Psychomotor disorders

“Psychomotor disorder occurs both in the way the subject is involved in action and in relationships with others. Psychomotor disorders are neurodevelopmental disorders that affect the perceptual motor dimensions of the subject adaptation to his/her environment. Aetiology is multifactorial and transactional and associates genetic, neurobiological, psychological and/or psycho-sociological factors acting at multiple levels of complementarity and expression. They are often situational and subtle, impeding first the adaptive mechanisms, constituting a source of inconvenience and suffering for subjects and their social environment. Clinical analysis is based on in depth knowledge of normal development. It requires specific investigations, including a psychomotor examination, to understand qualitative and quantitative aspects of the subjects perceptions, representations and actions.” (Albaret, 2001).

The characteristics of psychomotor disorders are the following (cf. figure 1):
1) They are perceptual-motor disorders that affect exploration (perceptual aspects), action (on the physical environment) and communication (non-verbal) functions and associated emotional manifestations.
2) They manifest themselves in the form of soft neurological signs indicating the existence of a minimal brain dysfunction.
3) They are associated with psychopathological symptoms, such as emotional factors that may be a reaction to perceptual-motor disorders but may also be comorbid psychiatric disorders.
4) They require an analysis of different dimensions (biological, ecological and teleological or intentional) in order to consider the etiological plurality (Albaret, 2001; Corraze, 1981, 1999, 2010).
**Perceptual-motor disorders in ADHD**

*Exploration functions*

During visual search tasks, children with ADHD demonstrate less efficiency at the lowest and highest levels of display complexity (Mullane & Klein, 2008, for review). They have some difficulties in blue–yellow colour discrimination related to the retinal dopaminergic function that is deficient (Banaschewski et al., 2006).

The integration of various sensory systems (somatosensory, visual, vestibular) necessary to maintain body equilibrium is perturbed and children with ADHD cannot successfully compensate particularly when sensory information from visual systems is removed or distorted (Shum & Pang, 2009). Haptic functions present some specific characteristics with reduced tactual discrimination (Parush, Sohmer, Steinberg, & Kaitz, 1997) and a deficit in the ability to modulate kinesthetic cues (Yochman, Parush, & Ornoy, 2004).

*Action functions*

In addition to hyperactivity which is one of the core problems in ADHD, Slaats-Willense, Sonneville, Swaab-Barneveld and Buitelaar (2005) investi-
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Gated motor flexibility and fluency in two tasks (tracking during circle drawing and pursuit of a randomly moving target). ADHD children displayed more problems on these tasks than normally developing children.

ADHD children experienced particular difficulties when complex fine movements are required during tasks, like copying, maze solving, and pursuit tracking (Korkman & Pesonen, 1994; Moffitt, 1990). Eliasson, Röxblad and Forssberg (2004) demonstrated that ADHD children have deficits in programming precise movements to reach a target when on-line visual feedback is withdrawn, with however a large within-subject variability, and movement trajectories are more jerky. Motor control in close-loop movements are also more difficult for these children (Lee, Hung, Yang, Chen-Sea, & Tsai, 2010). Coordination problems affect fine motor skills, particularly handwriting (Adi-Japha, 2007).

When the qualitative components of 12 fundamental movement skills, assessed by the Test of Gross Motor Development-2\(^1\) (Ulrich, 2000), were compared between children with and without ADHD, there were significant differences between groups with large effect sizes (1.4 to 2.6) indicating that ADHD children may be at risk for developmental delays (Harvey, Reid, Grizenko, Mbekou, Ter-Stepanian, & Joober, 2007).

Impairment in motor coordination is more important when the inattention component of ADHD is present: in fine motor skills for ADHD–Predominantly Inattentive type and in gross motor skills for ADHD–Combined type (Piek, Pitcher, & Hay, 1999).

Soft signs in ADHD

Soft signs are considered to be a manifestation of minor neurological dysfunction (Hadders-Algra, Heineman, Bos, & Middelburg, 2002) and have been reported for a long time as an integral part of ADHD (Rutter, Graham, & Yule, 1970). Recently, there has been some reconsideration in connection with the concept of cognitive endophenotype (Chan, McAlonan, Yang, Lin, Shum, & Manschreck, 2010; D’Agati, Casarelli, Pitzianti, & Pasini, 2010; Fellick, Thomson, Sills, & Hart, 2001; Uslu, Kapçi, & Öztöp, 2007). How-

\(^1\) TGMD-2 assess six locomotor skills (e.g., run, gallop, hop, leap, horizontal jump, and slide) and six object control skills (e.g., striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll).
ever they may be present in other psychiatric disorders like obsessive-compulsive disorders or schizophrenia (Chan & Gottesman, 2008; Chan et al., 2010; Jaafari, de la Cruz, Grau, Knowles, Radua, Wooderson, 2013). The presence of soft signs is correlated with different measures of executive function, verbal and visual memory (Chan, Wang, Wang, Chen, Manschreck, & Li, 2009) and this correlation seems to indicate an aggravating risk factor for ADHD. These signs include in particular mirror movements (MacNeil, Xavier, Garvey, Gilbert, Ranta, & Denckla, 2011) supposedly linked with anomalies in white matter (D’Agati et al., 2010), and dysrhythmia (Cole, Mostofsky, Gidley Larson, Denckla, & Mahone, 2008; Pasini, D’Agati, Pitzianti, Casarelli, & Curatolo, 2012; Uslu et al., 2007).

Emotional and affective factors in ADHD

These factors are mainly found in motivational problems (Barkley, 1997): these children present more specific difficulties in maintaining the focus required by their work, especially when it is long and monotonous. They have a motivational self-regulation disorder.

Psychopathological comorbidities are frequent in ADHD: oppositional defiant disorder (54-67%); conduct disorder (20-50%); anxiety disorder (10-40%); mood disorders (20-30%); bipolar disorder (10-20%) (Biederman, 2005; Jensen et al., 2001; Maughan et al., 2004; Ralston et al., 2004; Stefanatos & Baron, 2007; Tannock, 2009; Serrano et al., 2013).

Assessment of ADHD: the dual pathway model and the Laby 5-12 test

Alongside the clinical signs, various tests help determine the type and degree of neuropsychological and psychomotor dysfunctions in ADHD. They can be grouped into four main different categories: attentional processes (Stroop test, cancellation tests like d2 test, Trail making test), executive functions and impulsivity (Matching pictures test, Tower of London test, Corsi blocks, Figural fluency, Wisconsin card sorting test), soft signs, temporal perception (Albaret, Soppelsa, & Marquet-Doléac, 2010; Baron, 2004). In complement to the measures mentioned above and relying on Sonuga-Barke’s two-pathway model, we recently developed and normed a mazes test on a French population, the Laby 5-12 test (Marquet-Doléac, Soppelsa, & Albaret, 2010). Proposed by Sonuga-Barke (2003), the dual pathway model tries to account for the heterogeneity of clinical presentations. It corresponds with Barkley’s
hybrid model relying on certain executive functions (Barkley, 1997) and with the delay aversion model that emphasizes the subjects disability in a waiting situation (Sonuga-Barke, Taylor, & Heptinstall, 1992). Barkley’s model (1997) postulated the presence of a defect in primary behavioral inhibition that affects different executive functions (verbal and nonverbal working memory, self- motivation and arousal, recovery or ability to organize elements in an original way). This results in a lack of organization and motor control resulting in the presence of behaviors unrelated to the current task, incomplete, unstable stereotyped actions, and a limited capacity to produce new or complex motor sequences. The delay aversion model (Sonuga-Barke et al., 1992) considers two types of situations. When waiting time is imposed, the child tries to escape the unbearable nature of this situation by focusing on elements of the external environment to accelerate the subjective perception of time (inattention) or by motor stimulation (hyperactivity). If, instead, response time is left for the child to regulate, children with ADHD seek to reduce a maximum of the time, which results in impulsivity.

Recently, Sonuga-Barke, Bitsakou and Thompson (2010) have proposed a third component in their model, measuring neuropsychological processing time with a continuation\(^2\) test, a duration discrimination task and an anticipation-coincidence task. They compared three groups (children with ADHD, siblings thereof, and a control group) on several neuropsychological tasks enabling them to distinguish subtypes of ADHD, based on the three areas studied (inhibition, delay aversion, and perception of time). The percentage of subjects with problems in two or three of these areas is no more than that due to chance, which reinforces the idea of independence of these three neuropsychological profiles.

The Laby 5-12 test (Marquet-Doléac et al., 2010) consists of 4 sets of 3 mazes (angular airy, angular compact, circular airy, circular compact) of increasing complexity (see Figure 2). Three types of errors are considered: the wrong direction, distance travelled in the wrong directions and cut/touched lines.

The raw data is dependent on the strategy of each child, these errors are reported and the total time used to calculate several indices: a general error index, a delay aversion index taking into account the number of cut lines, and an inhibition index calculated from the distance traveled. The results of

\(^2\) In a continuation paradigm subject to synchronize a digital hit with a periodic auditory signal and continue typing when it disappears.
the normative sample (928 children aged 5 to 12 years 11 months) helped provide several administration methods for children 5 to 7 years on the one hand and those from 8 to 12 years on the other hand, with a number of labyrinths ranging from 6 to 9, depending on whether the test is used as a screening tool or a standard test.

These various indices decrease with age, but remained higher for boys. In the 8-12 years age group, the children aged 8 to 11 years were comparable on all indices, but by a significant decrease was noted for the children of 12 years. These results are consistent with studies showing different developmental periods of executive functions, with different trends depending on the measured functions and tests used (Levin et al., 1991, Roy, Gillet, Lenoir, Roulin, & Le Gall, 2005; Sevino, 1998; Zesiger, 2009 for a detailed review).

Figure 2: Samples of Laby 5-12 test (angular, circular), courtesy Hogrefe Publishing France.

A pathological validation was performed on a group of 11 children with ADHD, with an average age of 9 years, age and sex matched to a control group. A significant difference was found for all indices. The test-retest reliability was studied on 91 subjects reviewed at an interval of six weeks. Results indicate that there is no significant difference between these two sets of measures on the indexes, unlike the low fidelity test - retest mentioned in previous maze tests of the same type (Krikorian & Bartok, 1998; Porteus, 1965). The inter-raters reliability is excellent for the wrong directions and distance travelled, but the determination of the number of cut lines requires
training time. The measure of internal consistency, performed using Cronbach coefficient $\alpha$ is high ($\alpha = .83$ for 5-7 years, $\alpha = .85$ for 8-12 years). The sensitivity is better for standard versions with a higher number of used mazes.

**Psychomotor therapy**

The general principles of psychomotor therapy with ADD/ADHD children have been known for over twenty years and have been refined in many cases (Albaret & Corraze, 1991; Corraze & Albaret 1996; Marquet-Doléac, Soppelsa, & Albaret 2005; Soppelsa, Gonzalès, & Tan Ham, 1996). More recently, psychomotor therapies efficiency and care issues have been replaced by the principle of evidence based therapy (Rivière, 2010). Two studies have evaluated inhibitory processes and problem solving therapy in order to challenge new features in the ADHD theory model. In both studies the children weren’t medicated. In the first study 25 subjects with ADHD aged 9 years 10 months on average were randomly assigned into two groups: the experimental group ($n = 17$) and the control group ($n = 8$) composed of children on the referral waiting list (Marquet-Doléac, Soppelsa, & Albaret, 2006). We used a rehabilitation program with 3 different tasks selected to stimulate inhibitory processes. The child is engaged for six 45 minutes sessions: the first task is a resistance to external stimuli task during which the child must follow a line (that becomes increasingly complex) with a pencil over a period of 5 minutes. The second is a task of inhibitory control and response time using a deck of cards, where for example you must strike on the queen, the king and the ten but not on the jacks or any of the other cards. The third is a task of working memory with the game Rush Hour© in which the child must free a target vehicle from an enclosed space that is partly occupied by other vehicles. A significant interaction between the two groups and test-retest reliability factor was found for the number of errors and the accuracy index of the Matching pictures test (Marquet-Doléac, Albaret, & Bénesteau, 1999), as well as the number of errors made on the Porteus mazes test. There was no significant interaction on the Tower of London and the d2 attention test.

The results indicate a decrease of errors between the test and the retest for the subjects in the experimental group, while these results stayed the same or deteriorated in control subjects. This improvement can be seen as a consequence of inhibition processes that encourage children to "stop, look and
listen" (Douglas, 1972) before giving a response, thereby reducing their impulsive behaviors.

A second study (Chagneau & Soppelsa, 2010) used problems solving, a method whose pertinence in the treatment of children with ADHD has been demonstrated (Shure & Spivack, 1982). A protocol with six 45 minutes sessions was proposed. Children were randomly assigned into two groups (7 children ADHD with an average age of 9 years 2 months, were compared to a control group paired in age). The protocol had three sets of problems. The first one was a computer game (Incredible Machine ®) where the subject must use tools to put a ball in a target. The second was a gross motor movement problem solving task (the child had to search for "treasures" hidden in the room without touching the ground with his/her feet; get a hoop in different conditions; try to capture two strings hanging from a ceiling but that are too far apart to be held at the same time, run with a Marble ®, make a trail for conduct to take the marble to a particular place; or Meccano® constructions without using existing models (for example, make a catapult). The therapist guides the child through the different parts of the problem, helps the child focus on a relevant object and provides explicit approaches in problem solving. Results showed no interaction between the Group Test-retest reliability factors on all measures performed.

The third study (Chagneau & Soppelsa, 2010) is based on the principle of contrast of two treatments. The two previous protocols are implemented and associated with a population of thirteen ADHD children (6 children begin with the work on inhibition processes, 7 by problem solving). All are compared with a control group of 13 ADHD children. The results show a significant difference between the experimental group and the control group. The evolution of the number of correct responses, the number of errors, and the accuracy of the matching pictures test index between test and retest shows significant improvements. Results of the Stroop test, Tower of London test, d2 Test and Porteus mazes do not show significant differences.

The results of the two studies confirmed an effect of treatment on inhibition processes but not on problem solving. However, we can consider that the increase of success is due to the association of the two protocols without any order effect. The temporal aspect of action is always considered; it starts from the organization of the session with time display devices (clock driver tasks) to facilitate the identification of the structure of the session (Corraze & Albaret, 1996).
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The lack of significant results in the problem solving study indicates that this is not the analysis of the action status that fails for ADHD children but the time management. We think that various exercises on prospective or retrospective estimation of task duration, anticipation-coincidence exercise, or maintaining a tempo tasks can also be effective (Marquet-Doléac & Soppelsa, 2009; Puyjarinet, 2011).

References


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