

HEART AND MIND INTERACTION FOR ADHD

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Abstract. ADHD is considered one of the most common neurobehavioral disorders of childhood and among the most prevalent chronic health conditions affecting school-age children. This makes research of psychophysiological correlates of ADHD very important. The aim of our pilot study was to find out the specific aspects of autonomic regulation of a sensorimotor activity in children with ADHD. To assess objectively the functional state dynamics of the children, the technology of event-related telemetry of the heart rate was used (cogni-nn.ru, Lobachevsky State University). This technology integrates the ApWay.ru Web platform for the controlled activation of primary cognitive functions. The conducted study allowed us to reveal some specific aspects of sensorimotor activity and autonomic regulation for children with ADHD. A digital map of psychophysiological status based on the integration of indicators of sensorimotor activity and event-related parameters of autonomic regulation can be an effective tool to increase the specificity, sensitivity and reliability of the diagnosis of ADHD in children.

Keywords: ADHD, psychophysiological markers, sensorimotor activity, event-related telemetry of the heart rate (ERT HR)

List of abbreviations

ADHD – attention deficit hyperactivity disorder

RT – reaction time

ERR – error

ERT HR – event-related telemetry of the heart rate

HRV – heart rate variability

VLF, LF, HF – very low, low and high frequency bands are the power in the HRV power spectrum ranges between 0.0033 and 0.04 Hz, 0.04–0.15Hz and 0.15–0.40Hz respectively

TP – total power of the variability spectrum of the R–R intervals

LF/HF – sympathovagal balance

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a childhood-onset disorder that has a relatively high prevalence worldwide, ranging from 2.2% to 17.8%. ADHD is considered one of the most common neurobehavioral disorders of childhood and among the most prevalent chronic health conditions affecting school-age children (Efron, 2015; Zavadenko et al., 2014). This makes research of psychophysiological

correlates of ADHD very important. No less significant is the autonomic maintenance of cognitive functions; therefore, the search for autonomic components of cognitive functional systems is promising (Thayer et al., 2012). Objective physiological indices of ADHD can be applied not only for preclinical diagnostics, but also for monitoring the dynamics of the state with ADHD.

The aim of our pilot study was to find out the specific markers of autonomic regulation of a sensorimotor activity in children with ADHD.

Methods

A total of 33 subjects between 5 to 11 years of age participated in the study: 11 children with ADHD and 22 children without diagnosis. To assess objectively the functional state dynamics of the children, the technology of event-related telemetry of the heart rate was used (cogni-nn.ru, Lobachevsky State University) (Polevaya et al., 2019). This technology integrates the ApWay.ru Web platform for the controlled activation of primary cognitive functions (Fig. 1).

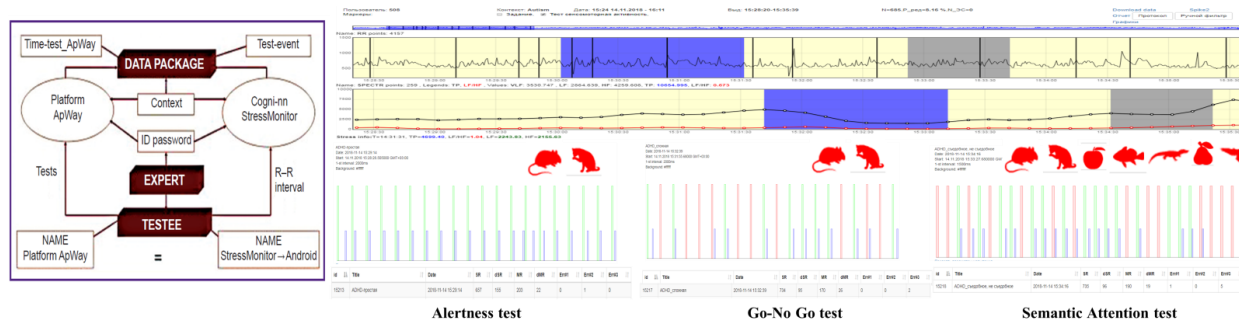


Fig. 1. Architecture of event-related telemetry technology and Web platform for the controlled activation of primary cognitive functions with three subtests (alertness test, go-no go test and semantic attention test)

To assess attention deficits, we used three subtests:

1. Alertness test: this subtest measures the RTs to simple visual target; stimulus: picture of a cat and a mouse, a total of 20 trials.

2. Go-No Go test: this subtest measures selective attention; stimulus: picture of a cat and a mouse; there are one target and one non-target stimuli, all in five positions of the screen; a total of 20 trials.

3. Semantic Attention test: this subtest measures semantic capacity; stimulus: picture of a fish, a pear, an apple, a crocodile, an eagle and a cat; target were only «edible objects»; a total of 30 trials.

The main parameters were RTs for correct responses and number of false reactions (ERR1 - event skipping, ERR2 – double or multiple click, ERR3 – clicking on a non-target stimulus).

Specific aspects of autonomic regulation of a sensorimotor activity were estimated on the base of technology of event-related telemetry of the heart rhythm (cogni-nn.ru, Lobachevsky State University). In the pseudo real time mode, the preprocessing and spectral analysis of heart rate is implemented as follows:

- the received R–R signal is «sliced» into time windows of 100 s with a time shift of 10 s;
- the spectrum of non-uniform signals is calculated for the obtained windows by the method of discrete Fourier transform;
- the spectrum is divided into ranges, and the power of each range is calculated: VLF (0.003–0.040 Hz), LF (0.04–0.15 Hz), HF (0.15–0.4 Hz);

- the derivative characteristics are calculated, namely, the total spectrum power $TP = VLF + LF + HF$ and the sympathovagal balance LF/HF .

The study fully conforms to the 1964 Declaration of Helsinki, as revised in October 2013 (Fortaleza, Brazil). All subjects or patients (or their legal guardians) signed voluntary informed consent forms agreeing to thermal imaging examination.

Results and discussion

The specificity of behavior in ADHD is manifested in parameters reflecting the cognitive component of sensorimotor activity for all tests. The motor component of sensorimotor activity corresponds to the age norm (Fig. 2).

With both primary and complex sensorimotor activity, such indicators as number of stimulus skips for ADHD children, being compared to the control group are significantly higher (Fig. 3).

The autonomic regulation of a sensorimotor activity in children with ADHD is characterized by a reduction in the central contour of heart rhythm regulation, a significant decrease in the power of low-frequency and high-frequency components of the HRV spectrum, and an increase in the autonomic balance indexes (Fig. 4).

Unlike the control group, ADHD children reveal less connected indicators of sensorimotor activity and vegetative regulation; particularly, ADHD group is lacking of HF-HF/LF

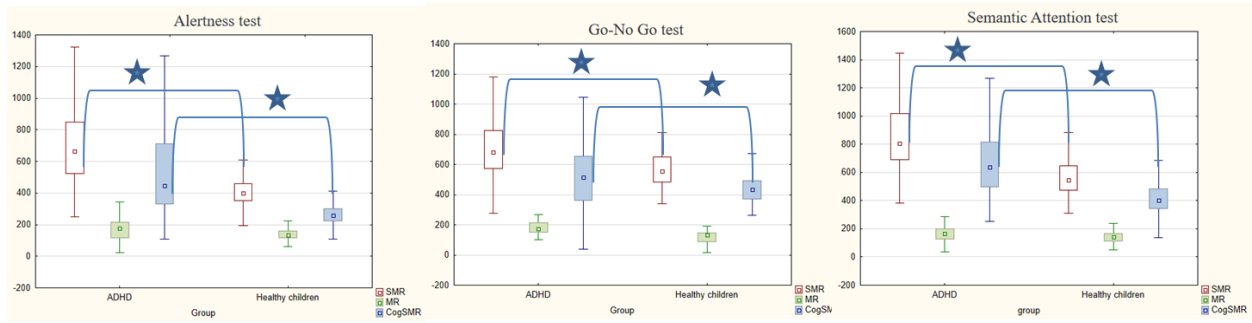


Fig. 2. The specificity of sensorimotor activity: reaction times (SMR – red boxes), key press duration (MR – green boxes) and cognitive component of sensorimotor activity (CogSMR – blue boxes) for three subtests (alertness test, go-no go test and semantic attention test) by two groups (ADHD and healthy children)

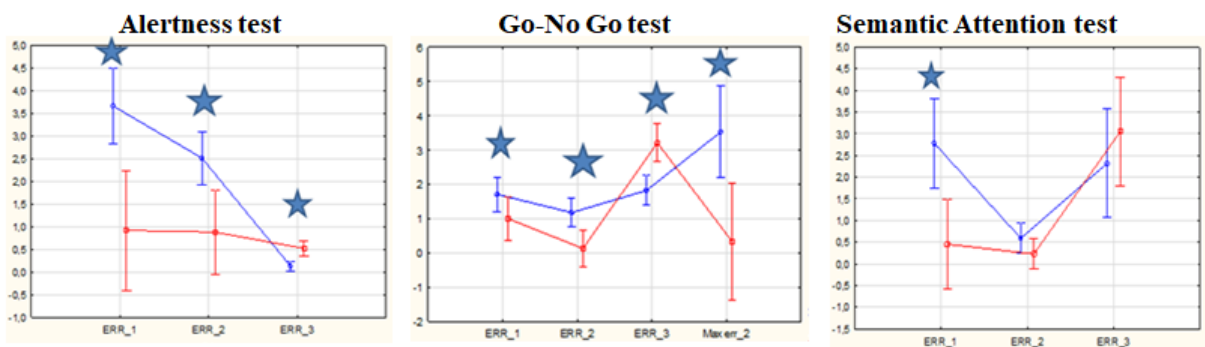


Fig. 3. Number of false reactions: ERR_1 – skipping target stimulus; ERR_2 – double tap; ERR_3 – inappropriate stimulus selection, ADHD (blue line) and healthy children (red line)

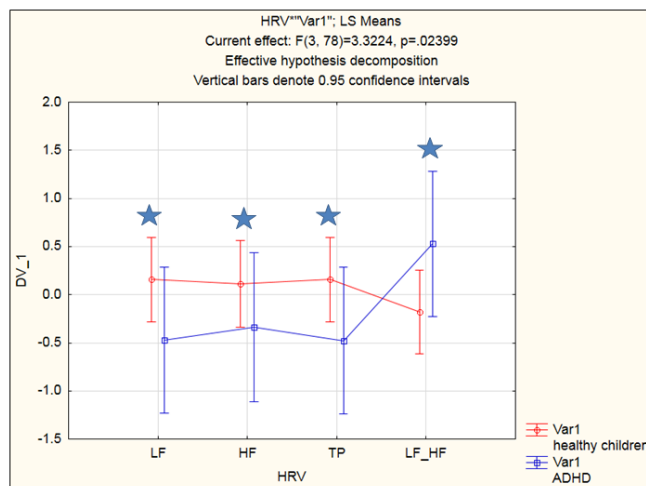


Fig. 4. Autonomic regulation of a sensorimotor activity: the power of LF (0.04–0.15Hz) range, the power of HF (0.15–0.40Hz) range, TP – total power of the variability spectrum of the R–R intervals and LF/HF – sympathovagal balance for ADHD (blue line) and healthy children (red line)

links, MR-SMR links for simple reactions, MR simple – MR complex reactions. There's a sig-

nificant link between simple MR and sympathetic NS as for the controls ($r = 0,53$) and for

ADHD ($r = 0,98$) groups, but it's much stronger for ADHD group.

Conclusion

A digital map of psychophysiological status based on the integration of indicators of sensorimotor activity and event-related parameters of autonomic regulation can be an effective tool

to increase the specificity, sensitivity and reliability of the diagnosis of ADHD in children.

Acknowledgement

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