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Relationship Between The Rhythmic Activity Of The Cerebral Cortex And The Manifestation Of Impulsivity / Reflexivity.

Kozachuk N, Shvartz L, Zhuravlov O*, Poruchynskyi A, Dmytrotsa O, Abramchuk O, Poruchynska T, Zhuravlova O, and Hoshko L.

Lesya Ukrainka Eastern European National University, Lutsk, Ukraine

ABSTRACT

The most significant EEG differences were obtained by us for the purpose of receiving the indicators of the coherence of the brain biopotentials in Δ-, θ-, β-frequency bands. These EEG differences were obtained in the course of performing tasks of the divergent type that are associated with the cognitive style of "impulsivity-reflexivity", which in its turn is based on the ability of an individual to make quick or slow decisions. It was established that in males, who are reflexive, the level of spatial synchronization was higher than the one of impulsive men in the Δ-, θ-, and β-frequency bands while performing the divergent task. And this was mainly achieved due to closer long-distance connections of the frontal areas of the cerebral cortex with occipital, temporal and parietal areas.

Keywords: coherence, electroencephalogram, cognitive style.

Corresponding author

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INTRODUCTION

Neurodynamics of brain in individuals of different sex in the process of achieving high results of creative thinking is largely dependent on the type and complexity of the problem [5, 7, 8, 11] and reflects the psychophysiological characteristics of the research participants [1]. However, only a small number of works is devoted to the study of the relationship of psychophysiological properties and neurophysiological mechanisms, which underlie the realization of complex forms of mental activity of humans [2, 8, 10, 12]. A few EEG studies related to the allocation of groups of people according to cognitive style were conducted in different age groups, often without regard to the sex of the research participants and with the application of different methodological approaches. Therefore, today it is very difficult to systematize and generalize the obtained results. At the same time, even these results suggest that the style of perception and information processing (cognitive style) affects the strategy of achieving high results of mental activity and correlates with some EEG patterns [6, 9].

EXPERIMENTAL

Subjects

The study involved 95 men and 98 women aged 18-21 years. The research was conducted in accordance with generally accepted bioethical norms in compliance with relevant international provisions on experimental work and clinical research. Study participants (volunteers) gave a written voluntary consent to participate in the study.

Data Psychophysiology

The notion of cognitive style "impulsivity/reflexivity" was determined.

Data Electroencephalography

The electrical activity of the cerebral cortex of 193 men and women aged 18-21 was recorded during assignments of divergent types. The electrical activity of the cerebral cortex was recorded in monopolar way from 19 leads according to the international system 10/20 (Fp1, Fp2, F3, F4, F7, F8, Fz, C3, C4, Cz, T3, T4, T5, T6, P3, P4, Pz , O1, O2) with the help of the hardware-software complex "Neyrokom" developed by the scientific and technical center of electronic medical devices and technologies "HAI-Medika" National Aerospace University "KhAI" (certificate of registration № 6038/2007 from 26 January 2007).

The indicators of performance capacity and coherence of EEG in frequency ranges were analyzed: delta (0,5-4,0 Hz), theta, alpha-1, alpha 2, alpha 3, beta. Determining the frequency limits of theta, alpha-1, alpha 2, alpha 3 and beta rhythm was carried out based on the individual frequency of alpha rhythm of each patient [3].

Registration of EEG was carried out in the following experimental situations: at rest with eyes closed, at rest with eyes open, at rest with eyes open and focusing on mental activity, performing the task of convergent type, performing the task of a divergent type.

RESULTS AND DISCUSSION

The analysis of the obtained results showed that in all frequency bands among the female research participants, greater coherence was observed in persons with impulsive cognitive style, and among the male participants - in persons with reflexive cognitive style. In addition, we found out that in groups of "impulsive" women, coefficients of coherence are higher than in the groups of "impulsive" men in all of the studied frequency bands. Concerning the "reflexive" research participants, different ratios of coherence coefficients in different frequency bands of the EEG were observed. Thus, in the Δ-, θ- and α2- bands, the coefficients of coherence in the male and female subjects with reflexive cognitive style did not differ; in the α1-band - the coefficients were higher in the group of women; in α3-, β-rhythm - in the group of men. A more detailed analysis showed that in the range of slow frequencies of EEG, the above-described characteristic features were related to the female group in all experimental situations, in the male group - to all types of situations, except

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for the state when focusing on mental activity, where intergroup differences in the coefficients of coherence were absent.

However, taking into account the factor of "electrode site" showed that women have more pairs of electrode sites, coefficients of coherence between which significantly statistically differ in the participants with impulsive and reflexive cognitive style. In females with impulsive cognitive style, a specific pattern of coherent relationships in different experimental situations was formed. The above-mentioned coherent relationships were more cohesive than in the group of "reflexive" women. Thus, in a state of rest with closed eyes and when performing a divergent task, there were closer connections that "converged" in the occipital area of the right hemisphere; at rest with eyes open and while performing a convergent task - in the frontal-lateral area of the right hemisphere. When preparing oneself for mental activity and focusing on it, there was no clearly expressed center where connections converged. The common characteristic for all experimental situations was that the main differences between the female participants with impulsive and reflexive cognitive style were related to interhemispheric relationships.

In men, the most significant differences were established in the course of the task of divergent type: the connections of the frontal areas with occipital were more closely related in the research participants with reflexive cognitive style (Fig. 1).

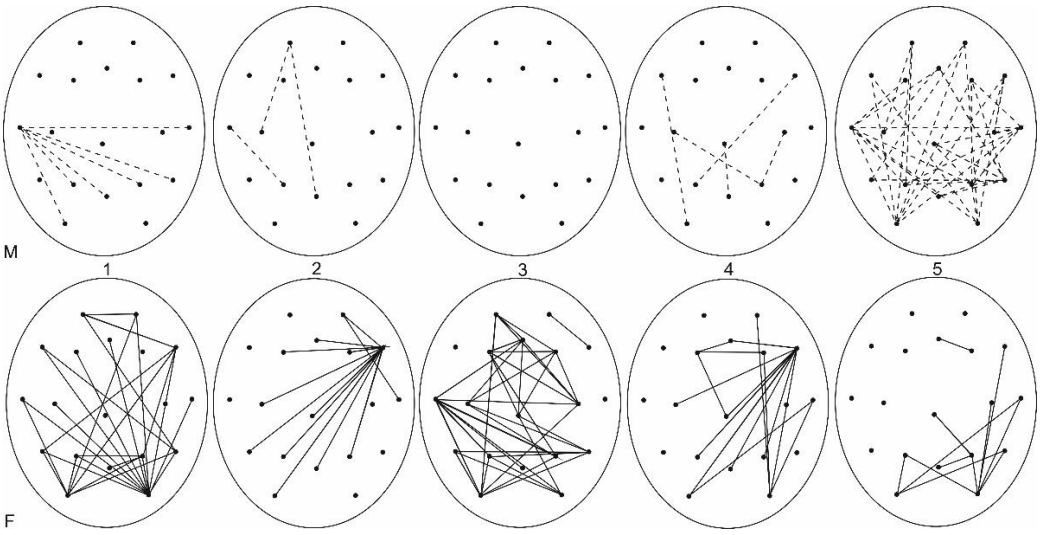

Figure 1: Intergroup differences of coherence in the Δ-band.

The solid line indicates the connections between the electrode sites, the coefficients of coherence between which are higher in the participants with impulsive cognitive style; dotted line - research participants with reflexive style. M stands for men, F - for women. 1 - at rest with eyes closed, 2 - at rest with eyes open, 3 - at rest with eyes open with preparing oneself for mental activity, 4 - performing the task of the convergent type, 5 - performing the task of the divergent type.

In the θ-band, as well as in the Δ-band, in women, a greater number of pairs of electrode sites is observed, coefficients of coherence between which were statistically significantly different in the groups of participants with different cognitive styles. In a state of rest in women with impulsive cognitive style, it was observed that closer connections of the frontal areas were predominantly with parietal areas, occipital lobe and temporal back areas of the brain than in women with reflexive cognitive style. In other experimental situations, the topography of closer connections was more chaotic, with no well-defined pattern (Fig. 2).

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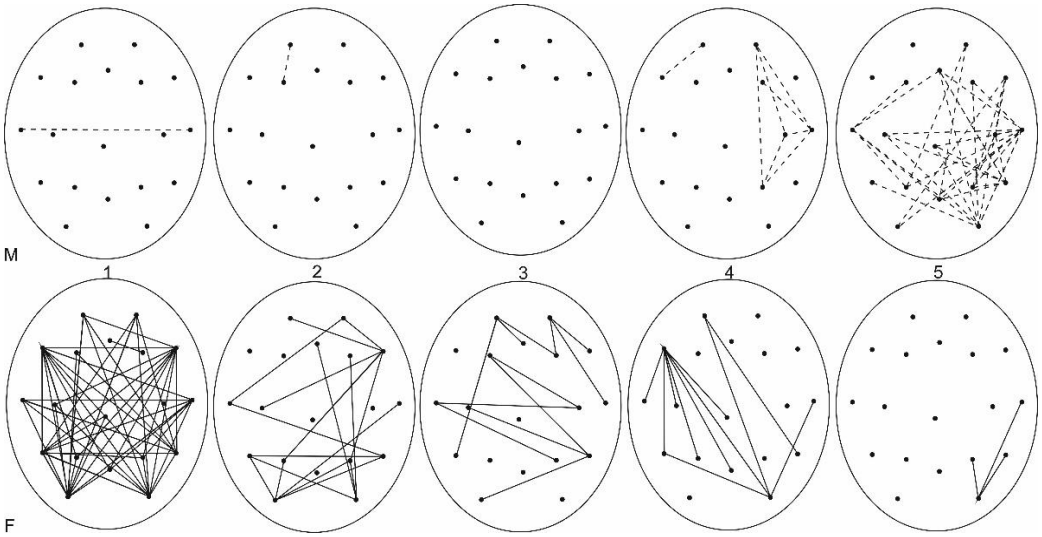

Figure 2: Intergroup coherence differences in the θ-band.

The solid line indicates the connections between the electrode sites, the coefficients of coherence between which are higher in the participants with impulsive cognitive style; dotted line marks participants with reflexive style. M - men, F - women. 1 - at rest with eyes closed, 2 - at rest with eyes open, 3 - at rest with eyes open with preparing oneself for mental activity, 4 - performing the task of the convergent type, 5 - performing the task of the divergent type.

The analysis of the interaction of the factors "gender", "experimental situation" and "cognitive style" in the α- and β-band revealed the same tendencies as in the slow frequency ranges - among women greater coherence was observed in impulsive participants, among men - in reflexive ones (see Fig. 2).

In the range of α-frequencies in men with reflexive cognitive style, the average coherence rates were higher than in the group of participants with impulsive cognitive style. However, taking into account the factor of "electrode site" it was observed that in men, far fewer connections statistically significantly differentiated between groups with different cognitive styles. The highest number of statistically significant differences was detected in three experimental situations: at rest with closed eyes, performing the convergent task type, and performing the divergent task type (Fig. 3).

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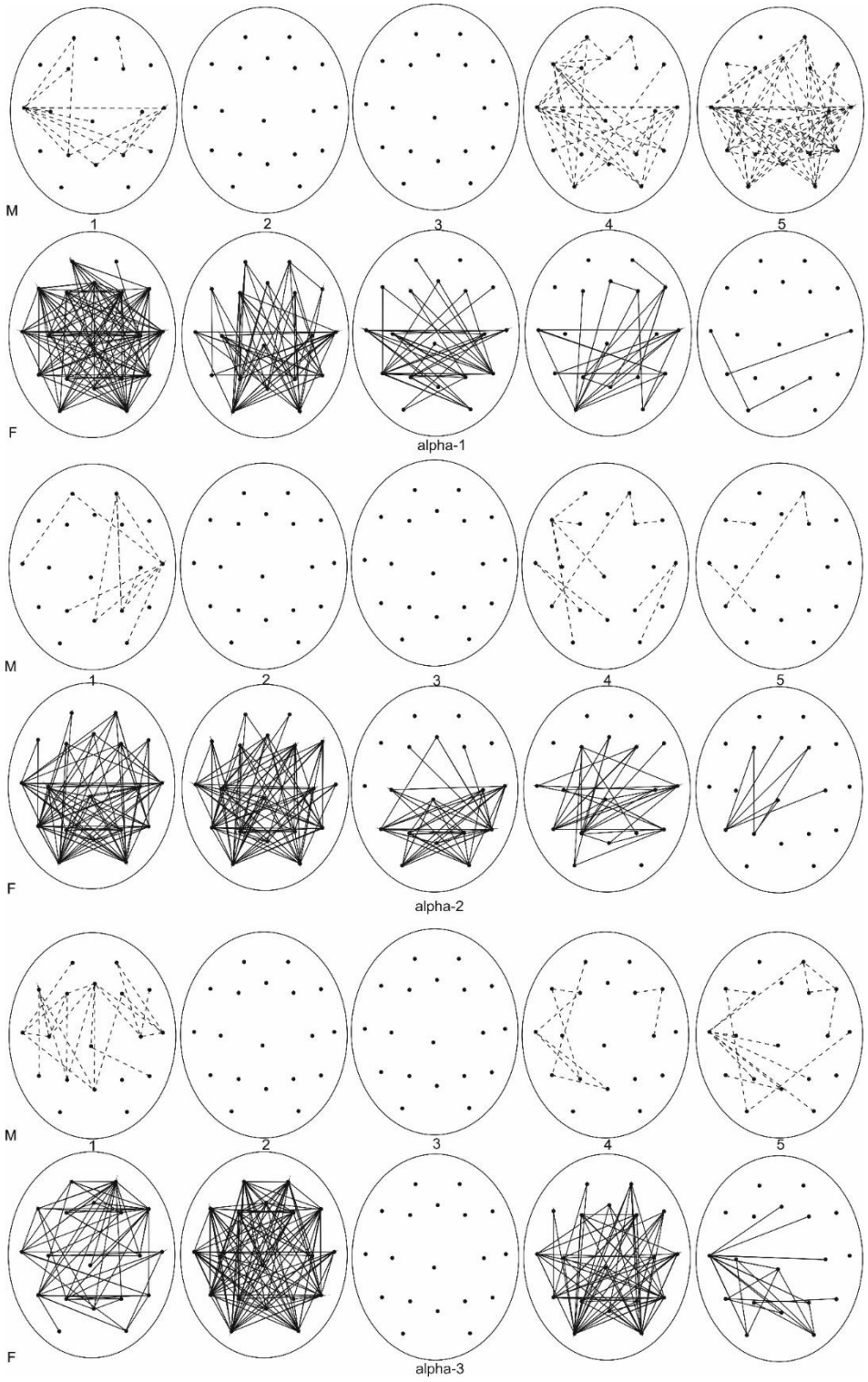

Figure 3: Intergroup coherence differences in the α-band.

The solid line indicates the connections between the electrode sites, the coefficients of coherence between which are higher in the participants with impulsive cognitive style; dotted line - with reflexive style. M - men, F - women. 1 - in a state of rest with closed eyes, 2 - in a state of rest with eyes open, 3 - at rest with eyes open and focusing on mental activity, 4 - performing the task of the convergent type, 5 - performing the task of the divergent type.

It was also found out that in different sub-bands of α-rhythm, the number of such connection differed significantly. In the α-1 range, they prevailed in number. In men with a reflexive cognitive style in the α1-range at rest with closed eyes, interhemispheric and left hemisphere connections were greater; while performing the convergent task - back associative and left brain ones; during the performance of the divergent task - back associative connections (see Fig. 3).

In women, the number of statistically significant differences was much higher and related to a greater number of experimental situations. In the α1- and α2-bands in women with impulsive cognitive style, in comparison with women with reflexive cognitive style, the connections of the back associative areas were stronger and connections of the front-associative areas with back associative ones were more closely aligned. In the α-3 band, this tendency manifested itself less clearly (see Fig. 3).

In the β-band, in both male and female participants, there was approximately the same number of connections, the coefficients of coherence between which statistically significantly differed within the research participants with different cognitive styles.

The general tendency was that connections in men with reflexive cognitive style and in women with impulsive cognitive style connections were more closely linked between the front and back associative areas. But in men, the differences mainly revealed themselves at rest with eyes closed and during mental activity, and in women - at rest with open and closed eyes and during a convergent task (Fig. 4).

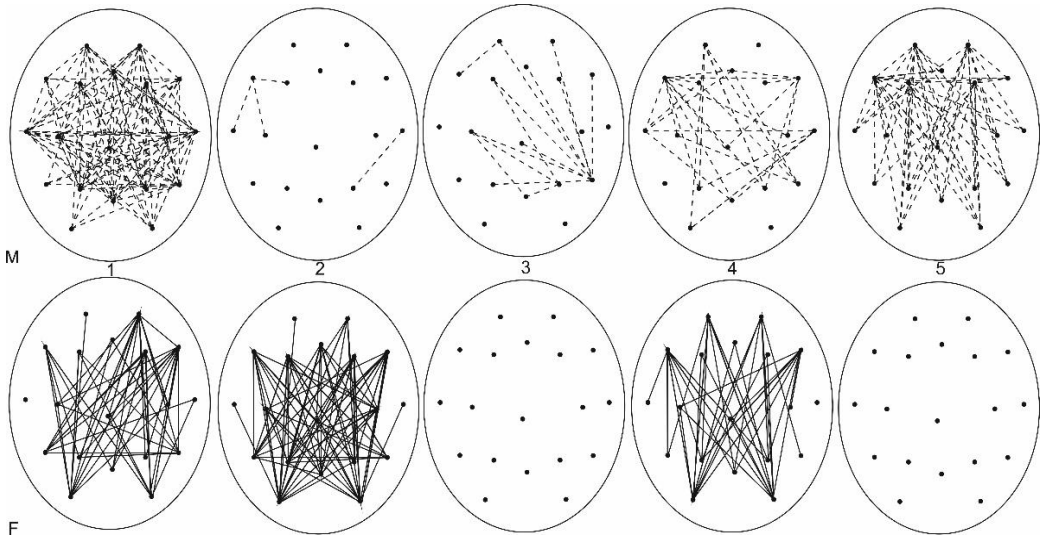

Figure 4: Intergroup coherence differences in the β-band.

The solid line indicates the connections between the electrode sites, the coefficients of coherence between which are higher in the participants with impulsive cognitive style; dotted line - with reflexive style. M - men, F - women. 1 - at rest with eyes closed, 2 - at rest with eyes open, 3 - at rest with eyes open with preparing oneself for mental activity, 4 - performing the task of the convergent type, 5 - performing the task of the divergent type.

The obtained results confirm the characteristic feature we described previously, namely, that in men the productivity of divergent thinking is greater in cases when the more front and back associative areas function more separately and the greater the level of coherence of the frontal cortex biopotentials is [4]. The division of men according to cognitive styles showed that this is manifested in the case when the research participants perform an "adequate" type of task acceptable for their cognitive style, namely, performing the divergent task by men with impulsive cognitive style. If the task is "not convenient" for the inherent cognitive style of a participant, the nature of the spatial synchronization of the bipolarities of the cerebral cortex becomes more complicated. This confirms the previously described mechanism by us, according to which high results of creative thinking in case it is inadequate to a certain cognitive style or other psychological

characteristics, then the task is achieved at higher price - high energy costs (according to the redundancy principle) [4].

CONCLUSION

The cognitive style "impulsivity-reflexivity", which is based on the ability of an individual to make a quick or slow decision, is reflected in the peculiarities of the spatial synchronization of biopotentials in the Δ-, θ-, β-frequency bands of the EEG when performing the task of the divergent type in men. In women, the differences in spatial synchronization of biopotentials of the cerebral cortex associated with cognitive style were revealed in Δ-, θ-, α-, β- frequency bands of EEG in all experimental situations, except for the situation while performing the task of divergent type.

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