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Natalia Ievpak
Illya Kuznetsov
Oksana Rakovets
Ivanna Marchuk

The effect of working memory and social interactions training on ERP features

The influence of working memory and social interactions training on evoked brain cortex electrical activity were studied. It was shown, that after working memory training, the ERP features did not changed significantly. While social interactions efficacy training leads to increase in N2 wave amplitude. In our opinion, obtained results support the Herrmann's "social intelligence" theory.

Key words: social intelligence, working memory, brain cortex evoked activity.

Introduction. Our previous results have shown the difference of ERD/ERS reactions on socially-significant stimuli between altruistic-oriented and egoistic-oriented persons [5]. The difference between those two groups was alpha-band specific (mainly, upper alpha), resulting in evident desynchronization effect, which was stronger for altruistic stimuli for egoistic-oriented persons, and stronger for egoistic-oriented stimuli for altruistic-oriented persons. The upper alpha-rhythm is considered to be influenced by dopaminergic transmitter system [2]. While the dopamine is the main transmitter of executive system and social interactions have the key importance for humans, there's nothing unexpected in obtaining the mentioned results. Anyway, the dopaminergic system is closely associated with another executive system function – namely, working memory [1; 7]. This leads us to conjecture, that enhancing one of the functions – social activity or working memory – should lead to enhancement in another function. The key question is the priority of the functions – which executive functions will affect another in greater extend? Thus, the main goal of our study was examining of mutual influence, reflected in evoked brain activity, of working memory and social interaction level.

Methods. The study was conducted on 19 volunteers, females, 19–22 years old, right-handed. The subjects were divided into two groups – 10 persons in first group, 9 persons in second group. The persons from the first group were trained for working memory enhancement, the persons from second group were trained for enhancement of social interaction efficacy. The training for working memory enhancement was based on working with span board task [6] – 30 minutes every day, 10 days consequently (fig. 1). The training for enhancement of social interactions was based on "stone-scissors-paper" game [3] and the task, developed by us. The second task included the manipulation of small board inclination by two persons simultaneously, with the goal to direct a small sphere to the center of the board. For making task more difficult and enhancing the interaction between two persons, each person was staying only on one leg during the task. Both tasks for social interaction enhancement were conducted during 15 minutes each, 30 minutes total daily, 10 days consequently. To avoid social adaptation for second task, the interacting pairs were formed from different subjects each day in occasional manner.

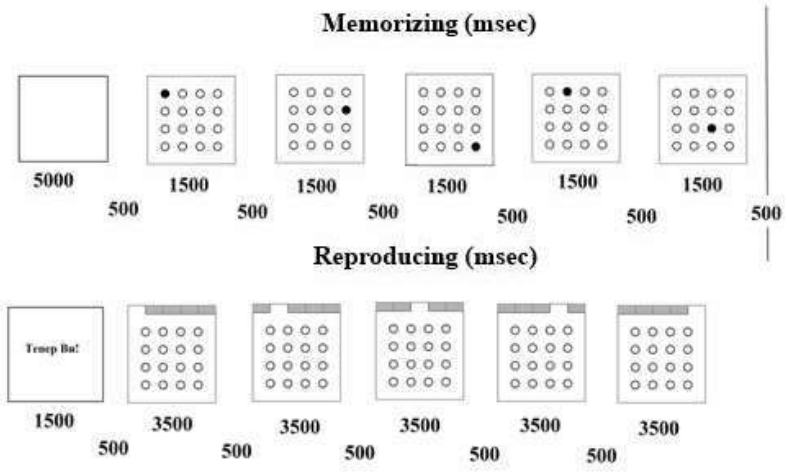

Fig. 1. **Span board task, used for working memory training, modified** [5]

The evoked brain cortex activity was registered for both groups before and after the whole training cycle. We used a simple odd-ball paradigm for P300 registration. The N200-P300 complex is a standard ERP feature for studying working memory load [8]. The subjects were instructed to push button on presented images with animals (target) and to ignore the presented images, which didn't have animals (non-target). The task included 50 target stimuli with 25 % target presentation probability.

The obtained data were processed using variation statistics methods, including mean, standard mean error and t-Student's statistics with significance level of $p \leq 0,05$.

Results and discussion. It was shown, that the ERP for the first group unexpectedly did not changed significantly after working memory training. We expected the shortening and decreasing in amplitude of P300 wave after training, but the analysis showed a slight increase in P300 amplitude and latency (fig. 2). We consider, that increase of brain neuronal structures, involved in working memory maintaining, is the only way to explain this result.

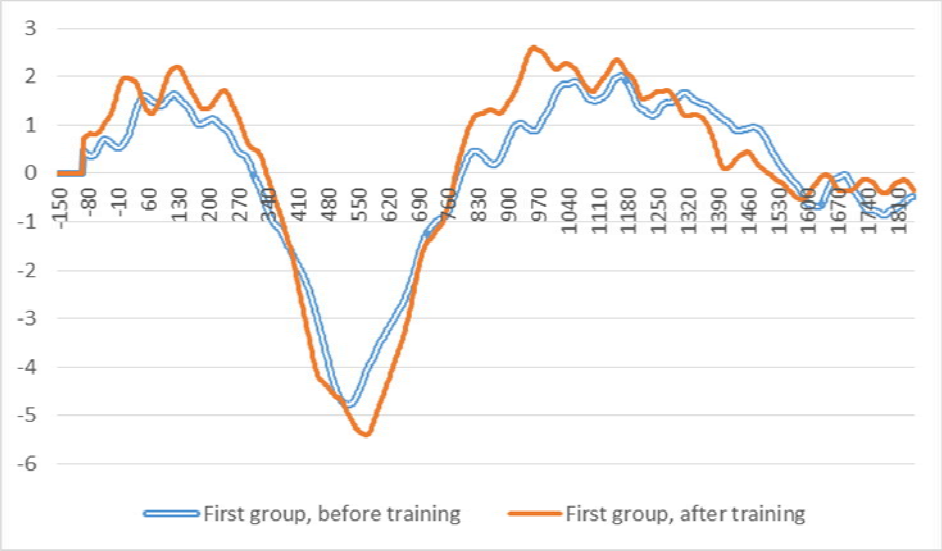

Fig. 2. **ERP waves of the first group, before and after working memory training, P3 lead**

We suppose, that the time period of our experiment was not long enough for trained working memory mechanisms to adopt for training and the expected decrease in number of neuronal structures, involved in working memory maintaining should decrease (with increase in working memory performance because of better neuronal organization) somewhat later. Anyway, this result shows no large enhancement of neuronal organization for processing working memory task.

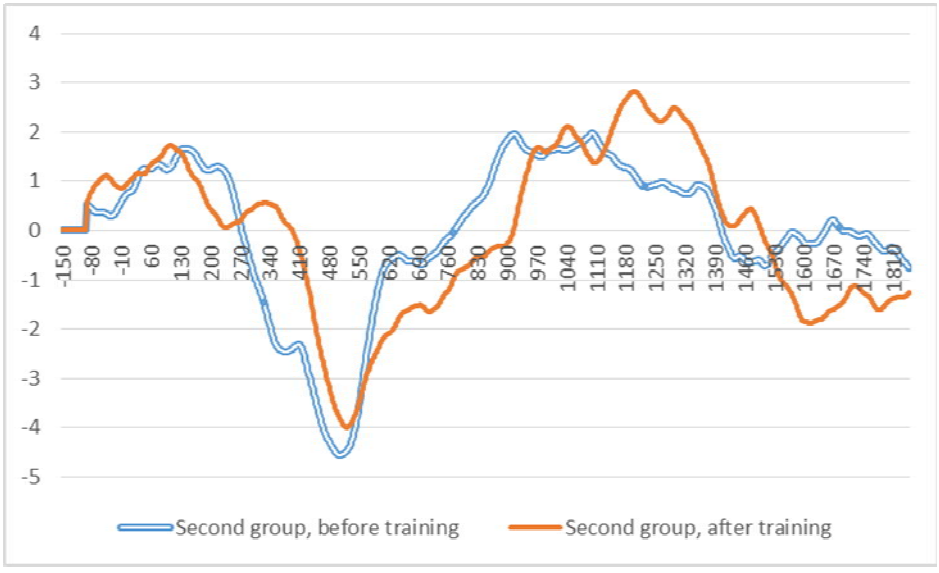

Fig. 3. **ERP waves of the second group, before and after social interaction enhancement training P3 lead**

Concerning the results of the second group, it was shown, that after social interactions enhancement training, their ERP change dramatically. The most prominent difference between before- and after-training ERPs was a significant increase in amplitude of N2 wave (with 330 msec approximate latency, fig. 4), which reflects the working memory load, thus giving us the opportunity to suppose the enhancement in working memory performance.

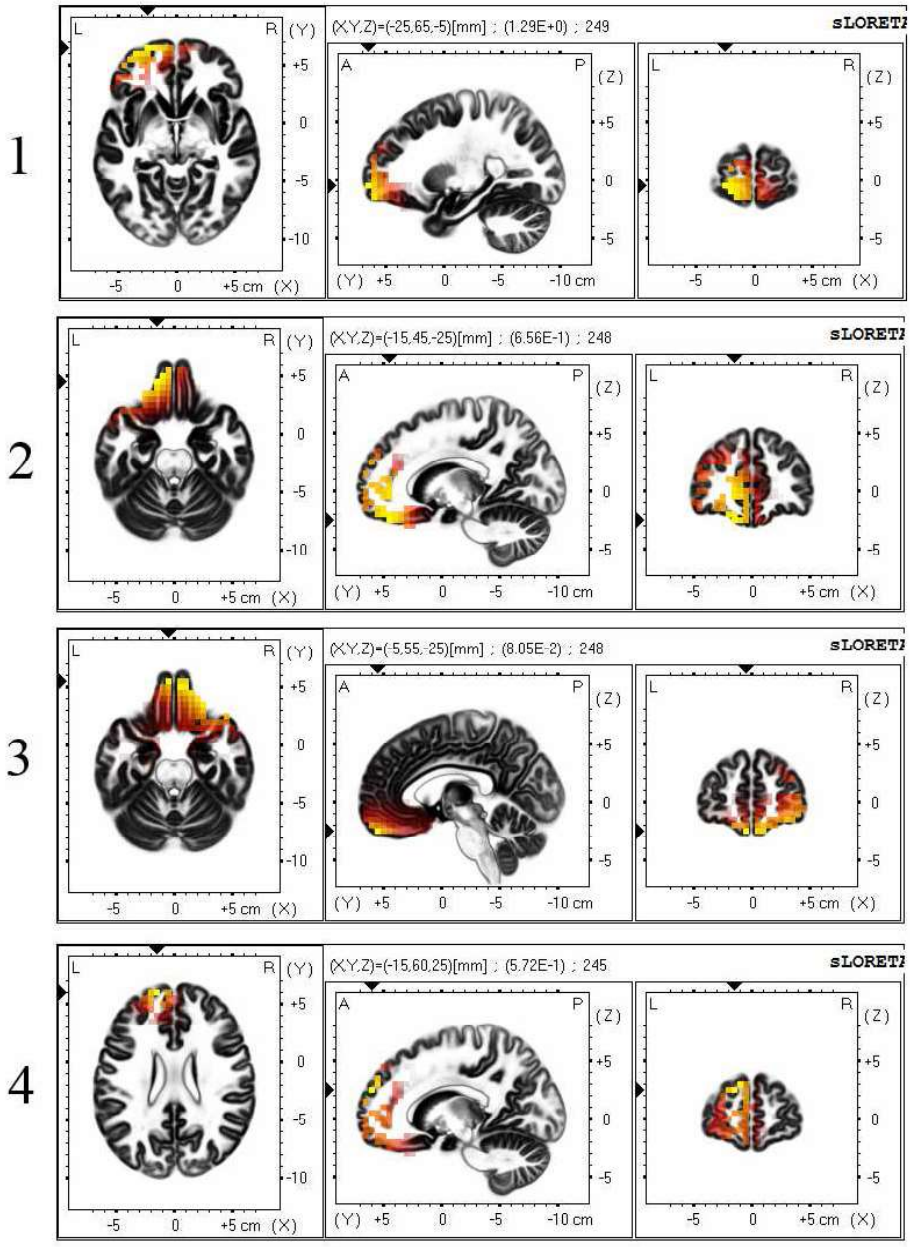

Fig. 4. **sLORETA of N2 wave of first group before (1) and after (2) working memory training, sLORETA of N2 wave of second group before (3) and after (4) social interactions enhancement training**

The results of low-resolution tomography (sLORETA) show the increase in left anterior cingulate cortex activity on 340 msec latency (which corresponds N2 wave) after training in both groups, thus confirming the improved functioning of working memory in both groups. Anyway, the second group has more expressed activity in this regions.

In general, obtained results show the key role of social activity for working memory performance. We consider the simple explanation of this effect – the social stimuli are a very strong positive reinforcements for human beings, and thus positive social activity load leads to enhancement in working of positive reinforcement system, with dopamine as a key neurotransmitters – and thus, to better support of memory

traces in working memory, and, most probably – in long-term memory. Our results support the theory of "social intelligence", proposed by Herrmann [4]. Indeed, the social factors reveal a greater importance on brain functioning, thus allowing to suppose, that social cognitive abilities play a leading role in human evolutionary and ontogenetic development of general cognitive functions, not vice versa, as "general intelligence" theories suppose.

Conclusion and further perspectives. Our result show the greater importance of social cognitive functions for general brain functions. These results support the theory of "social intelligence". Anyway, the theory of "social intelligence" operates with the concepts of cognitive functions on species and evolutionary level, while our study reveals the possibility of heterogenic involvement and interaction of the same mechanisms on organism and cell level. Further studies should find the exact neural hollowmarks of different evolutionary pressure on mechanisms social and general cognitive functions.

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Євпак Наталія, Кузнєцов Ілля, Раковець Оксана, Марчук Іванна. Вплив тренування оперативної пам'яті та соціальних взаємодій на характеристики КВП. Здійснено вивчення впливу тренування оперативної пам'яті та соціальних взаємодій на показники викликаної електричної активності кори головного мозку людини. Показано, що після тренування оперативної пам'яті характеристики ВП суттєво не змінюються, тоді як після тренування ефективності соціальних взаємодій в обстежуваних зростає амплітуда хвилі N2. На нашу думку, отримані результати свідчать на користь гіпотези «соціального інтеллекту» Херрманн.

Ключові слова: соціальний інтелект, оперативна пам'ять, викликана активність мозку.

Евпак Наталья, Кузнецов Илья, Раковец Оксана, Марчук Иванна. Влияние тренировок оперативной памяти и социальных взаимодействий на характеристики КВП. Как показали наши предварительные исследования, электрическая активность коры головного мозга при реакции на социально значимые стимулы имеет основные отличия для групп эгоистично-ориентированных и альтруистично-ориентированных испытуемых в области альфа-диапазона. Подобные отличия могут также указывать на особенности работы системы оперативной памяти в указанных группах. В нашем исследовании мы регистрировали КВП по методике Р300 в испытуемых, которые проходили тренировку оперативной памяти (10 человек), и испытуемых, которые проходили тренировку повышения эффективности социальных взаимодействий (9 человек). Показано, что в первой группе после тренировок не произошло значительных изменений в параметрах ВП, тогда как во второй группе наблюдалось увеличение амплитуды компонента N2, что указывает на более эффективную работу системы оперативной памяти после тренировки социальных взаимодействий. Данные результаты подтверждают гипотезу «социального интеллекта» Херрманн, согласно которой ведущую роль в развитии когнитивных способностей играли когнитивные функции не общего характера, а функции, необходимые для успешного осуществления социальных взаимодействий.

Ключевые слова: социальный интеллект, оперативная память, вызванная активность мозга.

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