CASE STUDY

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Neuronal, cognitive and social indicators for the control of aggressive behaviors in sport

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SUMMARY

Introduction: The goal of our research was to describe the neurophysiological and neuropsychological parameters of the control of aggressive behaviors in an athlete of world rank, a javelin thrower, who underwent neurotherapy.

Case history: The patient described here was an Olympic athlete who placed much lower than expected in the games. His mental state was measured in three respects: neuronal (using event-related potentials), social, and cognitive (using standardized tests). He then went through a program of neurotherapy; HRV biofeedback was used for ten minutes over two days, along with EEG feedback (neurofeedback) for 20 minutes. Before neurotherapy, the amplitudes of the ERPs under a NOGO stimulus (motor inhibition) were in the normal range.

Results: A high score for the control of aggression was accompanied by auto-aggression, which corresponds to cortical inhibition, and can cause negative emotions towards others to be suppressed and directed towards oneself, and thus may contribution to the creation of contusions, along with low scores for external and general aggression. After Alpha Training, the subject was quicker in reaction than the norm. The differences in the ERPs for NOGO conditions were statistically significant. These results may be an essential indicator of a high level of behavior control (not intention), including aggressive behaviors.

Keys words: aggression, sport psychology, social skills, event-related potential (ERP)

INTRODUCTION

Contemporary neuroscience is searching for interactions among three levels of analysis: the social, the cognitive, and the neuronal. On the social level, interest is focused on the interpersonal interactions that affect the behavior of individuals and groups; on the cognitive level, the mechanisms for processing the information that is used on the social level; on the neuronal level, the neuronal and neurohormonal mechanisms operative in the brain, which constitute the substrate for both the cognitive and social levels (Pąchalska, 2012, Ochsner & Lieberman, 2001; Grossmann & Johnson, 2007; Senju & Johnson, 2009; Beauchamp & Anderson, 2010; Skuse & Gallagher, 2011).

Research performed using functional techniques for brain imaging indicate that damage to particular brain regions (e.g. the medial prefrontal cortex) significantly reduces social competence, without affecting competencies in other domains. In the light of these results it turns out that many and various brain regions are involved in social skills, such as empathy (Sedikides, Skowronski & Dunbar, 2006; Dunbar & Shultz, 2007; Lieberman, 2002; Gibson, 2002).

Disturbances of social intelligence are associated with damage to the medioventral prefrontal regions of the frontal lobe, the fronto-insular cortex, and partially also the right occipital-parietal junction, the superior temporal gyrus, and the supraorbital cortex. Persons with damage of this sort display a lack in insight, lack of initiative, and an increased level of reactive behaviors, a lack of endurance, an inability to anticipate and plan, impaired judgement, lack of reaction to emotional experiences, or an excessively expressive affect (Stone 2006; Adolphs, 2001).

The basis for the kinds of aggressive behaviors known as "intermittent explosive disorder" (IED) is dysfunction of the amygdala and structures of the hypothalamus, the thalamus, and the frontal lobes (Tebartz van Elst, Woermann, Lemieux, Thompson & Trimble, 2000).

Bilateral disorders of bioelectric activity occur in patients with partial seizures and IED-type aggression. The right-sided focal disturbances visible in EEG occur less often in persons with IED. This may imply that the left hemisphere plays a larger role in the development of IED. Aggressive behaviors of this sort correlate strongly with global and verbal IQ (Herzberg & Fenwick, 1988).

The control of impulsive behavior is located in the prefrontal cortex (F7 and F8). A comparison of the crossed correlation coefficients with the SKIL data base shows disturbances in communication between the frontal and prefrontal cortex and the right temporal cortex, which may indicate a lack of control over anger (Thompson & Thompson, 2012).

The purpose of our research was to describe the neurophysiological and neuropsychological parameters for the control of aggressive behaviors on the part of an athlete of world stature, a javelin-thrower, subjected to neurotherapy.

CASE STUDY

The present study involves a male athlete, a javelin thrower, 25 years old, a member of the Polish national team at the London Olympics in 2012, considered a world-class competitor (personal best: 84.99 m, which would have brought him a gold medal in London). After he achieved this personal best, the media and sport circles exerted frequent and strong psychological pressure on him, in the form of the expectation of a medal, which brought the patient considerable stress. During the training period immediately preceding the games, he suffered an ankle contusion. Despite the pain, however, he continued to prepare for the Olympics, though he used permissible analgesics and participated in physiotherapy. A standard program of procedures was used for that purpose. Taping was also used to immobilize the joint. He attended the Olympics, but took only 22nd place, which commentators attributed to the combination of the contusion and the strong pressure he was feeling, which diminished his self-assurance and weakened his faith in success. After he returned to Poland, the patient underwent arthroscopy on 3 September 2012 and was diagnosed with "posterior conflict of the ankle joint."

At this time the patient underwent intensive, goal-directed neurofeedback training for two days, every day, after an hour of training. HRV biofeedback was used for ten minutes over two days, along with EEG feedback (neurofeedback) for 20 minutes in a bipolar assembly with electrodes at points C3 and C4, on a Thought Technology apparatus, an 8-channel ProComp Infiniti from BIOMED Neurotechnology. The training was conducted by a psychologist with an international certificate in neurotherapy from the Workshop of the Sports Neuropsychology Section of the Polish Neuropsychological Society, Jedrzej Śniadecki, from the University of Physical Education and Sport in Gdansk, Poland.

The training protocol was developed based on the results obtained by the QEEG method. The electrodes were placed according to the international 10-20 localization system. The patient was prepared for the tests in the standard manner, with the impedance of the electrodes below 5 kiloOhms. The frequency of 913 H was reinforced during the training. The patient sat in a relaxing armchair (from the NEEDO company) with a foot support to provide a comfortable body position, especially for the affected foot. The head was laid back against a headrest, while the arms were comfortably arranged on the chair's armrests. The monitor displaying the stimuli was located below the line of sight on a separate table.

This procedure was dictated by the athlete's request for immediate intervention in a difficult psychological situation after he had obtained an unsatisfactory result at the Olympics, and by the lack of any such strategic, goal-oriented program for the process of neuromodulation and renewed reintegration of cognitive control for athletes competing at the highest level of their sport.

The control of aggressive behaviors was assessed with Z. Gaś's Psychological Inventory for the Aggression Syndrome (Polish Inwentarz Psychologiczny Syndromu Agresji, or IPSA). We also used the the APIS-Z, a multi-dimensional battery that serves to measure global intelligence (Ciechanowicz, Jaworowska, Matczak & Szustrowa, 1995), with particular attention to the scales that measure the ability to understand human behaviors and to plan the effect on others in interpersonal relations. In this research project we made use of an idiographic description of the indicators of the social behavior of the individual, which is a nomothetic complement to research on behavior (Shaughnessy, Zechmeister & Zechmeister, 2006). We assumed that this idiographic research, represented by the present study, will allow for an accurate analysis and description of the individual, including the neurophysiological and neuropsychological parameters of his behavior. The scientific hypotheses that emerge from the study of this case will then be tested in the future, using a more rigorous methodology.

We used 3 methods in our research, corresponding to three levels of analysis: neuronal, social, and cognitive.

The neuronal level

In order to specify the neurophysiological indicators of the control of behavior and emotion we used ERP methods. An electroencephalogram (EEG) was recorded using a 21-channel Mitsar EEG (http://www.mitsarmedical.com) with 19-channel heads using tin electrodes, including Fz, Cz, Pz, Fp1/2, F3/4, F7/8, T3/4, T5/6, C3/4, P3/4, and O1/2 (full cap diagnostics). The headset (electrohead) was placed on the patient's head according to the 10-20 system standard (cf. Fig. 1). The electrodes were referenced to the ear lobes (off line), and the signals were delivered at a rate of 250 Hz (frequency 0.5-30 Hz). The lower electrode was placed on the forehead. Resistance was maintained below 5 kΩ. The subject sat straight on a comfortable chair, looked at a computer screen (17-inch) that was 1.5 meters away from him (cf. Fig.2). The forms of the ERP waves were averaged and processed off-line, and trials with errors were automatically excluded.

The ERPs were established in response to a second stimulus in a time interval of 700 ms after the presentation of the second stimulus for the GO and NOGO

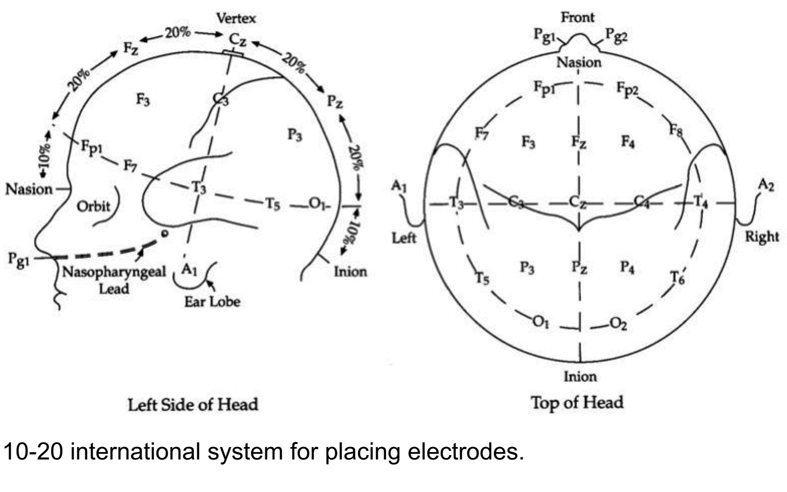

Fig. 1. The 10-20 international system for placing electrodes.

Fig. 2. The subject during recording of the QEEG

signals (Kropotov & Mueller, 2009). The independent constituents of the evoked potentials of the subject were compared with the HBI normative data base for the 17-33 age bracket. The independent constituents of the ERPS of the healthy persons were also compared with their states before and after intervention.

Evoked motor potentials precede body movements (probably also aggressive behavior towards others in sport) and accompany them, while their amplitude is proportional to the force and speed of the muscle contraction. We can observe them in the precentral region of the cortex (the motor core; Thompson & Thompson, 2012).

The social level

In order to measure the intensity of the control of aggressive behavior, we used the Psychological Aggression Syndrome Inventory (Polish Inwentarz Psychologicznego Syndromu Agresji, IPSA) developed by Zbigniew Gaś (1980). The IPSA consists of 8 scales, which can be grouped into 3 syndromes: autoaggression (S), latent aggression (U), and external aggression (Z). The IPSA also tests revenge behavior (O), general aggression (WO), and the control of aggressive behaviors (K).

The cognitive level

In order to measure the subject's social skills we used the APIS-Z test (Matczak, Jaworowska, Szustrowa & Ciechanowicz, 1995). This is a test of general intelligence for college students. The test has been normalized on nationwide samples of students from different major subjects. From among the eight scales of the APIS-Z we chose the Behavior Scale, which measures familiarity with social rules. It consists of 15 closed questions dealing with the reasons for which one ought to observe rules in contacts with other people, such as giving up one's seat to an older person, not reading other people's mail, or not revealing other people's secrets. For purposes of description and comparison of the results we used the recalculated results for the Behavior Scale, which refer to the following norms:

- 0-1 point - very low score;
- 2-3 points - low score;
- 4-5 points - average score;
- 6-7 points - high score;
- 8-9 points - very high score.

All these tests were administered twice: before neurotherapy began and again after it was completed.

The experiment was performed with the consent of the subject and of the Bioethics Committee.

RESULTS

Our subject showed no statistically significant divergences from the HBI normative data. He was 100 ms faster than the average and almost twice as consistent in his responses when compared to average results (in comparison with the HBI normative base). The EEG recording did not show any statistically significant divergences from reference values for OO, OZ, or GO/NOGO.

The behavioral scores achieved by our subject are presented in Table 1.

Both his overall aggression score (30 points) and his external aggression score (14 points) are below the average scores for athletes and other persons in highly competitive professions. Our subject's score for the control of aggressive behaviors was higher (20 points) than those of other athletes. His autoaggression (10 points) was higher than that of other athletes.

Our subject's results from the Behavior subtest of the APIS-Z test are shown in Table 2.

His overall result was 26. The raw score placed him, with an 85% probability, in the interval <22 ; 30>, which corresponds to the interval <2 ; 4> on a decile scale. It could be said that, against the background of other students, our subject

Table 1. Behavioral scores obtained by the subject athlete

	Omission errors	Commission errors	Reaction time	Divergence of response
Recording	0	0	273	3.9
Controls	4.4.%	0.6 %	378	8.3
P values	0.58	0.54	0.22	0.21

Table 2. The significance of differences between average values of athletes competing in track and field, handball, football, volleyball, wrestling, karate, and judo boxing (Ziółkowski & Włodarczyk, 2003)

	Track and field n=30	**Karate** n=30	**Handball** n=30	**Wrestling** n=30	**Football** n=30	**Volley-ball** n=30	**Boxing** n=30	significance of differences	
								F	between groups
	1	2	3	4	5	6	7		
C	15.43	14.23	11.96	15.20	13.26	15.66	7.80	8.74	3 and 1,4,6 7 and 1,2,3,4,5,6
S	5.8	8.23	7.93	7.10	7.36	6.56	13.56	5.77	7 and 1,2,3,4,5,6
E	12.16	17.63	19.83	16.73	21.43	15.83	33.83	12.48	1 and 2,3,4,5 7 and 1,2,3,4,5,6 5 and 6
GAI	38.23	53.80	62.33	51.23	60.03	45.76	98.46	17.36	1 and 2,3,4,5 7 and 1,2,3,4,5,6 3 and 6 5 and 6

obtained average results. His general abilities as measured by the APIS-Z were also at an average level for the reference group.

When the particular subtests were analyzed using data in the confidence intervals for raw scores, we were able to state that, against the background of the normalizing group, on four subtests (Number transformation, Stories, and Blocks) our subject's scores were average to high; on two subtests (Behavior and Classification), low to average; and on three subtests (Squares, Synonyms, and New words), low results in comparison to the normalizing group.

The results indicated that our subject has well developed visuo-spatial skills (in tasks requiring orientation in space), abstract and logical skills (in respect to understanding by analogy with numerical material), and social skills (in respect to familiarity with social norms and understanding of social situations. His results were also average in respect to social skills involving familiarity with social rules, as well as inductive reasoning (detecting the relations between objects).

The subject obtained results that were significantly above average in the Blocks subtest, while the scores for Synonyms and New Words were below average.

The mean of the subject's profile was 3.25. The results are given in Table 3.

An analysis of our results shows that the subject did not present any statistically significant divergences from the neurophysiological parameters associated with the control of behavior in comparison to the normative data. The amplitudes

Table 3. Results obtained by the subject for specific subtests of the APIS-Z

Behavior	4-3.25=0.75	|0.75| < 1.48
Squares	2-3.25=-1.25	|1.25|< 1.28
Synonyms	0-3.25 = -3.25	|3.25|>1.25 significant (minus)
Classification	3 – 3.25= -0.25	|0.25|<1.31
Transformation of numbers	5-3.25=1.75	|1.75|> 1.40
New words	1-3.25= -2.25	|2.25| >1.21 significant (minus)
Blocks	6 – 3.25 = 2.75	|2.75|>1.55 significant (plus)
Stories	5-3.25=1.75	|1.75|> 1.53

of the potentials evoked by the NOGO stimulus (prompting a motor inhibition) were within the normal range at baseline.

Alpha training produced the greatest statistically significant change in ERPs in the NOGO condition. These results may be an essential indicator of a high level of control of behavior (not intention), including aggressive behavior. After neurotherapy, the subject was quicker than the norm in his reactions, which is of fundamental importance, since he is an Olympic competitor, who would be expected to show better than average results in this respect (cf. Kropotov, 2009).

The subject's social consciousness, i.e. his comprehension of simple and complex social situations, did not display any deviation from national norms. His abstract and logical skills, and his visuo-spatial skills, differ significantly from the norm, and are higher than those from the remaining subtests. The subject's verbal skills, in terms of both vocabulary and verbal fluency, are a weak point and are below normal.

It can be stated that the subject's scores for general aggression and external aggression are below the scores achieved by other athletes, while his control of aggressive behavior is much higher than that of other athletes.

The subject's autoaggression is greater than that of other athletes (which corresponds to cortical inhibition, and may cause negative emotions towards others to be suppressed and directed to himself, thus contributing to the contusion).

CONCLUSIONS

1. Before neurotherapy, the patient described here presented with ERP amplitudes in response to NOGO stimuli (initiating a motor inhibition) that were not outside the normal range.
2. A high score for the control of aggression was accompanied by a high score for autoaggression (which corresponds with cortical inhibition, and may cause

negative emotions towards others to be redirected to himself, possibly contributing to a contusion) and low scores for external and general aggression.

3. After the application of Alpha training, the subject was faster in his reactions than the norm. The differences in the NOGO conditions were statistically significant. These results may be a significant indicator of a high level of control of behavior (not intention), including aggressive behaviors.

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