

Executive functions assessment and treatment at preschool age: a case report of a child at risk of ADHD

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ABSTRACT

An attention deficit hyperactivity disorder (ADHD) single case was analyzed using a battery of developmentally sensitive measures of executive functions in young children. The child was then trained with executive function tasks similar to tests in which he had failed. A training program was administered individually in 45 minute sessions, 3 days a week for a month. The child was tested before training, after training, and in a five-months follow-up. Results show improvements in executive function tasks. Positive ecological impact of the training was confirmed by parents and teachers.

Keywords: Executive functions; Developmental disorders; ADHD; Working memory, Hyperactivity; Impulsivity

1. INTRODUCTION

During the preschool years, children acquire the social, behaviour, and academic skills that allow them to cope successfully elementary school. Not all children master these crucial skills before they enter first grade. For some children, difficulties with impulse control, attentional capacity, and hyperactivity hinder the ability to benefit from the valuable lessons of preschool and later academic experiences. In some cases, early difficulties never dissipate and they become a serious disorders such as Attention-Deficit/Hyperactivity Disorder (ADHD).

ADHD is a developmental condition characterized by a combination of inattentive, hyperactive, and impulsive behaviour. It is presumed to have a major organic component.

Research on cognitive deficits associated with ADHD has examined a set of basic cognitive processes known collectively as executive functions.

Executive functions (EF) are high order self-regulatory, cognitive processes that aid in the monitoring and control of thought and action. These skills comprise inhibitory control, planning, attentional flexibility, error correction and detection, and resistance to interference (Carlson, 2005; Sonuga-Barke, 2005; Sonuga-Barke, Bitsakou & Thompson, 2010).

Although there are many models of executive control, largely derived from the neuropsychological performance of adults, one underutilized method to understand the nature of executive control is to examine such skills early in ontogeny – when abilities are developing rapidly. (Anderson, 2002 and 2008).

There is a substantial evidence from various tasks that indicate that the preschool period is a phase of rapid acquisition of executive competencies that are supported by substantial maturation in prefrontal structures and functional systems. These developing brain-behaviour relations are probably affected by genetic and environmental influences and sometimes can result in specific developmental outcomes.

There are some studies that indicate that EF is implicated in a range of developmental disorders and early developing psychopathologies (Pennington & Ozonoff, 1996; Barkley, 1997; Blair, Zelazo & Greenberg, 2005).

Recently, researchers theorizing on ADHD have emphasized poor behavioural inhibition as the central deficiency of the disorder (Barkley, 1997; Sonuga-Barke, 2005; Sonuga-Barke et al., 2010). Rarely does the diagnostic procedure of ADHD take into consideration the analyses of EF sub-domains other than inhibition.

2. METHOD

In this study, we describe a single case of a preschool child at risk of ADHD and we discuss:

1. The possibility and the usefulness of a neuropsychological assessment, within the diagnostic process that comprehensively considers both general (e.g. language, behavioural self-regulation) and specific aspects (highly selective neuropsychological processes).
2. The necessity to ensure the effectiveness of therapeutic intervention by objective measurements as well as with valid and shareable assessments.

2.1. Case report

The child arrived as an infant neuropsychiatry outpatient (of Italian nationality) at the age of 3.6 years old following scholastic advice due to severe behavioural difficulties. The hyperactivity subsisted at home: “Always restless, he breaks toys, throws himself on the ground ...”. His parents reported low tolerance to frustrations that led him to aggressive behaviour demonstrated both towards himself (“He scratches his face”) and others. They also reported difficulties in emotional and physical regulation e.g. as a newborn he would stop crying with difficulty. Linguistic and psychomotor achievements were described as normal. No pathological signs could be attributed to the prenatal, birth or post-natal period.

His parents, belonging to a modest socioeconomic environment with low educational level, displayed good parental skills and were highly cooperative with clinical staff. The boy's family history does not present any neuropsychiatry disorders, even though there were some similarities between father and son's behavioural dispositions to hyperactivity correction.

The child attended nursery school and teachers reported that he was very lively, touched everything and preferred games that involved movement. As for his behaviour towards his classmates, teachers describe, “He is aggressive ..., then he kisses them”. His aggressive behaviour was evident especially when he was picked on. He was loving and caring with younger children, but always ready to fight with the older ones. This aggressiveness seems to be linked to low tolerance to frustrations and to limited interactional skills with his peers. The teachers described many episodes of impulsive behaviour.

2.2. Assessment

An initial assessment (T0) was made to complete the diagnostic picture and to ideate a treatment plan. A second assessment (T1) took place at the end of the therapy and lasted for a month. The final one (T2) took place as a follow-up after a five months break. In order to evaluate the ecological impact of the disorder and the effectiveness of the therapy a SDQ (The Strengths and Difficulties Questionnaire; Goodman, 1999) was used both in the initial (T0) and in the follow-up assessment (T2).

During the assessment the child displayed “explosive” behaviour with an attention liability which was evident in his continuous exploration and impulsive use of objects in his reach. However, he cooperated with the assessment requests. His arousal could be modulated by simple verbal orders in a

low tone of voice that interrupted his inappropriate behaviour. In this phase the child's self-regulation seemed linked to the presence of an adult that guided him in being more adaptable to changes in the environment.

In a second/third phase neuropsychological and constructive procedure tasks were administered to the child to estimate his verbal comprehension.

The psychometric measures are linked to subdomain of executive functions: working memory, inhibitory control, attentional flexibility, set shifting and abstraction and planning.

Executive functions were evaluated with preschool age tasks adapted to the Italian population and compared to the relative normative data (Stievano, Valeri, Totonelli & Curcelli, 2006).

The tasks employed were:

- I. Working memory: "Spin the pots" visual search task (Hughes, 1998).
- II. Inhibitory control: Luria's "fist and finger hand game" currently used in clinical assessments of adults with frontal damage (Hughes, 1998).
- III. Attentional flexibility: magnets pattern-making task adapted from Frith (1972), and used as a measure of frontal function (Hughes, 1998).
- IV. Set shifting and Abstraction.
Flexible Item Selection Task (Jacques & Zelazo, 2001).
- V. Planning.
Tower of London.

Emotional and behaviour profiles were also evaluated with a clinical interview by means of a Strengths and Difficulties Questionnaire (SDQ), a questionnaire filled in by the parents. The SDQ is a brief behavioural questionnaire that enquires about 25 attributes, positive and negative. The 25 items were divided into 5 scales of 5 items each, generalizing scores for: problem solving, hyperactivity, emotional symptoms, peer problems, and prosocial behaviour. All but the last were summed up to generate a total difficulties score.

3. RESULTS

3.1. First assessment results (T0)

His difficulties in maintaining attention led to the necessity of cognitive level assessment with a short clinical test (Block Building). The results showed that his mental age corresponded to his chronological age. His linguistic level both in production and in comprehension was also adequate. There were not visual-spatial, or praxic coordination difficulties.

3.2. Internal profile of executive functions

In T0 and T1 all tasks relative to EF sub-domains were corrected, except for “The Tower of London” (planning). With respect to inhibitory control, Luria’s “fist and finger hand game” showed perseverative errors both in the imitative and conflict conditions, with difficulties when the task requested set-shifting. In the conflict condition, when the child should perform the opposite movement, he was totally incapable of acting correctly. The use of language as a guide slightly modified his performance, yet he did not manage to achieve sufficient results compared to normative data for Italian.

His use of verbal language initially towards the adult and then directed to himself was a positive cognitive tool to bear in mind when formulating a therapeutic path. The connection between language and behaviour has been underlined by a great number of researchers, from Vygotskij’s to Barkley.

Attentional flexibility and categorization, were assessed with the magnets pattern-making task and FIST (the Flexible Item Selection Task: a measure of set shifting in preschoolers). The results showed that attentional flexibility and categorisation skills were not adequate according to the normative data. Working memory was assessed with the “Spin the pots” task and resulted sufficient.

3.3. Emotional and behaviour profile

The clinical observation showed hyperactivity and inattention. The SDQ questionnaire displayed pathological scores in three out of the five scales: Problem solving, hyperactivity/inattention, problematic relationships with peers. The total difficulties score was found to be pathologic, even though the scores for emotional signs and social behaviour were adequate.

3.4. Therapeutic plan

The plan comprised specific goals (lacking neuropsychological processes) for the achievement of a more functional interactive modality. The intervention was essentially based on:

- a. Use of language as behavioural guide.
- b. Interruption of non-functional behaviour.
- c. Self regulation of affect, motivation and arousal (Barkley, 1997).

Some practical examples of intervention according to these would be: give time-outs (interrupt activities for a while), address him without shouting and regulate his arousal when it excessively rises.

Specific goals previously identified with the initial (T0) neuropsychological assessment were treated in the following way.

Attentional flexibility and visual selective attention were treated by a task that involved perception of different coloured objects (toys and Lego bricks) and of their spatial disposition, based on an adult's verbal instructions.

Another example of a training task related to attentional flexibility was based on the magnets pattern-making task administered to the child before treatment (T0). The task consisted in reproducing, according to a model, rows of coloured nails that had to be placed on a small riddled board, arranged in series of three.

At the beginning, perseverative errors were frequent, the child expressing difficulty in set-shifting; he persisted in using the same colour that had started the pattern. Sometimes he would lose control during the task and start to proceed by chance. During training the perseverative and random errors were gradually less. Other than flexibility, in this task selective visual and sustained attention were stimulated.

Inhibitory control, as specific goal, was reinforced with inhibition activities such as stopping reactions when confronted with objects that evoked specific use (keeping a ball in his hands without throwing it immediately). The use of inhibitory control tasks was based on Luria's "fist and finger" hand game. The child was asked to copy two different movements that the adult performed alternatively (imitative condition). Subsequently the child was asked to perform the opposite movement (conflict condition) of the one he had observed.

The period of training lasted a month with 10 sessions that took place three times a week.

3.5. End of therapy assessment (T1)

3.5.1. Executive functions profile

In this phase we assessed only the executive functions.

Working memory was confirmed to be adequate. Tests in inhibitory control and attentional flexibility were significantly improved ($p < 0.01$). The FIST test for abstraction and flexibility resulted in the lowest limit of the norm (below 1 sd).

3.6. Follow-up (T2)

Following an interval of 5 months an assessment was made to ensure the stability of the training effects in time.

The child was more cooperative when a cognitive assessment on the Wechsler scale, WPPSI (Italian adaptation by Orsini and Picone, 1996) was administered. IQ (total) results were in the low limit of the norms (85). Probably these data underestimate his actual cognitive abilities, as he tended to give impulsive and persevering responses. Grammatical verbal comprehension was confirmed as a stable strength area despite his attentive difficulties.

3.6.1. Executive function profile (T2)

As in T1, abstraction and flexibility resulted in a low limit of the norm. A test on inhibitory control confirmed the positive and stable evolution achieved in this area: the child produced more than 6 correct responses in a row in 15 trials. Table 1 show the rates achieved by the participant the three assessments. Scores are represented as a percentage estimate of the normative sample with respect to the subject's score.

The significance of the results was verified using the Crawford and Howell test (1998) (1 tail; $p < 0.01$) that analyses statistic differences between the score of the subject and the control sample considering average score and standard deviation.

Table 1. Data (percentage rates) control sample rates below subject's score

	INHIBITION CONTROL	FLEXIBILITY MAGNETS PATTERN-MAKING TASK	FIST ABSTRACTION	FIST FLEXIBILITY	WORKING MEMORY
T0	0	1.4 *	Not assessable	Not assessable	34,68
T1	2	13.04	18.51	38.47	50
Follow-up	2	11.78*	4.81*	19.78	47.83

* 1 tail $p < 0.01$ Test of Crawford (Crawford & Howell, 1998) Italian normative data (Stievano et al., 2005).

T0 (Initial assessment).

T1 (Second assessment).

T2 (Final assessment).

FIST (Flexible Item Selection Task; Jacques & Zelazo, 2001).

Attentional flexibility evaluated with pattern-making task and with FIST led to significant differences confirmed by Crawford test.

Results of the first task underline an important compromise ($p < 0.01$) of the ability in T0 and in the follow-up, but not in T1.

FIST results do not show significant differences from the control group in all assessments. Abstraction variables in the FIST test could be linked to a capacity to detect perceptive differences in the various configurations. This ability is highly influenced by selective visual attention. T0 and T1 results were compared to normative data relative to 3-year-old children, T2 results with 4-year-olds. EF development significantly changed, improving their performances, between the ages of 3 and 4 (Stievano et al., 2006) determining a specific evolutionary trajectory. The data analyses from the 3 assessments showed that, in spite of the treatment, this significant increase did not take place.

3.6.2. Emotional and behavioural profiles

Clinical observation indicated a reduction of hyperactivity and inattentiveness.

The SDQ questionnaire results showed some improvements. Only hyperactivity and inattention resulted on a pathological scale, but at a lower rate. Emotional and social behaviour were confirmed to be adequate. The total scores changed placing the child in the borderline area.

Table 2. SDQ – the Strengths and Difficulties Questionnaire (Goodman, 1997): rates in T0 and T2

	T0 (MARCH 2006)	T2 (FOLLOW-UP) (SEPTEMBER 2006)
Total difficulties score	26 (pathologic)	14 (borderline)
Emotional symptoms scale	3	2
Conduct problem scale	9 (pathologic)	3 (borderline)
Hyperactivity scale	10 (pathologic)	7(pathologic)
Peer problem scale	4 (pathologic)	2
Prosocial scale	6	7

4. DISCUSSION

Neuropsychological literature has described inhibition control defiance in ADHD children and compromised flexibility in autistic spectrum disorder subjects (Pennington & Ozonoff, 1996). However, the case studied here presents a compromised flexibility in an ADHD child along with inhibitory control deficit.

The comparison of the three assessment procedures confirmed the efficacy of the training independently of maturational aspects. After the training a significant improvement in inhibitory control and flexibility/abstraction were confirmed even though flexibility was still atypical. No significant improvements took place between the assessment at the end of the therapy and the follow-up.

4.1. Ecological impact of the treatment

Positive ecological impact of the training was confirmed by parents, teachers and SDQ questionnaire. Especially the use of language in behaviour regulation brought about important improvement. Perhaps, the skills taught in a controlled setting with a high degree of environmental support provide the evidence of the effects in developing adaptive interventions for children with disorders of executive functions. This paper could be considered an example of a program to teach problem solving using language mediation and considering specific neuropsychological processes that can be taught either through clinical or school special education programs. This treatment could provide the child who has an executive function disorder, with sufficient skills to enable generalization beyond the specific clinic setting in which the skills are taught. Once the child has learned a series of specific procedures for adaptive of executive thinking, she or he could often use procedures to inhibit impulsive behaviour and become more flexible.

The case described here in this paper underlines the utility of neuropsychological assessment that comprises an assessment of executive functions, in preschool age children with behavioural difficulties.

Meta-cognitive abilities, such as language and self-regulation allow the child to overcome specific difficulties in weak neuropsychological processes.

The assessments carried out in different times gave a broad vision of the evolution that took place in accord with developmental neuropsychology, where the analysis of developmental trajectory is considered crucial.

The approach used in this case might be considered (over-)simplified and mechanical compared to other educational approaches. The partiality of

the analysis and rehabilitation procedures, considering the high complexity of psychical processes, could be considered not adequate. However, if we contemplate that the use of language, as a behavioural regulator, is commonly found in other pedagogic approaches that do not stem from neuropsychological rehabilitation we can consider this approach correct and complementary to other educational methods for children like the one described in this study.

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