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Changes in Cortical Activity in Altered States of Consciousness: The Study of Meditation by High-Resolution EEG

L. I. Aftanas and S. A. Golosheikin

Institute of Physiology, Siberian Division, Russian Academy of Medical Sciences, ul. Timakova 4, Novosibirsk, 630117 Russia

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Abstract—The specific features of the topology of spectral powers and coherent interregional interrelationships in the narrow, individually determined δ-, θ-, α_1-, α_2-, and α_3-frequency bands were studied by means of high-resolution EEG (62 channels) in novice and experienced meditators (NMs and EMs) at rest and under the conditions of generation of an altered state of consciousness characterized by inactivation of cognitive activity and the occurrence of a positive emotional experience of happiness. EMs in the meditation-free state were found to be characterized by a shift in the values of the individual α frequency to a lower-frequency region of the spectrum, along with higher, compared to NMs, θ-, α_1-, α_2-, and α_3-band power values, which probably reflects the cumulative character of the influence of long-term meditative practice. The effective achievement of altered states of consciousness in EMs was associated with an increase in the local θ- and α_1 powers in the anterior cortical areas, as well as long-distance coherence between the prefrontal and posterior associative cortex with the formation of a center of gravity in the left prefrontal region (lead AF_3). According to the data of the correlation analysis of the EEG power values and the data of subjective scaling of the meditation state, the θ-power values were positively associated with positive emotional experiences and negatively associated with the level of mental activity. The results of this study are consistent with current concepts that the θ and α activities in narrow frequency bands reflect the activity of multifunctional neuronal networks selectively associated with processes of cognitive and affective activity.

Meditation is a complex neurocognitive process inducing changes in psychic, cortical, and autonomic functions. The aggregate of these changes allows the meditative states occurring to be classified as altered states of consciousness, differing from ordinary wakefulness, relaxation at rest, and sleep [1–3]. The results of research into meditation in the last three decades provide sufficiently convincing evidence that regular meditative practice leads to stable functional changes in the psychophysiological status of humans [4–7]. The few EEG investigations established that, along with various reactive manifestations of altered states of consciousness under meditation conditions [2, 8–11], long-term practice of qigong, zen, and yoga leads to an increase in the θ and α power [6, 11–13], whereas transcendental meditation practice increases the θ, α, and β power [9, 14–17] along with an increase in α and β coherence bilaterally in the anteroposterior direction [4, 18].

These changes in bioelectrical activity in experienced meditators are observed either at rest or for a certain time after exiting the meditative state. Studies of the contingent negative variation (*CNV*) reveal the optimizing effects of long-term meditation on the conditioning and executive mechanisms of cortical responses [19]. However, the absence at present of data on the subtle frequency and topographic characteristics of the brain activity reflecting the inertial (cumulative) effects of meditation significantly impoverishes current notions of the central mechanisms of altered states of consciousness.

As compared to previous EEG investigations of meditation, this work is characterized by several specific features. First, due to the presence of functional differences between narrow frequency components in conventional EEG rhythms [20–23], the boundaries of the narrow Δ-, θ-, α_1-, α_2-, and α_3-frequency bands and, accordingly, their widths were determined individually, depending on the individual α frequency [24, 25]. Second, the use of high-resolution EEG (62 channels) provides for a more adequate topographic analysis of regional activation processes during the meditative process. Third, as a model of an altered state of consciousness, we selected Sahaja yoga meditation, which, in contrast to other meditative techniques (e.g., transcendental meditation [2]) is characterized not only by processes of internalization of attention, but also the occurrence of an emotional state of happiness or bliss [26].

Thus, the purpose of this work was to study with the use of high-resolution EEG the specific features of the topology of spectral powers and coherent interregional interrelationships in humans with a long working experience of meditation practice, at rest and during the meditation process.

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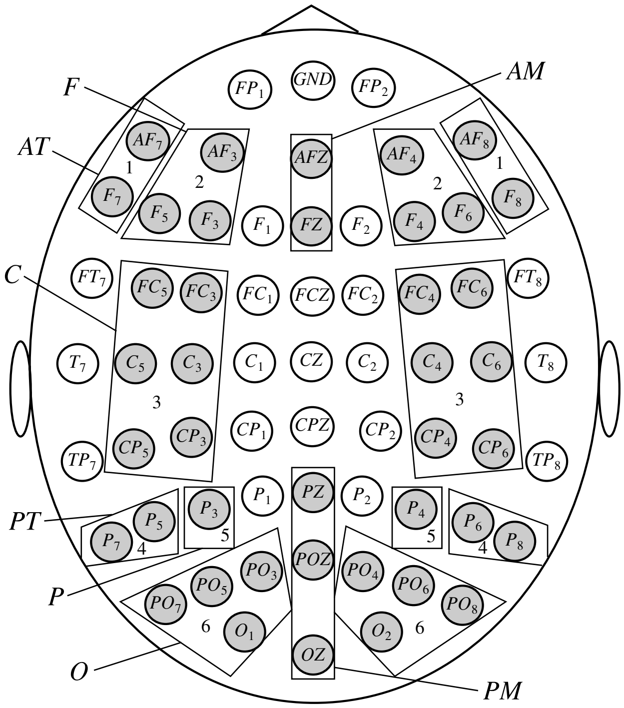

Fig. 1. The scheme of the arrangement of electrodes and 12 combined groups (6 for each hemisphere) used for analysis, along with the anterior and posterior midline zones (*AM* and *PM*, respectively) (see Methods for explanation).

METHODS

Twenty-seven healthy right-handed volunteers aged between 25 and 45 years who regularly practiced Sahaja yoga meditation were recruited for the study. Depending on the duration of practice, all the participants were divided into two experimental groups: group 1, including novice meditators (NMs), whose working experience was less than 6 months (n = 11: men, 5; women, 6; mean age M = 35.18; SD = 7.33) and group 2, including experienced meditators (EMs), whose working experience was 3–7 years (n = 16: men, 6; women, 9; mean age M = 35.00; SD = 7.14). Before the beginning of the study, the subjects from both groups were assessed with respect to levels of trait anxiety (*STAI-t*) [27, 28] and alexithymia (*TAS*-20) [29], as well as extroversion/introversion, neuroticism, and psychotism (*EPQ*) [30].

A 62-channel EEG (bandpass 0.3–50 Hz, quantization frequency 500 Hz) was recorded monopolarly using the Scan 4.1.1 program, the ESI-128 system (NeuroScan Labs), and a modified 64-channel cap with built-in Ag/AgCl electrodes (QuikCap, NeuroSoft, Inc.). The reference electrode was on the tip of the nose (Fig. 1). A vertical and horizontal electrooculogram (EOG) was additionally recorded to control oculomotor artifacts.

After recording of the state of rest with open eyes, the subject was to pass through three sequential stages: the first stage, entering into meditation; the second stage, deep meditation, in which the maintenance of self-consciousness is accomplished against the background of completely inhibited mental activity (the state of consciousness without thought); and the third stage, exiting from the state of meditation [26]. The experimenter sent audible signals notifying the subjects of the beginning of all three periods. Upon attainment of the state of consciousness without thought, the subject pressed the feedback button. The EEG was recorded throughout the three periods. After the experiment, the subjects responded to three questionnaires with unipolar (0–9) scales (0 indicated the absence of the phenomenon; 9, the greatest degree of its manifestation): (1) please estimate the level of your mental activity during the meditation state; (2) did you experience, and to what degree, a positive emotional experience of happiness (bliss, satisfaction) during meditation?; and (3) did you experience, and to what degree, anxiety (worry, dissatisfaction) in the process of meditation due to the instability of the meditative state or the impossibility of attaining it?

After recording of the EEG, oculomotor artifacts were corrected by using a specialized algorithm [31]. In addition, fragments containing uncorrected oculomotor, myographic, motor, and other artifacts were eliminated after visual analysis. To analyze spectral powers and coherence, only artifact-free 8.192-s fragments were used (three fragments for each experimental stage).

In the analysis, we used a technology that determined individual bands based on the calculation of the individual alpha frequency (*IAF*) separating the upper and lower α bands [24, 25]. The bandwidth constituted 20% of the *IAF* [24]. Using this method, the following frequency bands and their boundaries were specified: Δ, from ($IAF \times 0.2$) to ($IAF \times 0.4$) Hz; θ, from ($IAF \times 0.4$) to ($IAF \times 0.6$) Hz; α_1, from ($IAF \times 0.6$) to ($IAF \times 0.8$) Hz; α_2, from ($IAF \times 0.8$) to ($IAF \times 1.0$) Hz; and α_3, from ($IAF \times 1.0$) to ($IAF \times 1.2$) Hz. The group-averaged *IAF* values in EMs (M = 9.42 Hz, SD = 0.53) appeared to be significantly lower than in NMs (M = 10.04 Hz, SD = 0.48) ($p < 0.005$). Each EEG fragment was subjected to fast Fourier transform (*FFT*) with the use of Parzen's window. The power values obtained were averaged within individual bands and subjected to log transformation to normalize the distribution. The power values for the three EEG fragments of each stage of the study were averaged between each other.

For statistical analyses, all the electrodes were divided into 12 clusters forming six cortical zones in each hemisphere (Fig. 1): anterotemporal (*AT*), frontal (*F*), central (*C*), parietotemporal (*PT*), parietal (*P*), and occipital (*O*). The spectral power values for the individual electrodes applied to the relevant zone were averaged between each other for each experimental condition. The same EEG fragments were used for analyzing

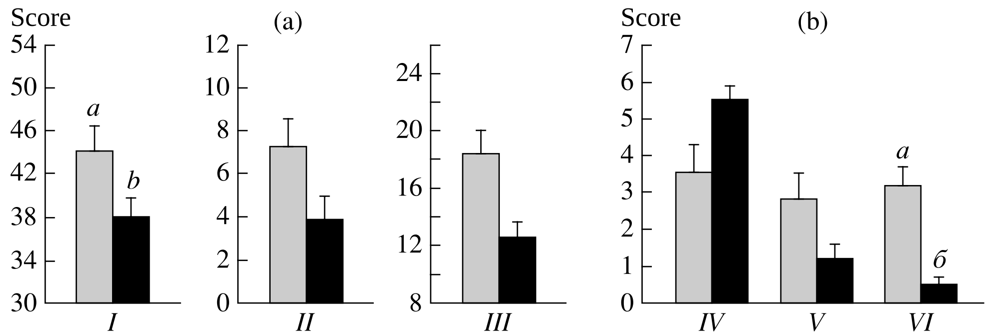

Fig. 2. The means and standard errors of the psychosomatic values and the estimates as judged by the subjective reporting scale: (a) psychosomatic values before the experiment; (b) subjective estimates of the meditation state: (*a*) novice meditators; (*b*) experienced meditators. Abscissa, psychometric parameters: *I*, trait anxiety; *II*, neuroticism; *III*, difficulties in identification of feelings; *IV*, emotions of happiness; *V*, level of mental activity; *VI*, anxiety.

coherence. The coherence values were calculated for all possible electrode pairs.

The statistical analysis of EEG powers was carried out using ANOVA with repeated measurements in intragroup factors. Correction of the Greenhouse–Geisser degrees of freedom was made if necessary. The results of the subjective reports and changes in the coherence values were assessed by Student's *t*-test.

RESULTS

According to the psychometry data, EMs were characterized by lower values of trait anxiety ($F(1.25) = 5.97$; $p < 0.022$), neuroticism ($F(1.25) = 5.41$; $p < 0.028$), as well as by a lower score in the subscale as "Difficulties in Identification of Feelings" ($F(1.25) = 12.46$; $p < 0.002$) of the alexithymia questionnaire. Taken together, these data reflect a higher psychoemotional stability and better capacity for identifying emotions in EMs compared to NMs (Fig. 2a).

According to subjective estimates of the successfulness of meditation (Fig. 2b), EMs attained a significantly greater intensity of experience of the state of happiness than NMs ($M_{EM} = 5.54$, $M_{NM} = 3.56$, $p < 0.014$) and a lower level of mental activity ($M_{EM} = 1.19$, $M_{NM} = 2.82$, $p < 0.025$). At the same time, NMs reported the occurrence of anxiety and agitation related to the attempts to attain the target meditative state ($M_{EM} = 3.22$, $M_{NM} = 0.54$, $p < 0.000$).

The results of the four-way ANOVA of spectral powers for six symmetrical zones (Group [GR 2: NM, EM] × Hemisphere [HS 2: LH, RH] × Experimental Condition [EC 2: rest with closed eyes, meditation] × Localization [LOC 6: *AT*, *F*, *C*, *PT*, *P*, *O*]) showed that EMs, compared to NMs, had significantly greater power values in most of the bands, predominantly in the posterior regions of the cortex, irrespective of the experimental condition. This is evidenced by significant interactions of the GR × LOC factors for the θ-($F(5.125) = 10.14$; $p < 0.000$), α_1-($F(5.125) = 4.04$; $p < 0.022$), α_2-($F(5.125) = 3.51$; $p < 0.046$), and α_3-($F(5.125) = 14.82$; $p < 0.000$) bands (Fig. 3).

As a result of three-way ANOVA for symmetrical cortical zones (GR(2) × HS(2) × EC(2)), significant GR × EC interactions were obtained for the frontal regions in the θ-($F(1.25) = 6.48$; $p < 0.017$) and α_1-($F(1.25) = 5.13$; $p < 0.033$) bands. In the α_2 band, this interaction was significant in virtually all the zones explored: *AT* ($F(1.25) = 9.27$, $p < 0.005$), *F* ($F(1.25) = 6.76$, $p < 0.015$), *PT* ($F(1.25) = 6.39$; $p < 0.018$), *P* ($F(1.25) = 7.06$; $p < 0.014$)), and *O* ($F(1.25) = 7.05$, $p < 0.014$). Analysis of the corresponding interaction means (Fig. 4) shows that, during meditation, EMs display an increase in the θ and α_1 powers in the frontal regions and an increase in the α_2 power in the anterotemporal and frontal regions, whereas NMs are characterized by significant desynchronization of α_2 power in the posterior (*P*, *PT* and *O*) regions (($p < 0.028$). Finally, the α_3 band appeared to be insensitive to the meditative process in both groups.

The two-way ANOVA (GR[2] × EC[2]) of the spectral power values in the midline leads showed the following results. In the *AM* zone (Fig. 1), the significant GR × EC interaction in the θ- (*AFz*: $F(1.25) = 7.47$; $p < 0.011$; *Fz*: $F(1.25) = 7.04$; $p < 0.014$), α_1-(*AFz*: $F(1.25) = 5.57$; $p < 0.026$; *Fz*: $F(1.25) = 6.79$; $p < 0.015$), and α_2-(*AFz*: $F(1.25) = 6.15$; $p < 0.020$) bands shows that, during meditation, EMs display a power increase in these bands, whereas NMs are characterized by the absence of significant power changes (Fig. 4). Moreover, the significant GR × EC interaction revealed in the *PM* zone (Fig. 1) only for the α_2 band (*Pz*: $F(1.25) = 5.40$, $p < 0.029$; *POz*: $F(1.25) = 6.64$, $p < 0.016$; *Oz*: $F(1.25) = 5.57$; p) was determined by the desynchronization effects in NMs under the conditions of the meditative process (Fig. 4).

According to the results of statistical analysis, it was only θ coherence that appeared to be sensitive to the meditation state (Fig. 5). The EM group was characterized by an increase in the short- and long-distance coherent couplings, predominantly in the anteroposte-

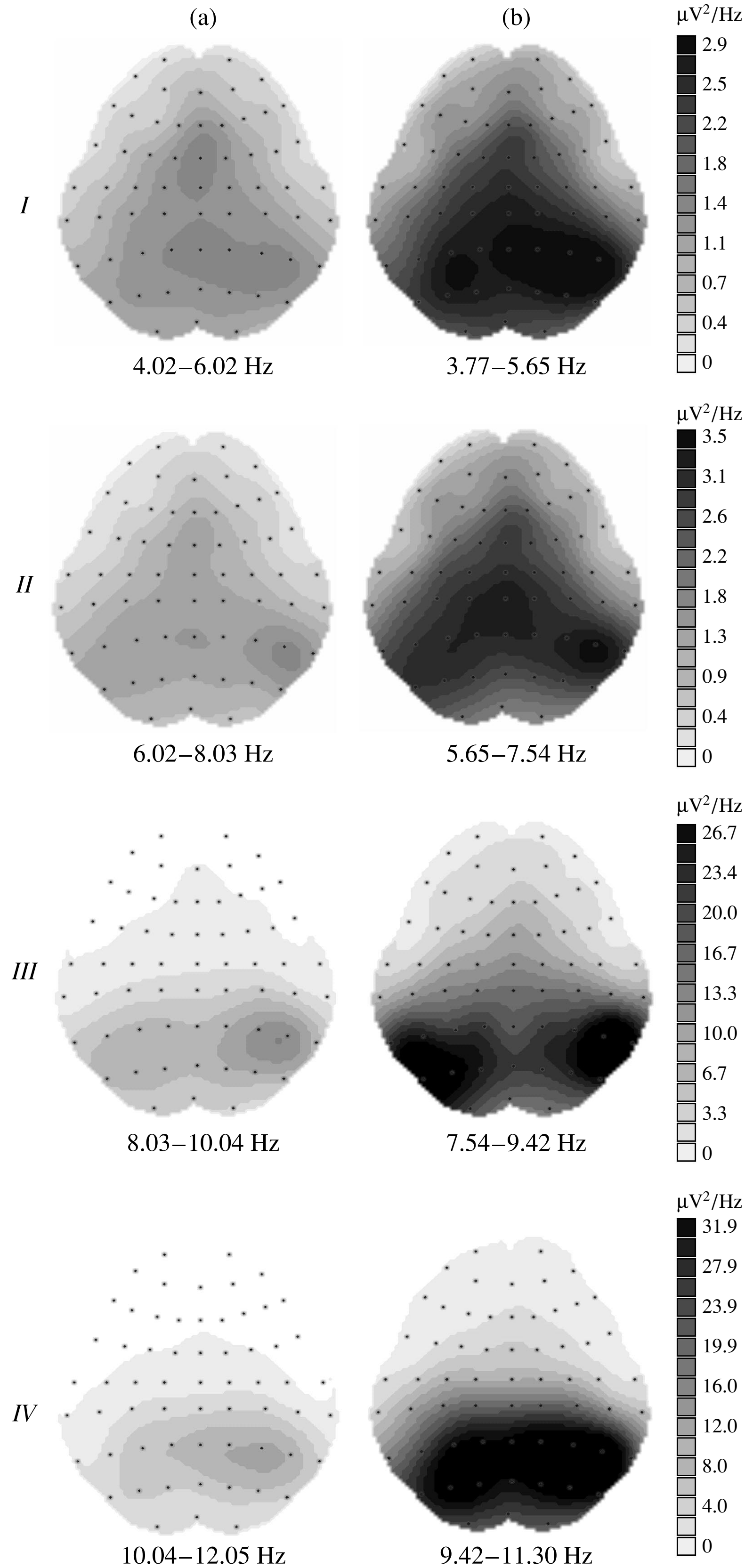

Fig. 3. Distribution of spectral power in (*I*) the θ, (*II*) α_1, (*III*) α_2, and (*IV*) α_3 bands for the groups of (a) novice and (b) experienced meditators.

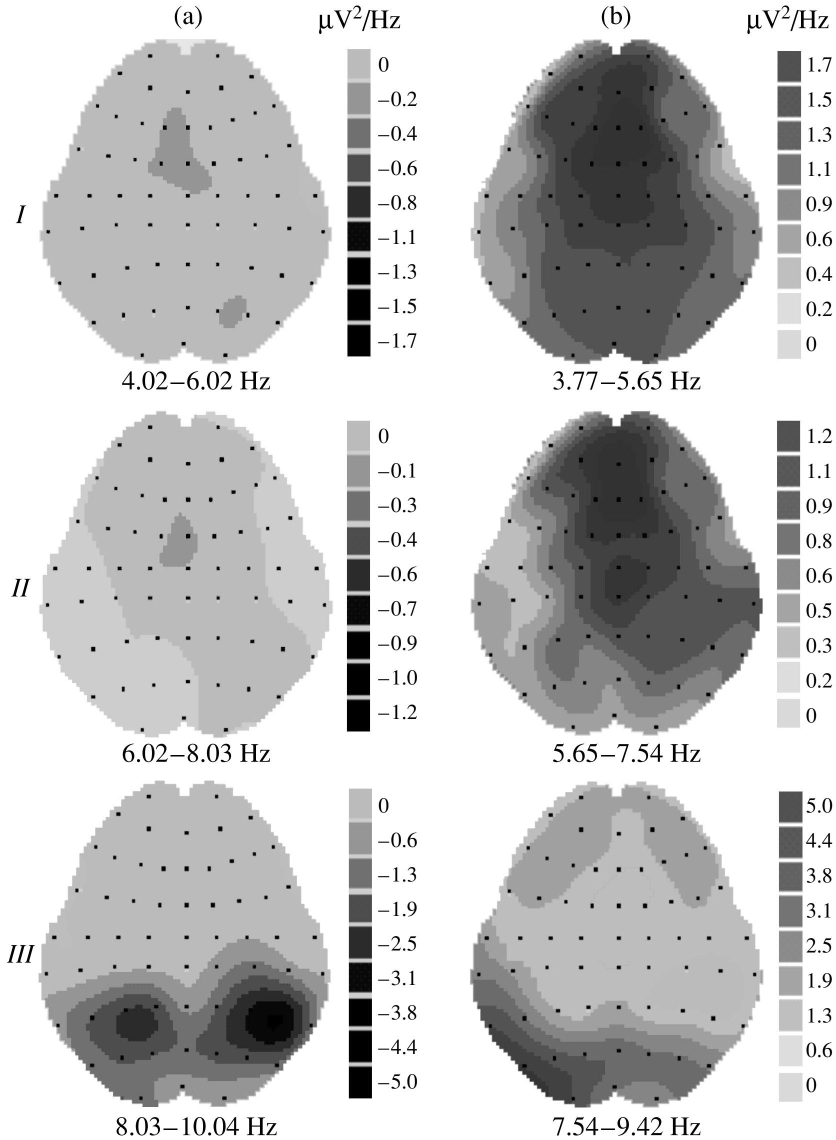

Fig. 4. Changes in the spectral power in (*I*) the θ, (*II*) α_1, and (*III*) α_2 bands between the states of rest with closed eyes and meditation for the groups of (a) novice and (b) experienced meditators.

rior direction with a markedly pronounced center of gravity in the left prefrontal region (lead AF_3), along with a less marked decrease in the intra- and interhemispheric coherence in the posterior cortical regions.

The correlation analyses established that the intensity of the experience of happiness under meditation conditions is positively associated with the increase in θ power in the frontal and mediofrontal cortical zones (significant correlations in the range from r = +0.44 to r = +0.55) (Fig. 6). In its turn, the intensity of mental activity correlated negatively with θ power in the frontal, mediofrontal, right central, and mediocentral regions (significant correlations from r = –0.43 to r = –0.60). In the α_1 band, the intensity of mental activity correlated negatively with the power values in the mediocentral (*FCz*, *Cz*, and *CPz*) and adjacent leads (significant correlations from r = –0.41 to r = –0.50) (Fig. 6). Finally, no significant correlation was found between the subjective values and changes in the α_2 and α_3 power.

DISCUSSION

As shown by the results of the study, experienced meditators are characterized not only by dynamic shifts associated directly with the altered state of consciousness, but also by stable neurophysiological shifts in the structures of the central nervous system.

The observed shift in EMs in the values of the individual frequency of α activity to a more low-frequency spectrum band, along with the higher values of the powers θ, α_1, α_2, and α_3 activity in the state of unaltered

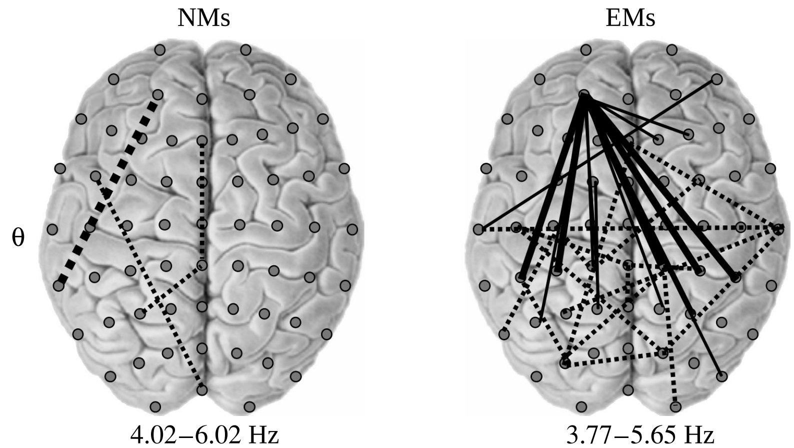

Fig. 5. Changes in coherence between the states of rest and meditation for the groups of novice meditators (NMs) and experienced meditators (EMs) in the θ band. The solid lines indicate an increase in coherence; the dotted lines, a decrease in coherence (bold lines: $p < 0.001$; thin lines: $p < 0.01$).

consciousness, is likely to reflect the cumulative character of the influences of long-term meditative practice. Regular meditation practice seems to cause relatively stable changes in cortical rhythmicity in experienced meditators, which, in turn, forms the basis for qualitatively different mechanisms of neurophysiological functioning [2, 9, 17]. One of the possible consequences of these changes is a general increase in psychoemotional stability in experienced meditators, who, compared to beginners, are characterized by lower values of trait anxiety and neuroticism and also display a better ability to identify emotions. These results agree with the data of other authors on the lower levels of anxiety and neuroticism [4–6], wider spectrum of positive emotional experiences [32], and quicker recovery after stressful effects [4, 12] in experienced meditators. The reverse correlates between the α-activity power and the blood plasma level of cortisol revealed in long-term meditators are sufficiently representative [16].

The comparison of dynamic changes in the cortical activity of experienced and novice meditators under conditions of generating an altered state of consciousness revealed the most convincing differences in cortical changes in the local θ and α_1 power in the anterior cortical regions and in θ coherence in the anteroposterior direction: the effective generation of an altered state of consciousness by experienced meditators was associated with an increase in the local θ and α_1 power, as well as with long-distance θ coherence.

Recently, it has become ever more evident that the emotional θ-rhythm, connected with corticolimbic interaction and "limbic" in its origin, seems to be intimately related to the cognitive component of emotional response in humans and the increase of the θ rhythm in emotions does not lead to a mere neocortical activation by limbic structures [33]. In light of current concepts, an increase in the θ rhythm in the anterior divisions of the human brain is regarded as a manifestation of increased activation. This supposition is based on the results of experimental investigations, in which an increase in θ power in these cortical areas is associated with an increase in the orientation response [34, 35] and concentration of attention [36], the effectiveness of encoding of new information in the memory [23, 25, 37], and the processing emotional information [38, 39], as well as with an increase in cognitive demand [40] (for a review, see [23]). Along with the θ activity of the anterior divisions of the cortex of the left and right hemispheres, the so-called frontal midline θ rhythm (*Fm*θ) is identified, which is observed in the *AFz* and *Fz* leads in the EEGs of healthy subjects under conditions of concentration of attention (including meditation processes), revealing significant correlates with autonomic activity [11, 41, 42]. The results of recent investigations with the use of high-resolution EEG and magnetoencephalography indicate that the neuronal networks of the frontal divisions of the left and right hemispheres providing for the functions of attention, including the anterior cingulate cortex (*ACC*), may be *Fm*θ generators, while the *Fm*θ changes during the performance of sequential cognitive tasks, reflect the alternating activity of the medial prefrontal cortex and *ACC* [43, 44]. The increase in θ power revealed in the anterior leads in experienced meditators falls into the category of the θ and *Fm*θ processes, reflecting the involvement of the neuronal networks oscillating at the θ-activity frequency into the mechanisms of internalization of attention and generation of positive emotional experiences (the occurring state of happiness) associated with the meditative process studied. This supposition is confirmed by the results of correlation analysis, according to which the θ-power values correlate positively with positive emotional experiences and negatively with mental activity. The inactivation of the cognitive component in this meditative process seems to create the context (prerequisites?) for the occurrence of a positive emotional experience. At the same time, the absence of

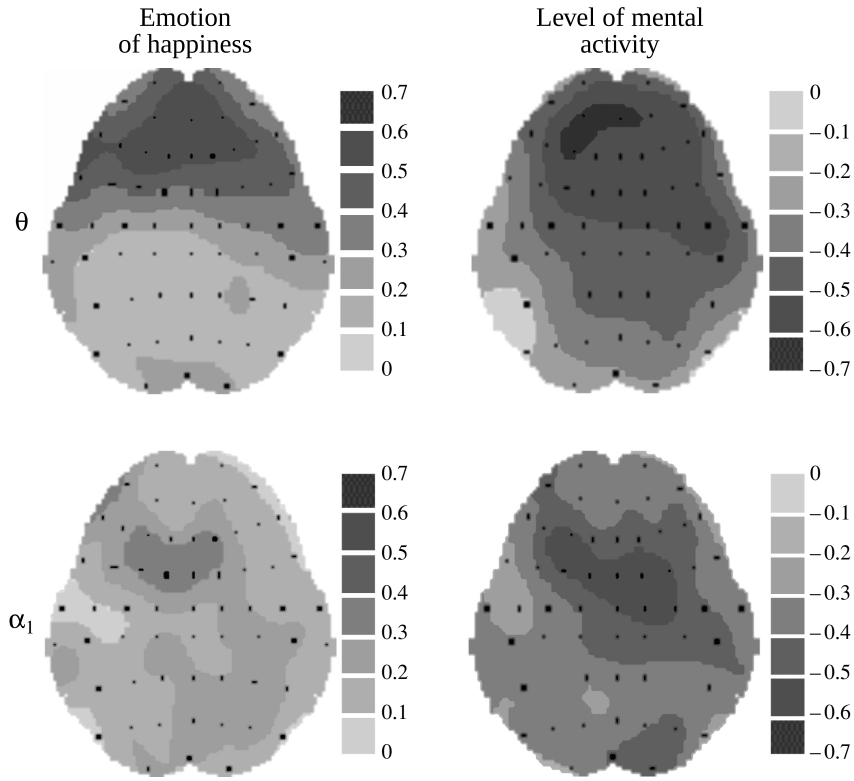

Fig. 6. Maps of correlation between the values of the subjective report and changes in the θ and α_1 spectral power (the state of rest as compared to the state of meditation). Significant positive and negative correlations begin with the scale values +0.4 and –0.4.

anterior θ and *Fm*θ synchronization in the meditation phase in novice meditators may be linked to the experience of the emotions of anxiety and disappointment by these subjects due to the inability to attain and/or reliably retain the desired meditative state. This observation is consistent with data of earlier investigations on negative correlates between *Fm*θ activity and the intensity of experience of anxiety [41].

Changes in α power during meditation can be determined by both functional heterogeneity of different α bands [23] and the specific features of the meditative state. According to the data of recent factor-analytical and other special studies, discrete independent factors were identified in the α band and additional evidence of the different functional significance of these frequencies was obtained: desynchronization in the lower and middle α band is associated with processes of external attention such as vigilance and expectancy, whereas desynchronization in the upper α band reflects an increase in cognitive activity [23, 45]. It can be suggested that the ability of experienced meditators to attain the target meditative state is afforded by successfully rendering ineffective the mechanisms of external attention, which is reflected in α_1 and α_2 synchronization of the anterior cortical regions. On the contrary, the activity of the processes of expectancy against the background of unsuccessful attempts to attain the meditative state was reflected in the α_2 desynchronization of the posterior cortical regions. And, finally, areactivity of the cognitive α_3 band in experienced meditators, when meditation is characterized by inhibition of cognitive activity, appears to be quite natural.

Changes in the interregional coherence interrelationships appeared to be another important correlate of the meditative state. According to the generally accepted point of view, coherence changes are regarded as an indicator of the informational flow along local and/or long-distance cortical–cortical projections [21, 46, 47]. It can be suggested that, in the general context, an increase in the long-distance connectivity in the θ band between the anterior and posterior brain divisions in experienced meditators is a necessary prerequisite for the general intensification of information processing connected with the induction of altered states of consciousness [46, 47]. At the same time, the predominance of activation of long-distance connections coupling remote areas of the frontal and parietal associative cortex, with the simultaneous formation of the center of gravity [46] of the increase in coherence located in the left prefrontal region, is probably necessary for generating positive emotional experiences. The few studies of the EEG coherence also indicate an increase in the levels of synchronization for positive emotions and a decrease for negative emotions [48, 49], and the works devoted to anterior cortical asymmetries and emotions [49–53] evidence the involvement of the prefrontal left hemispheric regions in the processes of generation of positive emotions. Finally, in a recent investigation in our laboratory, we obtained data indicating the enhancement of induced θ synchronization in the anterior temporal regions of the left hemisphere in response to the presentation of positive emotional stimuli [39].

CONCLUSION

Thus, our study established that, at the physiological level, experienced meditators are characterized by an increase in the baseline power of slow rhythms in the brain cortex and a shift in the individual α frequency to a lower frequency region. At the same time, the meditation process proper in these subjects is accompanied by differential changes in the narrow EEG frequency bands, which reflect the selective involvement of cortical neuronal networks in the mechanisms of internal attention and emotional information processing. However, the differences in the modal frequency of α activity in experienced and novice meditators may be due to a better capacity for meditation in individuals with a decelerated α rhythm rather than the influence of meditation practice. In any event, the answer to this question can be obtained from longitudinal investigations using larger samples of subjects. The data of psychometric analysis lead us to suggest that regular training of the mechanisms of internal attention and the positive emotional experiences occurring during the meditation process increase psychoemotional stability. Finally, the data obtained agree with present-day concepts that the θ and α activities in narrow frequency bands reflect the activity of multifunctional neuronal networks selectively associated with processes of cognitive and affective activity [23, 38, 49, 54, 55].

REFERENCES

1. Lou, H.C., Kjaer, T.W., Friberg, L., *et al.*, A ^{15}O-H_2O PET Study of Meditation and the Resting State of Normal Consciousness, *Hum. Brain Mapp.*, 1999, vol. 7 (2), p. 98.
2. Travis, F. and Pearson, C., Pure Consciousness: Distinct Phenomenological and Physiological Correlates of “Consciousness Itself,” *Int. J. Neurosci.*, 2000, vol. 100, p. 77.
3. Newberg, A., Alavi, A., Baime, M., *et al.*, The Measurement of Regional Cerebral Blood Flow during the Complex Cognitive Task of Meditation: A Preliminary SPECT Study, *Psychiatr. Res.*, 2001, vol. 106 (2), no. 10, p. 113.
4. Gaylord, C., Orme-Johnson, D., and Travis, F., The Effects of the Transcendental Meditation Technique and Progressive Muscle Relaxation on EEG Coherence, Stress Reactivity, and Mental Health in Black Adults, *Int. J. Neurosci.*, 1989, vol. 46, nos. 1, 2, p. 77.
5. Panjwani, U., Gupta, H.L., Singh, S.H., *et al.*, Effect of Sahaja Yoga Practice on Stress Management in Patients of Epilepsy, *Indian J. Physiol. Pharmacol.*, 1995, vol. 39 (2), p. 111.
6. Lee, M.S., Bae, B.H., Ryu, H., *et al.*, Changes in Alpha Wave and State Anxiety during ChunDoSunBup Qi-Training in Trainees with Open Eyes, *Am. J. Clin. Med.*, 1997, vol. 25 (3, 4), p. 289.
7. Infante, J.R., Torres-Avisbal, M., Pinel, P., *et al.*, Catecholamine Levels in Practitioners of the Transcendental Meditation Technique, *Physiol. Behav.*, 2001, vol. 72 (1, 2), p. 141.
8. Han, W., Zhang, L., and Xia, Y., The Difference in EEG Theta Waves between Concentrative and Nonconcentrative Qigong States—A Power Spectrum and Topographic Mapping Study, *J. Tradit. Chin. Med.*, 1994, vol. 14 (3), p. 212.
9. Istratov, E.N., Lyubimov, N.N., and Orlova, T.V., Dynamic Features of Altered States of Consciousness in Transcendental Meditation, *Byull. Eksp. Biol. Med.*, 1996, no. 2, p. 128.
10. Arambula, P., Peper, E., Kawakami, M., and Gibney, K.H., The Physiological Correlates of Kundalini Yoga Meditation: A Study of a Yoga Master, *Appl. Psychophysiol. Biofeedback*, 2001, vol. 26 (2), p. 147.
11. Kubota, Y., Sato, W., Toichi, M., *et al.*, Frontal Midline Theta Rhythm Is Correlated with Cardiac Activities during the Performance of an Attention-Demanding Meditation Procedure, *Brain Res. Cogn. Brain Res.*, 2001, vol. 11, p. 281.
12. Khare, K.S. and Nigam, S.K., A Study of Electroencephalogram in Meditators, *Indian J. Physiol. Pharmacol.*, 2000, vol. 44 (2), p. 173.
13. Kamei, T., Toriumi, Y., Kimura, H., *et al.*, Decrease in Serum. Cortisol during Yoga Exercise Is Correlated with Alpha Wave Activation, *Percept. Mot. Skills*, 2000, vol. 90, no. 3, part 1, p. 1027.
14. Delmonte, M.M., Electrocortical Activity and Related Phenomena Associated with Meditation Practice: A Literature Review, *Int. J. Neurosci.*, 1984, vol. 24 (3, 4), p. 217.
15. Travis, F.T., Eyes Open and TM EEG Patterns after One and after Eight Years of TM Practice, *Psychophysiology*, 1991, vol. 28, no. 3 (a), p. 58.
16. Mason, L.I., Alexander, C.N., Travis, F.T., *et al.*, Electrophysiological Correlates of Consciousness during Sleep in Long-Term Practitioners of the Transcendental Meditation Program, *Sleep*, 1997, vol. 20 (2), p. 102.
17. Lyubimov, N.N., EEG and Evoked Potentials Changes with the Use of a Special Form of Psychological Training (Meditation), *Fiziol. Chel.*, 1999, vol. 25, no. 2, p. 56.
18. Travis, F. and Wallace, R.K., Autonomic and EEG Patterns during Eyes-Closed Rest and Transcendental Meditation (TM) Practice: The Basis for a Neural Model of TM Practice, *Conscious. Cogn.*, 1999, vol. 8 (3), p. 302.
19. Travis, F., Tecce, J.J., and Guttman, J., Cortical Plasticity, Contingent Negative Variation, and Transcendent Experiences during Practice of the Transcendental Meditation Technique, *Biol. Psychol.*, 2000, vol. 55 (1), p. 41.
20. Fedotchev, A.I., Bondar’, A.T., and Akoev, I.G., Rhythmic EEG Structure of Humans: Present-Day State and Study Trends, *Usp. Fiziol. Nauk*, 2000, no. 3, p. 39.
21. Sviderskaya, N.E. and Korol’kova, T.A., Spatial Organization of Electrical Brain Processes: Problems and Solutions, *Zh. Vyssh. Nervn. Deyatel.*, 1997, vol. 47, no. 5, p. 792.
22. Harmony, T., Fernandez, T., Silva, J., *et al.*, Do Specific EEG Techniques Indicate Different Processes during Mental Calculation?, *Neurosci. Lett.*, 1999, vol. 266, p. 25.

23. Klimesch, W., EEG Alpha and Theta Oscillations Reflect Cognitive and Memory Performance: A Review and Analysis, *Brain Res. Rev.*, 1999, vol. 29, p. 169.

24. Doppelmayr, M., Klimesch, W., Pachinger, T., and Ripper, B., Individual Differences in Brain Dynamics: Important Implications for the Calculation of Event-Related Band Power, *Biol. Cybern.*, 1998, vol. 79, p. 49.

25. Doppelmayr, M., Klimesch, W., Schwaiger, J., *et al.*, Theta Synchronization in the Human EEG and Episodic Retrieval, *Neurosci. Lett.*, 1998, vol. 257 (1), no. 20, p. 41.

26. Rai, U.C., *Medical Science Enlightened. Life Eternal Trust*, London–New York, 1993.

27. Khanin, Yu.L., Cross-Cultural Perspectives of the Diagnosis of Individual Differences: Methodological and Conceptual Problems: *Vopr. Psikhol.*, 1989, no. 4, p. 118.

28. Spielberger, C.D., Gorsuch, R.L., Lushene, R., *et al.*, Manual for the State-Trait Anxiety Inventory, Palo Alto, CA: Consulting Psychologists Press, 1983.

29. Bagby, M., Parker, J.D.A., and Taylor, G.J., The Twenty-Item Toronto Alexithymia Scale—I. Item Selection and Cross Validation of the Factor Structure, *J. Psychosom. Res.*, 1994, vol. 38, p. 23.

30. Hanin, Yu., Eysenck, S.B.G., Eysenck, H.J., and Barrett, P., A Cross-Cultural Study of Personality: Russia and England, *Person. Individ. Differ.*, 1991, vol. 12, p. 265.

31. Semlitsch, H.V., Anderer, P., Schuster, P., and Presslich, O., A Solution for Reliable and Valid Reduction of Ocular Artifacts Applied to the P300 ERP, *Psychophysiology*, 1986, vol. 23, p. 695.

32. Severtsen, B. and Bruya, M.A., Effects of Meditation and Aerobic Exercise on EEG Patterns, *J. Neurosci. Nurs.*, 1986, vol. 18, no. 4, p. 206.

33. Simonov, P.V., *Emotsional'nyi mozg* (Emotional Brain), Moscow: Nauka, 1981.

34. Demiralp, T. and Basar, E., Theta Rhythmicities Following Expected Visual and Auditory Targets, *Int. J. Psychophysiol.*, 1992, vol. 13 (2), p. 147.

35. Basar, E., Basar-Eroglu, C., Karakas, S., and Schurmann, M., Oscillatory Brain Theory: A New Trend in Neuroscience, *IEEE Eng. Med. Biol. Mag.*, 1999, vol. 18, p. 56.

36. Sasaki, K., Nambu, A., Tsujimoto, T., *et al.*, Studies on Integrative Functions of the Human Frontal Association Cortex with MEG, *Brain Res. Cogn. Brain Res.*, 1996, vol. 5 (1, 2), p. 165.

37. Klimesch, W., Doppelmayr, M., Russegger, H., and Pachinger, T., Theta Band Power in the Human Scalp EEG and the Encoding of New Information, *Neuroreport*, 1996, vol. 17, no. 7 (7), p. 1235.

38. Krause, C.M., Viemero, V., Rosenqvist, A., *et al.*, Relative Electroencephalographic Desynchronization and Synchronization in Humans to Emotional Film Content: An Analysis of the 4–6, 6–8, 8–10, and 10–12 Hz Frequency Bands, *Neurosci. Lett.*, 2000, vol. 286 (1), no. 26, p. 9.

39. Aftanas, L.I., Varlamov, A.A., Pavlov, S.V., *et al.*, Affective Picture Processing: Event-Related Synchronization within Individually Defined Human Theta Band Is Modulated by Valence Dimension, *Neurosci. Lett.*, 2001, vol. 303, p. 115.

40. Hankins, T.C. and Wilson, G.F., A Comparison of Heart Rate, Eye Activity, EEG, and Subjective Measures of Pilot Mental Workload during Flight, *Aviat. Space Environ. Med.*, 1998, vol. 69, no. 4, p. 360.

41. Inanaga, K., Frontal Midline Theta Rhythm and Mental Activity, *Psychiatr. Clin. Neurosci.*, 1998, vol. 52, p. 555.

42. Ishii, R., Shinosaki, K., Ukai, S., *et al.*, Medial Prefrontal Cortex Generates Frontal Midline Theta Rhythm, *Neuroreport*, 1999, vol. 10, p. 675.

43. Asada, H., Fukuda, Y., Tsunoda, S., *et al.*, Frontal Midline Theta Rhythms Reflect Alternative Activation of Prefrontal Cortex and Anterior Cingulate Cortex in Humans, *Neurosci. Lett.*, 1999, vol. 274, p. 29.

44. Allman, J.M., Hakeem, A., Erwin, J.M., *et al.*, The Anterior Cingulate Cortex. The Evolution of an Interface between Emotion and Cognition, *Ann. N.Y. Acad. Sci.*, 2001, vol. 935, p. 107.

45. Klimesch, W., Doppelmayr, M., Russegger, H., *et al.*, Induced Alpha Band Power Changes in the Human EEG and Attention, *Neurosci. Lett.*, 1998, vol. 244, p. 73.

46. Petsche, H., Approaches to Verbal, Visual, and Musical Creativity by EEG Coherence Analysis, *Int. J. Psychophysiol.*, 1996, vol. 24, p. 145.

47. Weiss, S., Müller, H.M., and Rappelsberger, P., Theta Synchronization Predicts Efficient Memory Encoding of Concrete and Abstract Nouns, *Neuroreport*, 2000, vol. 11, p. 2357.

48. Hinrichs, H. and Machleidt, W., Basic Emotions Reflected in EEG-Coherences, *Int. J. Psychophysiol.*, 1992, vol. 13, p. 225.

49. Aftanas, L.I., Lotova, N.V., Koshkarov, V.I., *et al.*, Nonlinear Dynamic Complexity of the Human EEG during Evoked Emotions, *Int. J. Psychophysiol.*, 1998, vol. 28, p. 63.

50. Crawford, H.J., Clarke, S.W., and Kitner-Triolo, M., Self-Generated Happy and Sad Emotions in Low and Highly Hypnotizable Persons during Waking and Hypnosis: Laterality and Regional EEG Activity Differences, *Int. J. Psychophysiol.*, 1996, vol. 24, p. 239.

51. Aftanas, L.I., Lotova, N.V., Koshkarov, V.I., and Popov, S.A., Nonlinear Dynamical Coupling between Different Brain Areas during Evoked Emotions: An EEG Investigation, *Biol. Psychol.*, 1998, vol. 48, p. 121.

52. Rusalova, M.N. and Kostyunina, M.B., Informational Theory of Emotions: A Psychophysiological Study of Mental Reproduction of Joy, *Ross. Fiziol. Zh. im. I.M. Sechenova*, 2000, vol. 86, no. 5, p. 548.

53. Davidson, R.J., Jackson, D.C., and Kalin, N.H., Emotion, Plasticity, Context, and Regulation: Perspectives from Affective Neuroscience, *Psychol. Bull.*, 2000, vol. 126, p. 890.

54. Basar, E., Basar-Eroglu, C., Karakas, S., and Schurmann, M., Gamma, Alpha, Delta, and Theta Oscillations Govern Cognitive Processes, *Int. J. Psychophysiol.*, 2001, vol. 39, p. 241.

55. Basar, E., Schurmann, M., and Sakowitz, O., The Selectively Distributed Theta System: Functions, *Int. J. Psychophysiol.*, 2001, vol. 39, p. 197.