

Is Resting Anterior EEG Alpha Asymmetry a Trait Marker for Depression?

Findings for Healthy Adults and Clinically Depressed Patients

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Key Words

Depression · Emotion · Laterality · Anterior brain activation · EEG alpha power · Resting EEG · Temporal stability

Abstract

Several lines of evidence suggest that asymmetric anterior brain activation is related to affective style, linking left hemisphere activation to positive affect and right hemisphere activation to negative affect. However, previous reports of left frontal hypoactivation in depressed patients were not confirmed in recent studies. This study evaluated additional characteristics of resting EEG alpha (8–13 Hz) asymmetry in 15 clinically depressed patients and 22 healthy adults by recording EEG activity on two separate occasions, 2–4 weeks apart. Across both sessions, group differences in anterior EEG asymmetry were compatible with the original hypothesis. However, groups differed in temporal stability of anterior EEG asymmetry, which was retest reliable in controls but not depressed patients. In contrast, temporal stability of posterior EEG asymmetry was acceptable in both groups. Increased variability of anterior EEG asymmetry may be a characteristic feature for depression, and, if so, this would challenge the notion that anterior EEG alpha asymmetry is a trait marker for depression.

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Introduction

A growing body of evidence strongly suggests that the right and left cerebral hemispheres are differentially involved in the regulation and processing of emotion [1]. During the past two decades, anterior electroencephalographic (EEG) alpha power asymmetry, an inverse measure of relative brain activation, has been related to hemispheric specialization of fundamental dimensions of affect, resulting in a model of anterior asymmetry and emotion [1, 2]. This model postulates an association between individual differences in anterior activation asymmetry and emotion: individuals with a relative stronger left-sided activation are biased toward positive-valenced stimuli and approach-related behavior, whereas those with a relative stronger right-sided activation are biased to negative-valenced stimuli and withdrawal-related behavior. In agreement with this hypothesis is that brain-damaged patients with lesions in left frontal areas also showed symptoms of depression [3, but see also 4]. Because temperament abnormalities in depression are commonly characterized by low positive emotionality, i.e. loss of pleasurable engagement [5], reduced left anterior activation may be related to core symptoms of depression.

Left anterior hypoactivation during rest, as reflected by increased left frontal EEG power in the alpha band (8–13 Hz), has been reported in acute depressed [6] as well as

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remitted patients [7]. In nondepressed individuals, resting EEG alpha asymmetry was found to be stable over time [8–10] and therefore assumed to reflect individual differences. In further agreement with the anterior asymmetry and emotion model is that anterior EEG alpha asymmetry, firstly, predicted affective reactivity [11] and, secondly, showed a relation to individual differences in temperament [10, 12, 13]. Infant studies emphasize the importance of asymmetric anterior brain activation for behavior that is associated with biological features of depression [1]. Hence, functional anterior brain asymmetry has been considered as trait marker for the vulnerability to depression, and left anterior hypoactivation in depression is hypothesized to reflect underactivation of the approach system [1, 2].

For several years, brain activation has been explored by means of quantitative EEG, where EEG alpha activity (8–13 Hz) is considered as an inverse correlate of cerebral activation [14]. Recent imaging evidence seems to support this assumption. Using positron emission tomography (PET), Cook et al. [15] found a significant negative correlation between absolute power in the EEG alpha frequency range and simultaneously recorded H¹⁵O PET-derived cortical activation [15].

Subclinically depressed college students identified by high scores on the Beck depression inventory (BDI) showed increased left frontal alpha power, which is interpreted as left frontal hypoactivation [16]. Similar relations of BDI scores to anterior EEG asymmetry were also reported for healthy men [13]. Among clinically depressed patients, there is ample evidence of left-sided [17] or left anterior hypoactivation [6, 18–21], although there are also several contradictory findings [22–24]. However, studies differ widely in EEG methodology (e.g. recording and epoch length, site of reference electrode), patient diagnosis and symptomatology, and medication status. At least, these methodological differences cause tremendous problems when comparing findings. For example, the internal consistency of EEG alpha power asymmetry is inadequate when based on 1-min recording intervals [25]. As another problem, the studies cited above differ with respect to the particular anterior scalp locations (F3/4, F7/8, T3/4) and the specific recording condition (eyes open vs. eyes closed) for which significant effects were found.

From a theoretical point, empirical evidence according to the hypothesized state independence of left frontal hypoactivation in depression is important, particularly because mood states are suspected to modify resting anterior alpha asymmetry in depression [26]. Only one clinical study reported EEG findings for depressed patients that

were repeatedly tested [27]. In this study, left anterior hypoactivation was unchanged in patients with seasonal affective disorder (SAD) after 2 weeks of phototherapy. However, the study's results are based on a small sample size of four, and a generalization from SAD to other depressive subtypes is questionable. Therefore, the study by Allen et al. [27] does not provide an adequate estimate for the temporal stability of anterior asymmetry in depression.

The present study aimed to investigate the temporal stability of anterior EEG alpha power asymmetry in a larger sample of depressed patients and healthy adults. Based on the majority of findings reported in the literature, we hypothesized that left anterior hypoactivation, as indicated by greater left than right alpha power in resting EEG, will be related to depression. Furthermore, anterior EEG asymmetry was predicted to serve as trait index of depression and should consequently be stable over time in both clinically depressed patients and healthy adults.

Method

Participants

Depressed inpatients were recruited from the depression ward of the State Mental Hospital Arnsdorf, Germany, so that participation did not affect therapeutic treatment. Diagnosis and clinical state were assessed on separate sessions within a few days of the EEG recording sessions. A structural clinical interview [28] was taken by a trained graduate student, and consensus diagnosis was established together with an experienced psychiatrist (H.H.). Patients were excluded if they had a past history or current symptoms of bipolar affective disorder, organic brain disorder, psychosis or substance abuse. Patients were also excluded if there was a change in medication status during the time of participation, since means of treatment were unaffected by participation in this study.

Patients who received lithium as medication were removed from further analysis, because lithium is known to modify EEG alpha asymmetry [29, 30]. Whether other psychotropic medication systematically alters frontal EEG alpha asymmetry is not known yet. In one study on rhesus monkeys [31], diazepam caused a decrease in power in the 4- to 8-Hz frequency band, most pronounced in the left frontal region. In humans, alterations in EEG alpha asymmetry due to antidepressants were not evident [32, 33], nor did experimental variations of serotonergic activity alter EEG alpha asymmetry [34], but this evidence is based on only a few relevant studies. Although several pharmac-EEG studies analyzed effects of antidepressants, data analysis was typically restricted to midline positions [35]. Therefore, these studies do not provide topographic information. In one recent drug study, the therapeutic effects of the two antidepressants tianeptine and fluvoxamine were associated with a shift in anterior EEG alpha power asymmetry [36] in healthy individuals. As of yet, it is unclear whether psychotropic antidepressants have a normalizing effect with regard to brain activation asymmetry, as assessed by EEG alpha power. Further research is necessary to address this issue.

From the initial sample of 33 retested patients within the course of this study, 18 patients had to be excluded after all clinical informa-

tion became available after testing. This report includes only those 15 patients who met all inclusion criteria. According to the International Classification of Diseases [37], 2 patients were diagnosed as having a medium depressive episode (F32.1), and 13 patients had a severe depressive episode without psychotic symptoms (F32.2), 1 of them also meeting criteria for dysthymia (F34.1). The majority of patients were initially tested after receiving a fixed dosage of psychotropic antidepressant medication for at least 6 days, with most patients being on fixed dosage for a considerably longer period. Patients received trimipramine (n = 8), doxepin (n = 3), amitriptyline (n = 2), or citalopram (n = 1). Eleven patients received additional anxiolytic medication (lorazepam). One patient did not receive any psychotropic medication. Hospital staff and interested volunteers were recruited as controls through locally posted advertisements, and screened for current or past history of psychiatric illness or substance abuse. A retest for all participants was scheduled 2–4 weeks after the initial EEG recording session. Handedness was assessed with the Edinburgh Handedness Inventory [38]. Participants were also requested to report their mood on the BDI [39], and the Positive and Negative Affect Scales [40] were assessed immediately after EEG data collection. Demographic and self-report data for both patient and control groups are summarized in table 1. Among the patients were 10 females and 5 males, the control group consisted of a similar gender ratio of 15 females and 7 males. Although control participants were not selected to match the patients in gender, age, education and handedness, sample characteristics were kept similar to facilitate group comparisons. Whereas group differences in resting EEG alpha power asymmetry are not well known for gender, handedness is suspected to covary with resting brain activation asymmetry [41]. Written informed consent was obtained from all participants.

EEG Data Collection and Quantification

EEG data were collected from 19 scalp positions during four 2-min periods while participants were resting quietly in a comfortable armchair. Each period of resting EEG was recorded with either eyes open (O) or eyes closed (C). Order of conditions was the same in both EEG sessions, and counterbalanced across participants (i.e. OCOC or COCO).

A Ceegraph AC amplifier system and a stretch lycra cap were used to collect EEG data from 19 scalp locations (10-20 system). Using a forehead ground and linked earlobes (A1-A2) as reference, recordings were taken from 3 midline sites (Fz, Cz, Pz) and 8 homologous pairs of electrodes over each hemisphere (Fp1/2, F3/4, F7/8, C3/4, T3/4, T5/6, P3/4, O1/2). EEG impedances were kept below 5,000 Ω and within 500 Ω at homologous sites, including A1-A2. Vertical electro-oculograms were recorded to facilitate artifact recognition. The EEG signal was band-pass filtered (0.1–30 Hz) and digitized at 256 Hz. Continuous EEG data were divided offline in 2-second epochs (75% overlap) and rejected if visual inspection indicated eye movements or other recording artifacts. For eyes open, controls produced more artifact-free epochs than patients across recording sessions (controls, mean = 258, range 71–400, vs. patients, mean = 137, range 41–321; $t_{(35)} = 4.02$, $p < 0.001$), but there were no group differences for eyes closed (controls, mean = 326, range 77–458, vs. patients, mean = 350, range 153–462; $t_{(35)} = -0.70$, n.s.). However, as stated below, internal consistency of EEG alpha power asymmetry was highly reliable across conditions in both groups. A Hamming window [9] was then applied over the distal 50% of each epoch. Absolute spectral power (μV^2) as a function of frequency was derived by means of fast Fourier transformation. Epochs were averaged separately for eyes open and eyes closed

Table 1. Demographic and self-report data

	Patients (n = 15)	Controls (n = 22)
Gender, women:men	10:5	15:7
Age, mean (range)	48.5 (23–64)	45.9 (26–64)
Education, mean \pm SD	9.4 \pm 1.6 ¹	9.7 \pm 1.9
Handedness, left:right	1:14	3:19
Days between EEG recording sessions, mean \pm SD	22.5 \pm 4.7	21.7 \pm 4.2
BDI ² , mean \pm SD	20.8 \pm 11.2 ³	5.1 \pm 3.7
State mood, session 1		
Positive affect, mean \pm SD	2.7 \pm 0.9	2.9 \pm 0.8
Negative affect, mean \pm SD	1.5 \pm 0.5	1.1 \pm 0.2
State mood, session 2		
Positive affect, mean \pm SD	2.7 \pm 0.8 ¹	3.0 \pm 0.6
Negative affect, mean \pm SD	1.5 \pm 0.5 ¹	1.1 \pm 0.2

¹ n = 14.

² Groups differed significantly, $t_{(12,3)} = 4.8$, $p < 0.001$ (two tailed).

³ n = 12.

condition. Power density values were then ln transformed to normalize data [42]. Statistical analyses were restricted to power in the EEG alpha band (8–13 Hz) to limit Type I error probability, and because previous studies on individual differences in anterior activation asymmetry have focused on this frequency range.

Statistical Analysis

Previous studies involving measures of anterior asymmetry have reported effects at mid-frontal (F3/4), lateral-frontal (F7/8), and anterior-temporal (T3/4) sites (see [24] for a detailed discussion). For these locations, significant parametric intercorrelations of asymmetry measures were obtained in the present data for depressed patients ($r = 0.68$ – 0.94) and healthy controls ($r = 0.69$ – 0.94). Therefore, electrode sites were pooled within anterior left (F3, F7, T3) and right (F4, F8, T4) regions to reduce the amount of data [17]. Like previous studies, mid-parietal (P3, P4) sites were included to control for regional effects of EEG alpha power [7, 16].

To examine the hypothesized group differences in anterior alpha asymmetry, data from the two recording sessions were submitted to a $2 \times 2 \times 2 \times 2$ repeated-measures analysis of variance (ANOVA), including session (1, 2), hemisphere (left, right), and region (anterior, posterior) as within-subjects factors, and group (patients, controls) as a between-subjects factor. Significant interactions were examined through simple effects to locate the source of interaction (BMDP-4V) [43]. To increase statistical power, condition (eyes open, eyes closed) was not included as factor. Furthermore, an explicit goal of this study was to evaluate psychometric properties of alpha asymmetry for both groups separately, and, as described below, this evaluation involved both recording conditions.

Asymmetry measures were also computed by subtracting left-sided power density from right-sided power density at homologous sites (ln right minus ln left). Higher scores on this asymmetry index are interpreted to reflect greater left-sided activation [10]. Temporal stability (rest-retest reliability) of alpha power asymmetry was examined by

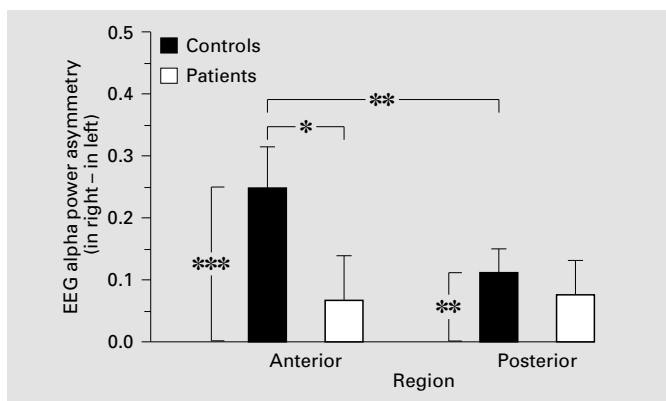


Fig. 1. Mean (\pm SEM) alpha asymmetry (ln right minus ln left) scores at anterior and posterior sites for healthy controls and depressed patients, averaged over session 1 and session 2. Positive scores indicate more left hemispheric activation. Means were collapsed across mid-frontal (F3, F4), lateral-frontal (F7, F8) and anterior-temporal (T3, T4) sites for the anterior region, and computed for mid-parietal (P3, P4) sites for the posterior region. The interaction region by group, calculated for the asymmetry indices, was significant, $F(1, 35) = 4.99, p = 0.032$. Significant mean differences (simple effects, two tailed) are indicated. * $p < 0.1$; ** $p < 0.01$; *** $p < 0.001$.

computing the Pearson correlations separately for the four indices (anterior: F8-F7, F4-F3, T4-T3; posterior: P4-P3). Internal consistency was determined by Cronbach's α computations of alpha power asymmetry indices, based on two measures for eyes open and two measures for eyes closed conditions. These calculations were done separately for each of the four scalp sites of interest and for each of the two recording sessions. To explore the relationship of anterior asymmetry and mood, correlations of positive affect, negative affect, and overall mood [10] to anterior asymmetry measures were performed.

Results

The results of the repeated measures ANOVA revealed significant main effects for group, $F(1, 35) = 5.49, p = 0.02$, hemisphere, $F(1, 35) = 11.02, p = 0.002$, region, $F(1, 35) = 143.75, p < 0.001$, and session, $F(1, 35) = 5.84, p = 0.02$. Confirming earlier findings [22], depressed patients (mean = 0.55, SD = 1.05) had more alpha power than nondepressed controls (mean = -0.15, SD = 0.97). As expected, posterior sites (mean = 0.53, SD = 1.09) showed more alpha power than anterior sites (mean = -0.27, SD = 0.86). There was also more alpha power over the right (mean = 0.20, SD = 1.05) than left (mean = 0.06, SD = 1.07) hemisphere, and at session 2 (mean = 0.18, SD = 1.08) than at session 1 (mean = 0.08, SD = 1.04).

A significant hemisphere by region interaction, $F(1, 35) = 4.10, p = 0.05$, was indicative of a slightly more

pronounced anterior than posterior right-larger-than-left EEG alpha power asymmetry, although simple effects for hemisphere were highly significant for both regions (anterior, $F(1, 35) = 10.52, p = 0.003$; posterior, $F(1, 35) = 8.73, p = 0.006$). More importantly, there were regionally dependent differences between groups in left-versus right-sided alpha power, which was supported by a significant hemisphere by region by group interaction, $F(1, 35) = 4.99, p < 0.032$. Simple interaction effects revealed that the hemisphere by region interaction was significant only for controls, $F(1, 35) = 11.19, p = 0.002$, but not for patients, $F(1, 35) = 0.02, n.s.$ A suggested hemisphere by group simple interaction effect emerged only at anterior, $F(1, 35) = 3.40, p = 0.07$, but not at posterior sites, $F(1, 35) = 0.35, n.s.$ Finally, simple hemisphere main effects, calculated for each group and each region, revealed significant greater right than left alpha power only for controls, particularly at anterior sites [anterior, $F(1, 35) = 15.96, p < 0.001$; posterior, $F(1, 35) = 7.76, p = 0.009$], but not for patients [anterior, $F(1, 35) = 0.82, n.s.$; posterior, $F(1, 35) = 2.34, n.s.$]. No other significant interaction effects were found in the overall $2 \times 2 \times 2 \times 2$ analysis.

To illustrate the interaction effects involving hemisphere, EEG alpha power asymmetries (ln right minus ln left) are plotted in figure 1 (interaction effects of two-level factors are statistically equivalent to lower-order effects in an ANOVA on level difference scores). Collapsed across both sessions, controls showed a pronounced left sided activation over the anterior region, i.e. more right than left hemisphere alpha power, and less pronounced left-sided activation over posterior sites, whereas EEG alpha power asymmetry was insignificant in patients for both regions. In contrast to EEG alpha power asymmetry over anterior regions, posterior asymmetry did not differ significantly between patients and controls.

To facilitate comparison with previous research, and because a session main effect indicated overall differences in EEG alpha power between both testing sessions, repeated-measures ANOVA were computed post hoc for each session. These analyses revealed for session 1 suggestive interactions of hemisphere by group, $F(1, 35) = 3.56, p = 0.07$, and hemisphere by region by group, $F(1, 35) = 3.23, p = 0.08$. In session 2, neither of these interactions reached statistical significance [hemisphere by group, $F(1, 35) = 0.50, n.s.$; hemisphere by region by group, $F(1, 35) = 2.31, p = 0.14$].¹

¹ To address the concern that variations in vigilance may affect group differences in EEG alpha asymmetry, data were reanalyzed by including a factor *vigilance*, which was operationalized by comparing the first 4 min and the last 4 min of each 8-min recording session. Neither the corresponding five-way

We further examined internal consistency and temporal stability for each group. Internal consistency computations for each of the four homologous electrode pairs were based on four asymmetry measures during rest, i.e. two measures with eyes open, and two measures with eyes closed. Internal consistencies ranged from 0.84 to 0.98 in the control group, and from 0.87 to 0.98 in the patient group (table 2). These results strongly suggest that EEG alpha power provides a reliable asymmetry measure, irrespective of group, region and session, when averaged over condition (eyes open vs. eyes closed). Excellent reliability in both groups further indicated that group differences in the number of artifact-free epochs (see above) did not bear on reliability.

For nondepressed individuals, temporal stability of EEG alpha power asymmetry (table 2) revealed significant stabilities across the different scalp regions ($r = 0.46$ – 0.69). For depressed patients, however, a significant test-retest stability of $r = 0.57$ emerged only for mid-parietal sites; for anterior regions, correlations between recording sessions 2–4 weeks apart were around zero ($r = -0.22$ to 0.09) and not significant.

Additional correlational analyses of self-reported positive and negative affect scores did not reveal any systematic relationship to EEG alpha power asymmetry, neither in patients nor in controls.

Discussion

The present study evaluated regional characteristics and their statistical properties of asymmetric brain activation in depression by assessing EEG alpha power during rest at two different recording sessions. In agreement with prior findings [6, 18–21], depressed patients differed from healthy controls in resting anterior EEG asymmetry when data were collapsed across the two recording sessions separated by 2–4 weeks. Depressed patients failed to show more left than right anterior alpha activity, whereas healthy controls had markedly more right than left anterior alpha activity, i.e. a relative greater activation of left anterior regions. No group differences were found for mid-parietal EEG asymmetry. Although it should clearly be noted that the lack of frontal EEG asymmetry seen in depressed patients did not exactly match previous findings, the direction of group differences in frontal EEG

ANOVA hemisphere \times region \times session \times vigilance \times group nor calculations done separately for each recording session revealed evidence for a significant contribution of the factor vigilance (i.e. for the main effect of vigilance and all interactions involving vigilance, $p > 0.10$).

Table 2. Internal consistency and temporal stability of EEG alpha power asymmetry

	Internal consistency session 1/session 2	Temporal stability
Patients (n = 15)		
Mid-frontal	0.87/0.94	0.09
Lateral-frontal	0.96/0.98	-0.22
Anterior-temporal	0.97/0.98	-0.05
Mid-parietal	0.95/0.91	0.57*
Controls (n = 22)		
Mid-frontal	0.94/0.95	0.69**
Lateral-frontal	0.97/0.98	0.46*
Anterior-temporal	0.93/0.97	0.53*
Mid-parietal	0.84/0.95	0.68**

Internal consistency based on Cronbach's α , temporal stability estimations computed as Pearson's correlations. * $p < 0.05$; ** $p < 0.01$ (two tailed).

asymmetry is in line with the theory of a left frontal hypoactivation in depression.

In our study, anterior EEG asymmetry was based on alpha power collapsed across three anterior sites (F3/4, F7/8, T3/4), since initial data analyses did not show any systematic differences in EEG asymmetry for these locations. Furthermore, internal consistency measures of EEG alpha power asymmetry revealed excellent scores of Cronbach's α for both patients and controls, regardless of scalp region. This finding extends previous research of EEG alpha power asymmetry in healthy individuals [8, 9, 25], by demonstrating that this measure is similarly reliable in clinically depressed patients.

In the present study, EEG alpha asymmetry was solely calculated on the basis of data derived by a linked-earlobes reference, although this reference is critically discussed in the literature [44]. In a previous study [45], we compared linked-earlobes-referenced data to computational Cz-referenced and common-average-referenced data (19-channel recording). The linked-earlobes reference channel comprised less alpha activity in a resting condition, and the corresponding data reflected more appropriately the basic occipitoparietal topography of EEG alpha activity in healthy individuals. However, the results in this report should be interpreted minding the linked earlobes reference, because asymmetry measures derived by different ways of EEG reference may [6, 7, 9, 11] or may not [24, 25, 45] provide similar results. Future work should address this issue with high-density EEG

recordings to provide higher spatial resolution and the possibility for several additional reference montages.

More importantly, group differences emerged for the analysis of temporal characteristics in anterior EEG asymmetry. Whereas posterior EEG asymmetry was acceptably stable over time in both patients and controls, only controls showed adequate temporal stability of anterior EEG asymmetry. For controls, the level of test-retest stability confirms earlier reports [8–10]. Concerning the insufficient stability of anterior EEG asymmetry in depressed patients, our results differ clearly from one previous report that investigated only four bipolar patients [27]. The group differences in temporal stability of anterior EEG alpha power asymmetry reported here were not biased due to group differences in reliability (internal consistency). It is therefore likely that the temporal instability of anterior EEG alpha power asymmetry provides essential, additional information when characterizing depressed patients in terms of EEG correlates.

Our finding of instable anterior EEG alpha power asymmetry in patients is particularly noteworthy, because this measure has been considered a trait marker for depression [7]. Several reasons may contribute to this instability. First, there is preliminary evidence on an association of state affect and EEG alpha power asymmetry in depression [26]. For this reason, we have explored the relation of the subjects' self-reported mood and anterior EEG asymmetry, but neither in healthy controls nor in depressed patients did we find a significant relation between positive affect, negative affect or a combined measure of mood and anterior EEG asymmetry [for methodology, 10]. Thus, we did not find evidence that state mood is linked to variations in frontal EEG asymmetry, but, of course, we cannot exclude this possibility.

Second, the majority of depressed patients received pharmacological treatment during the course of the study. Although antidepressants are generally not known to alter EEG alpha asymmetry [32, 33], a few studies have related therapeutic effects of antidepressants to a shift in anterior EEG alpha power asymmetry [29, 36]. As stated in the Method section, patients were only included in the study if their medication did not change between testing sessions. However, since patient medication was determined by the course of clinical treatment rather than by the experimental design, the possible influence of antidepressants on anterior EEG alpha asymmetry and its temporal characteristics was uncontrolled in this study. Whether regionally restricted alteration of anterior EEG asymmetry is caused by antidepressant medication is not known yet. Future research may determine whether mood im-

provements in clinically depressed patients due to antidepressant medication are accompanied by a shift towards higher left anterior activation.

A third reason for the observed instable anterior EEG asymmetry in depressed patients may derive from the fact that other clinical symptoms, which often accompany mood disorders, but do not represent core symptoms of depression, could also have an impact on asymmetric brain activation. In particular, different forms of anxiety are associated with different patterns of asymmetric hemispheric activation, thereby raising the issue that a comorbidity of depression and anxiety may conversely affect EEG topography [17, 46]. It is conceivable, that different clinical symptoms obscure EEG lateralities and vary over time. However, it was beyond the scope of this study to investigate the influence of possible mediator variables like different forms of anxiety.

The temporal instability of anterior EEG alpha power asymmetry in depressed patients is also most likely the cause for the weak relationship of anterior EEG asymmetry to depression that was found in separate analyses for each recording session. If increased variability of anterior EEG asymmetry is indeed a characteristic feature for depression in general, or for some depressive subtypes, this fact may then help to explain recent failures to replicate earlier reports on left frontal hypoactivation in depression. Most previous studies collected EEG data simply only at *one* recording session [6, 16–21, 23; for a discussion on further possibilities for these failures, see 24]. Although our findings clearly need independent replication, a major goal for future studies should be to unveil circumstances that lead to temporal instability of asymmetric EEG activation seen over anterior brain regions.

To sum up, the findings reported in this study add to the growing body of evidence to show alterations of anterior brain activation in depression. Since anterior EEG asymmetry lacked temporal stability in depressed patients in this study, it appears too premature to consider anterior EEG alpha power asymmetry a trait marker for depression. Further research is needed to uncover the temporal characteristics of anterior EEG asymmetry to clinical features of depression.

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