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Neuromotor task training

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Chapter I
Introduction

Despite normal intelligence, about 5 to 10% of school-aged children have difficulty adequately performing movement tasks that are part of their daily routine. Because of their motor difficulties, they might not get asked to play by peers, or they might withdraw from leisure activities because they feel they lack sufficient skills to enjoy participating. General practitioners, when consulted by parents about a child's poor motor performance, may refer the children to a paediatric physiotherapist (PPT). PPTs can draw on an array of treatment approaches. Evidence for the effectiveness of these approaches for children who perform movement tasks poorly, however, is scarce. The aim of this thesis is to evaluate a new physiotherapeutic treatment programme called 'Neuromotor Task Training' (NTT). NTT was developed especially for children with poor motor performance in daily activities.

Developmental Coordination Disorder

Over the years many labels have been used to describe children with motor difficulties, e.g. abnormal clumsy children (Orton, 1937), physically awkward children (Wall et al., 1990), children with coordination problems and difficulties (Sugden & Henderson, 1994), children with specific developmental disorder of motor dysfunction (World Health Organisation, 1992). The term which is fast becoming internationally accepted is developmental coordination disorder (DCD). DCD was first introduced in 1987 in the 'Diagnostic and Statistical Manual for Mental Disorders' (APA; DSM-III; 1987). The label DCD can be applied when four criteria are met (Table 1):

Table 1. Diagnostic Criteria for Developmental Coordination Disorder (APA: Diagnostic and Statistical Manual of Mental Disorders-IV-TR; 2000; page 58).

Criterion	Description
A	Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones (eg, walking, crawling, sitting), dropping things, "clumsiness", poor performance in sports, or poor handwriting.
B	The disturbance in criterion A significantly interferes with academic achievement or activities of daily living.
C	The disturbance is not due to a general medical condition (e.g., cerebral palsy or muscular dystrophy) and does not meet the criteria for a Pervasive Developmental Disorder.
D	If Mental Retardation is present, the motor difficulties are in excess of those usually associated with it.

Nature and aetiology of the disorder

The DSM-IV criteria are not so specific that all children who meet the criteria make up a homogeneous group. Children with DCD differ in the motor skills they experience difficulties with. Frequently reported skills that are hard to master are writing and drawing, dressing (incl. buttoning, tying shoe laces), locomotion (walking, climbing or descending stairs, hopping, running, jumping), handling tools (such as scissors, cutlery, hammer, garden tools), speech (irregularities, stammer), constructional play, ball skills, and outdoor play and sports (skipping rope, swinging, roller skating, swimming, climbing, etc.) (Geuze, 2007). There may be several reasons why a child succeeds or fails. Research into the underlying processes has shown a wide range of deficits associated with DCD (e.g.: proprioceptive, kinaesthetic, visual perception of object size and object orientation, motor planning, motor programming, execution of movements, timing, force control, internal modelling, ability to disengage attention, interhemispheric transfer). In a meta-analysis, Wilson and McKenzie (1998) found that visual spatial processing is the main deficit associated with DCD. However, also in dysfunction of underlying processes a lot of variance exists between children with DCD. Some subgroups of children with DCD have been described, but what subgroups are found depends heavily on how children were selected, and the test items and statistical methods used by researchers (Macnab et al., 2001). In addition, children with DCD not only differ in the motor skills they experience problems with, or the underlying processes that are causing the deficit, but also in the extent to which they suffer from (different) co-morbidities or co-occurring problems such as attention deficit and hyperactivity disorder (ADHD). It is thus important to realize that the aetiology of the motor coordination difficulties might differ for each individual child. Because the group of children with DCD referred to receive treatment will be very heterogeneous, therapy can not follow a fixed recipe.

Long-term consequences

In contrast with what lay people, school teachers and healthcare professionals often believe, at least 50-75% of children with DCD do not outgrow their problems (Cantell, Smyth & Ahonen, 1994; Christiansen, 2000; Geuze & Borger, 1993; Hellgren, Jilbergt, Gillberg, & Enerskog, 1993; Losse, et al., 1991). Actual figures are assumed to be higher, but can not be proven due to lack of motor tests suitable for use with adolescents. Lack of practice, due to not participating in physical activities, may inhibit further motor development, possibly aggravating existing performance differences between a child with DCD and its peers. The poor performance of a child often invites ridicule by their peers. In the long term, suffering from DCD can lead to difficulties in other behavioural domains such as self concept, social skills, and academic success. Children with DCD might for example not fulfil their cognitive potential (Losse et al., 1991). In children with both motor (DCD) and attention problems (ADHD) a higher incidence of

depression has been found; 13% versus 7% in typically developing children (Gillberg & Gillberg, 1989). In addition, as children with DCD often withdraw or are being shut out from sport settings or playgrounds, their fitness becomes less (Peters et al., 2004), which raises their chance of clustered cardiovascular risk (Andersen et al., 2006). A vulnerability for other possible diseases as osteoporosis, obesity, type 2 diabetes mellitus, mental health problems has been described as well (Petersen et al., 2004). Given the impact poor motor performance can have in childhood and later, when children grow up, it is important for children with mild motor problems to be identified and treated.

Effectiveness of Treatment programmes

The available treatment methods for children with DCD can roughly be divided into process-oriented and task-oriented approaches. Process-oriented are those treatment methods that aim at the underlying process or processes which the child has not developed adequately for his/her age and which are thought necessary for the successful performance and acquisition of motor skills. In these approaches, a task is broken down into subcomponents that are trained separately. By addressing the underlying processes, transfer to many tasks in which the trained processes are necessary is expected which would be an advantage. It is, however, very difficult to derive the true underlying processes, and to design activities that address these processes. Examples of these methods are the widely used sensory integration therapy (Ayres, 1972) and kinaesthetic training (Laszlo et al., 1988). Mandich et al. (2001) reviewed the literature and concluded that although process-oriented (bottom-up) approaches have a long tradition, these approaches have not shown to be reliably better than no treatment at all. In a meta-analysis of 13 intervention studies, Pless and Carlsson (2000) also found little support for process-oriented treatment effectiveness.

More recently, task-oriented approaches have been developed in which specific skills are taught. Examples are: a task-specific intervention programme developed by Revie and Larkin (1993), the 'cognitive orientation to daily occupational performance (CO-OP)' programme developed in Canada (Martini et al., 1995, Polatajko et al., 2001), and 'Neuromotor Task Training' (NTT) in the Netherlands. For task-oriented (or top-down) approaches the evidence is accumulating (Pless & Carlsson, 2000; Mandich et al., 2001).

Neuromotor Task Training

NTT was developed because the effectiveness of available intervention programmes was disappointing. In traditional treatment sessions, Dutch physiotherapists often apply what they have learned on various courses in an eclectic fashion. In stead of practising functional skills, traditional treatment programmes focus on prerequisites which are believed mandatory for adequate task performance. These programmes provided to

children with DCD do not comply with current insights. In literature, research concerning motor learning has concentrated on three distinct subjects: a) how to instruct people, b) how to practice skills, and c) how to provide feedback. In addition, one notices three consistent findings which are important in relation to training motor skills in children with a coordination disorder: the low level of transfer from one acquired motor skill to the next, the large contextuality of the acquired motor functions, and the 'time on task principle'. The newly developed NTT treatment programme incorporates recent scientific knowledge on the variables affecting motor control and motor learning in order to enhance motor learning in general, in particular as regards the transfer of skills to activities of daily living. In this introduction, the important variables will be mentioned. For a more detailed description of NTT, we refer to Schoemaker and Smits-Engelsman (2005).

NTT is a tailor-made, child-centred, and mainly task-oriented treatment programme. It focuses strictly on teaching those skills that a child needs in daily life. A physiotherapist treating according to NTT teaches those motor tasks with which a child experiences problems. A child will not be practising a wide range of assumed conditions that do not form part of that specific skill. Not the selective improvement of mobility or muscle strength is regarded as proper therapeutic goal for improving motor functions; it is creating interactions between the child and its environment that will result in acquiring new or improved motor functions. The ultimate goal of NTT is the ability of a child to transfer the skill acquired in the treatment situation to his or her daily life situation. The higher the resemblance between the treatment situation and the circumstances in which the skills are needed in daily life, the more successful the transfer of skills practised to daily life will be.

Therapists start by assessing the strengths and weaknesses of a child's functional motor performance. They select the tasks that will be trained. These tasks will be different for each child, depending on its individual needs as well as the expectations, capabilities, and motivation of both the child and its parents/carers. The therapist will determine the entrance level of training of a skill by loading various aspects of the task performance. For example, in goal-directed movements, speed or accuracy in relation to distance and target size can be examined. During the assessment, therapists analyze which processes are involved in deficient motor skill performance. For instance, a child may fail to learn a specific motor skill due to lack of motivation, fear of failure, attention problems, or lack of understanding how to execute a particular skill. However, successful performance might also be hampered by motor control processes such as action planning (making wrong choices under changing stimulus/response conditions), movement planning (inability to perform the skill as complexity increases or sequences become longer), motor programming (poor timing of movement patterns and sequences), parameter setting (executing an activity but not with the required speed

and force; non optimal use of biomechanical characteristics), or initiating force (fine-tuning of the force recruitment is coarse).

During NTT, functional training exercises are designed in such a way that the therapists can continue to analyse which motor control processes are deficient within the task to be trained. For example, if ball catching improves in a secure and supportive surrounding, task training will aim at more psychological processes. If however a child can catch the ball only when standing still or warned beforehand, gradually ball catching in more complex or more attention demanding situations will by trained. If the child hasn't developed a throwing pattern yet, the opportunity of merely throwing a variety of objects (that vary in size, weight, material) will be given. Later, a demand on parameter setting will be introduced by propelling the object over various distances or by aiming the objects at targets of different sizes. Through this approach, functional skills are trained in such a way that they tap the processes that are thought to be involved in the child's motor problems.

Special attention is paid to how therapists teach the children. Explicit motor learning in general and transfer in particular can be enhanced by applying effective motor teaching principles. What principles are used depends on the child's learning stage. When children try to acquire new motor skills, they go through distinct stages. Fitts and Posner (1967) described a three-stage model which is still one of the most influential models for motor acquisition (Magill, 2001). For each skill to be learned, therapists trained in NTT guide children with DCD through these three stages. In the first stage, the beginning level, children are engaged in cognitive activities to detect what movement co-ordination pattern will be required to achieve the goal of the skill. They need to solve problems such as 'what is the goal of this task'; 'which limbs do I need to achieve this goal?'; and 'in what position do I need to hold my limbs?'. In this phase, therapists might demonstrate the task, provide time for (guided) self-discovery, compare the task with familiar tasks, or provide immediate, precise and positive knowledge of performance. In this phase, constant practice is required, as the goal of treatment in this phase is to acquire a basic co-ordination pattern. During the second stage, the intermediate level of motor learning, variability of practise within the same skill is introduced. Children learn to master the basic co-ordination pattern of the skill and refine their performance. They still make errors in this stage, but their errors are fewer and less variable. Changes in task demands (speed, accuracy, weight, material) provide the child the opportunity to vary task performance. In this way, task performance may be refined and adapted to the specific demands of several task situations. It is hypothesised that variability of practice will enhance transfer of learning during treatment to daily life motor skill performance (Magill, 2001). In this stage, therapists can provide ample opportunity to practice, a supportive non-threatening environment, short practice sessions with frequent breaks, and constructive feedback. Only after much practice, children will reach the third stage of skill learning, the

advanced level. In this stage, children are able to perform a skill almost automatically, thus without much conscious attention. Therapists can promote enthusiasm, provide encouragement and motivation, provide feedback on specific aspects, use many different relevant contexts of increased difficulty (as close as possible to real life situations), increase complexity by combining tasks (sequentially and temporally), and suggest alternative strategies. A common idea of the relationship between contextuality and transfer to novel contexts is that the more variants of a specific task are met in training, the greater the likelihood that any future variant will be one previously met (Magill, 2001).

Although NTT is a task-oriented approach, the theoretical framework behind it differs from other recently developed task-oriented approaches, such as CO-OP (Polatajko et al., 2001). In CO-OP, DCD is considered to be a motor learning disorder and cognitive strategies are taught to enhance motor learning. This is in contrast with NTT, which is based upon a cognitive neuroscience approach to motor control. Although cognition plays a role in NTT treatment, for instance when therapists ask various questions about task performance and problem solving, cognitive strategies are not explicitly taught but motor tasks are trained in various, gradually more challenging, circumstances. During NTT, the therapists tap the motor control processes that are assumed to be deficient while training functional skills. NTT focuses on learning a task within a variety of contexts. In the example of ball throwing, the distance, the angle, the target size or even the weight of the ball may be varied. In this way, the parameterization process is trained. NTT might, therefore, appear as a mere process-oriented approach, but (goal-directed) ball throwing is practised within a task specific training paradigm.

This new Dutch treatment approach has become part of the curriculum for paediatric physiotherapists at Avans+, university for professionals.

Aims and outline of this thesis

The main objective of this thesis was to evaluate 'Neuromotor Task Training (NTT)', a new physiotherapeutic programme developed especially for children with developmental coordination disorder. Because NTT is task-oriented and pays special attention to the question of how children are taught motor skills, we also wanted to gain an understanding of the assumed intervening mechanisms of NTT. To evaluate NTT, we conducted two studies: (1) a controlled trial in which two groups of children with DCD participated (chapter 2-5), and (2) a trial in which children participated who were diagnosed as having DCD based on poor grapho-motor ability (chapter 6).

For the controlled trial, two groups of children with DCD were recruited. In both groups, all children experienced motor problems in school and/or at home. These groups were not randomly selected but existing groups, which made them vulnerable for initial differences. Because these differences might be relevant for the extent to

which the groups develop spontaneously or due to treatment, in chapter 2, we compare the motor and behavioural characteristics of the groups. In chapter 3, we present the controlled trial. In this chapter, we investigated whether 9 'weekly' 30-minute sessions of NTT were effective for children suffering from DCD. In addition, because NTT is a task-oriented approach and effects of therapy are often small in terms of total scores on general movement tests, we investigated whether children improved particularly on tasks comparable to those trained. Furthermore, we explored whether behavioural characteristics of the children, such as attention problems, interacted with the extent to which their treatment was successful. In the courses on NTT, therapists were taught about motor learning theories, and the best ways to improve motor learning. In chapter 4, we describe the development of a taxonomy of the verbal actions of physiotherapists that aimed at enhancing motor learning. With the motor teaching principles taxonomy (MTPT), we investigate whether therapists were treating the children according to the NTT guidelines with regard to motor learning. As the physiotherapists' verbal actions were intended to improve motor learning, we examined the associations between the teaching principles used and the success of treatment after 9 and 18 treatment sessions (chapter 5).

In chapter 6, we present a study evaluating the effectiveness of NTT in children with poor grapho-motor ability. In the first study (chapter 2 to 5), we used mainly general motor tests to select children or to evaluate NTT. But one of the most common reasons for remediation is problems with handwriting. Handwriting is a very complex fine motor skill, and children with poor grapho-motor ability might thus form a specific subgroup of children with DCD. The DSM-IV explicitly mentions handwriting as an example of the daily motor activities which pose difficulties for children with DCD (Table 1, APA, criterion A). Therefore, in chapter 6, we describe a study in which we selected children with DCD on the basis of poor grapho-motor ability. To evaluate NTT, we used one of the manual dexterity test items (the flower trail drawing item) of an often used general motor test (the Movement Assessment Battery for Children, M-ABC; Henderson & Sugden, 1992). Besides changes in the outcome on the flower-trail item, we wanted to gain insight into changes in the underlying drawing process brought about by NTT. For this reason, the children performed the flower-trail item on an XY-digitizer.

Finally, in chapter 7, we present and discuss the main findings of the studies conducted and described in this thesis. General conclusions are presented and recommendations for further research are suggested.

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