Reaction time assessment in children with ADHD

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ABSTRACT
Attention deficit, impulsivity and hyperactivity are the cardinal features of attention deficit hyperactivity disorder (ADHD) but executive function (EF) disorders, as problems with inhibitory control, working memory and reaction time, besides others EFs, may underlie many of the disturbs associated with the disorder. **Objective:** To examine the reaction time in a computerized test in children with ADHD and normal controls. **Method:** Twenty-three boys (aged 9 to 12) with ADHD diagnosis according to Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, 2000 (DSM-IV) criteria clinical, without comorbidities, Intelligence Quotient (IQ) ≥ 89, never treated with stimulant and fifteen normal controls, age matched were investigated during performance on a voluntary attention psychophysical test. **Results:** Children with ADHD showed reaction time higher than normal controls. **Conclusion:** A slower reaction time occurred in our patients with ADHD. This findings may be related to problems with the attentional system, that could not maintain an adequate capacity of perceptual input processes and/or in motor output processes, to respond consistently during continuous or repetitive activity. **Key words:** ADHD, executive functions, inhibitory reaction, reaction time and working memory.

Avaliação do tempo de reação em crianças portadoras do transtorno do déficit de atenção/hiperatividade (TDAH)

RESUMO
Déficit de atenção, impulsividade e hiperatividade são os pontos cardinais do transtorno do déficit de atenção/hiperatividade (TDAH), mas as desordens da função executiva (FE) tais como os problemas no controle inibitório, memória operacional e tempo de reação, dentre outras funções executivas (FEs) podem estar subjacentes a muitos distúrbios associados a esta desordem. **Objetivo:** Avaliar o tempo de reação em meninos portadores do TDAH. **Método:** Participaram 23 pacientes do sexo masculino, de idade entre 9 a 12 anos de idade, com diagnóstico de TDAH sem co-morbididades, estabelecido segundo os critérios do Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM-IV), com Quoeficiente Intelectual (QI) ≥ 89, que não tivessem sido medicados para o TDAH. Grupo controle, seguindo os mesmos critérios em relação ao sexo, idade, QI. O teste utilizado foi o teste psicofísico da atenção voluntária (TPAV). **Resultados:** Os pacientes do TDAH apresentaram maior tempo de reação na execução do teste em relação aos controles. **Conclusão:** O tempo de reação apresentou-se mais longo em nossos pacientes portadores do TDAH. Estes achados podem estar relacionados aos problemas do sistema atencional; este grupo não pôde manter uma adequada capacidade de percepção de dados processados e/ou, em responder regularmente durante atividades contínuas ou repetitivas. **Palavras-chave:** TDAH, funções executivas, inibição de resposta, tempo de reação e memória operacional.
Attention deficit hyperactivity disorder (ADHD) is characterized by the combination of attention deficit, hyperactivity and impulsiveness, and is the most commonly diagnosed behavioural disorder of childhood. An estimated 3% to 6% of our children and adolescents present such disorder, which interferes in their family, school and social environments, as well as in their school achievement and emotional and affective development. The ADHD diagnosis is fundamentally clinical, based on clear and well defined operational criteria, deriving from classification systems such as Diagnostic and Statistical Manual of Mental Health Disorder, Fourth Edition, 2000 (DSM-IV).

ADHD can be considered a neurobiological disease with alterations in some brain areas and associated circuits. The main affected brain regions are the prefrontal and parietal cortex, the cerebellum, basal ganglia and the associated circuits, which imply in an alteration of the inhibitory control, working memory, reaction time, besides others executive functions.

Reaction time is the period between the emerging of the target stimulus and the subject's motor response, i.e., it is the behavioural measurement that the subject can demonstrate their capacity to process the information. In this type of evaluation, only the correct answers are considered.

The aim of this study is assess the reaction time in children with ADHD and normal controls through a visual voluntary attention psychophysical test (VVAPT), especially focusing on the reaction time measures. This experiment was performed to assess the voluntary attention using the reaction time assessment through a computerized test.

**METHOD**

The participants were boys with ADHD combined type, ages 9 to 12, without comorbidities, clinical diagnosis according to DSM-IV criteria, IQ≥89, never treated with methylphenidate and who were followed-up in the outpatient clinic for ADHD at the Central Institute’s Infant Neurology Service and at the Children’s Institute of the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP). The control group followed the same criteria for gender, age and IQ. This research was approved by the Ethical Committee and by the Board of the Neurology Department and the Division of Psychology of the Central Institute of HCFMUSP and all the caregivers signed the informed consent.

This task was done using the “Micro experimental Laboratory- Mel” (Mel professional v 2.01- Psychology Software Tools, Inc). This software modifies the input and output systems of the computer, allowing registration of reaction time in milliseconds. The tests were administered in a PC (IBM compatible) with a 15” screen. A joystick was used as interface between patient and computer screen. The battery administration lasted an average of 30 minutes. Initially, the participant was instructed to pay attention to an informative cue that was a cross (fixation point) (Fig 1). It was presented on the center of the computer screen and each participant should stare at throughout the test. After an interval of 700 ms an arrow / pointer is presented which indicates, with a validity of 70%, the appearance of the target (square) to the correct side (the test is constituted of three blocks, which the arrow pointed to the right, left, fixed and alternated respectively). After an interval of 800 ms, a square is presented for 17 ms and, when noticing it, the participant must respond by pressing the frontal button of a joystick with the index finger of their dominant hand, as quick as possible. There are two different situations for the appearance of the target. In the first situation, the arrow/pointer and the
square appear on the same direction (valid condition and probability of 70%) and in the second situation the arrow /pointer and the square appear on opposite sides (invalid condition and probability of 30%). Before this procedure, it was done a training session with the joystick to guarantee the reliability of the results, because it minimizes the possibility of low performances due to low familiarity with the tools.

To ensure that each response represented a true response to the stimulus, only accurate responses occurring between 150 msec and 1000 msec after target onset were analyzed. We hypothesized that an invalid cue would cause a larger increase in RT in the ADHD patients compared to the control groups which would not differ from each other.

The Mann-Whitney, a non parametric-test for related samples was used in the analysis of the results. The adopted level of significance was 5%.

**RESULTS**

The children with ADHD showed reaction time significantly higher than normal controls in VAPT. The results and mean values for reaction time of performance on this test are showed in Table. When the arrow/pointer appeared on the opposite side (invalid condition) the results were worst for the both groups (Fig 2). There were not difference between the groups in the reaction time when the arrow/pointer to the right, as a valid condition.

**DISCUSSION**

We used the VVAPT experiment with the aim to study the reaction time. Psychophysical is a quantitative
The cognitive-energetic model of Sergeant, emphasizes the importance of the “arousal” and “activation” systems, which control the stimulus perception and production of response, respectively. According to this author, these two processes are maintained and modulated by a third process, “effort” system, which is defined as the energy required to perform the demands and would be related to motivation of the individual. The “arousal” system was associated with the processing of the stimulus and would be highly influenced by the intensity and novelty of it. The “activation” system would be more related to readiness to respond and is strongly influenced by task variables such as preparation, alertness, time of day and time on task.

According some authors deficits in the readiness, organization and monitoring of the responses were more evident in children with combined subtype of ADHD, while losses in the ability of detection and orientation to the stimuli were related to children with predominantly inattentive ADHD. In our opinion, the patients with ADHD combined presents difficulties with the two systems, “arousal” and “activation” and this can be understood by the difficulty in separating the subtypes of ADHD predominantly inattentive and combined, what was also observed by others authors.

In conclusion, despite the small number of patients included in the current trial, the performance in this task of ADHD group, that had a slower reaction time, suggest that the VVAPT may be another possible test to be used in the evaluation of these patients. We understand that although the ADHD diagnostic is clinical, this type of instrument may be used at some times, to analyze attention and also the executive functions of the patients with ADHD, as it involves a series of simultaneous controls for proper response. Maybe it will be a good instrument to show in an objective way the effects of treatment in these patients.

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