QUALITATIVE NEUROPSYCHOLOGICAL ASSESSMENT
IN CHILDREN WITH ATTENTION DEFICIT DISORDER

ABSTRACT

Backgrounds. The syndrome of attention deficit disorder is one of the most frequent types of disabilities in pre-scholars. The present study analyses the results of fulfilment of tasks of qualitative neuropsychological assessment in Mexican children with and without diagnosis of attention deficit disorder. Methods. The sample includes fourteen children with attention deficit disorder. The control group of sixteen normal children of the same age and the same social level took part in the study. All children assisted kindergartens and were between 5 and 6 years old. Neuropsychological qualitative assessment was applied to all children in order to characterise functional features of execution of the tasks. Results. The most significant differences between two groups were obtained for the functions of voluntary regulation of activity and spatial functions. Examples of fulfilment of tasks of neuropsychological assessment are presented together with some criteria for qualification of difficulties. Our results permit to complete clinical comprehension of syndrome of attention deficit disorder from neuropsychological point of view. Discussion. Our discussion establishes the necessity of concrete qualitative interpretation of results of neuropsychological assessment according to the concept of brain mechanisms considered in neuropsychology.

INTRODUCTION

The syndrome of attention deficit disorder is one of the most frequent clinical pictures in pre-scholars [1][2][3][4]. Significant percentage of learning disabilities in primary school is related to this syndrome in different countries. Different researchers try to discover the mechanisms and causes of the syndrome of attention deficit disorder from different scientific disciplines. Genetic, prenatal and postnatal pathologies, neurobiological, neuromorphological, neurophysiological, alimental and social factors can be mentioned among these causes [5][6][7]. At the present moment it is difficult to
find unanimous opinion between specialists in relation with mechanisms and causes of the syndrome [7][8].

According to our opinion, one of specific goals of child neuropsychology, in this field, is to characterise and precise functional participation of brain cortical and subcortical mechanisms, which underline difficulties in learning disabilities and different developmental syndromes. Such mechanisms are understood as components of complex brain distributed functional systems, which take part in realization of different actions during diverse periods of development[3][8]. This point of view is related to the tradition of qualitative assessment and description of development difficulties in cultural and historical conception of development and differs strongly from psychometric and psychiatric assessment and cognitive interpretation based on direct localization of symptoms [9][10].

Some efforts have been done in this direction. For instance, it was found that not only frontal zones are responsible for the syndrome of attention deficit disorder, but also other functional brain systems[9][10].

Recently, neuropsychological assessment has become a part of analysis of causes of the syndrome of attention deficit disorder together with medical, psychiatric and behavioural assessment. Some authors mention that the possible neuropsychological mechanism might be related to insufficient regulation and voluntary control and dynamic alterations in superior psychological functions [11]. Other researchers [6] have established four variants of neuropsychological defects in 28 children with diagnostic of attention deficit disorder and hyperactivity: 1) retardation in the formation of dominance of left hemisphere and of cortical-subcortical regulation (42% of subjects); 2) dysfunction of right hemisphere in right-handed children (20% of subjects); 3) dysfunctions of posterior zones of both hemispheres and of frontal zones (29% of subjects); 4) insufficient selective work of frontal lobes (9% of subjects).

Frequently, it is suggested that insufficient functioning of frontal lobe of both hemispheres can conduce to clinical picture of attention deficit disorder [12]. In is important to mention that such is predominant opinion, which was not changed in recent literature [13]. However, it is possible to find another point of view and opposition to this traditional relation between attention deficit disorder and frontal orbital lobes [14]. For
instance, some papers have stressed that a part of group of children with hyperactivity syndrome present low level of general regulation and level of brain activation[15].

Our own previous studies showed that the most frequently affected brain factors in children with attention deficit disorder are programming and control, kinetic motor organisation of movements and actions and spatial functions [16][17][18]. It was shown that, in different ages during ontogenetic development, different brain mechanisms might be responsible for children’s difficulties and that the problem consists not only on some kind of alterations or dysfunction of cortical frontal lobes.

Studies dedicated to qualitative neuropsychological assessment have pointed out that each age of psychological development has its own specific features. For instance, in pre-school age the clinical picture includes a lot of different symptoms, which may not be reduced to only one brain mechanisms as frontal lobes functioning. These symptoms include difficulties with programming and control of voluntary activity, kinetic motor organisation of movements and actions with objects, complex spatial functions of orientation (analysis and synthesis) and the level of general cortical activation of activity. Participation of spatial functions in the syndrome of attention deficit disorder at pre-school age, the age before children start formal school education and assist kinder gardens, with children from 5 to 6 years old who received diagnosis of attention deficit disorder, was really an interesting point, because these difficulties are not usually noticed in children with diagnosis of attention deficit disorder [17]. Such functional deficits conduct to low level of voluntary activity, serious difficulties with self-regulation and to absence of psychological readiness for school. Graphic actions (drawing) show also very low level of development. This clinical constellation of difficulties with both self-regulation and spatial organization is typical and was described in 25 Mexican and 25 Russian pre-scholars in comparison with same quantity of normal children of same age [8].

In next psychological ages, as ages of school learning, from 6 to 12 year old, another combinations constellation of functional deficits was fond. For example, in first three years of primary school, at the age between 6 and 9 years old, at least four variants of difficulties from neuropsychological point of view were observed: 1) predominant deficit of programming and control, 2) low level od general brain activation;
3) deficit of spatial functions and 4) combination of deficit of programming and control and low level of brain activation [10][19]. The authors do not insist that these are the only possible variants, which might be found in children who receive diagnosis of attention deficit disorder. The important point for us is that there are definitely different variants of this syndrome, which might not be explained only using the term of executive functions or frontal dysfunction as it states in literature usually[2][4][7].

Another interesting fact is that detailed analysis of group of Mexican children of school age with low level of general brain activation has shown that some of these children might receive diagnosis of attention deficit disorder by child neurologist [20]. It is obvious that their difficulties were different in comparison with children how showed problems with self-regulation or in spatial organization. However, all of them receive same diagnosis: attention deficit disorder.

From this point of view, the methods of correction have to correspond to functional brain mechanisms identified during neuropsychological evaluation. In the opinion of some authors, the diagnosis of syndrome of attention deficit disorder or of minimal brain dysfunction does not show true mechanisms of the defects [8]. Such term seems to be too general and doesn’t permit to differentiate specific cases of children who present any kind of motor problems or hyperactivity on the bases of brain damage or other kinds of developmental problems.

The objective of the present study is to show the differences in neuropsychological qualitative assessment of Mexican pre-schoolchildren from 5 to 6 years old with and without attention deficit disorder.

**METHOD**

Our study represents qualitative description of clinical manifestations of functional difficulties presented by children with diagnosis of attention deficit disorder in comparison with normal children of same age and same social and cultural living conditions in Mexico. No kinds of statistical or psychometric tests were applied for the assessment. The goal of the assessment was to characterize strong and weak cortical and subcortical mechanisms of brain functioning according to systemic and functional analysis of their participation in psychological actions. Such kind of
analysis was proposed by Luria’s qualitative neuropsychological approach [8][13]. The method of syndromic functioning analysis consists of identification of types of errors and difficulties, which might be detected during assessment. The errors and difficulties appear when the adult collaborates with the child asking him/her to fulfill different kinds of tasks: independent drawing, coping tasks, naming, playing, using objects and so on. The neuropsychologist analyses these difficulties and relates them to functional state of different brain cortical and subcortical levels. Such procedure permits to establish typical kinds of fulfillment of different tasks of neuropsychological assessment and to describe participation of brain functional systems in children’s actions [10][18].

Subjects.

The total of 30 children of pre-school age was included in the study. Two groups of pre-scholars were conformed for the study: children with diagnosis of attention deficit disorder (N=14) and control group (N=16). Fourteen pre-school children with diagnostic of attention deficit disorder were selected for the study. The age of the children was from 5 to 6 years and the average age 5.27. Sixteen regular children with no kind of developmental or behavioural difficulties or learning disabilities from the same socio-economic background and of the same age participated as control group. The average age for the control group was 5.61.

All children from both groups assisted third grade of urban kindergartens of the city of Puebla, Mexico. The children had no neurological or psychiatric disturbances in their history. Attention deficit disorder was established by an external specialist in accordance with interview procedure. The children presented no other kinds of developmental problems or medical syndromes with the exception of attention deficit disorder established by an external specialist (child neurologist). All of them presented symptoms of attention deficit disorder. Children from control group didn’t present such symptoms neither learning disabilities.

Material. The Breath Neuropsychological Scheme for Children created according to linguistic features of Spanish language and psychological features of pre-school age (from 5 to 6 years) has been applied for assessment[21]. The Scheme bases on
Luria’s neuropsychological approximation for diagnostics and the methods of neuropsychological assessment in children [22][10][18]. The Scheme was designed by the authors of the article and is broadly used for qualitative neuropsychological assessment in countries of Latin America. The tasks of Scheme are created according to the psychological possibilities of Mexican children of pre-school age (between 5 and 6 years). The Scheme implies qualitative analyses of the process of execution of the tasks in order to establish correlation with the functioning of cortical and subcortical brain systems and doesn’t pretend to give any kind of quantification.

In this study we report only results of assessment of brain mechanisms identified as essential for clinical picture of attention deficit disorder, such are: programming and self-control of voluntary activity and spatial functions of synthesis and analysis. The tasks for programming and control characterise participation predominantly of frontal cortical and subcortical structures, while the tasks for spatial functions characterise mostly participation of posterior parietal, occipital and temporal zones (TPO).

The tasks for assessment of the functioning of neuropsychological brain mechanisms of programming and control included the following items: 1) manual co-ordination; 2) co-ordination of digits; 3) copy and continuation of graphic sequence; 4) verbal conflictive task presented in form of a game. The tasks for assessment of spatial functions include the following items: 1) copy of the house and 2) free drawing of boy and girl [21]. All tasks were accessible for regular population of children of the age from 5 to 6 years old.

Procedure.

The children from the group with diagnosis of attention deficit disorder and from control group submitted to qualitative neuropsychological assessment. The assessment was individual with each child with the duration of 50 minutes.

The tasks of manual co-ordination and co-ordination of fingers imply execution of sequence of movements by a child following the motor model of hand movements shown by an adult. The instruction for the task is: “See how I move my hands (fingers) and do same movements as I do”.
The task for copy and continuation of graphic sequence implies the coping and independent drawing of the model on the sheet of paper by pencil (Example 1).

Example 1. Graphic sequence.

In the verbal conflictive task, the child has to hit once on the table if he or she hears the word “red” and has to hit twice on the table if he or she hears the word “white”. The adult pronounces the verbal sequence of sentences:

*The hills are covered with white snow.*

*The boy plays with red ball.*

*In the morning the sky is blue.*

*The girl has the red bowl.*

*The flowers in the vase are white and red.*

The task of copy of the house implied the observation of the model and coping of the same model (Example 2). The instruction is: “Look at the house and draw the same exact house” on this paper with the pencil.

Example 2. Model of the house.
The task of free drawing of “boy” and “girl” consisted of independent drawing by the child without any model. The instruction was: “Draw on the paper a girl (and afterwards, the boy) as you like. Please, explain, where is the girl and where is the boy and why”.

**Analysis of results of execution of the tasks.**

All the tasks were marked (qualified) from 1 to 4 according to presence and absence of difficulties and the possibility to notice own mistakes: 1 - correct execution (absence of difficulties); 2 – mistakes and execution with self correction; 3 – severe difficulties with constant mistakes without self correction; 4 – total impossibility of execution and absence of self correction.

**RESULTS**

The results have pointed out differences in execution in both groups of children. The majority of children with attention deficit disorder have shown impossibility for the execution of all the tasks related to the functioning of regulation and control (frontal lobes) with the exception of the item of coordination of fingers, where the difficulties were not so severe. The execution of this task was possible, however, only one child was able to fulfil this task without mistakes. **Neuropsychological assessment** pointed out severe difficulties in the tasks related to functioning of regulation and self-control and spatial functions [18].

The task of copy and continuation of graphic sequence and verbal **conflict** task (game with instructions) resulted to be the most difficult tasks for children with attention deficit disorder. Examples 6, 7, 8 and 9 show the execution of the task of copy and continuation of graphic sequence by two subjects with attention deficit disorder and two children from control group.

The tables 1 and 2 show that the majority of children from control group were able to realise the task from the first attempt (coordination of fingers) or with self-correction (manual coordination and sequence). The verbal conflictive task was too difficult for
78.57% children with attention deficit disorder and for 12.50% of the children from control group.

Table 1. Execution of tasks for frontal lobes by children with attention deficit disorder (%)

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Manual coordination</th>
<th>Coordination of fingers</th>
<th>Sequence</th>
<th>Conflicitive task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.00</td>
<td>7.14</td>
<td>0.00</td>
<td>7.14</td>
</tr>
<tr>
<td>2</td>
<td>21.42</td>
<td>35.71</td>
<td>21.42</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td>57.14</td>
<td>35.71</td>
<td>71.42</td>
<td>78.57</td>
</tr>
</tbody>
</table>

Table 2. Execution of tasks for frontal lobes by control group (%)

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Manual Coordination</th>
<th>Coordination of fingers</th>
<th>Sequence</th>
<th>Conflicitive Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>43.75</td>
<td>62.50</td>
<td>18.75</td>
<td>12.50</td>
</tr>
<tr>
<td>2</td>
<td>50.00</td>
<td>31.25</td>
<td>56.25</td>
<td>37.50</td>
</tr>
<tr>
<td>3</td>
<td>6.25</td>
<td>0.00</td>
<td>25.00</td>
<td>43.75</td>
</tr>
<tr>
<td>4</td>
<td>0.00</td>
<td>6.25</td>
<td>0.00</td>
<td>12.50</td>
</tr>
</tbody>
</table>

The analyses showed that the average of perseveration during the execution of all the tasks per subject is 6.2 in children with attention deficit disorder and 2.68 in normal children.

The statistical analyses (Mann-Whitney U Test) of the results showed significant differences between the execution of the children with attention deficit disorder and control group in all tasks related to functioning of the frontal lobes: manual coordination - P = < .000; coordination of fingers – P = < .001; sequence - P = < .000; verbal conflicitive task - P = < .000 (Figure 1).

Figure 1. Execution of the tasks for frontal lobes of both groups (average)
Example 6. Task of copy and continuation of the sequence.
Subject C.C. (control group)

Example 7. Task of copy and continuation of the sequence.
Subject J.J. (control group)
Example 8. Task of copy and continuation of \textit{graphic} sequence.
Subject C.R. (attention deficit disorder)

Example 9. Task of copy and continuation of \textit{graphic} sequence.
Subject E.F. (attention deficit disorder)

The results of the execution of the tasks related to the functioning of the posterior zones (parietal, occipital and temporal zones) of both hemispheres, responsible for spatial functions, have shown the following. None of the children with attention deficit disorder was able to complete this task appropriately. For the majority of the children, this task was impossible (80% of the subjects). The same phenomenon was observed in the task of the free drawing of boy and girl (table 3). Normal children also have difficulties in these tasks, however the percentage of impossibility is much lower than in children with attention deficit disorder.

Some of the typical characteristics of drawings of children with attention deficit disorder are: transparent house (in 57.10% of the cases), absence of necessary details (in 100% of cases), difficulties with the distribution of the picture on the paper (in 93.33% of the cases) and images difficult to recognise (in 42.80% of cases). The mentioned problems can manifest difficulties with posterior zones of both hemispheres (Stiles & Thal, 1993). The execution could be compared to ones of patients with brain damage in posterior parietal, occipital and temporal (TPO) zones.

Normal children neither present perfect pictures, but their executions might be characterised as moderate mistakes with essential details of images (68.75% of cases) and difficulties with the distribution of the picture on the paper (in 81.25% of the cases). Transparent images were not observed, nor the difficulties with recognition of their pictures.
The examples 10, 11, 12, 13, 14, and 15 show the fulfilment of the tasks of copy of the house and drawing of boy and girl by subjects from group of children with attention deficit disorder and control group.

The analyses (Mann-Whitney U Test) of the results showed significant statistical differences between the execution of the children with attention deficit disorder and control group in the tasks related to the functioning of posterior zones (TPO zones): copy of the house - \( P < .001 \) and free drawing \( P < .000 \) (Figure 2).

Table 3. Execution of tasks for posterior zones by children with attention deficit disorder and children from control group (percentage).

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Copy of a house (attention deficit disorder)</th>
<th>Copy of a house (control group)</th>
<th>Free drawing (attention deficit disorder)</th>
<th>Free drawing (control group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00</td>
<td>6.25</td>
<td>0.00</td>
<td>6.25</td>
</tr>
<tr>
<td>2</td>
<td>0.00</td>
<td>37.50</td>
<td>0.00</td>
<td>37.50</td>
</tr>
<tr>
<td>3</td>
<td>20.00</td>
<td>43.75</td>
<td>20.00</td>
<td>43.75</td>
</tr>
<tr>
<td>4</td>
<td>80.00</td>
<td>12.50</td>
<td>80.00</td>
<td>12.50</td>
</tr>
</tbody>
</table>

Figure 2. Execution of the tasks for posterior zones of both groups in two tasks (average of total impossibility)
Example 10. Copy of the house.
Subject A.L. (control group)

Example 11. Copy of the house.
Subject P.S. (control group)
Example 12. Copy of the house.  
Subject A.K.M. (attention deficit disorder)

Example 13. Copy of the house.  
Subject B.S. (attention deficit disorder)
Subject P.S. (control group)

Example 15. Free drawing.
Subject B.S. (attention deficit disorder)

boy
girl
DISCUSSION

Our results have shown significant differences in execution of the tasks commonly used in neuropsychology for functioning of frontal cortical and subcortical structures and posterior zones by children with attention deficit disorder and children from control group. According to the literature, frontal lobes and posterior zones represent brain formations of great complexity in their structure and functioning [23][24][25][26][27][28]. These zones are extremely sensible for negative social and organic influence and present complex process of systemic maturation [29].

The functions of frontal lobes are related to the self-control, programming and regulation of voluntary and conscious activity and with personality in general. Some authors write that insufficient functional development of frontal lobes can be related to specifics variants of learning disabilities [30][31][32]. For example, such mistakes in writing as perseverations, anticipations and repetitions of letters, words or parts of letter and words are called as regulative disgraphy or regulative difficulties during acquisition of writing process at school [33]. The absence of orientation, which guarantees the strategy of reading, attention and understanding of complex grammar structures is one of the main obstacles for normal acquisition of reading [34]; the same type of difficulties can be found in assimilation of mathematics and problem solution [35].

Such difficulties are related to two neuropsychological factors or mechanisms, which are related to functioning of anterior cortical and subcortical structures: 1) serial organisation of actions and movements and 2) programming and control of voluntary activity. Satisfactory functioning of both factors is necessary for adequate development of a child during pre-scholar infancy. Insufficient serial organisation in speech conducts to reduction of vocabulary, semantic structure and grammar and to difficulties with comprehension of sense of texts and own construction of complex sentences and texts [36].

It is broadly known in neuropsychology that the mechanisms of spatial analysis and synthesis, related to posterior brain zones, are necessary not only for space and corporal orientation, but also for such activities as drawing, writing, reading and mathematics [34]. Some studies have shown that the organisation of material on paper depends on appropriate functioning of posterior zones of right hemisphere [37].

According to our results, children with attention deficit disorder showed poor execution in the tasks, which required participation of the factors of serial organisation, control and programming and space factors. It is possible to suppose that they might have difficulties in future process of school learning.

We have to stress that the children from the control group do not show complete development of the mentioned functions according to their results. This date can
probably reflect heterogeneous character of development of psychological functions [38][39][13]. However, in comparison with the children with attention deficit disorder, normal children of the same age are able to correct their own mistakes. At the same time, the index of impossibility is significantly lower. **This fact proves the statement that complete favourable formation of voluntary activity takes place during initial school age in the conditions of external organisation and planning of child’s activity of acquisition of basic scientific concepts guided by teacher**[40][41]. We might think that this process lasts during the whole period of school education, from the age of 6 to 12 years and even later.

One of the most difficult tasks for children with attention deficit disorder was the verbal conflict task. According to some authors, such tasks are the most sensible for the prediction of the result in learning activity during school age [41].

As for spatial functions, according to our data, it might be concluded that none of the studied children from both groups has developed the habits of drawing and objects representation. At the same time, children with attention deficit disorder present particular severe difficulties as complete impossibility of drawing or copying of perceptive models of known simple objects. We suppose that mistakes of normal children are related to poor practice and absence of external organisation and orientation from adults during realization of such types of activity. In their case, we may say that the level of development of graphic activity is low. As for the children with attention deficit disorder, the problems are much more severe and show, together with the absence of exercising, functional retardation of posterior brain zones.

Our study has revealed significant differences in fulfilment of the tasks for frontal lobes between normal children and children with attention deficit disorder. Other studies report that children of the age of 6 years make mistakes in the tasks for serial organisation of movements (manual coordination) and this date by itself cannot serve for definite prognosis and should be contrasted and compared to other characteristics of execution in other tasks of assessment. According to this consideration, we propose to take into account several indexes during qualitative neuropsychological assessment of children of pre-school age as: 1) difficulties with self regulation and control of activity; 2) motor difficulties in the tasks for sequential organization of movements and 3) problems with space organization and distribution of the elements in drawing tasks.

**Low functional level of anterior and posterior cortical and subcortical structures** observed in children with attention deficit disorder confirm the necessity of elaboration of special programmes of correction, which has to include development and formation of correspondent neuropsychological factors[18]. Such factors are programming and control and spatial organization of orientation,[23][24][25][26][27][28]. The absence of orientation is one of the main obstacles for normal acquisition of reading [34] and mathematics and problem solution [35]. Space factors are necessary not only for space and corporal orientation, but also for such activities as drawing, writing, reading and mathematics [34]. According to our findings, it is important to prevent learning disabilities in children with attention deficit disorder by elaboration and application of
appropriate methods [42][43][44]. The period of pre-school education might be the appropriate period for prevention and application of correspondent methods favourable for psychological development.

The results show that difficulties presented by children at the age of 5 and 6 years with diagnosis of attention deficit disorder might not be related to only one brain mechanism and might not be explained as only problems of regulation. Regulation problems are definitely present in the children, but the do also have severe problems of spatial organization and orientation. When specialists apply only psychometric tests or questions from manuals DSM-IV [45] or DSM-V [46] so commonly used in countries of Latin America, no specific clinical feature might be noticed. Psychometric tests don’t help for understanding of correlation between kinds of mistakes or difficulties and brain functioning participations, while questions for parents and teachers don’t consider real abilities and disabilities of children with developmental problems. The methods of qualitative neuropsychological assessment should be known and taken into account as one of the possibilities of clinical study of children with difficulties. The data of qualitative assessment might help to establish the paths and strategies of correction and organization of teaching at school and day-to-day life of the child. On the contrary, psychometric assessment might normally help only for formal terms of diagnosis.

CONCLUSIONS

1. The children with attention deficit disorder have shown impossibility for fulfilment of the majority of the proposed tasks in comparison with children from control group.

2. The most difficult tasks for children with attention deficit disorder were verbal conflict task, copy and continuation of the sequence, copy of the house and free drawing of boy and girl.

3. Children from control group make certain mistakes on these tasks, but they tended to correct them independently.

4. Neuropsychological mechanisms of regulation and control and spatial orientation take part in the clinic picture of attention deficit disorder at preschool age.

5. There is no only brain mechanisms or cause in the cases of attention deficit disorder in children at the age from 5 to 6 years.
REFERENCES


