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Positive Emotional Experience: Induced by Vibroacoustic Stimulation Using a Body Monochord in Patients with Psychosomatic Disorders: Is Associated with an Increase in EEG-Theta and a Decrease in EEG-Alpha Power

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Abstract Relaxation and meditation techniques are generally characterized by focusing attention, which is associated with an increase of frontal EEG Theta. Some studies on music perception suggest an activation of Frontal Midline Theta during emotionally positive attribution, others display a lateralization of electrocortical processes in the attribution of music induced emotion of different valence. The present study examined the effects of vibroacoustic stimulation using a Body Monochord and the conventional relaxation music from an audio CD on the spontaneous EEG of patients suffering from psychosomatic disorders ($N = 60$). Each treatment took about 20 min and was presented to the patients in random order. Subjective experience was recorded via self-rating scale. EEG power spectra of the Theta, Alpha-1 and Alpha-2 bands were analysed and compard between the two treatment conditions. There was no lateralization of electrocortical activity in terms of the emotional experience of the musical pieces. A reduction in Alpha-2 power occurred during both treatments. An emotionally positive attribution of the experience of the vibroacoustically induced relaxation state is characterized by a more pronounced release of control. In the context of focused attention this is interpreted as flow experience. The spontaneous EEG showed an increase in Theta power, particularly in the frontal medial and central medial area, and a greater reduction in Alpha-2 power. The intensity of positive emotional feelings during the CD music showed no significant effect on the increase in Theta power

Keywords EEG power · Theta · Alpha · Lateralization · Vibroacoustic stimulation · Monochord · Music · Emotional experience

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Introduction

The present study investigated the effect of vibroacoustic stimulation on the spontaneous EEG, by using a Body Monochord compared to a conventional audio CD with relaxation music in psychosomatic patients. In the last decades in German speaking countries the treatment Body Monochord used as a music-therapeutical body oriented relaxation method has been adopted in therapeutic practice. In the treatment with a Body Monochord the patient lies on a resonance box standing on four feet. Below the sound box there are up to 60 strings tuned on the same tone pitch (or choice of octave or fifths tuning). The practitioner sits beside the Body Monochord and strokes evenly across the strings with the fingers of both hands. This creates a monotonal sound carpet with a distinct emergence of an overtone series. In addition, the vibration caused by the contact of the body with the resonance box is directly perceived by the patient. In general, patients suffering from psychosomatic disorders show a more negative concept of their body, e.g. like self-acceptance of the body, attitude

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towards physical contact and physical wellbeing (Stumpf et al. 2010). Since aside from the acoustic sound experience the treatment with a Body Monochord also consists of stimulation through vibrations of the instrument, which directly affect the body, the treatment with a Body Monochord might be a useful relaxation method with a possible beneficial impact on the perception of one's own body. Former publications give evidence that through the reception of monochord sounds and the vibroacoustic stimulation caused by the Body Monochord deep states of relaxation can be experienced, combined with an altered body perception, a feeling of well-being and pleasant mental images (Harthog 2001; Jungaberle et al. 2003; Rose and Wies 2008; Sandler et al. 2008; Zeuch 1999). However, frightening feelings of loss of control and unpleasant mental images can also occur (Moser 1997; Sandler et al. 2008; Timmermann 1989).

The aim of this study was to examine whether the spontaneous EEG activity during a relaxation state induced by vibroacoustic stimulation by means of a Body Monochord differs from a state of relaxation induced by listening to relaxation music presented by audio CD. The potential clinical and therapeutic benefits of various relaxation methods have been explored extensively (Jacobs 2001). Apart from relaxed muscles and a calm environment, the prerequisites for the occurrence of a physiological relaxation response are supposed to be the ability to focus attention, letting go of goal-oriented analytical thinking and the receptiveness to and tolerance of unusual experiences of relaxation (Benson et al. 1974; Smith et al. 1996). In different relaxation and meditation methods different objects of focus are given, so that the external attention is directed to a mental self-object in order to avoid external distraction and to increase self-referential attention (see Review: Cahn and Polich 2006). For music-related relaxation inductions the object of focus is specified externally by the music being heard. Various studies report that music and particularly soothing slow music can induce a psychophysiological relaxation response with reduced subjective experience of stress (Bernardi et al. 2006; Bradt and Dileo 2009; Bradt et al. 2011; Sokhadze 2007; Weeks and Nilsson 2011; White 1999).

Sensory stimulation by a Body Monochord adds an additional external focus of attention, which may enhance the self-referential experience (Sandler et al. 2008). Vibroacoustic Therapy is a somatosensory stimulating treatment that exists in addition to a Body Monochord, whereby the music is presented via a bed with built-in speakers, so that additional tactile vibrations can be physically perceived (Rogers et al. 2007). Studies on various clinical patient groups demonstrated relaxation effects and symptom reduction (anxiety, pain, fatigue) (Mariaozouls et al. 1999; Patrick 1999). The relaxation effect seems to be especially promoted by low frequencies (infrasound) (Boyd-Brewer and McCaffrey 2004; Spitzer et al. 2005).

The effects of relaxation music and especially vibroacoustic stimulation on EEG via Body Monochord have been studied less extensively. Lee et al. (2012) have reported an increase in Theta- and a decrease in Alpha activity in posterior regions while listening to monochord sounds. Sandler et al. (2008) have demonstrated that the treatment with a Body Monochord can induce an altered state of consciousness according to Ludwig (1966) and Farthing (1992), which is associated particularly with an altered perception of body and space and positive feelings of relaxation and safety. The EEG showed an increase in Theta power. Alpha power showed a slight decrease, but this was not statistically significant. Alterations of EEG Alpha- and Theta activity during a treatment with a Body Monochord had been reported earlier in two single case reports (Fachner and Rittner 2003).

There is an inverse relationship between alpha activity and cortical activation (Goldman et al. 2002). Whereas synchronized Alpha oscillations (pronounced regular Alpha amplitudes) are generally associated with reduced cognitive activity (e.g. Pfurtscheller et al. 1996), Alpha desynchronization (collapse of Alpha activity), on the other hand, is considered to be an indicator of cognitive demand, information processing, memory performance and attention (e.g. Dujardin et al. 1993; Klimesch et al. 2005; Klimesch 1999).

An increase in Alpha activity was also observed while listening to music (Iwaki et al. 1997; Lin et al. 2010) and is seen by Kay et al. (2012) within the context of relaxation and introspection.

Frontal Theta activity is recognised as a correlate of focused attention and memory search (Attention: see e.g. Deiber et al. 2007; Pennekamp et al. 1994; Schacter 1977; Memory processes see e.g. Bösel 1993; Pennekamp et al. 1994). Since meditation and relaxation methods include a concentrative focus on a mental stimulus, the increase in frontal Theta in this context, which was demonstrated in various studies, is also discussed as being associated with concentration and attention processes (Aftanas and Golocheikine 2001; Baijal and Srinivasan 2010; Cahn and Polich 2006; Kubota et al. 2001; Jacobs and Lubar 1989; Lagopoulos et al. 2009).

In addition to a focused attention performance, the Frontal Midline Theta is also associated with emotional processing. Frontal Midline Theta is generated by the ACC in the medial prefrontal cortex (Ishii et al. 1999). PET and fMRI studies have shown that the medial prefrontal cortex is involved in various emotions such as joy, anger, sadness and disgust (Phan et al. 2002). The activation of these brain structures during attention related processes was detected in imaging meditation studies (Lazar et al. 2000, Lou et al.

1999) and has also been discussed in the context of coupling attention and emotion processes (Lane et al. 1998). EEG studies of the emotional evaluation of music have shown an increase in Frontal Midline Theta during the positive valence of the presented music (Sammler et al. 2007, Lin et al. 2010).

Some EEG studies on music perception support the model of frontal lateralization of emotion by Davidson (1998). Results revealed greater left frontal activation of the cortex when listening to positively connoted music and right frontal activation when listening to sadly and anxiously connoted music (Altenmüller et al. 2002; Gagnon and Peretz 2000; Schmidt and Trainor 2001; Tsang et al. 2001). Emotional arousal during listening to Beethoven's 5th symphony seems to be associated with right-frontal suppression of lower alpha activity (Mikutta et al. 2012). However, other studies point against the model of the asymmetry of emotion processing (e.g. Blood and Zatorre 2001; Khalfa et al. 2005).

The inconsistent findings might be due to the differences in the choice of music. Above all it seems unclear whether it was really the music which actually induced the expected emotions. Besides, lateral electrocortical effects have been shown to be dependent on the musical structure (Tsang et al. 2001) and therefore must not necessarily be attributed to emotional experience.

Apart from the characteristics of music and its musical structure parameters, the emotional experience of music largely depends on individual and social musical influences and the actual situational context (Benenzon 1983). Thus, the possibility of influencing specific emotions through music is somewhat limited. Most studies of music perception deal with identification of emotions that are associated with short music sequences (e.g. Sammler et al. 2007; Altenmüller et al. 2002; Schmidt and Trainor 2001; Gagnon and Peretz 2000) and possibly activate cognitive processes in the neocortex, rather than processes of dealing with emotions.

Hypotheses

The emotional experience during vibroacoustic stimulation during a Body Monochord treatment (Sandler et al. 2008) and probably also during ordinary relaxation music can be both pleasant and unpleasant. The following hypotheses will be tested:

- whether vibroacoustic stimulation differs from the purely auditory relaxation music. It is assumed that due to a stronger sensory stimulation the exposure to a Body Monochord causes an increase in focusing attention. This is reflected electrocortically in higher frontal EEG Theta activity and particularly in Frontal Midline Theta.
- whether a pleasant and unpleasant experiences are reflected differently in the synchronization and desynchronization of theta activity in the frontal regions. With a positive experience an increase in the frontal and particularly in the Frontal Midline Theta is expected.
- whether the extent of positive experience is associated with a lateralization of cortical activation. Given the inverse relationship between cortical activity and Alpha activity, it is expected that a lower left frontal Alpha activity will be observed during a pleasant experience and a lower right frontal Alpha activity during an unpleasant experience.

Methods and Materials

Participants

85 patients participated in the study during their inpatient treatment at the Department of Psychosomatic Medicine at Charité—Universitätsmedizin Berlin. EEG data of patients with very low Alpha activity (individual Alpha peak $<1.5\ mV^2$) in the rest condition (N = 12 and patients who discontinued treatment (Body Monochord N = 6, CD-music N = 1), as well as the patients who were taking centrally acting medications at the time of treatment (N = 6) were excluded from the analysis. The EEG data from 60 patients (31 of whom were women) aged between 21 and 76 years (M = 46.8, SD = 12.4) were included in the study.

According to the diagnostic criteria of ICD-10 the spectrum of diagnoses of the analysed patients was as follows: 12 patients with depressive disorder (F31, F32, F33), 11 patients with anxiety disorder (F40, F41), 19 patients with adjustment disorder (F43.2) and 18 patients with somatoform disorders (F45). Only right-handed patients were assessed in the EEG data analysis. The patients were selected coincidentally for this study and the treatment with the Body Monochord took place only once at the time of the investigation. None of the patients had previous experiences with the Body Monochord. The study was approved by the ethics committee—Charité—Universitätsmedizin Berlin (application number: EA1-290-12) and informed consent was obtained from all patients.

Procedure

After attaching the EEG electrodes, each patient received 2 treatments: a 20-min exposure on a Body Monochord with 64 strings (tone pitches: D3, A2, D2, with additional A1 and D1 at three strings each) and apart from that a 20-min presentation of slow consonant relaxation music which was played on an audio CD. The Body Monochord was constructed by the manufacturer of musical instruments Bernhard Deutz in Berlin (http://www.deutz-klangwerkstatt.de; a sound sample is available at http://psychosomatik.charite.de/forschung/koerpererleben_koerperzentrierte_therapieverfahren/). The musical piece "Clouds" by Canzani (2003) was chosen for the presentation of the relaxation music. The composition consists of a series of similar repetitive consonant melodic phrases of panpipes with piano accompaniment. The original duration time of 16.55 min was prolonged to 20 min by additional repetitions of some melodic phrases, using audio processing software.

Both kinds of treatment were presented in succession with a break of five to ten minutes in between, in which the patients answered a questionnaire on their subjective experience. The chronological order of the two treatments was randomized. During the musical presentation of the CD the patients kept lying on the Body Monochord. Immediately before the first and second treatment a 2-min resting EEG recording was made in the lying down position. The patients kept their eyes closed during all EEG recordings. Patients were given instructions to do nothing else than listening to the sounds and the music. Data acquisition was done from about 10 a.m. to 12 p.m.

Emotional Experience

The subjective experiences that occurred during the exposure to the Body Monochord and the exposure to the CD music were immediately recorded by means of a self rating scale, presented on a 7-point Likert scale. The questions were based on the dimensions of experience of the Phenomenology of Consciousness Inventory (PCI) by Pekala (1991, German version by Rux 2002), a questionnaire for assessing altered states of consciousness, which can arise e.g. during relaxation states (Vaitl et al. 2005).

For assessing positive emotional experiences of the relaxation state, patients were asked about feelings of joy, kindness and safety. Of these categories the mean values were calculated for each subject. Since negative feelings like fear, anger, sadness were not distinct and differed only very slightly between patients, categories of emotionally negative response were not included in this evaluation. Positive emotional experience correlated moderately highly with concentration, inwardly directed attention, relaxation and release of control (relinquishing control over one's experience). Release of control was significantly more pronounced during the Body Monochord exposition compared to the CD Music (Sandler et al. 2015). The corresponding statistical values of the 60 patients analysed in this study is shown in Table 1.

EEG-Recording and Analysis

EEG was derived from 28 active Ag/AgCl electrodes (Fp1/2, F3/4, F7/8, Fc1/2, Fc5/6, C3/4, Cp1/2, Cp5/6, T7/8, P3/4, P7/8, O1/2, Fz, Fcz, Cz, Pz) and positioned according to the international 10-10 system on an elastic cap (Easy Cap, Falk Minow services, Munich/Germany). The reference was made against two connected electrodes on the left and right mastoid bones. The AFz-electrode was used as a zero electrode (grounding). Additional four electrodes recorded an Electrooculogram to register eye movements and related artefacts (Table 2).

The electrode impedances were below 10 kOhm, with most impedances reaching values below 5 kOhm. Signal amplification and digital recording was carried out using BrainAmp device (Brain Products) at a sampling rate of 500 Hz (Online-band-filter .1–100 Hz; 24 dB/oct.) on the Vision Recorder software (Version 1.02, Brain Products).

The EEG data was processed using Vision Analyzer software (version 1.05, Brain Products). The frequency range was limited with a bandpass filter (.1–70 Hz; 24 dB/oct.) and disturbances from the electricity network were filtered out using a notch filter (50 Hz). Using Independent-Component-Analysis the eye artefact correction was performed over the entire raw data. The subsequent EEG analysis was conducted for the 2-min rest derivations before the treatments and for the 2-min intervals during the periods of 0–2, 5–7, 11–13 and 17–19 min following the start of the Body Monochord and music exposure. The time intervals were divided into 60 segments of 2 s and checked again by visual inspection for remaining artefacts. The amplitude criteria set out in the Vision Analyzer were Min. −90 microvolts and Max. 90 microvolts.

The artefact-free segments were subjected to a Fast Fourier Transformation with a resolution of .488 Hz (effective analysis of 2048 ms, zero padding). Subsequently, for every derivation location the power values obtained by frequency analysis were averaged for each 2-min segment. Among the 60 patients analysed in this study there was an average of 56 artefact-free segments, which were used in the calculation ($SD = 5.8$, range 22–60). Due to the fact that the individual alpha frequency range is (amongst other things) dependent on age (Klimesch 1999), by using the method of Doppelmayer et al. (1998), a maximum peak of the individual alpha frequency (IAF) for each patient was determined from the EEG resting condition. Following the instructions of this method the individual frequency bands for Theta, Alpha-1, Alpha-2 were derived for each person starting from IAF of the first resting condition as an anchor point (see Table 3).

Due to the high inter-individual variance of the absolute EEG power values, event-related desynchronization (ERD) and synchronization (ERS) based on Klimesch et al. (1990)

Table 1 Pearson correlations between positive emotional experience during the treatments and the response categories 'release of control', 'concentration', 'inwardly directed attention' and 'relaxation', measured via self-rating scales

N = 60	Positive emotional feeling during treatment with the Body Monochord	Positive emotional feeling during treatment with the CD-music	Significance of the differences between the levels of correlations
Release of control	.54	.33	p = .07
Concentration	.55	.60	n.s.
Inwardly directed attention	.46	.40	n.s.
Relaxation	.59	.61	n.s.

Table 2 Comparison of the mean values of the response category 'release of control' between the two treatments conditions (*t* test for dependent samples)

	Body Monochord	CD-music	Mean difference	T	df	Sig. (2-tailed)	Effect size Cohen's d
Release of control	4.22	3.37	.850	3.281	59	.002	.54

Table 3 Determination of the individual frequency bands depending on the individual alpha frequency peak as an anchor point according to Doppelmayer et al. (1998)

Frequency band	Determination of frequency ranges		Absolute frequency ranges			
	From	To	Lower bound		Upper bound	
			M	SD	M	SD
Theta	0.4 × IAF	0.6 × IAF	4.02	.39	5.6	.59
Alpha-1	0.6 × IAF	0.8 × IAF	6.05	.59	7.46	.074
Alpha-2	0.8 × IAF	1.0 × IAF	7.96	.75	9.61	.94

Table 4 EEG derivation locations from which the ERD/ERS mean values for the frontal, centro-temporal and parieto-occipital regions of both hemispheres were obtained

Derivation location	Electrodes	
	Left hemisphere	Right hemisphere
Frontal	Fp1, F3, F7, Fc1, Fc5	Fp2, F4, F8, Fc2, Fc6
Centro-temporal	C3, Cp1, Cp5, T7	C4, Cp2, Cp6, T8
Parieto-occipital	P3, P7, O1	P4, P8, O2

were calculated for a better comparison of the EEG data. The calculation was done using the following formula and expressed in percentages:

$$100 - \{(\text{Frequency band power Reference interval} \\ -\text{Frequency band power Test interval}) \\ /\text{Frequency band power Reference interval}\} \times 100.$$

The respective EEG resting condition derivation prior to the Body Monochord or music exposure was used as reference interval. Subsequently, the mean values of ERD/ERS of the individual derivation locations for the frontal, centro-temporal and parieto-occipital regions of both hemispheres were obtained (see Table 4).

For the statistical analysis of the Frontal Midline Theta effect, the following mean values were averaged: the percentaged Frontal Midline Theta power and the percentaged theta power of the central-medial, parietal-medial, frontal-lateral, centro-lateral and parietal-lateral occipital derivation regions (see Table 5). According to Mitchell et al. (2008) the maximum for Frontal Midline Theta is at Fz and F3/4. Sammler et al. (2007) localise Frontal Midline Theta at Afz, Fz and Fcz. In this study the F3/4 and Fc1/2 were included in the Frontal Midline Theta-localization, since Fz and Fcz ultimately represent an integration of these derivation locations.

Statistical Data Analysis

Statistical data analysis was performed using the statistical software SPSS (Version 20). The alpha error level was set at 5 %. The specifications for alpha error of variance analytical significance tests were based on the Greenhouse-

Table 5 EEG derivation locations for the mean values of percentage Frontal Midline Theta power and the percentage theta power of the central-medial, parietal-medial, central-lateral and parietal-lateral-occipital regions

Derivation region	Eelectrodes
Frontal midline Theta	Fz, Fcz, F3, F4, Fc1, Fc2
Central medial Theta	Cz, C3, C4
Parietal-medial Theta	Pz, P3, P4
Frontal-lateral Theta	Fp1, Fp2, F7, F8, Fc5, Fc6
Central-lateral Theta	Cp1, Cp2, Cp5, Cp6, T7, T8
Parieto-lateral-occipital Theta	P7, P8, O1, O2

Geisser-adjusted degrees of freedom. Multiple comparisons in post hoc analyses and t-tests were adjusted using the Bonferroni method.

Statistical Analysis of the Theta, Alpha-1 and Alpha-2 Frequency Bands

In order to test the various effects on the ERD/ERS a mixed linear model was calculated separately for the three frequency bands (Theta, Alpha-1, Alpha-2) for the whole sample (N = 60) by using full maximum likelihood estimation. The following predictors were chosen as fixed effects: 'positive feeling', 'kind of treatment', 'chronological order of treatment', 'point in time of measurement', 'hemisphere', 'region of derivation', the interactions 'kind of treatment x positive feeling' and the interaction 'hemisphere x positive feeling'. The data has a 2-level hierarchical structure, whereby the various EEG data are nested in the individual patients (level 1) and the patients are nested in the different kinds of diagnoses (level 2). To test the effect of the diagnoses on the EDR/ERS, we ran the model by calculating random intercepts for diagnoses. See the following equation:

$$Y = b_{0i} + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10}$$

$$b_{0i} = b_0 + \mu_j$$

Y is the Outcome variable (mean value of the ERD/ERS of the EEG), b0 is the Baseline (intercept), µi is theVariability in intercepts depending on the diagnoses, b1 to b10 is the Regression slopes, X1 is the Predictor (positive emotion), X2 is the Predictor (treatment chronological order: dummy variables: 0 = 1st treatment; 1 = 2nd treatment), X3 is the Predictor (kind of Treatment: dummy variables: 0 = CD-music; 1 = Body Monochord), X4 is the Predictor (point in time: linear growth curve), X5 is the Predictor (hemisphere: dummy variables: 0 = left, 1 = right), X6 is the Predictor (frontal region of derivation), X7 is the Predictor (central region of derivation), X8 is the Predictor (positive emotion x kind of treatment), X9 is the Predictor (hemisphere x positive emotion), X10 is the Predictor (positive emotion x kind of treatment x point in time)

As the interaction 'positive emotion x kind of treatment x point in time' showed high significance in all frequency bands (Theta, Alpha-1, Alpha-2), we calculated the following mixed linear model for each frequency band separately for both of the tow treatments:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

Y is the Outcome variable (mean value of the ERD/ERS of the EEG), b0 is the Baseline (intercept), b1 to b4 is the Regression slopes, X1 is the Predictor (positive emotion), X2 is the Predictor (treatment chronological order: dummy variables: 0 = 1st treatment; 1 = 2nd treatment), X3 is the Predictor (point in time: linear growth curve), X4 is the Predictor (positive emotion x point in time)

Statistical Analysis of Frontal Midline Theta

Due to the fact that the interaction 'positive emotion × kind of treatment × point in time' showed high significance and thus the increase of EEG theta activity depended on the intensity of experienced positive emotions and differs between the two kinds of treatments, for the EEG analysis of Frontal Midline Theta we compared those subjects, whose emotional experiences of the two treatments differed significantly. The total sample was divided into tertiles using the mean differences between positve emotional feelings, measured via Likert scale, during both treatments (1. tertile: BM > Mu; 2. tertile: BM = Mu; 3. tertile: BM < Mu). The analysis of Frontal Midline Theta was performed for the subgroups 'BM > Mu' und 'BM < Mu'. The mean differences between the two low and the two high positive emotional ratings were marginal between the analysed subgroups 'BM > Mu' and 'BM < Mu' and showed no significance in the *t* test for independent samples (see Fig. 1).

The mean differences of the absolute EEG Theta power between the resting conditions of both subgroups 'BM < Mu' and 'BM > Mu' were neither significant calculating *t* tests for independent samples.

In order to check an increase in ERS of Frontal Midline Theta during the Body Monochord treatment experienced in an emotionally positive way, an ANOVA with repeated within-subject factors 'derivation region-1′ (frontal, centro-temporal, parieto-occipital), 'derivation region 2′ (medial, lateral) and 'point in time' (T2 = 5–7 min, T3 = 11–13 min, T4 = 17–19 min) was calculated. In the CD music exposure (regardless of the emotional experience) and in the lower emotionally positive rating of the Body Monochord there was no significant increase in ERS of Frontal Midline Theta compared with the initial level of the

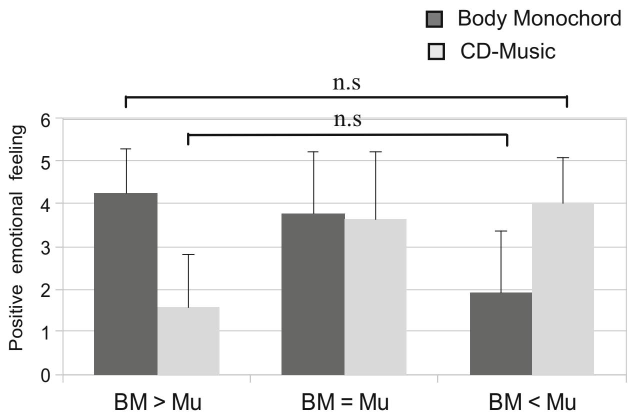

Fig. 1 Means and standard deviations of positive emotional feelings, measured via 7-point Likert scale, during the Body Monochord (BM) and CD music (Mu) exposure for the subgroups: BM > Mu, BM = Mu, BM < Mu

resting condition. This was calculated using a paired t-test for the mean value of the three measuring points T2, T3, and T4. Thus, no further ANOVAs were calculated with respect to Frontal Midline Theta.

Results

Mixed Linear Model for the Theta, Alpha-1 and Alpha-2 Frequency Bands

The factor 'diagnoses' did not show any effect on random intercepts in any frequency band (Theta: Wald $Z = .88$, $p = .379$; Alpha-1: Wald $Z = 1.36$, $p = .174$; Alpha-2: Wald $Z = 1.37$, $p = .171$) with the result that the kind of a patient's diagnosis did not show any influence on the EEG-activity.

Table 6 shows the estimated parameters of the predictors of the mixed linear model for the ERD/ERS of the Theta, Alpha-1 and Alpha-2 frequency bands. For the three frequency bands the predictors 'hemisphere' and 'hemisphere x positive emotion' were not significant. Thus, there was no lateralization of electrocortical activity in terms of the emotional experience of the musical pieces.

In the Theta and Alpha-1 bands the ERD/ERS did not differ significantly between the regions of derivation (frontal, central, parieto-occipital), whereas in the Alpha-2 band the dummy variables 'frontal region of derivation' and 'central region of derivation' were highly significant, with the result that the EEG activity in these regions was significantly higher than in the parieto-occipital region.

In the Theta and Alpha-1 bands a significant effect of the predictor 'treatment chronological order' was found. During the second treatment exposure the Theta and Alpha-1 power was significantly lower than during the first treatment exposure (Theta: $b = -10.7$, $p < .001$; Alpha-1: $b = -10.8$, $p < .001$). No significant effect of the predictor 'treatment chronological order' was found in the Alpha-2 band ($b = -1.38$, $p = .30$).

The predictor 'kind of treatment' was significant in the Theta ($b = -6.40$, $p = .048$) and Alpha-2 band ($b = 8.82$, $p = .001$), which indicates that in the beginning of the treatment with the Body Monochord, Theta activity was distinctly lower and Apha-2 activity was distinctly higher than during the beginning of the treatment with the CD music. The predictor 'point in time' showed significance in the Theta ($b = 2.11$, $p = .015$) and Alpha-2 band ($b = -4.58$, $p < .001$), with the result that there was a general increase in Theta activity and a decrease in Alpha-2 activity over time. The interaction 'positive emotion x kind of treatment' was highly significant in the Alpha-1 and Alpha-2 bands (Alpha-1: -4.16, $b < .001$; Alpha-2: $b = -5.99$, $p < .001$) and the interaction 'positive emotion x kind of treatment x point in time' showed high significance in all of the three frequency bands (Theta: $b = 3.07$, $p < .001$; Alpha-1: $b = 1.59$, $p < .001$; Alpha-2: $b = 1.17$, $p < .001$). This means that the change over time in EEG activity depended on the intensity of experienced positive emotions and differed between the two kinds of treatments, which is shown in the following paragraph.

Mixed Linear Model: Separately for Body Monochord and CD Music

The estimated parameters of the predictors of the mixed linear model for the ERD/ERS of the Theta, Alpha-1 and Alpha-2 frequency bands, which were calculated separately for the treatment with the Body Monochord and the CD music, are presented in Table 7. Figure 2 shows the ERD/ERS of the respective frequency bands amongst the patients with low, middle and high intensity of positive emotional feelings. Low intensity of positive emotional feeling was defined as a score from 0 to 2, middle from 2.33 to 4 and high from 4.33 to 6 according to the measuring via self rating scale. The predictor 'treatment chronological order' was again significant in the thata- and Alpha-1 bands—both in the treatment with the Body Monochord (Theta: $b = -9.17$, $p = .001$; Alpha-1: $b = -8.25$, $p < .001$) and the treatment with the CD music (Theta: $b = -10.92$, $p = < .001$; Alpha-1: $b = -12.68$, $p < .001$). Due to the greater reduction of the alpha-2 activity in the parieto-occipital area, we additionally calculated the mixed linear model separately for the frontal and parieto-occipital regions, which showed similar results. Thus only the estimated parameters of the mixed linear model for the entire scalp regions are presented here.

Table 6 Estimated parameters of the mixed linear model for the ERD/ERS of theta, alpha-1 and alpha-2 bands as outcome variables

N = 60	Theta				Alpha-1				Alpha-2			
	Estimated parameter				Estimated parameter				Estimated parameter			
Predictor	b	df	t	Sig.	b	df	t	Sig.	b	df	t	Sig.
Baseline (Intercept)	104.35	240.5	29.9	.000	98.33	11.8	28.65	.000	79.21	10.1	17.19	.000
Positive emotion	−.01	2876.8	−.014	.989	1.12	2877.6	2.13	.033	1.00	2877.3	1.52	.129
Treatment chronological order	−10.07	2878.2	−6.45	.000***	−10.08	2876.3	−10.17	.000***	−1.38	2876.2	−1.03	.301
Kind of treatment	−6.40	2879.9	−1.98	.048*	1.75	2876.9	.79	.428	8.82	2876.8	3.18	.001**
Point in time	2.114	2876.1	2.44	.015*	−.74	2876.0	−1.25	.210	−4.58	2876.0	−6.19	.000***
Hemisphere	−1.43	2876.1	−.44	.657	1.52	2876.0	.69	.486	1.54	2876.0	.56	.576
Frontal region of derivation	2.52	2876.1	1.38	.168	1.50	2876.0	1.22	.229	8.46	2876.0	5.40	.000***
Central region of derivation	2.46	2876.1	1.35	.178	2.27	2876.0	1.83	.068	8.25	2876.0	5.27	.000***
Positive emotion × kind of treatment	−1.41	2880.0	−1.37	.171	−4.16	2876.0	−5.92	.000***	−5.99	2876.7	−6.77	.000***
Positive emotion x Hemisphere	.33	2876.1	.37	.713	−.48	28756.0	−.79	.428	−.45	2876.0	−.59	.552
Positive emotion × kind of treatment × point in time	3.07	2876.1	9.30	.000***	1.59	2876.0	7108	.000***	1.17	2876.0	4.14	.000***

Both the treatment with the Body Monochord and the CD music are included in the model

*p < .05; **p < .01; ***p < .001

Table 7 Estimated parameters of the mixed linear model for the ERD/ERS of Theta, Alpha-1 and Alpha-2 bands as outcome variables, calculated separately for the treatment with the Body Monochord and the CD music

N = 60	Theta				Alpha-1				Alpha-2			
	Estimated parameter				Estimated parameter				Estimated parameter			
Predictor	b	df	t	Sig.	b	df	t	Sig.	b	df	t	Sig.
Body monochord												
Baseline (Intercept)	104.50	1440	19.75	.000	96.59	1440	32.73	.000	83.59	1440	20.20	.000
Positive emotion	−2.69	1440	−2.02	.044*	−2.39	1440	−3.21	.001**	−3.12	1440	−2.99	.003**
Treatment chronological order	−9.17	1440	−3.33	.001**	−8.25	1440	−5.37	.000***	1.15	1440	.53	.595
Point in time (growth curve)	−1.95	1440	−.76	.451	.13	1440	.09	.926	−.58	1440	−.29	.773
Positive emotion x point in time	4.05	1440	5.82	.000***	1.38	1440	3.56	.000***	.20	1440	.37	.713
CD music												
Baseline (intercept)	107.12	1440	37.14	.000	102.45	1440	37.09	.000	85.86	1440	27.14	.000
Positive emotion	−.67	1440	−.87	.384	.23	1440	.32	.753	.87	1440	1.02	.306
Treatment chronological order	−10.92	1440	−6.89	.000***	−12.68	1440	−8.36	.000***	−3.15	1440	−1.81	.070
Point in time (growth curve)	1.19	1440	.83	.406	−2.18	1440	−1.59	.113	−5.26	1440	−3.34	.001**
Positive emotion × point in time	.56	1440	1.36	.175	.42	1440	1.06	.288	−.03	1440	−.07	.942

*p < .05; **p < .01; ***p < .001

Body Monochord

Theta During the treatment with the Body Monochord significant effects were found for the predictor ‘positive emotion’ ($b = -2.69$, $p = .044$) and the interaction ‘positive emotion x point in time’ ($b = 4.05$, $p < .001$) for the Theta band, which means that the intensity of positive emotional feelings had a significant impact on the increase in theta activity over time, which was distinctly higher in patients with high intensity of positive emotional feelings than in patients with medium or low intensity. The negative b-value for the predictor ‘positive emotion’ might be explained by the fact that the curves traced by lines are approximating, which might lead to an overestimation of the 1st point in time of measurement of subjects with medium and low intensitiy of positive feelings. However, when the interaction ‘positive emotion x point in time’ was deleted in the mixed linear model, the b-value of ‘positive emotion’ became positive. Something similar applies for the Alpha-1 band.

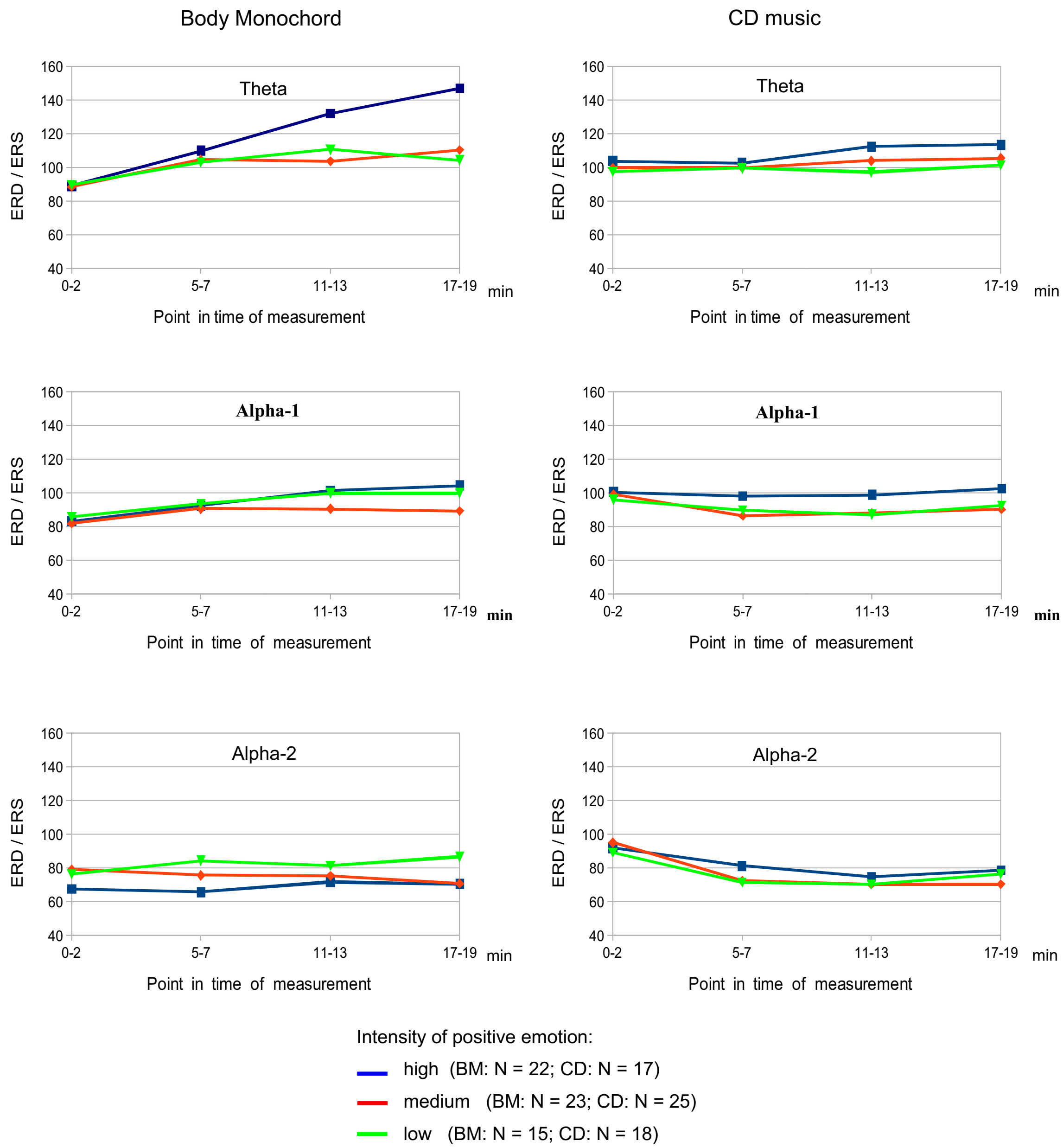

Fig. 2 Event related desynchronization/synchronization (ERD/ERS) of respective frequency bands amongst patients with different intensity of positive emotional feelings during the treatment with the Body monochord (BM) and the CD music (CD). Low intensity of positive emotional feeling was defined as a score from 0 to 2, middle from 2.33 to 4 and high from 4.33 to 6 according to the measuring via self rating scale

Alpha-1 The predictor 'positive emotion' ($b = -2.39$, $p = .001$) and the interaction 'positive emotion × point in time' ($b = 1.38$, $p < .001$) were also highly significant in the Alpha-1 band. After an initial decrease in Alpha-1 activity the following increase is lower in patients with medium intensity of positive emotional feelings. Overall the increase in Alpha-1 activity of patients with low or high intensity of positive emotional feelings did not exceed the initial level of Alpha-1 activity of the resting state.

Alpha-2 In the Alpha-2 band only the predictor 'positive emotion' showed significance ($b = -3.12$, $p = .003$). This indicates that patients with higher intensity of positive emotional feelings showed lower electrocortical Alpha-2 activity, which did not change significantly over time.

CD Music

During the treatment with the CD music no significant effect was found for the predictor 'positive emotion' and the interaction 'positive emotion × point in time' for any of the three frequency bands (Theta, Alpha-1, Alpha-2), with the result that the intensity of positive emotional feelings did not show any significant influence on the change in EEG activity. In the Alpha-2 band the predictor 'point in time' was significant ($b = -5.26$, $p = .001$), with the result that during the CD music there was a general decrease in Alpha-2 activity, independent of the intensity of positive emotional feelings.

Frontal Midline Theta

Figure 3 shows the absolute EEG theta power of the resting condition and of the averaged three measurement points T2 = 5–7 min, T3 = 11–13 min, T4 = 17–19 min after start of treatment for the two subgroups (BM > Mu; BM < Mu) during both treatment sessions. Figure 4 shows the averaged ERS of the three measuring points T2, T3, and T4 for the different derivation areas for the subgroup 'BM > Mu' during the treatment with the Body Monochord.

The factor 'derivation region 1′ was not significant, which means that the total Theta activity in the frontal area is not significantly different to the Theta in the centro-temporal and parieto-occipital areas. However, a significant effect for the factor 'derivation region 2′ ($F[1,19] = 7.89$; $p = .011$; $\eta^2 = .293$) was found, which indicates a significant increase in medial Theta ($M = 148.5$) compared to the lateral Theta ($M = 135.4$). On the other hand, no significant interaction effect was found for the factor 'derivation region 1 × derivation region 2′. However, in the paired t-test significant mean differences were found between medial and lateral Theta for the frontal and central area (Mfrontal-medial = 148.9; Mfrontal-lateral = 135.4: $t = 2.69$; $df = 19$; $p = .042$, Cohen's $d = .26$/Mcentral-medial = 154.0; Mcentral-lateral = 141.8: $t = 3.14$; $df = 19$; $p = .015$; Cohen's $d = .17$). The differences between parietal-medial ($M = 142.8$) and parietal-lateral-occipital theta ($M = 133.6$) were not significant.

Discussion

The aim of this study was to examine how the treatments with a Body Monochord, on the one hand, and relaxation music on the other hand, affect the spontaneous EEG, depending on the intensity of positive emotional feelings with patients suffering from psychosomatic disorders. The findings are based on patients with Alpha-EEG. It should be mentioned that the frequency bands for Theta, Alpha-1 and Alpha-2, which were calculated according to the method of Doppelmayer et al. (1998), seem rather low compared to the frequency bands generally defined in the literature. Clinical disorders (affective disorder, adjustment disorder, somatoform disorder) showed no influence on the EEG activity.

Sequence Effect

The EEG showed an unexpected sequence effect in the Theta and Alpha-1 bands. In both frequency bands the percentual EEG power was significantly lower during the second treatment, than during the first one. This result is in correspondence with the findings that the treatment that was presented first was experienced emotionally more positively than the second treatment exposure (Sandler et al. 2015). This could be due to the fact that in these patients the willingness to engage in the offered treatment subsided with the duration of the study. In this context theta can be interpreted as an indicator of increased attention (Deiber et al. 2007; Pennekamp et al. 1994; Schacter 1977) and emotionally positive experience (Sammler et al. 2007; Lin et al. 2010) during the first treatment exposure. Slow alpha has been discussed as an indicator of decreasing sympathetic autonomic neural activity (Takahashi et al. 2005). Phasic desynchronised slow alpha is associated with increased attention on cognitive tasks (Klimesch 1999) and desynchronised tonic slow alpha occurs during the transition from waking to sleeping states (Klimesch 1999; Tanaka et al. 1997). Desynchronised alpha-1 during the second treatment is possibly associated with a decreased willingness of cognitive processing of sensory input, in the sense of tonic EEG changes.

Lateralization

No hemispheric differences were found in the Theta and Alpha bands in relation to the degree of emotionally positive experience of the two treatments. Thus, this study does not support the model of lateralization of emotion by Davidson (1998) in terms of emotionally positive experience or positive mood. It must be noted, that clear emotionally negative mental states were not sufficient or did not appear often enough for any sufficient statement to be made regarding the lateralization of a negative emotional state.

Increase in EEG Theta activity

EEG Theta activity during the treatment with the Body Monochord is not in general higher than during the exposure to the CD music. Thus the hypothesis that a stronger sensory stimulation causes a general increase in focusing attention, which is reflected electrocortically in higher frontal EEG Theta activity, was not confirmed.

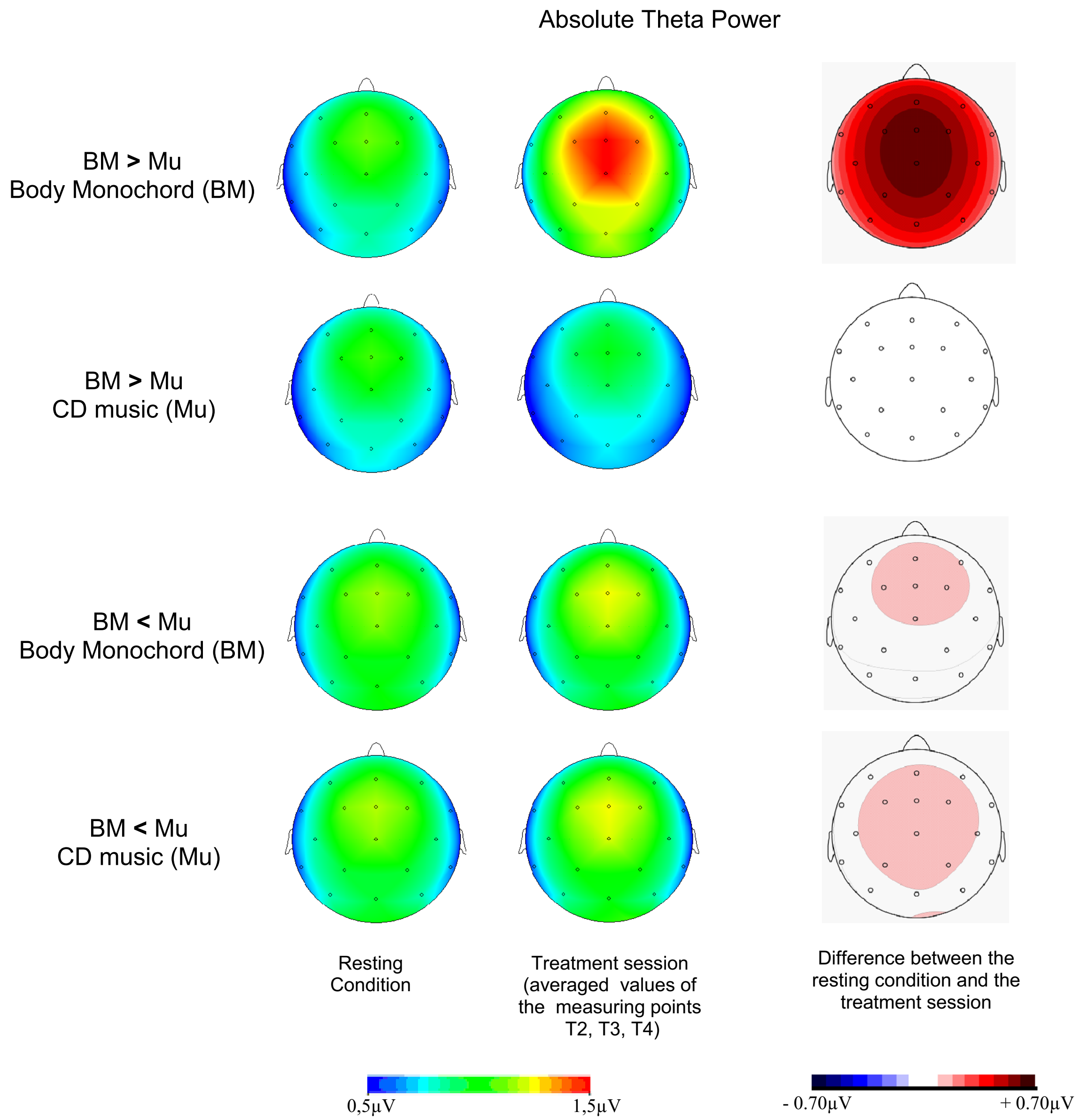

Fig. 3 Absolute Theta power of the resting condition and of the averaged three measurement points after start of treatment sessions (T2 = 5–7 min, T3 = 11–13 min, T4 = 17–19 min) and the differences between the resting condition and the treatment session. First and second row: Subgroup of patients, who experienced the Body Monochord in an emotionally more positive way than the CD music (BM > Mu; N = 20). Third and fourth row: Subgroup of patients, who experienced the Body Monochord in an emotionally less positive way than the CD music (BM < Mu; N = 20)

Rather, the increase in Theta activity during the treatment with the Body Monochord depends on the intensity of positive emotional feelings. If the Body Monochord is experienced in a distinctly more positive way than the CD music, a significant Theta increase over the entire cortex takes place during the Body Monochord exposure with a greater increase in the medial and particularly in the medial-frontal and medial-central areas. If the Body Monochord is rated emotionally less positively, then Theta remains approximately on the same level as in the initial resting condition. Similarly, no significant changes in Theta activity occur during the reception of relaxation music with familiar musical structures, regardless of the emotional experience and the related state of mind.

Even if the intensity of positive emotional feelings during the two kinds of treatments were rated in similar high levels, other processes seemed to take place during the Body Monochord treatment when compared to ordinary relaxation music. The increase in Theta activity can also be interpreted as an indicator of increased memory

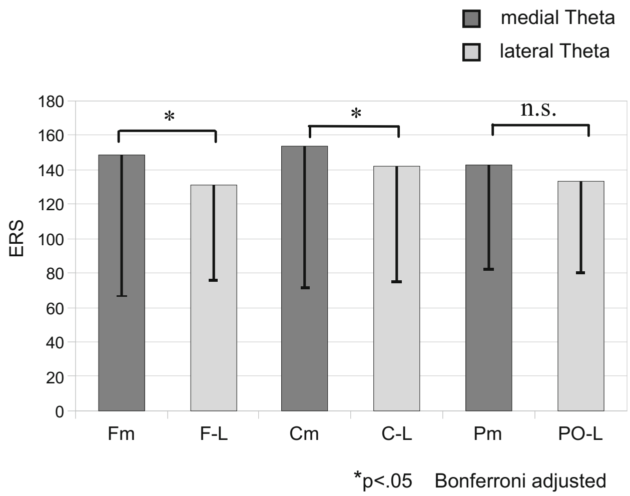

Fig. 4 Means and standard deviations of event related synchronization (ERS) of the medial theta and the lateral theta amongst patients who experienced the Body Monochord emotionally more positively than the CD music (N = 20). *Fm* Frontal Midline Theta, *F-L* frontal lateral Theta, *Cm* central medial theta, *C-L* central lateral theta, *Pm* parietal medial Theta, *P-O* parieto-occipital lateral Theta

performance (Klimesch 1999; Pennekamp et al. 1994; Bösel 1993) aligning the unfamiliar sound structures and sensory impressions after initial orientation and familiarization with stored information in a neural association network.

Perhaps the increase in Theta points to a stronger focus of attention (Deiber et al. 2007; Pennekamp et al. 1994; Schacter 1977). Above all an increase in Frontal Midline Theta could be observed in the group of patients, who experienced higher intensity of positive emotional feelings during the treatment with the Body Monochord compared to listening to the audio CD, which is discussed particularly as an indicator of increased attention and concentration (Aftanas and Golocheikine 2001; Baijal and Srinivasan 2010; Jacobs and Lubar 1989; Lagopoulos et al. 2009; Kubota et al. 2001; Pan et al. 1994). However, it should be noted that the posthoc tests, which showed significant differences between medial and lateral Theta in the frontal and central areas, followed a non-significant interaction effect in the ANOVA. Nevertheless, the result might indicate that attention might focus to a greater extent on sound and body awareness, caused by physical-sensory stimulation and attention engagement via the unfamiliar sound structures of the Body Monochord, which is aligned with an increase in Frontal Midline Theta and extended into the central region. The body-related experience of vibration was confirmed by patients in the qualitative self-report. Concerning lower emotional ratings of the Body Monochord, it is likely that patients were no longer participating in the treatment, but instead were mentally distracted and were not paying attention.

Contrary to the Body Monochord exposure during the emotionally positive experience of the relaxation music exposure no increase in the Frontal Midline Theta was found—although Frontal Midline Theta has been associated with positive emotional evaluation, thus implying positive emotional experience (Sammler et al. 2007; Lin et al. 2010). The present study examined an emotional state for a period of 20 min, whereas previous studies of music perception were mostly limited to shorter sequences of musical performance when the participants had to name the emotions associated with the musical structures. These were perhaps less concerned with actually experienced positive or negative emotional states. Consequently, differences in Frontal Midline Theta are possibly more related to differences in musical structure and the cognitive processing of these. Supporting this consideration, Bekkedal et al. (2011) postulated that frontal EEG Theta differentiates less between emotions, but rather is associated with arousal and cognitions.

A Theta increase during the emotionally positive experience of the Body Monochord treatment could also be interpreted as an indicator of a hypnagogic state, as it is discussed in Vaitl et al. (2005) in the context of relaxation methods. Jacobs and Friedman (2004) associate the rise of theta activity during a relaxation response in wider regions of the cortex with a reduction of cortical excitation. Contrary to phasic EEG changes that result from mental-cognitive demands, the Theta synchronization and Alpha desynchronization in tonic EEG changes indicate a decrease in vigilance, as observed in states of drowsiness and the transition from sleep to wakefulness (Klimesch 1999). According to Tanaka et al. (1997) a Theta increase can be observed towards the end of the transition from sleep to wakefulness (Sleep Stage 1 according to Rechtschaffen and Kales 1968) and over the entire scalp region. Parallel to the Theta increase, a migration of the Alpha-2 activity from posterior to anterior occurs, which is generally lower than in the waking state, but which at the end of sleep stage 1 displays a higher anterior rather than posterior activity. During the Body Monochord treatment, the reduction of the Alpha-2 activity occurs immediately at the start of the treatment and remains approximately at the same level over time in relation to the frontal and parieto-occipital region. Thus, no migration is observed from posterior to anterior, which would be expected in a hypnagogic state according to Tanaka et al. (1997). Furthermore a desynchronization of Alpha-1 band occurs during the transition from waking to sleeping state, which does not occur during the Body Monochord exposure. The alpha-2 desynchronization can be observed during both treatment exposures. Instead of indicating a hypnagogic state, it can be interpreted in the context of sensory stimulation and the associated cognitive processes. These are potentially more activated by the emotionally positive experience of the Body Monochord than by a less emotionally positive experience of the Body Monochord and ordinary relaxation music. The reduction of the alpha activity is in conflict with studies, which report an increase in alpha activity in the context of music and relaxation (Iwaki et al. 1997, Kay et al. 2012). The correlative association between positive emotional experience and the ability of concentration and inwardly directed attention, measured in the self rating scale (Sandler et al. 2015), is an indication that there was no loss of vigilance in terms of the transition from a waking to a sleeping state.

Flow Experience

Based on these results the hypothesis might be proposed that the positive experience of the Body Monochord possibly corresponds to the flow experience described by Csikszentmihalyi (1990). This is a joyful autotelic experience, which is described by full concentration on a targeted activity. The individual is absorbed in the activity and worries disappear. It may lead to changes in self-perception and an altered experience of time. A prerequisite for this is that the activity is located above the threshold for boredom and below the threshold for excessive demand and threat. In relation to the reception of sensory-musical stimuli this means that the sounds must not seem boring, but rather must be a challenge, without being too threatening or overwhelming. Probably due to the unusual nature of sound and the additional physical stimulation, the Body Monochord is a greater challenge than CD music with familiar structures, and thus enables a greater flow experience. The release of control, which is more pronounced and correlates with a positive experience on the Body Monochord (Sandler et al. 2015), could be interpreted as a joyful absorption in a state between boredom and excessive demand. Participants of the Body Monochord treatment might allow themselves to have unfamiliar experiences and unknown body sensations, which greatly characterize their state of consciousness, because the participants are probably able to assimilate these sensations adequately. In this state of consciousness, on the one hand attention might be focused on sensory events, on the other hand it might be encoded and matched with contents of memory. These activities may be reflected in the reduction of the Alpha-2 activity and the increases in the Theta activity.

Conclusion

Positive emotional experience of a state of relaxation induced by vibroacoustics and music is not associated with lateralization of electrocortical activity. Vibroacoustic stimulation with a Body Monochord appears to induce states of relaxation, which are experienced as pleasant by a subset of patients and is associated with focused attention and a simultaneous release of control. This is accompanied by a synchronization of Theta activity over the entire scalp, particularly the medial frontal and central regions, and a desynchronization of Alpha-2. Relaxation music on an audio CD does not induce these changes in EEG theta. In this context, especially the roles played by the experience of bodily vibrations or by the lack of structure of the monotonal, harmonically rich acoustic sound may be the subject of further investigation.

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