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Double trouble? Movement behaviour and psychiatric conditions in children: An opportunity for treatment and development

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ABSTRACT

Children with neurodevelopmental disorders often show problems in movement behaviour. Clinical motor features such as clumsiness, odd postures, hyperactivity and tics occur frequently in children with psychiatric conditions. Most dance/movement therapists recognize these, and consequently tailor treatment to the abilities of their clients. In view of treatment strategies, it is important to know which motor features are associated with which psychiatric conditions, and how movement problems be influenced by movement interventions. Therefore, this article focuses on clinical movement features, gross motor problems, neurodevelopmental aspects and movement interventions for children with emotional, behavioural and autism spectrum disorders.

Movement behaviour in psychology and psychiatry

As psychology grew out of philosophy, the Platonic undervaluation of the body compared to the mind and the Cartesian body–mind dualism in Western philosophy contributed to the idea that psychology should be concerned first and foremost with mental phenomena. Consequently, movement and motor control have been and continue to be neglected by mainstream psychology, even up till now (Rosenbaum, 2005). Recently, however, psychologists have started to acknowledge the relevance of the fact that people interact with the environment through movement and that they learn about themselves and their world by moving in it. In the words of Rosenbaum (2005, p. 313): 'motor control [. . .] lies at the heart of the science of mental life and behaviour because it joins the two' (Rosenbaum, 2005, p. 313).

Like in general psychology, the same undervaluing of movement behaviour has been noticeable in general psychiatry. Psychomotor abnormalities are predominantly viewed as mere epiphenomena, and even when they are deemed of clinical significance, little information is provided on this topic in psychiatric textbooks. Motor abnormalities do receive attention in psychiatry as far as they concern side-effects of pharmacotherapy. According to Gillberg and Kadesjö (2003), few psychiatrists are aware of the specific motor problems that are often comorbid with psychiatric disorders. Exceptions to this general picture include motor retardation as a feature of major depressive disorders (see Sobin & Sackeim, 1997) and as a negative symptom in schizophrenia (Röhricht & Priebe, 2006).

Movement behaviour in developmental perspective

Interestingly, in developmental psychology and child psychiatry movement behaviour has since long been a focus of attention. It is Darwin who seems to have set the stage in this respect. After having demonstrated, in his famous "The expression of emotions in man and animals" (1872), the intrinsic relations between emotion and bodily movements, he offered a detailed description of movements and motor responses to various conditions of stimulation, based on his day-to-day notebook of his oldest child (Darwin, 1877). One of the most famous researchers in developmental psychology who went beyond the body–mind dualism was Piaget (1952). He claimed that in the sensorimotor stage of development children gain knowledge of their surroundings through physical exploration. That is, mental development is dependent on perception and movement, and cannot be understood as an isolated, internal phenomenon. Along similar lines, it has been argued that motor performance is essential for children as they actively explore their world, thereby developing themselves and their skills in a continuous interactive process, in which each new skill opens new opportunities for a child to engage in new activities and interactions (Bernstein, 1967; Gibson, 1988; Thelen, 2000).

Moreover, psychologists started to recognize that motor performance is not only important during the first years of development, but that its impact continues well into the school age period. During

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this period children engage in new activities, increase their action radius and broaden their horizon beyond the primary family environment. Especially gross motor skills, such as running, jumping, catching and throwing balls become important, as they are essential for participating in games and plays with peers (Wall, 2004). Unsurprisingly, children with impaired gross motor skills are now known to be at risk for a range of physical, psychosocial and psychiatric problems such as poor self-concept, lack of social support, and anxiety (Dewey, Kaplan, Crawford, & Wilson, 2002; Piek, Baynam, & Barrett, 2006; Skinner & Piek, 2001; Smyth & Anderson, 2000; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006).

In child psychiatry, movement behaviours have received due attention as potentially relevant clinical features. Rutter, Taylor, and Hersov (2004) pointed to several significant motor abnormalities, i.e. restlessness, fluttering, fidgeting, hyperactivity, walking on tiptoes, motor excitement, motor slowness, motor stereotypes, tics, mannerisms, head banging, self-biting, catatonic states, and medication-induced movement disorders, such as tremors and tardive dyskinesia. Particularly for autism spectrum disorders (ASD) psychomotor features, such as ill-coordinated movements and odd postures, have since long been a focus of clinical interest. For instance, the importance of clumsiness as a clinical feature has been a matter of debate since the first description of Asperger syndrome in 1944 (Ghaziuddin, Tsai, & Ghaziuddin, 1992; Ozonoff et al., 2008; Wing, 1981). Clumsiness may occur in a variety of other child psychiatric conditions, such as in attention deficit/hyperactivity disorder (ADHD) and in anxiety disorders (see for instance Erez, Gordon, Sever, Sadeh, & Mintz, 2004; Fliers et al., 2009), and gross motor impairments in children have been suggested to be phenotypic indicators for future schizophrenic disorders (Erlenmeyer-Kimling et al., 2000). Furthermore, in view of the growing awareness that child psychiatric disorders often co-exist and symptoms are shared across disorders, Gillberg (2010) stated that the investigation of motor abnormalities should be an integral part of the (neuropsychological) clinical examination of all young children who are presented with behavioural or emotional problems in clinical settings.

At present, neurodevelopmental perspectives dominate in child psychiatry. Child psychiatric symptoms and disorders are largely explained by abnormalities in brain functioning, either globally, i.e. there are impairments in the functioning of the brain as a whole, or locally, i.e. a particular brain region is not functioning optimally. As these neurobiological impairments occur in childhood when the brain is still developing and connections between brain regions are still evolving, the outcome on a behavioural level is unsure. As stated by Denckla (2003), "the brain is an organ that is sculpted at every level by experiences, including education" (p. 387). As a consequence, neurodevelopmental perspectives on child psychiatry incorporate motor functioning as a relevant diagnostic domain.

Clinical movement observation

During the mid-20th century, movement- and body-oriented therapies came to the fore. Several forms of such therapies were introduced, all sharing the basic idea that movement, physical exercise and bodily experiences might be employed as therapeutic means to alleviate psychological and psychiatric problems. These approaches stem from different traditions. For instance, in the USA and the UK the development of movement therapy rooted in modern dance as a performing art and the first movement therapists were often dancers themselves (Röhricht, 2009; van Wieringen, 1997). Today the Kestenberg Movement Profile (KMP), which is strongly influenced by Laban's notions, is frequently used to obtain diagnostic information for clinical populations (Cruz & Berrol, 2004; Loman & Merman, 1996; Payne, 2006).

In contrast to the USA and the UK, movement observation in continental Western-European psychiatry grew out of physical education, as teachers were assigned to activate psychiatric patients by means of offering games, gymnastics, dance, and sports (Probst & Bosscher, 2001). In Germany, Ernst Kiphard, a sports teacher and originator of the 'Psychomotorische Übungsbehandlung', introduced the 'Trampolin-Körperkoordinations-Test' and later the 'Hamm-Marburger Körperkoordinationstest' for clinical purposes in child psychiatry (Kiphard & Schilling, 1970). In the Netherlands and Flanders, the first attempts to systematically investigate movement characteristics of psychiatric patients arose during the 50s and 60s (van Roozendaal, 1957, 1973). Based on phenomenological traditions, particularly on the work of Merleau-Ponty (1945) and Buytendijk (1948, 1963), van Roozendaal developed a method of systematic movement observation in clinical psychiatry. Later, Simons built on the work of van Roozendaal to develop the Louvain Observation Scales for Psychomotor Therapy, which were widely used in psychiatric practice in Belgium (Simons, Van Coppenolle, Pierloot, & Wauters, 1989).

Thus, although clinical movement observation of psychiatric patients is rooted in different traditions, throughout the Western world movement behaviour is accepted by therapists as a clinically significant feature. Yet, it seems that scientifically valid knowledge about which movement features are associated with which psychiatric conditions, and, to what extend movement problems can be influenced by interventions, is still scarce. Given the importance of movement behaviour in developmental perspective, this article focuses on children. Therefore, the movement characteristics of three groups of children with psychiatric disorders will be discussed next.

Movement characteristics of children with psychiatric disorders

In line with epidemiological psychiatric research and clinical care programmes three broadly defined categories of psychiatric disorders in children can be are distinguished: emotional disorders, behavioural disorders, and autism spectrum disorders (Egger & Angold, 2006). Not only are these disorders likely to have distinct neurological and neurobiological substrates, they also typically demand different treatment strategies, tailored of course to individual characteristics and symptoms (Emck, Bosscher, Beek, & Doreleijers, 2009).

Children with *emotional disorders* are characterized primarily by symptoms of depression and anxiety. On a syndrome level, Achenbach (1991) refers to these as internalizing problems. Although in DSM-IV anxiety disorders and mood disorders are defined separately, they are here grouped because of the high level of comorbidity of these disorders and the strong heterotypic continuity of depression and anxiety (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003).

The clinical features of mood and anxiety disorders include several body- and movement-related aspects. Anxiety disorders in children are associated with psychophysiological symptoms, such as shortness of breath and high muscle tension, which directly affect the child's movement behaviour. Children with anxiety disorders engage less often in physical activity, and their play behaviour is characterized by withdrawal and diminished enjoyment (APA, 1994; Kirkcaldy, Shephard, & Siefen, 2002; Klein, 1994; Sadock & Sadock, 2003). Trauma-related anxiety is associated with problematic body experiences, such as pain and feelings of discomfort, that contribute to a negative body image and problems with moving and playing (Lamers-Winkelman, 1997; Sadock & Sadock, 2003). Depression in children is associated with somatic complaints such as abdominal pains, fatigue, reduced ability to experience pleasure,

decreased general activity and psychomotor agitation or retardation (APA, 1994). Moreover, when interacting with other people depressive children express themselves predominantly through nonverbal communication (Harrington, 1994). In children younger than school age, features such as psychomotor retardation and lack of brightening in response to joyful events are related to the melancholic subtype of depression (Luby, Mrakotsky, Heffelfinger, Brown, & Spitznagel, 2004).

In contrast, children with *behavioural disorders* are characterized primarily by problems interacting with others, also described as externalizing problems (Achenbach, 1991). Here, the DSM-IV classifications ADHD, oppositional defiant disorder, and conduct disorders are grouped, also in view of the frequent co-occurrence of these disorders.

The DSM-IV criteria for ADHD include several items that are related to motor characteristics, including fidgeting, running about or excessive climbing (possibly linked to subjective feelings of restlessness), difficulties in playing, and acting as if 'driven by a motor' (APA, 1994). Age-inappropriate features such as hyperactivity and excessive impulsivity are hallmarks of the movement behaviour of children with ADHD. Furthermore, children with ADHD exhibit problems in lateralization and are often left-handed (Reid & Norvilitis, 2000). General coordination difficulties and soft neurological signs are frequently reported (Blondis, 1999; Denckla, 2003; Sadock & Sadock, 2003). Finally, about 50% of children with ADHD have comorbid Developmental Coordination Disorder (DCD) (Gillberg et al., 2004; Gillberg & Kadesjö, 2003; Rasmussen & Gillberg, 2000). Fine motor skills such as writing and tying shoelaces are typically the most problematic skills in the latter group (Pitcher, Piek, & Hay, 2003; Whitmont & Clark, 1996). Aendekerk and Verheij (1997) suggested that tension, restlessness, psychomotor agitation, and disturbed development of body awareness are often present in children with behavioural disorders. Furthermore, behavioural disorders and emotional disorders are usually intertwined, especially in young children, and it is an issue of debate whether these mixed disorders are characterized by psychomotor agitation (Baker, 1998; Denckla, 2003; Kashani, Heinfichs, Reid, & Huff, 1982; Marmorstein, 2007).

Children with *autism spectrum disorders* do not uniquely fall in either of the previous categories, as they often show a mixture of both emotional and behavioural problems, with deficits in communication and social development and restricted and repetitive behaviours as core features (APA, 1994). Therefore, this type of disorder counts as a third, separate category.

The movement behaviour of children with ASD is characterized by stereotyped and repetitive motor mannerisms and impairments of facial expression, body postures, and gestures (APA, 1994; Page & Boucher, 1998). Children with autism, a subgroup of children with ASD, exhibit marked obsessive slowing, an increase in posturing, or stereotyped and reduced movement as a forerunner of catatonia (Ghaziuddin, Quinlan, & Ghaziuddin, 2005). Further, children with ASD are often characterized as clumsy and as having problems in motor coordination (Berkeley, Zittel, Pitney, & Nichols, 2001; Ghaziuddin & Butler, 1998; Piek & Dyck, 2004). As many of these children also have learning difficulties, the interpretation of their deficient motor behaviour is complicated. Yet, clumsiness and poor gross motor performance are also mentioned as features of children with Asperger syndrome (Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994; Ghaziuddin et al., 1992; Manjiviona & Prior, 1995). Hyperactivity is another frequently associated feature; high co-occurrence rates for ADHD are reported: 67.9% for ASD and even 85% for Asperger syndrome (Ghaziuddin, Weidmer-Mikhail, & Ghaziuddin, 1998; Taylor, 1994; Yoshida & Uchiyama, 2004).

Altogether, it is clear that children with emotional, behavioural, and autism spectrum disorders are characterized by distinctive clinical movement features. The question rises if these children also have impairments in gross motor development, that is: how well do they perform on basic gross motor skills such as running, jumping and throwing balls?

Gross motor performance in children with psychiatric disorders

No one doubts the importance of gross motor skills like running, jumping, throwing, and catching for children participating in games and sports (Dewey et al., 2002; Smyth & Anderson, 2000; Wall, 2004). Children who perform poorly participate less in physical activities and practice less than their peers, which may widen the skill gap and lead to activity deficits and poor physical fitness (Cairney et al., 2005, 2007; Schott, Alof, Hultsch, & Meermann, 2007; Wall, 2004).

In a study with 100 child psychiatric participants in the Netherlands we examined which aspects of gross motor performance and physical fitness are affected in children with psychiatric disorders (Emck, Bosscher, van Wieringen, Beek, & Doreleijers, 2011).

Gross motor performance was measured with the Test of Gross Motor Development (TGMD-II) (Ulrich & Sanford, 2000). The test entails two subtests: *locomotion*, concerning movement behaviours that are used to transport the body from one place to another, and *object control*: movement behaviours aimed at projecting and receiving objects, especially balls, each based on six separate skills. The locomotion skills are: run, gallop, hop, leap, horizontal jump, and slide. The object control skills are: striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll. Interestingly, the TGMD-II measures the *quality* of the movement pattern, by providing age- and gender dependent criteria for each skill (see Figs. 1 and 2 for the illustration of two locomotor skills and their performance criteria).

Physical fitness was measured by the MOPER (Leyten, Kemper, & Verschuur, 1982) which consists of items that measure different aspects of neuromotor and aerobic fitness. Strength measurements were 'flexed arm hang', 'standing high jump' and 'ten leg lifts'. Speed measurements were 'ten times 5 m sprint' and 'plate tapping'. The flexibility measurement was a 'sit and reach' test. Apart from these neuromotor tasks, aerobic fitness was measured using the 'six-minute run' (Leyten et al., 1982; Runhaar et al., 2010). In contrast with the TGMD-2, the MOPER measures purely quantitative movement aspects such as time in seconds (arm hang) or distance in centimetres (high jump).

Regarding gross motor performance, a developmental delay of approximately three years for both locomotion and object control was found, indicating that the psychiatric group performed significantly worse than typically developing children. Furthermore, children with psychiatric disorders were characterized by very poor neuromotor and aerobic fitness. Although these findings pertained to all subgroups, some remarkable differences were present.

In children with *emotional disorders*, gross motor impairments were not as severe compared to the two other groups, although their physical fitness was equally low. Furthermore, locomotion and object control skills were unrelated in this group, a finding that sets them apart from children in the other two groups as well as from typically developing children. Since a neurologically based connection between balance dysfunction and anxiety in children has been documented (Bart et al., 2009; Erez et al., 2004), the variable patterns in gross motor performance in this group might be due to differential effects of balance problems on locomotion and object control.

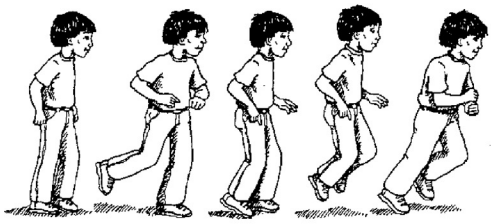
Although children with *behavioural disorders* performed worse on gross motor skills than those with emotional disorders, this was especially true for the locomotion subdomain. The correlations

(1)

Directions:
Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go".
Repeat a second trial.

Performance criteria:
1. Arms move in opposite to legs, elbows bent
2. Brief period where both feet ar off the ground
3. Narrow foot placement landing on heel or to (i.e. not flat footed)
4. Nonsupport leg bent approximately 90 degrees (i.e. close to buttocks)

(2)



Directions:
Mark off a distance of 25 feet with two cones or tape. Tell the child to gallop from one cone to another.
Repeat the second trial by galloping back to the original cone.

Performance criteria:
1. Arms bent and lifted to waist level at takeoff
2. A step forward with the lead foot followed by a step with the training foot to a position of adjacent to or behind the lead foot
3. Brief period where both feet are of the ground
4. Maintains a rythmic pattern for four consecutive gallops

Figs. 1 and 2. Run and gallop with directions and performance criteria according to the Guide for administering and scoring the TGMD-2 (Ulrich & Sanford, 2000, p. 46).

between locomotion and object control skills were in the normal range. Furthermore, and in line with earlier findings (Harvey & Reid, 2003), both neuromotor and aerobic fitness were clearly impaired in children with behavioural disorders, a fact that is often not acknowledged in clinical practice.

Children with *autism spectrum disorders* not only showed the largest impairments in both locomotion and object control skills, but the correlation between their scores for these subdomains was also significantly higher compared to the other psychiatric groups and typically developing children. Moreover, neuromotor and aerobic fitness scores were low, and several fitness measures correlated significantly with gross motor measures in this group. These results are in agreement with earlier findings indicating abnormally high correlations between ability domains in children with ASD which have been tentatively interpreted as reflecting an underlying impairment in the development of connectivity of brain systems (Belmonte et al., 2004; Dyck, Piek, Hay, Smith, & Hallmayer, 2006).

In addition to the study on gross motor skills and physical fitness, we conducted an experiment concerning the question if gross motor impairment in children with *emotional disorders* might be related to balance problems (Stins, Ledebt, Emck, van Dokkum, & Beek, 2009). We examined the spatio-temporal structure of the centre-of-pressure (COP) fluctuations in children with elevated levels of anxiety and a group of typically developing children while maintaining quiet stance on a force plate in various balance challenging conditions. Balance was challenged by adopting sensory manipulations that is standing with eyes closed and/or standing on a foam surface. We found that children with anxiety had overall more postural sway, and that their postural sway was overall less complex than sway of typically developing children. The pattern of postural sway showed that balance in the high anxious children was less stable and more attention demanding (i.e. less automatized), which was most prominent when the balance task was made more difficult by replacing the stable underground by an instable (foam) surface. These findings may indicate that balance problems may be (partly) responsible for the motor problems in children with emotional disorders. Keeping in mind that object control was affected more than locomotion in children with emotional disorders, this could be explained by its more attention demanding nature. Object control tasks are more difficult, because one has to maintain an upright balance while handling an object in a prescribed way, than maintaining dynamic balance in a locomotion task without an additional object handling task.

Psychiatric symptoms in children with gross motor problems

Because psychiatric disorders are often accompanied by gross motor problems, we wondered whether the reverse is also true, i.e., are children with gross motor problems at risk for psychiatric disorders? It is well known that children with gross motor problems are less likely to participate in games and play requiring skills like jumping, running, or throwing balls and that they tend to be physically less fit than typically developing children (Cairney et al., 2005, 2007; Cantell, Crawford & Doyle-Baker, 2007; Emck et al., 2011; Hands & Larkin, 2006). Moreover, gross motor problems are associated with negative self-perceptions (Peens, Pienaar, & Nienaber, 2008; Piek et al., 2006; Poulsen, Ziviani, & Cuskelly, 2006; Skinner & Piek, 2001). While children with gross motor problems are often referred to movement interventions, co-occurring psychiatric problems are seldom taken into account in movement

intervention programs. This might reduce the effectiveness of the programs in improving the broader health status of the children in question.

Hence, we investigated emotional and behavioural problems in a sample of elementary school-aged children who were referred to a movement program by their teachers because of gross motor problems (Emck, Bosscher, Van Wieringen, Doreleijers, & Beek, 2012). We focused on psychiatric disorders and syndromes, social functioning, and self-perceived competence, using parent and self-reports. A high percentage of the children in the sample (65%) met the criteria for at least one psychiatric classification and had significant social impairments. Furthermore, these children perceived themselves incompetent in both the motor and social domain. Anxiety disorders were most prevalent (45%), but also 23% of the children met the criteria for autism spectrum disorders: key symptoms of autism, such as stereotyped behaviour and fear of and resistance to change were abundant. These findings are in line with results of studies indicating that children with poor motor coordination are prone to deficits in social cognition and behaviour (Chen, Tseng, Hu, & Cermak, 2009; Cummins et al., 2005; Dewey et al., 2002; Tseng, Henderson, Chow, & Yao, 2004), and with evidence for a neurobehavioral link between balance and anxiety problems (Stins et al., 2009). Moreover, the findings support the suggestion of a common neurobiological link between motor problems and autism spectrum disorders (Allen, Müller, & Courchesne, 2004; Belmonte et al., 2004; Piek & Dyck, 2004).

Considering that the children in our sample often showed significant psychosocial and psychiatric problems, we agree with Peens et al. (2008) that interventions for gross motor-impaired children should not only focus on the motor problems, but also on psychosocial impairments. The combination of motor impairments and emotional, behavioural, or autism spectrum disorders compromises daily living, and high quality prevention and intervention are needed (Kopp, Beckung, & Gillberg, 2009). Since participation in movement activities will become more difficult for these children as they grow older, interventions addressing both physical and psychosocial problems should also start at an early age (Cummins, Piek, & Dyck, 2005; Wall, 2004). By all means, children who are referred to movement interventions should be screened for emotional and behavioural problems, which, if present, should be taken into account in adapting the interventions to the specific needs of the children (Emck et al., 2012).

PsyMot: psychomotor diagnosis

In view of the close relationship between psychiatric disorders and gross motor impairments in children, it seems important to complement psychiatric diagnosis with an assessment of movement behaviour. Therefore, we developed the PsyMot, a tool for diagnosis and indications for therapy (Emck, Hammink, & Bosscher, 2007). The aim of the PsyMot differs from the aim of well-known tests of motor performance like the Movement ABC (Henderson & Sugden, 1992) and the TGMD-II (Ulrich & Sanford, 2000). That is, the PsyMot is meant to decide if a child is indicated for movement- and body-oriented therapy, and to formulate personalized treatment goals. Although gross motor behaviour is the vehicle of the treatments in question, the spectrum of treatment targets is broader and includes *experiential goals* such as improving body acceptance and awareness and enhancing bodily self-expression, *behavioural goals* such as regulating energy and controlling impulsive movements, and *social goals* such as learning to play with peers and becoming 'kinesthetically attuned' (Sheets-Johnstone, 2003).

In the assessment procedure, the child is observed in standardized situations and questioned in a semi-structured way about self-perceived motor competence and body-experience (for a short description see Emck & Bosscher, 2010). In view of the importance and meaning of social bodily play from a neurodevelopmental perspective (Johnson, 2011; Nelson & Luciana, 2008; Sheets-Johnstone, 2003; Smith, 2010), observation of the child's movement behaviour in interaction with a peer is also part of the PsyMot procedure. The item pool was based on the (sub)domains of the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) (WHO, 2003, 2007). The procedure leads to standardized scores for two domains, 'functions' and 'activities and participation', and seven cluster scores, indicating topics in need of treatment. These clusters include body acceptance, participation and enjoyment, perceived physical and motor competence, motor performance, self-control, self-confidence and self-expression and, finally, playing and interacting with peers (see Fig. 3 for an illustration).

In several small studies (Broekman & ten Tusscher, 2008; de Jong & Klinkenberg, 2009; Ritbergen & Coenen, 2010; Sterk, 2011), the psychometric quality of the PsyMot in terms of interrater reliability, internal consistency and concurrent validity of the cluster scores proved to be adequate, but further investigation is needed before definite conclusions about reliability and validity can be drawn. Currently, different versions are being developed, tested and implemented (for instance: PsyMot-Y for youth, PsyMot-S short version, Portuguese version of the PsyMot, and PsyMot-ID for people with intellectual disabilities, Kay et al., 2014).

Theoretical notions

The findings of the studies described, are in line with current neurodevelopmental theories, which will be addressed in relation to the three main child psychiatric groups mentioned before.

First, our findings concur with theories about shared neuronal networks involved in balance and anxiety regulation, especially in the brainstem. The parabrachial nucleus is the core of the neural circuitry where interaction between amygdala-based emotional conditioning and cerebellum-based motor conditioning takes place (Balaban & Thayer, 2001; Erez et al., 2004). This nucleus is involved in emotional learning, whereas its motor output may produce emotional responses. Although the causal direction, i.e., whether motor problems trigger anxiety or vice versa, has not yet been ascertained (Bart et al., 2009), it appears that a process of mutual reinforcement between anxiety and motor problems plays an important role at the behavioural level. Moreover, the cerebellum is involved in conditioning processes related to implicit memory, and thus in the formation of associations between anxious feelings and balance (Erez et al., 2004; Johnson, 2011).

Second, the cerebellum may also be involved in autism spectrum disorders. The cerebellar circuitry is essential for motor performance, but atypical cerebellar activity – or developmental damage to the cerebellum – has also been frequently reported for autism (Allen et al., 2004; Allen & Courchesne, 2003; Belmonte et al., 2004). However, this atypicality has been reported for many neurodevelopmental disorders (Diamond, 2000; Piek & Dyck, 2004), whereas in the case of autism atypicalities are not restricted to the cerebellum, but are widespread across several other brain regions (Bloom, Nelson, & Lazerson, 2001; Johnson, 2011). Nevertheless, the cerebellum is of special interest, because it is both involved in motor functioning and in serving 'higher' cognitive functions (Diamond, 2000), in particular mentalizing or 'theory of mind', i.e., the ability to understand and interact with other people on the basis of comprehending another's thought process, feelings, beliefs, and knowledge. It is also known that children with ASD generally show deficits in aspects of 'theory of mind'. According to Allen et al. (2004) dysfunctioning of the cerebellum '. . . might be a key contributor to the development of certain diagnostic features of autism' (p. 269).

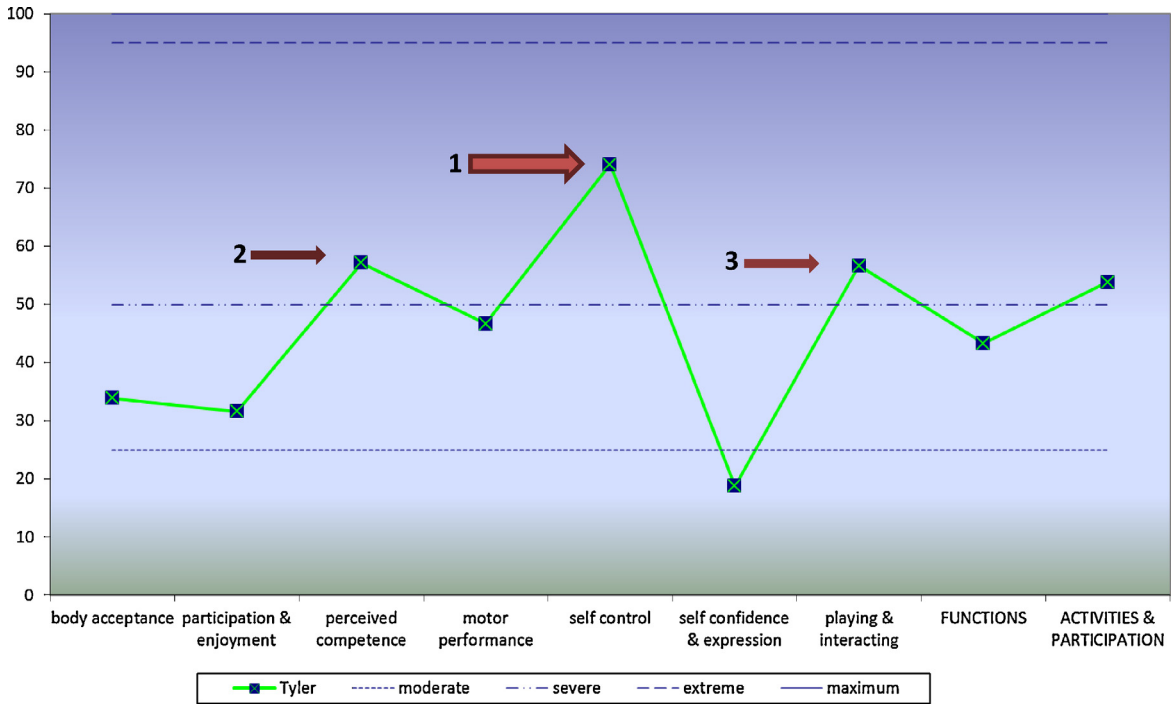


Fig. 3. PsyMot clusters cores for Tyler, a twelve year old boy with Attention Deficit Hyperactive Disorder and associated psychosocial problems. Explanation: since higher scores indicate more problems on a cluster, treatment goals for Tyler should be aimed at improving (1) self-control, preferably combined with (2) self-perceived physical and motor competence and (3) social play behaviour.

These considerations are reinforced by our studies which not only showed severe gross motor problems in children with autism spectrum disorders, but also that children selected on the basis of poor gross motor performance showed a high prevalence of symptoms of autism. Thus, we agree with the suggestion of Allen et al. (2004), Belmonte et al. (2004) and Piek & Dyck (2004) that cerebellar dysfunction constitutes a common neurobiological link between motor problems and ASD.

However, the cerebellum is not the only brain structure involved in ASD. For instance, it has been demonstrated that cerebellar abnormality in autism is associated with abnormal brain connectivity such that the development of high local neural connectivity coincides with low long-range neural connectivity, which impairs the coordination of several functions (Baron-Cohen & Belmonte, 2005; Belmonte et al., 2004). According to Mostofsky, Burgess, & Gidley Larson (2007) this may contribute to impairments in the development of complex motor skills and communicative gestures that are specific for autism. The remarkably high correlation between locomotion and object control scores we found in children with ASD, which is in agreement with the conclusion of Dyck et al. (2006) that ability domains in ASD are abnormally dependent, seems consistent with a 'connectivity hypothesis' with regard to autism: the weaker the interconnections between different brain structures, the stronger the negative effects on the different functions served by those structures (Belmonte et al., 2004).

Third, the findings in children with behavioural problems are of interest. According to Krain and Castellanos (2006), several brain structures are involved in ADHD, but 'the most robustly deviant region in brain associated with ADHD is the cerebellum' (p. 441). Notwithstanding this resemblance of ADHD with ASD, the significantly lower correlation between locomotion and object control scores in children with ADHD suggests that the neurodevelopmental mechanisms underlying these disorders might be different. In this regard, we refer to the neurodevelopmental view on ADHD as presented by Halperin & Healy (2011). They suggest that the clinical outcomes in ADHD reflect an interaction between deviant cortical development and compensatory mechanisms that develop throughout childhood. Especially in childhood, the period of the greatest neural plasticity, environmental enrichment by directed play and physical exercise could positively influence symptoms of ADHD by enhancing cognitive and behavioural development, and neural growth (Halperin & Healy, 2011).

Finally, it is important to realize that the neurobiological account of the relationships between psychiatric disorders and movement behaviour does not preclude the role of psychosocial and environmental factors. In particular, as has been suggested by Cairney (2011), an environmental factor may be responsible for the co-occurrence of gross motor problems and emotional disorders. Motor problems may lead to ridicule, exclusion from social play with peers, and social isolation, which in turn may shape psychological distress (Cairney, Hay, Veldhuizen, Missiuna, & Faught, 2010; Cairney, Veldhuizen, & Szatmari, 2010). Moreover, many genetic, biological and environmental interactions are still unknown. The influence of powerful environmental factors on brain development and functioning is increasingly recognized with respect to ADHD (Halperin & Healy, 2011; Sonuga-Barke & Halperin, 2010), providing support for movement interventions from neurobiological, environmental and psychosocial perspectives. Based on the notion of environmental enrichment as a powerful factor to influence neurodevelopment, Halperin & Healy (2011) proposed directed play and physical exercise as a means to promote brain growth and influence the underlying neural determinants of ADHD. Therefore, the acknowledgement of a complex interplay between environmental factors and neurodevelopmental processes is of outstanding importance for the development of diagnostic tools as well as for interventions.

Clinical implications

Given the results of our studies, and in line with neurodevelopmental perspectives a broad assessment of movement behaviour

– including interactional and expressive aspects, self-appraisal and body experience – is recommended as an integral part of the diagnostic procedure in child psychiatry (Cairney, Missiuna, Veldhuizen, & Wilson, 2008; Gillberg, 2010; Emck et al., 2011). It is also recommended that children with motor problems are screened for psychosocial problems and psychiatric symptoms, also because motor problems may be predictive for anxiety disorders (Piek, Barrett, Smith, Rigoli, & Gason, 2010) and schizophrenic disorders (Erlenmeyer-Kimling et al., 2000).

Most important, dance/movement therapy should be part of the standard treatment for children with neurodevelopmental disorders and psychiatric symptoms. The interconnections and interactions between psychiatric problems and movement behaviour which are addressed in dance/movement therapy, as well as theoretical accounts of their relationship, support its use in child psychiatric practice. Thereby, it is essential to tailor the intervention to the specific needs of the child and to focus on strengthening the child's self-concept (Dewey & Wilson, 2001; Peens et al., 2008). As stated before, treatment goals for dance/movement therapy range from experiential, to behavioural and social, and – according to the PsyMot procedure – they may concern body acceptance, participation and enjoyment, perceived physical and motor competence, motor performance, self-control, self-confidence and self-expression and, playing and interacting with peers. By using mirror-movements, a keystone of the therapeutic process of dance/movement therapy (Berrol, 2006, p. 303), one can address all of the above mentioned treatment goals if required. Moreover, the development of kinaesthetic attunement, which is of great importance for psychosocial and moral development, is specifically emphasized and stimulated by moving together (Loman & Merman, 1996; Sheets-Johnstone, 2003, 2010). In line with these notions, Erfer (2006) described the use of mirroring in a group setting for children with emotional and behavioural disorders to improve the development of body image and self-awareness, successively improving the awareness of others. More recently, Samaritter & Payne (2012) proposed a 'shared movement approach' in dance/movement therapy for children with autism spectrum disorders (ASD), in order to bring about relational movement experiences to increase a better sense of self. Since ASD seems to be characterized by lack of embodiment, not only teaching motor skills is supposed to be beneficial, but also eliciting facial expressions or body postures in children may help explicitly to 'entrain' the body with embodiment (Eigsti, 2013). Thus, dance/movement therapy can offer distinct bodily experiences that unmistakable are of great worth for children with developmental challenges.

Fortunately, the awareness that children with psychiatric disorders may benefit from movement- and body-oriented treatment approaches is increasing, and neurodevelopmental theories about possible mechanisms underlying their effects emerge (see for instance Cortese, 2013; Eigsti, 2013; Halperin & Healy, 2011; Rommel, Halperin, Mill, Asherson, & Kuntsi, 2013). In this regard, the advice of Rutter et al. (2004) is also noteworthy: "If a particular therapy is envisaged, assessment in that mode is usually indicated" (p. 30). It follows that children who come to the attention of a child psychiatric service deserve standard assessment of movement behaviour, regardless of the type of psychiatric symptoms they present. If clinicians overlook problems in the motor domain, the child is at risk of developing additional psychosocial problems, low physical fitness and associated health problems. Movement assessment at an early stage may not only prevent these additional problems, but may also serve to offer promising dance/movement interventions that enhance brain development. Consequently, movement assessment should be aimed at indicating children for dance/movement interventions with clearly formulated treatment goals.

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