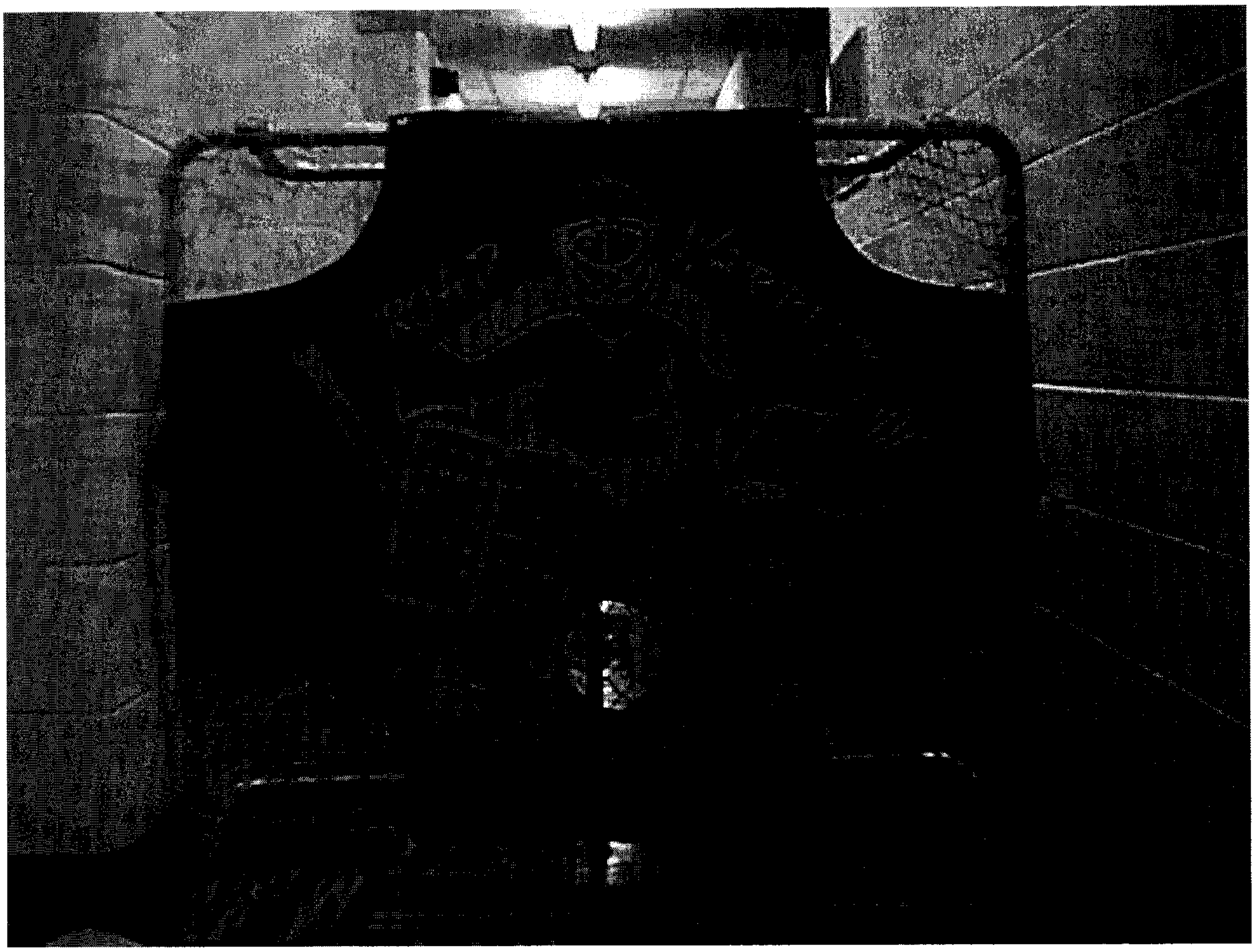
Children with physical coordination difficulties will have problems in physical education classes when learning and participating in physical activity.

Do you agree that __________________________ has physical coordination difficulties?
(Please circle one)

Strongly Disagree	**Disagree**	**Undecided**	**Agree**	**Strongly Agree**
1	**2**	**3**	**4**	**5**

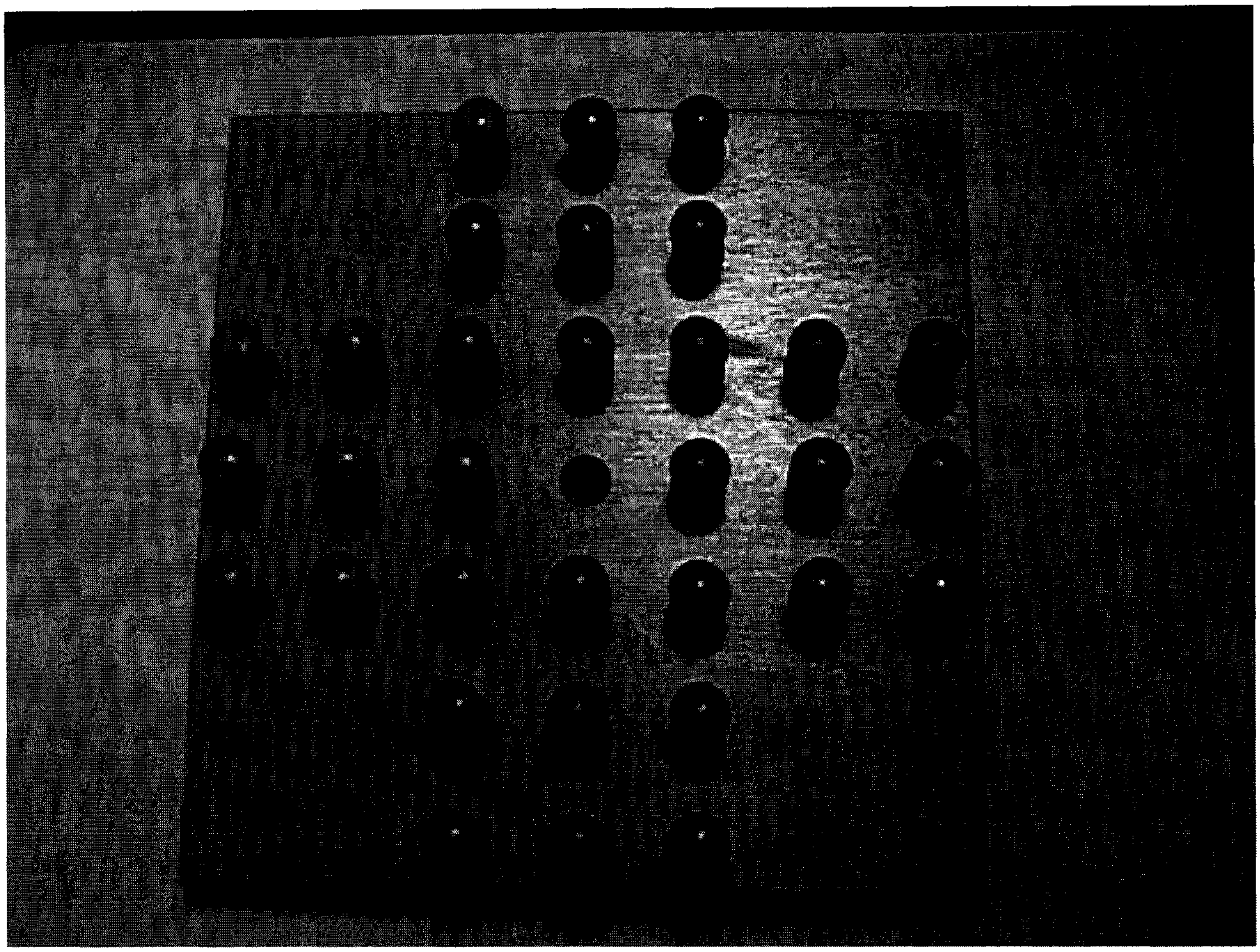
Appendix C

Photo of Hockey Net



Appendix D

Photo of Peg Solitaire Board



Appendix E

Operational Definitions of Codes – Hockey Shot

Code Descriptions for Sport Specific Problem-Solving Task

Goals

Specific Goal

Statement indicating what a person intends to achieve.

Goal Change.

Statement indicating that a former goal has been changed within the same shot. E.g. I am going to shoot for number 4, uh, no I'm going to shoot for number 3.

Goal Not Intended.

The participant verbally acknowledges that the puck enters a different hole than was intended.

Non-specific Goal.

The participant does not identify a specific goal he or she is or shooting for. E.g. I am shooting for 3 or 4, or I'm shooting for the bottom ones.

Higher Level Goals.

The participant indicates that a more specific goal is intended. E.g. I got it in, but it wasn't exactly in the middle, or I'm going to try to get 5 in a row in.

Challenge

Participant states that he is going to challenge himself by shooting at one of the "harder" shots. E.g. I am good at 3 and 4, I'm going to try something harder and shoot for number 5.

Goal Achieved.

Participant acknowledges that his goal has been achieved. For example, I got it in number 4!

Knowledge

Declarative Knowledge.

These statements include comments regarding the fundamentals or mechanics of the skill, co-ordination or flow of the sequence, movement tempo, or statements reflecting an awareness of imposed constraints, including game regulations. E.g. weight transfer, power.

Causal relationship.

The participant articulates that an event occurred because it was preceded by another event. E.g. The puck went to the left because I didn't follow through enough.

Coach or Teacher

Participant makes reference to a coach or teacher who has taught him about hockey. E.g. My brother told me to hold the stick like this.

Hockey Experience

Participant makes reference to his hockey experience or what he does when he is playing in a game or in practice. E.g. I usually get the puck in when I do slap shots.

Personal Learning Theories

Statement reflecting a person's personal belief about learning. I think that to get better I have to practice more.

Action Plan

Incomplete Action Plan

Participant begins to verbalize his or her action plan and doesn't finish the sentence or is very unclear about his or her intentions.

General Action Plan

Participant makes a very general statement. E.g.I'm going to do the same thing as last time.

Self-Motivational Strategy.

Statement that implies that the participant is using a general motivational. E.g. Keep going, I know I can get it.

Error Correction Plan.

Statement that implies the participant has previously identified a source of error and suggests an action plan or procedure to correct the error. E.g. next time I have to follow through better.

Specific Action Plan

Participant makes a specific statement. E.g. I am going to move more to the right to line up with number 4.

Type of shot
e.g. Wrist shot, slap shot

Instrument
e.g. I bring my stick back

Body part
e.g. I have my legs apart

Follow through
e.g. ...and I follow through

Shoot
e.g. ...and I'm going to shoot

Aim
e.g. ...and I aim for the 3

Chooses New Stick
Participant states that he is choosing a new stick from the three sticks available.

Switches Hand Orientation
Participant states that he is going to switch from shooting right handed to left handed and vice versa.

Emotion

Positive Affect.
Statements reflecting various enjoyable mental states. E.g. I'm happy about that shot.

Negative Affect.
Statements reflecting various distressing mental states. E.g. I am so mad I keep missing.

Monitoring

Error Detection.
Statement indicating that an error has been perceived. i.e. I missed

Error Detected in the Outcome.
Participant acknowledges that an error has been made in the outcome of the trial. E.g. It went over the net or, to far to the right.

Error Detected in Movement Pattern
The participant acknowledges that the error occurred in the movement pattern. E.g. I didn't follow through properly.

Specific Monitoring

Evidence of knowledge of overall performance over time. E.g.I think I only got it in once, I keep missing.

Off Task Attention Focus.

Statements that imply the participant is not paying attention to the task at hand. E.g. There is a penny on the floor over there; my cat ran away from home yesterday.

Attentional Control.

Statement which reflects an attempt to control one's focus of attention. E.g. I've got to concentrate.

Evaluation

Evaluation

A statement which implies a comparison has been made between the current trial and previous trial attempt(s). These statements usually refer to the participant's impressions of progress or the lack of progress. E.g. this one was better than the last one.

Evaluation of Strategy.

Participant evaluates the effectiveness or quality of the strategy used. E.g. Slap shots are not good for number 5.

Evaluation of shot.

The participant indicates whether the outcome of the shot was good or bad.

Task Difficulty Evaluation.

Statement which expresses a relationship between (perceived) task demands and personal resources. E.g. This is really hard, or I can't do high shots.

Other

Game Situation

Participant indicates that he is imagining he is in a real game situation. E.g. If I was at the Molson Centre right now the bells and lights would be going off.

Transition

Statements that occur before a thought or after a thought that do not contain any content. E.g. umm, ah, ugh....

Help Seeking

Participant seeks the help of the experimenter regarding the task. E.g. How do I hold the stick?

Clarifying Statement

Participant asks a procedural question of the experimenter or responds to something the experimenter said.

Appendix F

Operational Definitions of Codes – Peg Solitaire

Codes for Educational Problem-Solving Task

Goals

Specific Goal

Statement indicating the specific goal the participant intends to achieve.

Short Term Goal

Intermediate goal indicating a specific peg or pegs that the participant hopes to eliminate in the near future. E.g. I want to get these three out.

Goal Achieved

Participant acknowldeges that a plan that was articulated worked and he was able to remove the piece or section in question. E.g. my plan worked, I got this guy out.

Knowledge

Declarative Knowledge

These statements include comments regarding the rules of the game, and the overall objectives. E.g. I am only allowed to jump a peg if there is an open peg on the other side.

Action Plans

New Game Plan

Participant indicates that he is going to use a different move to start the game than the previous game. E.g. I'm going to start a different way than last time.

Old Game Plan

Participant indicates that he is going to use the same move to start the game that was used in the previous game. E.g. I'm going to do the same move as last time to start.

Change of Plan

Participant indicates a move he wants to make and then revises his plan. E.g. I'm going to jump him, no wait, I'm going to go this way instead.

Self-Motivational Strategy.

Statement that implies that the participant is using a general motivational. E.g. Keep going, I know I can get it.

Incomplete Action Plan.

Participant begins to verbalize his or her action plan and doesn't finish the sentence or is very unclear about his or her intentions.

General Action Plan

Participant makes a very general statement. E.g. Jump like this, or take him.

Specific Action Plan.

Participant makes a specific statement. E.g. I'm going to jump over to the right.

Strategy

Participant verbalizes that he was using a particular strategy (must use the word strategy). E.g. My strategy is working.

Sectional Plan

(the peg solitaire board is divided into four sides and the middle). Participant indicates which section he is trying to eliminate. E.g. I'm going to try to get all the pegs out of this section on the left.

Planning Ahead

Participants specifically refers to the future moves he wants to make. E.g. I'm going to move here and here in order to get this one over here out.

Emotion

Positive Affect.

Statements reflecting various enjoyable mental states. E.g. I'm happy about that shot.

Negative Affect.

Statements reflecting various distressing mental states. E.g. I am so mad I keep missing.

Monitoring

Inadequate Monitoring

Participant makes a series of statements indicating that he is unable to identify further moves in the game, he may think the game is over but in reality it is not. E.g. I'm looking for a move, I can't see any moves, I think I am done, do I have any moves.

Foresight-Difficulty

The participant states that he is aware of potential problems in the future (predicting and error). E.g. That guy is going to be stuck over there, I can't get him because all my pegs are over here.

Off Task Attention Focus.

Statements that imply the participant is not paying attention to the task at hand. E.g. my cat ran away from home yesterday.

Game Momentum

Statement that implies the participant is aware of the flow of the game. E.g I'm on a roll now.

Relax

Participant indicates that he needs to relax and concentrate on the game. E.g. I just need to relax.

Awareness of Completion

Participant is able to determine that the game is over and there are no more moves (and is correct in this assessment). E.g. ...and I have no more moves.

Evaluation

Task Difficulty Evaluation

Statement which expresses a relationship between (perceived) task demands and personal resources. E.g. This is really hard.

Other

Transition

Statements that occur before a thought or after a thought that do not contain any content. E.g. umm, ah, ugh....

Help Seeking

Participant seeks the help of the experimenter regarding the task. E.g. Do I have any more moves?

Clarifying Statement

Participant asks a procedural question of the experimenter or responds to something the experimenter said.

Appendix G

Frequency of Codes – Hockey Shot

DCD Hockey Code Frequencies

Participants	Challenge	Chooses a new stick	coach or teacher	Preference of shot	switches hand orientation	Goal	Goal Change
1	2	0	0	0	0	29	0
2	0	0	0	0	0	27	0
3	0	0	1	0	0	20	2
4	0	0	0	0	0	23	1
5	0	0	0	0	0	22	0
6	0	0	0	0	0	26	1
7	0	0	0	0	0	22	0
8	0	0	0	0	2	29	0
9	0	0	0	0	0	17	0
10	0	0	0	0	0	26	2
totals	2	0	1	0	2	241	6

Non-DCD Hockey Code Frequencies

Participants	Challenge	Chooses a new stick	coach or teacher	Preference of shot	switches hand orientation	Goal	Goal Change
11	0	0	0	0	0	34	3
12	0	0	0	0	0	21	4
13	0	0	0	0	0	25	0
14	0	0	0	0	0	21	0
15	3	2	0	0	0	24	1
16	0	0	0	0	0	27	0
17	0	0	0	0	0	13	0
18	0	0	0	0	0	22	0
19	0	0	0	0	0	28	0
20	0	0	0	0	0	25	3
totals	3	2	0	0	0	240	11

DCD Hockey (

Participants	Goal Not Intended	Non-specific Goal	Higher Level Goals	Declarative Knowledge	causal relationship	Action Plan
1	4	0	1	2	0	1
2	1	0	0	0	0	0
3	2	0	0	7	0	0
4	6	3	0	7	0	0
5	0	2	0	1	0	0
6	2	0	0	2	0	0
7	2	1	0	2	0	0
8	2	1	0	0	0	1
9	1	4	1	2	0	2
10	0	1	0	0	0	0
totals	20	12	2	23	0	4

Non-DCD Hoc

Participants	Goal Not Intended	Non-specific Goal	Higher Level Goals	Declarative Knowledge	causal relationship	Action Plan
11	3	3	2	6	0	2
12	2	2	0	2	0	0
13	0	1	0	4	1	0
14	0	1	0	0	0	0
15	0	3	0	11	0	0
16	3	0	0	0	0	0
17	0	3	1	7	0	0
18	2	1	0	1	0	1
19	0	0	2	0	0	0
20	1	0	1	1	0	1
totals	11	14	6	32	1	4

DCD Hockey (

Participants	Incomplete Action Plan	General Action Plan	Specific Action Plan	type of shot	instrument	body part	Personal Learning Theories
1	2	4	11	5	3	0	2
2	2	0	13	0	0	33	0
3	5	16	24	10	4	12	7
4	1	10	18	10	0	37	2
5	0	0	0	0	0	0	0
6	0	0	2	18	0	0	0
7	1	1	5	0	0	1	1
8	0	4	2	1	0	0	4
9	1	3	2	2	1	0	0
10	0	0	23	0	2	11	0
totals	12	38	100	46	10	94	16

Non-DCD Hoc

Participants	Incomplete Action Plan	General Action Plan	Specific Action Plan	type of shot	instrument	body part	Personal Learning Theories
11	0	8	13	38	3	6	6
12	0	2	4	3	0	0	0
13	0	6	21	21	15	15	0
14	0	4	8	0	0	0	0
15	0	2	11	7	6	17	3
16	3	3	16	0	2	3	1
17	2	3	10	2	3	4	2
18	4	11	13	15	4	7	1
19	1	0	33	0	1	72	2
20	0	1	10	0	2	3	8
totals	10	40	139	86	36	127	23

DCD Hockey (

Participants	Positive Affect	Negative Affect	Attentional Control	Error Detection	Error Detected in the Outcome
1	12	2	0	0	13
2	1	30	1	3	4
3	13	13	0	8	3
4	7	25	0	2	13
5	6	12	0	5	1
6	5	7	0	14	3
7	2	11	0	5	3
8	13	20	0	5	6
9	2	14	0	2	5
10	7	26	0	8	2
totals	68	160	1	52	53

Non-DCD Hoc

Participants	Positive Affect	Negative Affect	Attentional Control	Error Detection	Error Detected in the Outcome
11	8	22	0	2	8
12	2	26	0	17	6
13	2	1	0	3	10
14	1	3	0	1	0
15	1	7	2	4	3
16	7	5	2	11	7
17	4	8	0	7	20
18	7	13	0	6	7
19	12	4	0	2	12
20	2	6	0	7	11
totals	46	95	4	60	84

DCD Hockey (

Participants	Error Detected in Movement Pattern	Error Correction Plan	Self-Motivational Strategy	Strategy Change Following an Error	Monitoring
1	8	2	3	0	1
2	3	2	3	0	1
3	3	5	9	0	0
4	8	3	6	0	2
5	0	0	0	0	0
6	1	1	1	0	0
7	3	4	0	0	2
8	2	0	0	0	3
9	3	0	4	0	3
10	0	1	4	0	1
totals	31	18	30	0	13

Non-DCD Hoc

Participants	Error Detected in Movement Pattern	Error Correction Plan	Self-Motivational Strategy	Strategy Change Following an Error	Monitoring
11	4	1	7	0	0
12	0	1	8	0	3
13	10	6	0	0	1
14	2	5	4	0	1
15	4	1	2	0	4
16	1	5	2	0	2
17	3	14	6	1	0
18	2	2	2	1	4
19	0	0	1	0	1
20	3	3	4	0	5
totals	29	38	36	2	21

DCD Hockey (

Participants	Task Relevant Attention Focus	Off Task Attention Focus	Goal Achieved	Evaluation	Evaluation of Strategy	Evaluation of shot
1	0	0	5	0	0	0
2	0	1	0	1	0	0
3	0	0	7	0	1	3
4	0	0	3	2	2	4
5	0	0	3	1	0	0
6	0	1	5	0	0	0
7	0	0	1	0	0	0
8	0	0	2	0	0	1
9	0	8	1	0	0	2
10	0	0	7	0	0	1
totals	0	10	34	4	3	11

Non-DCD Hoc

Participants	Task Relevant Attention Focus	Off Task Attention Focus	Goal Achieved	Evaluation	Evaluation of Strategy	Evaluation of shot
11	0	1	1	5	0	1
12	0	1	1	1	0	0
13	0	0	2	0	4	3
14	2	0	1	0	0	1
15	0	0	0	0	0	0
16	0	8	5	0	0	0
17	0	0	1	5	0	3
18	1	1	2	0	0	1
19	0	0	12	0	0	1
20	0	0	2	0	0	3
totals	3	11	27	11	4	13

DCD Hockey (

Participants	Task Difficulty Evaluation	Awareness of Completion	Game Situation	Hockey Experience	Transition	Clarifying Statement
1	1	0	1	0	3	0
2	7	0	0	1	4	3
3	3	1	10	0	4	0
4	3	0	2	2	1	0
5	0	0	0	0	1	3
6	2	0	0	0	1	11
7	3	0	0	0	2	1
8	2	0	1	1	10	0
9	0	0	0	1	8	5
10	0	0	0	0	1	0
totals	21	1	14	5	35	23

Non-DCD Hoc

Participants	Task Difficulty Evaluation	Awareness of Completion	Game Situation	Hockey Experience	Transition	Clarifying Statement
11	1	0	2	0	3	7
12	3	0	0	0	2	3
13	3	0	0	0	3	3
14	1	0	0	0	2	4
15	2	1	0	0	3	5
16	3	0	0	0	3	5
17	7	0	0	1	7	0
18	2	1	0	0	3	4
19	1	0	0	1	5	0
20	1	0	0	0	6	4
totals	24	2	2	2	37	35

DCD Hockey (

Participants	Outcome Statement	totals
1	0	119
2	0	143
3	2	196
4	0	204
5	0	59
6	0	103
7	1	74
8	2	115
9	0	97
10	0	123
totals	5	1233

Non-DCD Hoc

Participants	Outcome Statement	totals
11	0	201
12	1	115
13	0	160
14	0	63
15	0	131
16	0	126
17	0	137
18	1	144
19	0	193
20	0	115
totals	2	1385

Appendix H

Frequency of Codes – Peg Solitaire

DCD Peg Solitaire Code Frequencies

Participants	Goals	short term goal	Goal Achieved	Declarative Knowledge	New game	old game p	Self-Motivational Strategy
1	0	3	0	0	1	1	0
2	1	0	0	0	0	1	0
3	0	1	0	0	0	0	0
4	1	6	0	0	0	1	0
5	0	0	0	1	0	0	0
6	0	0	0	0	2	0	0
7	0	0	0	0	1	0	0
8	0	7	0	1	1	0	1
9	0	1	0	0	0	0	0
10	1	4	0	1	0	0	0
totals	3	22	0	3	5	3	1

Non-DCD Peg Solitaire Code Frequencies

Participants	Goals	short term goal	Goal Achieved	Declarative Knowledge	New game	old game p	Self-Motivational Strategy
11	0	4	3	0	1	0	1
12	1	0	0	3	1	0	0
13	0	0	0	0	0	2	0
14	2	3	0	0	0	0	0
15	0	1	0	0	1	0	0
16	0	2	0	0	0	0	3
17	1	3	0	0	0	0	0
18	0	1	0	0	0	1	1
19	0	1	1	0	1	1	3
20	1	1	0	0	0	0	0
totals	5	16	4	3	4	4	8

DCD Peg Solitaire C

Participants	Personal Learning Theories	change of plan	Incomplete Action Plan	General Action Plan	Specific Action Plan	strategy
1	3	1	1	11	21	0
2	0	2	2	11	2	0
3	0	0	0	26	3	0
4	0	0	3	37	9	0
5	0	1	1	37	0	0
6	0	3	1	13	0	0
7	0	0	0	37	2	0
8	0	4	4	32	4	0
9	0	2	0	44	6	0
10	0	0	0	36	9	1
totals	3	13	12	284	56	1

Non-DCD Peg Solita

Participants	Personal Learning Theories	change of plan	Incomplete Action Plan	General Action Plan	Specific Action Plan	strategy
11	0	1	6	32	10	2
12	0	0	4	28	3	1
13	0	0	1	11	6	2
14	0	0	1	22	3	0
15	0	1	0	17	4	0
16	1	1	0	6	15	0
17	0	0	0	53	2	0
18	0	0	0	19	2	0
19	0	0	2	22	0	1
20	0	0	0	52	2	0
totals	1	3	14	262	47	6

DCD Peg Solitaire C

Participants	Sectional Plan	Planning ahead	Positive Affect	Negative Affect	Monitoring	Monitoring-inadequate	Off Task Attention Focus
1	1	3	0	2	13	0	0
2	0	0	0	1	3	0	0
3	0	0	0	0	2	4	0
4	11	6	0	0	11	0	0
5	0	0	0	0	1	4	0
6	0	0	5	2	8	2	1
7	4	2	1	1	8	0	0
8	3	5	11	8	28	2	0
9	0	2	1	3	8	0	0
10	11	0	6	1	19	0	0
totals	30	18	24	18	101	12	1

Non-DCD Peg Solita

Participants	Sectional Plan	Planning ahead	Positive Affect	Negative Affect	Monitoring	Monitoring-inadequate	Off Task Attention Focus
11	7	8	2	2	4	0	0
12	5	7	0	0	12	0	0
13	5	8	7	1	13	2	0
14	0	5	9	4	12	1	0
15	1	10	0	1	11	1	0
16	1	4	0	0	10	0	0
17	2	1	0	0	3	0	0
18	0	6	1	3	9	0	0
19	0	0	6	2	1	0	1
20	7	0	3	0	11	4	0
totals	28	49	28	13	86	8	1

DCD Peg Solitaire C

Participants	foresight-difficulty	game momentum	Awareness of Completion	relax	Evaluation	Task Difficulty Evaluation	Transition
1	1	0	3	0	1	7	2
2	0	0	0	0	0	0	3
3	0	1	1	0	1	0	3
4	1	0	1	0	1	0	10
5	0	0	0	0	0	0	3
6	1	0	1	0	5	3	10
7	0	0	0	0	4	0	9
8	1	0	1	0	14	2	9
9	1	0	2	0	3	0	2
10	0	0	3	0	7	1	1
totals	5	1	12	0	36	13	52

Non-DCD Peg Solita

Participants	foresight-difficulty	game momentum	Awareness of Completion	relax	Evaluation	Task Difficulty Evaluation	Transition
11	0	0	0	0	5	1	0
12	0	0	1	0	0	0	6
13	0	0	2	0	8	1	2
14	0	0	1	0	15	1	1
15	0	0	0	0	1	1	3
16	0	1	1	1	2	2	4
17	2	0	0	0	5	0	4
18	8	0	0	0	0	2	0
19	2	0	1	0	4	1	0
20	0	0	3	0	4	0	9
totals	12	1	9	1	44	9	29

DCD Peg Solitaire C

Participants	Help Seeking	Clarifying Statement	totals
1	0	0	75
2	0	0	26
3	0	0	42
4	0	0	98
5	0	0	48
6	1	0	58
7	1	0	70
8	0	0	138
9	0	0	75
10	0	0	101
totals	2	0	731

Non-DCD Peg Solita

Participants	Help Seeking	Clarifying Statement	totals
11	0	0	89
12	0	0	72
13	1	2	74
14	0	1	81
15	0	0	53
16	0	0	54
17	0	0	76
18	0	0	53
19	0	0	50
20	1	1	99
totals	2	4	701

Appendix I

Performance Scores on Hockey Shots

Goals Achievedon Each hole by DCD and non-DCD Groups

Participants	Holes					
	1	2	3	4	5	Total
DCD						
1	0	0	2	1	0	5
2	0	0	3	3	0	9
3	0	0	1	0	0	6
4	0	0	0	0	0	2
5	0	0	0	3	0	7
6	0	0	5	1	0	6
7	0	0	4	1	0	7
8	0	0	4	3	0	13
9	0	0	4	2	0	6
10	0	0	2	2	1	10

	Holes					
Non-DCD	1	2	3	4	5	Total
11	0	0	3	2	0	10
12	0	0	2	2	0	
13	0	0	3	0	0	10
14	0	0	1	0	1	10
15	0	0	5	4	0	5
16	0	0	2	1	0	10
17	0	0	9	4	0	14
18	0	0	2	3	0	6
19	0	0	3	4	0	7
20	0	0	3	4	0	6

Appendix J

Performance Scores on Peg Solitaire Games

DCD Performance Scores on Peg Solitaire Task			
Participants	Game #1	Game #2	
1	6	6	
2	6	24	
3	24	7	
4	8	2	
5	7	24	
6	8	24	
7	4	7	
8	8	6	
9	2	3	
10	6	8	
Non-DCD Performance Scores on Peg Solitaire Task			
Participants	Game #1	Game #2	
11	8	4	
12	7	7	
13	7	8	
14	7	7	
15	8	9	
16	8	6	
17	5	4	
18	6	6	
19	6	4	
20	7	8	