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IMPACT OF REGULAR MEDITATION PRACTICE ON EEG ACTIVITY AT REST AND DURING EVOKED NEGATIVE EMOTIONS

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The main objective of the present investigation was to examine how long-term meditation practice is manifested in EEG activity under conditions of non-emotional arousal (eyes-closed and eyes-open periods, viewing emotionally neutral movie clip) and while experiencing experimentally induced negative emotions (viewing aversive movie clip). The 62-channel EEG was recorded in age-matched control individuals (n = 25) and Sahaja Yoga meditators (SYM, n = 25). Findings from the non-emotional continuum show that at the lowest level of arousal (eyes closed) SYM manifested larger power values in theta-1 (4–6 Hz), theta-2 (6–8 Hz) and alpha-1 (8–10 Hz) frequency bands. Although increasing arousal desynchronized activity in these bands in both groups, the theta-2 and alpha-1 power in the eyes-open period and alpha-1 power while viewing the neutral clip remained still higher in the SYM. During eyes-closed and eyes-open periods the controls were marked by larger right than left hemisphere power, indexing relatively more active left hemisphere parieto-temporal cortex whereas meditators manifested no hemisphere asymmetry. When contrasted with the neutral, the aversive movie clip yielded significant alpha desynchronization in

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both groups, reflecting arousing nature of emotional induction. In the control group along with alpha desynchronization affective movie clip synchronized gamma power over anterior cortical sites. This was not seen in the SYM. Overall, the presented report emphasizes that the revealed changes in the electrical brain activity associated with regular meditation practice are dynamical by nature and depend on arousal level. The EEG power findings also provide the first empirical proof of a theoretical assumption that meditators have better capabilities to moderate intensity of emotional arousal.

Keywords aversive workload, EEG, emotion, hemispheric asymmetry, non-emotional arousal, meditation, regular meditation practice

Recent years have seen a growing interest in meditation as a tool for alternative therapy of stress-related and psychosomatic diseases. This tool is also used for improvement of mental peak performance, stress reduction, and training coping skills in the non-patient population. Meditation is a complex mental process involving changes in cognition, sensory perception, affect, hormones, and autonomic activity (Newberg & Iversen, 2003). Meditation has been defined as "intentional self-regulation of attention," a systematic mental focus on particular aspects of inner or outer experience. Meditation has been found in numerous studies to reduce experience of anxiety, anger, and fear, increase positive affect, enhance endurance to affective challenges and improve psychosocial coping ability (reviewed by Astin et al., 2003).

Researches on biological concomitants of meditation practice have mostly focused on changes that occur during a period of meditation compared with a resting control condition in a single experimental session (Travis, 1991; Kubota et al., 2001; Lehmann et al., 2001; Aftanas & Golocheikine, 2001, 2002). Although there is no evidence for structural changes through regular meditation practice, evidence is growing for enduring experience-related functional changes in a number of physiological systems. Meta-analyses suggest that experienced meditators manifest a decreased activation of the autonomic and endocrine systems as indexed by lower levels of respiration rate, heart rate, spontaneous skin conductance response, plasma lactate, catecholamines, and cortisol (Dillbeck & Orme-Johnson, 1987; Infante et al., 2001; Jones, 2001) along with increased immune response (Davidson et al., 2003). Regular meditation experiences are also reported to enhance nervous system functioning as measured by faster neural transmission (Dillbeck et al., 1981), perceptual processing (So Kam Tim, 1995), decision time, and performance (Cranson et al., 1991) speed. Meditation has been found to increase skin potential habituation rates reflecting generally enhanced adaptive strength (Gaylord et al., 1989).

Sparse EEG studies evidence enhanced low frequency activity during both eyes-closed and eyes-open periods (i.e., larger theta and alpha band power) (Delmonte, 1984; Travis, 1991; Lee et al., 1997; Khare & Nigam, 2000; Kubota et al., 2001; Travis et al., 2002). Findings on contingent negative variation (CNV) also suggest cumulative effects of meditation on cortical preparatory response (heightened late CNV amplitude in simple trials) and executive functioning (diminished distraction effects in letter trials (Travis et al., 2000). The present authors have not found any data on EEG activity and emotional processing in experienced meditators.

Considering the reported biological concomitants of meditation practice one should emphasize that there are two most extensively researched forms of meditation. Transcendental meditation, in which practitioners repeat a silent word or phrase with the goal of quieting (and ultimately transcending) the ordinary stream of internal mental dialogue (Travis & Pearson, 2000), and mindfulness meditation in which practitioners simply observe or attend to (without judgment) thoughts, emotions, sensations, perceptions, and so on, as they arise moment by moment in the field of awareness (Astin et al., 2003). The current EEG report focuses on enduring changes that can be detected in baseline brain function as well as in response to non-emotional and specific emotional challenge. The authors studied individuals daily practicing Sahaja Yoga meditation over the last 5–10 years. This technique involves mental states of internalized attention. The key experience during Sahaja Yoga meditation is a state called "thoughtless awareness" or "mental silence" in which the meditator is alert and aware but is free of any unnecessary mental activity. The state of thoughtless awareness is usually accompanied by emotionally positive experiences of bliss. In general, the outcome of meditative process is associated with a sense of relaxation and positive mood and a feeling of benevolence toward oneself and others (Rai, 1993).

The first objective of the present investigation was to examine how regular meditation practice influences EEG activity under conditions marked by different levels of non-emotional arousal (i.e., eyes-closed and eyes-open periods as well as viewing an emotionally neutral movie clip). The second one was to clarify meditation-related specificity of EEG activity patterns while experiencing negative emotions, experimentally induced by movie clips. It was predicted that meditators versus controls during controlled rest conditions (eyes closed and eyes-open periods) would show EEG signs of less tonic arousal and more internalized attention, whereas while viewing emotionally neutral movie clips they would show less attentional involvement. The second prediction assumed that when confronted with emotionally negative visual stimuli (aversive movie clip) meditators would manifest EEG signs of greater endurance to emotionally negative workload.

METHODS

Subjects

Healthy right-handed volunteers (20–40 years old) with normal or corrected-to-normal vision were assigned to the two experimental groups: Sahaja Yoga meditators (SYM, n = 25, 12 males, 13 females) and control individuals (n = 25, 13 males, 12 females) who never practiced any type of meditation. All the subjects (Ss) signed an informed consent to participate in the study and the research had received prior approval of the institutional ethics committee. The Ss were informed to refrain from exercise and consuming alcohol on the day of investigation. All the Ss were paid for participation in the study.

Stimuli

Four different movie clips were used in the experimental procedure. The first emotionally neutral movie clip was used only to adapt the Ss to the procedure and was excluded from the further analysis. Two clips showing emotionally neutral landscape scenes were used as neutral video stimulation. Negative emotional arousal was implemented by clip cut from Michael Haneke's film "Funny Games" (1997) (two young people abusing a family). All the video clips were in color and lasted 3 to 4.5 min.

Procedure

The Ss were seated in a comfortable armchair and the light in the room was dimmed. The experiment began with the 4 90 s randomly assigned eyes-open/eyes-closed baselines. After this, the Ss were shown 4 films over the course of the experiment. Before the film presentation specific instructions were used: "We are interested in how the scenes *themselves* make *you feel*. Therefore, your ratings should reflect the emotional impact of the segments *on you*, rather than your feelings due to other factors, such as weather or personal problems. People differ in emotionality. We are interested in how these film segments make *you* feel rather than in how you think you should feel or how you think others would feel" (McHugo et al., 1982).

Movie clips were presented on a 17'' ViewSonic monitor of the PC in digital video format (MPEG-IV). Soundtracks were presented via PCI128 Creative SoundBlaster over a pair of SONY SS-H150 speakers. Each clip trial consisted of: (1) 30 s relaxing segment, showing static landscape in order to minimize emotional traces from the previous film; (2) 30 s blank screen period; (3) brief countdown (from 5 to 0 with a step of 1 count per second), presented on the screen; (4) the target movie clip presentation ranging from 3 to 4.5 min; (5) subjective ratings, which assessed the Ss emotional reactions in response to the presented clip. Two different neutral clips were randomly presented before and after the aversive clip.

After the presentation of each clip the Ss had to rate the strength of their feelings on 9-point unipolar scales (from "not at all" to "very strongly") in 9 emotion categories, which were described by following 3-word groups of adjectives: (1) joyful, amused, merry; (2) sad, downhearted, blue; (3) angry, irritated, mad; (4) fearful, scared, afraid; (5) anxious, tense, nervous; (6) disgusted, turned off, repulsed; (7) contemptuous, disdainful, scornful; (8) surprised, amazed, astonished; (9) happy, warmhearted, elated (Izard et al., 1974; McHugo et al., 1982). All participants included in the study had never seen the movie clips prior to the experiment.

EEG Recording

Scan 4.1.1 software, 128-channel Electrical Signal Imaging System (ESI-128, NeuroScan Labs.), modified 64-channel QuikCap with imbedded Ag/AgCl electrodes (NeuroSoft, Inc.) and ElectroCap Gel (Weaver and Co.) were used to record EEG from 62 active scalp sites referenced to the tip of the nose. The ground electrode was attached to the center of the forehead. The impedance was kept below 5 kΩ. Vertical and horizontal electrooculogram was measured to control for ocular artefacts using QuikCap's electrodes. Vertical EOG was recorded with electrodes placed 2 cm above and below the middle of right eye. Horizontal EOG electrodes were placed as close as possible to the left and right outer canthi of the eyes. Calibration was done at 100 μV at 10 Hz. The EEG and EOG signals were digitally filtered at 0.3–50 Hz (-6-dB gain, ≥ –12-dB/octave slope) and amplified (gain 1000, resolution 0.084 μV/bit, range 5.5 mV) via SynAmps amplifiers, sampled at 500 Hz and stored for off-line analyses.

Data Analysis

Contributions of the EOG to the EEG were eliminated off-line by submitting the data to an eye movement correction algorithm (Semlitsch et al., 1986). In addition, individual EEG traces were manually inspected for any remaining eye-movement, EMG, or movement-related artefacts. Three artifact-free EEG segments (each of 8.192 s) were selected for each condition (i.e., eyes closed, eyes open, neutral and emotional movie clip conditions). For emotional clips the epochs were selected from the most emotional parts of the scripts (usually closer to the end of the clip). EEG segments were epoched into two 4.096 s (i.e., 2048 analog-to-digital conversion points) epochs, fast Fourier transformed (FFT) and averaged in the frequency domain using a Parzens window. The FFTs were then grouped into the delta (2–4 Hz), theta-1 (4–6 Hz), theta-2 (6–8 Hz), alpha-1 (8–10 Hz), alpha-2 (10–12 Hz), beta-1 (12–18 Hz), beta-2 (18–25 Hz), and gamma (25–45 Hz) frequency bands, log-transformed, and averaged across three EEG traces. EEG traces from two neutral film conditions were averaged in addition. For EEG data analysis initially EEG electrodes were collapsed into 18 clusters. This procedure resulted in 9 regional means for each hemisphere: frontopolar—Fp (Fp1/Fp2), anterior temporal—AT(AF7, F7/AF8, F8), frontal—F (AF3, F3, F5/ AF4, F4, F6), fronto-central—FC (FC1, FC3, FC5/FC2, FC4, FC6); central—C (C1, C3, C5/ C2, C4, C6), centro-parietal—CP (CP1, CP3, CP5/ CP2, CP4, CP6); parieto-temporal—PT (P5, P7/ P6, P8); parietal—P (P1, P3/P2, P4) and occipital—O (PO3, PO5, PO7, O1/ PO4, PO6, PO8, O2). The average power values across the respective electrode sites were calculated for these regional means for each frequency band and each experimental condition.

To check up for putative group differences in the spectral band power values during experimental conditions varying in arousal level, for each frequency band 4-way ANOVAs with the factors of group (GR 2: controls, meditators), experimental condition (COND 4: eyes open, eyes closed, neutral and aversive movie clips), hemisphere (HEM 2: left and right hemisphere), and Location (LOC 9: FP, AT, F, FC, C, CP, PT, P, O) were computed with repeated measurements on the last three factors. Additional analysis concerned EEG activation asymmetries. Preliminary analyses with symmetrical regions evidenced the sensitivity of parieto-temporal regions to laterality group differences within the implemented experimental design. To check up robustness of these associations the parieto-temporal regions were contrasted with the frontal ones using multidimensional statistical designs.

For each frequency band and selected symmetrical regions the 4-way ANOVAs with the factors of group (GR 2: controls, meditators), caudality (CAUD: frontal, parieto-temporal), hemisphere (HEM 2: left and right), and experimental condition (COND 4: eyes open, eyes closed, neutral and aversive movie clips) were computed with repeated measurements on the last three factors. To verify subjective emotional impact of the aversive movie clip individual self-report scores were subjected to the 3-way ANOVA with the factors of Group (GR 2: controls and meditators), movie clip (MC 2: neutral, aversive), and emotion (EMOT 9: surprise, amusement, joy, happiness, anger, fear, anxiety, sadness, disgust, disdainfulness) with repeated measurements on the last two factors. In all the ANOVAs significant interactions were examined through simple effects to locate the source of the interaction as well as by post-hoc (Scheffe-test) and planned comparisons. For all the analyses, degrees of freedom were Greenhouse-Geisser corrected where appropriate.

RESULTS

Spectral Band Power

Within the frame of the implemented paradigm effects of arousal manipulation were revealed in the theta-1, theta-2, alpha-1, alpha-2, and gamma frequency bands (Figure 1). According to significant interactions COND × LOC in the theta-1 ($F(24, 1152) = 18.62$, $p < .001$), theta-2 ($F(24, 1152) = 27.09$, $p < .001$), alpha-1 ($F(24, 1152) = 74.01$, $p < .001$), and alpha-2 ($F(24, 1152) = 83.54$, $p < .001$) bands and post-hoc comparisons, in both groups increasing arousal decreased EEG power with greater impact on posterior cortical regions. In the theta-1 and theta-2 frequency bands power values during eyes-closed periods were significantly larger than in all other conditions. In turn, alpha-1 and alpha-2 band power values are seen to gradually decrease as arousal increases: the largest power values were seen at the eyes-closed periods, whereas viewing of emotional film was marked by the lowest power values (all post-hoc comparisons at $p < .01$).

As for between-group differences, significant interactions GR × COND for the theta-1 ($F(3, 144) = 7.005$, $p < .003$), theta-2 ($F(3, 144) = 7.363$, $p < .002$), and alpha-1 ($F(3, 144) = 6.384$, $p < .006$) frequency bands evidenced that meditators versus controls show larger power values under conditions of lower arousal irrespectively of topography (Figure 1). Separate ANOVAs for each experimental condition specified further that for the theta-

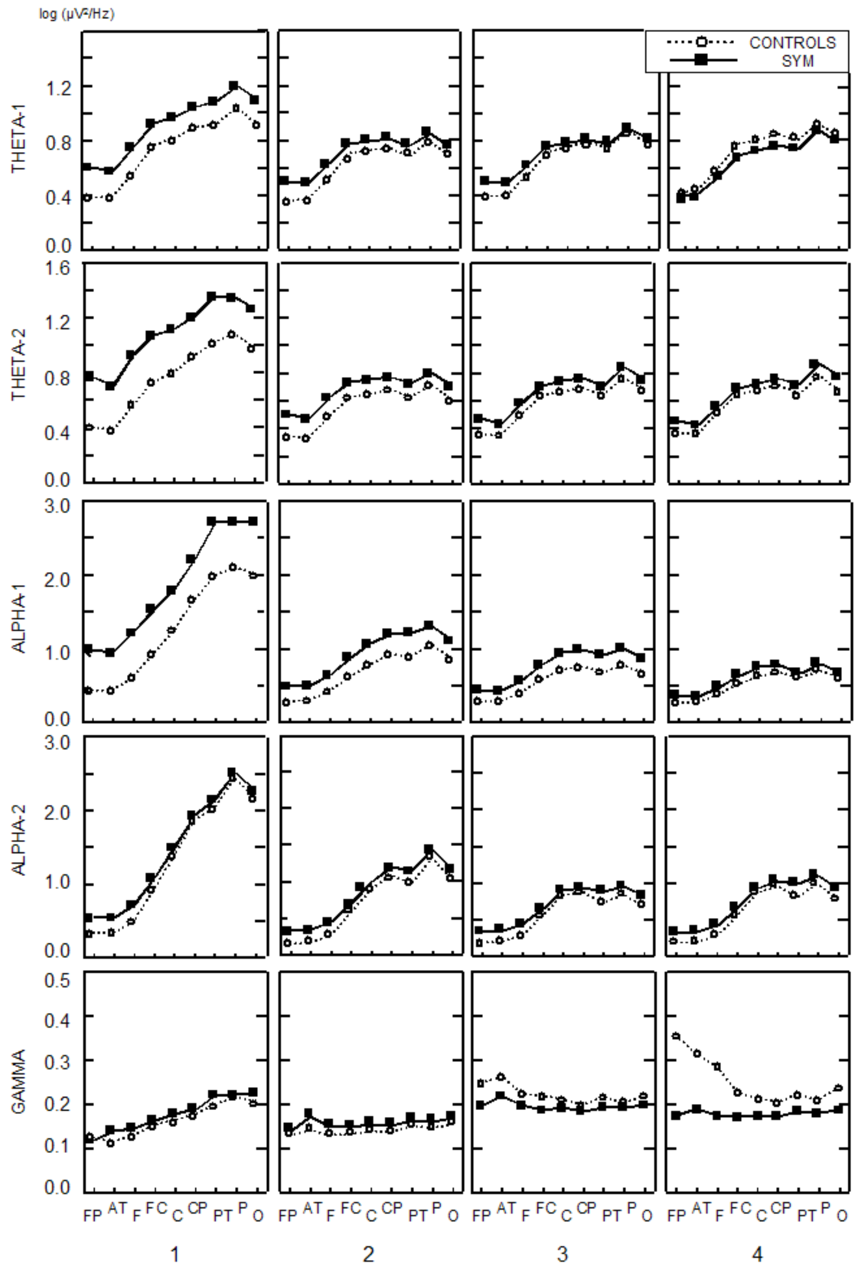

Figure 1. Topographic distribution of the mean theta-1, theta-2, alpha-1, alpha-2, and gamma power values for the controls and SYM in the eyes-closed (1) and eyes-open (2) periods as well as in response to emotionally neutral (3) and aversive (4) movie clips.

1 band this peculiarity is manifested in the eyes-closed period (GR: $F(1, 48) = 7.016$, $p < .011$), for the theta-2 it is indexed in both eyes- closed (GR: $F(1, 48) = 9.610$, $p < .003$) and eyes-open (GR: $F(1, 48) = 5.129$, $p < .028$) periods whereas for the alpha-1 band larger power values of meditators are observed in the eyes-closed (GR: $F(1, 48) = 11.182$, $p < .002$) and eyes-open (GR: $F(1, 48) = 4.360$, $p < .042$) periods as well as while viewing the neutral movie clip (GR: $F(1, 48) = 4.473$, $p < .040$) conditions. Analysis of significant interaction GR × COND × LOC ($F(24, 1152) = 3.72$, $p < .011$) for the gamma band shows that group differences were manifested only in affective clip condition (Figure 1). In the control group the aversive movie clip induced gamma power increase over Fp, AT, and F regions, whereas the meditators the clip did not yield significant power changes (aversive clip condition, GR × LOC: $F(8, 384) = 5.08$, $p < .010$, planned comparisons at $p < .05$).

Laterality group differences were revealed in the alpha-2 frequency band (Figure 2). According to interaction GR × COND × HEM × CAUD ($F(3, 144) = 3.618$, $p < .037$) and follow-up analysis, these differences are restricted to parieto-temporal regions and to eyes-closed (GR × HEM: $F(1, 48) = 6.47$, $p < .014$) and eyes-open (GR × HEM: $F(1, 48) = 3.83$, $p < .048$) periods. Separate ANOVAs by groups yielded interaction COND × HEM

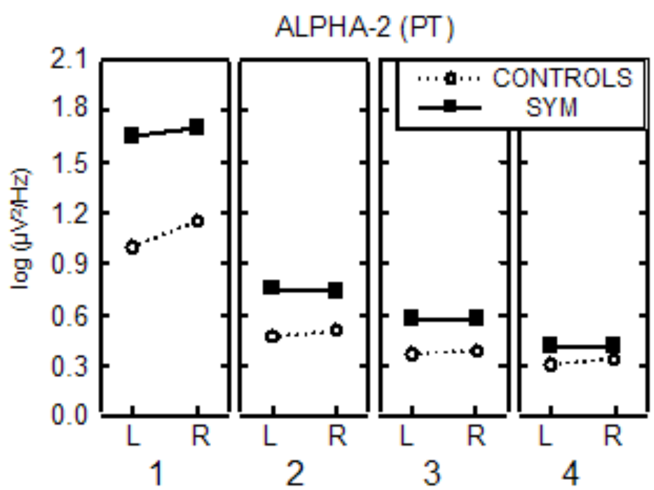

Figure 2. Hemispheric distribution of the mean alpha-2 power values over the parieto-temporal regions (PT) for the control and SYM groups in the eyes-closed (1) and eyes-open (2) periods as well as in response to emotionally neutral (3) and aversive (4) movie clips. L—left hemisphere; R—right hemisphere.

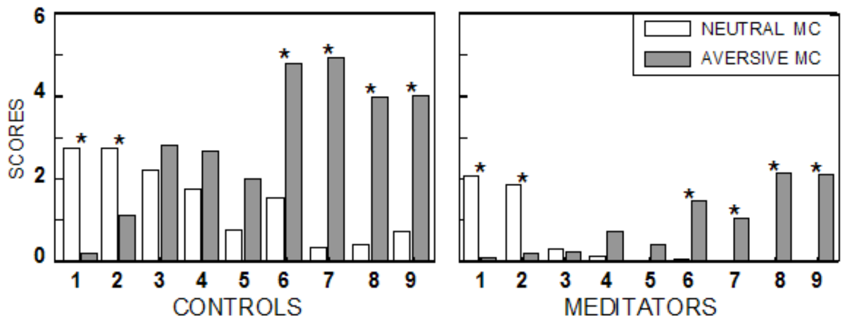

Figure 3. Self-reported ratings of emotional feelings, induced by the neutral and the aversive movie clips (MC) in the controls and SYM. $*p < .05$ (within-group post-hoc comparisons between the neutral and aversive movie clip conditions with the Scheffe test). 1—happy, 2—joy, 3—surprised, 4—sad, 5—fearful, 6—anxious, 7—angry, 8—disgusted, 9—contemptuous.

$F(3, 72) = 7.01$, $p < .006$) specifying that the controls are characterized by larger right than left hemisphere power during the eye-closed (HEM: $F(1, 24) = 11.62$, $p < .002$) and eyes-open (HEM: $F(1, 24) = 4.26$, $p < .045$) periods. No hemisphere differences were revealed while viewing emotionally neutral and aversive movies clips. In turn, meditators evidenced no hemisphere differences throughout all the four experimental conditions.

Subjective Response to the Aversive Movie Clip

The reliable effects associated with film emotionality were evidenced in the both groups. According to MC × EMOT interactions for the control ($F(8, 192) = 33.37$, $p < .001$) and SYM ($F(8, 192) = 30.72$, $p < .001$) groups, the emotional movie clip elicited emotions of anger, anxiety, disgust, and contempt while decreasing emotions of happiness and joy (all post hocs at $p < .01$). At the between-group level, statistical analyses have revealed influence of meditation practice on the subjective report ratings while viewing both the neutral and aversive movie clips, indexed by interaction GR × MC × EMOT ($F(8, 384) = 5.66$, $p < .001$). Analysis of the means of this interaction shows that in addition to lower scores for all the emotions but happiness while viewing the neutral clip the meditators versus controls demonstrate significantly lower emotional reactivity to the aversive movie clip (all planned comparisons at $p < .01$).

DISCUSSION

In the present study three experimental conditions modeled three levels of non-emotional arousal in the continuum "eyes closed—eyes open—viewing emotionally neutral movie clips." Findings from this continuum show that at the lowest level of arousal (eyes closed) SYM manifested larger power values in theta-1, theta-2, and alpha-1 frequency bands. Although increasing arousal desynchronized activity in these bands in both groups, the theta-2 and alpha-1 power in the eyes-open period and alpha-1 power while viewing a neutral clip remained still higher in the SYM.

Evidence emerging from the past decade suggests theta activity is implicated in a number of cognitive and affective states ostensibly unrelated to notion of general deactivation and sleep stages. A strong theta band power increase during concentrated task performance (Sasaki et al., 1996) and memory operations (reviewed by Klimesch, 1999) has been reported. Perception of emotional stimuli is accompanied by short-term theta synchronization indexing motivated attention (Aftanas et al., 2002, 2003) whereas emotional experience may be attended by longer lasting theta synchronization (Crawford et al., 1996; Hankins & Wilson, 1998). Prolonged enhancement of the theta power through regular EEG biofeedback training positively correlates with creative performance (Vernon et al., 2003). As for alpha, according to the modern view, activity in the low alpha frequency band is associated with vigilance and attention, whereas in the upper alpha band it is thought to reflect task-specific processes (such as perceptual and cognitive processes) (Klimesch, 1999). Alpha power is generally thought to be inversely related to activation in the wake healthy adult. Conventionally, decreases in alpha power reflect increases in activation (e.g., Lindsley & Wicke, 1974) and alpha power increases (synchronization) is taken to be a marker of cognitive inactivity, that is, "cortical idling" (Klimesch, 1999 for review). However, a growing body of evidence suggests that the notion of alpha synchronization reflecting cortical idling is no longer tenable. Alpha synchronization may be considered as marker of the activation of functionally involved brain areas, reflecting specific operations of higher brain functioning (Cooper et al., 2003 for review). More specifically, it has been shown to index the active inhibition of sensory information during internally directed attentional tasks such as mental imagery (Ray & Cole, 1985; Schupp et al., 1994).

As mentioned in the introduction, the key experience during Sahaja Yoga meditation is thoughtless awareness accompanied by an emotionally positive experience of bliss. According to the authors' previous findings on this meditation, both thoughtless awareness and bliss are accounted by enhanced theta and alpha activity along with decreased EEG dimensional complexity (Aftanas & Golocheikine, 2001, 2002). Importantly, in these studies subjective scores of emotional experience positively correlated with theta, whereas scores of thoughtless awareness negatively correlated (i.e., more power means greater mental silence) with both theta and alpha power. The authors concluded that although on the whole both theta and alpha power increases during meditation periods reflect internalized attention, theta power is more specifically related to the essential "core" (i.e., thoughtless awareness and bliss) of meditative experience (Aftanas & Golocheikine, 2001). In view of this, the authors speculate that in this study, which did not involve a meditative task, the eyes-closed and eyes-open periods imitate immersion into the accustomed ambience of meditative session. Such an immersion gives birth to elements of "pro-meditative" experience reminding states of thoughtless awareness and bliss accounted by enhanced theta and low alpha power. Increased arousal by presenting emotionally neutral movie clip desynchronize theta and alpha activity in both groups but at between-group level meditators are still characterized by higher power in the low alpha frequency range. It is felt that even while processing emotionally neutral (i.e., personally irrelevant) information, meditators keep on allocating attentional resources internally in order to inhibit irrelevant information. Although meditative states in general involve extended and distributed neuronal networks, they show clearly organized topographical, spatial patterns (Kubota et al., 2001; Lehmann et al., 2001; Aftanas & Golocheikine, 2001, 2002). However, in this study, in terms of topography, depending on the non-emotional condition meditators manifested greater theta-alpha power throughout the whole cortical plane. Such a peculiarity may index overall lower tonic arousal and propensity for internalized attention alike forming prerequisites for successful meditative experience. So, in line with the authors' first prediction, experienced meditators versus controls during controlled rest condition (eyes-closed and eyes-open periods) showed EEG signs of less tonic arousal and more internalized attention as well as less attentional involvement while viewing emotionally neutral movie clips.

The second prediction suggested EEG signs of greater endurance of meditators to emotionally negative workload. When contrasted with the neutral, aversive movie clip yielded significant alpha desynchronization in both groups, reflecting arousing nature of emotional induction (e.g., Lindsley & Wicke, 1974; Klimesch, 1999). In the control group along with alpha desynchronization, the movie clip synchronized gamma power over anterior cortical sites. Gamma activity has been conceptualized as providing universal "functional building blocks" of information processing and the hypothesis of a selectively distributed gamma system of the brain is now generally accepted (Basar et al., 2001). Arousal is regarded as a necessary condition for gamma activity. In states of extremely low arousal (anesthesia and non-REM sleep), there is minimal gamma activity whereas increased gamma activity may reflect a "focused arousal" in task-relevant neural circuitries during cognitive and emotional involvement (Sheer, 1984; Gross & Gotman, 1999; Rennie et al., 2000; Gemignani et al., 2000; Sebastiani et al., 2003). Combined alpha desynchronization and gamma synchronization to the aversive movie clip suggests heavier emotional workload on the controls than meditators. Heavier emotional impact on the controls is supported by self-reported ratings showing that the controls versus meditators manifested significantly higher rates of emotional arousal for negative emotions of anger, anxiety, disgust, and contempt. This is also consistent with the literature showing that meditators often show lower levels of negative affect (Astin et al., 2003) as well as with EEG findings on positive correlations of gamma activity with subjective intensity of negative emotional experience (Foster & Harrison, 2002). Finally, considering that high beta and gamma activity triggers peripheral autonomic responses during mental workload (Umeno et al., 2003), absence of gamma synchronization in the meditators could indirectly point to their lower autonomic involvement. Hence, regularly meditating individuals manifest capabilities to moderate intensity of negative emotional arousal. On evidence, derived from EEG spectral band power, this feature is indexed by non-involvement into emotional experience of gamma band activity.

One more facet of the presented report deals with resting EEG asymmetries. Except rare studies (e.g., Lehmann et al., 2001; Davidson et al., 2003), findings on EEG activation asymmetries and meditation are usually not emphasized. In the present study laterality group differences were revealed over parieto-temporal cortex in the upper alpha band during eyes-closed and eyes-open periods. The control group was marked by larger right than left hemisphere power, indexing, according to conventional interpretations (Davidson et al., 2003), relatively more active left hemisphere parieto-temporal cortex. Meditators manifested no hemisphere asymmetry. Considering the "cognitive" nature of the upper alpha band (Klimesch, 1999), left hemisphere bias in the controls may be ascribed to verbally mediated "inner dialogue," associated with everyday life events. In turn, symmetrical inter-hemispheric balance along with less active left hemisphere activity in the meditators than controls could be well explained by their "worked-out" propensity to mindfulness, that is, to reduced verbally mediated inner experience at rest.

Additional explication comes from well-established findings that regularly meditating individuals report lower levels of both state and trait anxiety than non-meditating ones. In view of this, relatively more active posterior cortex of the left hemisphere in the controls may be due to verball mediated anxious apprehension (Carter et al., 1986; Aftanas et al., 1996).

Overall, the present report emphasizes that the changes in the electrical brain activity associated with regular meditation practice are dynamical by nature and depend on arousal level. Experienced meditators manifest EEG signs of overall lower tonic arousal and greater proneness to sustain internal focus of attention. The EEG power findings are the first EEG-correlate of the theoretical assumption that meditators have better capabilities to moderate their intensity of emotional arousal.

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