Electrophysiological processing of happiness during conscious and subconscious awareness in depression

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ARTICLE INFO

ABSTRACT

Objective: Processing of positive emotions in depressed individuals is different from healthy ones but its physiological correlates especially during different levels of consciousness is not yet well-understood. This study investigated physiological correlates of emotional processing of positive emotions during hypnosis and consciousness in depressed individuals compared to healthy control with the electroencephalogram (EEG).

Method: Forty individuals classified in two groups of depression ($N = 20$, 10 females) and healthy control ($N = 20$, 10 females) participated in this study. Participants in each group underwent a positive emotional experience during hypnotic state and conscious state while their EEG pattern was recorded. The EEG power was analyzed for both groups during hypnosis and conscious state.

Results: Results showed that experience of happiness significantly changed EEG pattern compared to the resting state in both groups with a significant increase in the Beta band in the right hemisphere. However, the increase in the right temporal beta activity was significantly higher in healthy subjects compared to depressed ones. Furthermore, the experience of happiness was not significantly different during hypnotic and conscious states in both groups. A significant increase in the Alpha band was also observed in both groups during hypnotic experience but not conscious state.

Conclusions: Electrophysiological processing of happiness is not different during hypnosis and consciousness but is associated with an increase of Beta band in the right temporal hemisphere in both depression and healthy subjects.

1. Introduction

Depression is a prevalent psychiatric disorder characterized by altered emotional functioning (Diener et al., 2012). Despite various cognitive deficits in depression (Rostami, Kazemi, Nitsche, Gholipour, & Salehinejad, 2017), a key feature of depression is disturbed emotional processing, which generally is expressed as a negative bias in processing emotional information (Ritchey, Dolcos, Eddington, Strauman, & Cabeza, 2011). Biased emotional processing in depression is usually characterized by oversensitivity to negative emotions and hyposensitivity to positive emotions which are indicated by biased attention to positive and negative stimuli (Armstrong & Olatunji, 2012; Duque & Vázquez, 2015; Katharina et al., 2018; Nejati, Salehinejad, Shahidi, & Abedin, 2017). Specifically, individuals with depression show reduced attention for happy stimuli including happy faces (Duque & Vázquez, 2015). The cognitive formulations of depression suggest that abnormal processing of emotional information, which seems to be related to impaired cognitive cognitive functions (Salehinejad, Ghanavai, Rostami, & Nejati, 2017), appears to be implicated in the etiology and maintenance of depression and other emotional disorders (Armstrong & Olatunji, 2012).

Findings from studies using electroencephalogram (EEG) suggest predictable alterations in EEG patterns of depressed individuals. For example, frontal alpha asymmetry (FAA), with hyperactivation of the

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alpha band in the right frontal area, and frontal midline (FM) theta have been suggested as electrophysiological biomarkers for depression (Gold, Fachner, & Erkilla, 2013). In this line, a hypoactivity of the alpha band in the left frontal area is shown in depressed individuals (Coan & Allen, 2004; Diego, Field, & Hernandez-Reif, 2001). Moreover, unique EEG patterns are observed in depressed individuals during processing emotional information such as frontal EEG activity which is thought to reflect affective dispositions. A greater frontal EEG activity is found during conscious emotional experiences in depressed people which will be kept to normal activity after the end of emotional experience (Dennis & Solomon, 2010). Compelling evidence suggest a moderating role for frontal EEG asymmetry in at least some emotions and it has been suggested as a moderator for psychopathology in some disorders including depression (Coan & Allen, 2004). Nevertheless, there is still controversy on whether frontal EEG asymmetry is a moderator or mediator of emotional processing and whether it really predicts psychopathology in depression or not (Coan & Allen, 2004).

In addition to the frontal EEG asymmetry in depressed individuals, emotional processing in the healthy brain is carried out in an asymmetric way. It is well-known that the right hemisphere is more responsible for emotional processing known as the "right hemisphere hypothesis" (Gainotti, 1972). According to this hypothesis, the experience of emotion (i.e., mood and affect) is predominantly regulated by the right hemisphere (Demaree, Everhart, Youngstrom, & Harrison, 2005). Lateralized electrophysiological parameters measured during emotionally charged states show relative activation in the right hemisphere measured by decreased alpha power using EEG. Another well-known notion about asymmetric emotional processing concerns with the valence of emotion. The valence hypothesis postulates that the right hemisphere is specialized for negative emotion while the left hemisphere is specialized for positive emotion that are associated with a relatively increased right hemisphere activity during negative emotional states and relative increased left hemisphere activity with positive emotional states (Demaree et al., 2005).

Previous EEG studies about emotional stimuli especially discrete emotional states tried to differentiate responses to basic emotions in response to brief presentations of affective stimuli based on power shifts in specific EEG frequency bands (Andersen, Moore, Venables, & Corr, 2009; Davidson, 1992; Jaušovec, Jaušovec, & Gerlič, 2001). Although there appears to be fairly consistent theta synchronization in frontal regions of the brain during the earliest phases of processing affective auditory stimuli, the patterns are not readily distinguishable between specific emotions (Bekkedal, Rossi, & Panksepp, 2011). To date, it has not been possible to consistently differentiate brain responses to emotion-specific affective states or stimuli, and some evidence suggests the theta synchronization as a general arousal process rather than specific indices of specific emotional states (Bekkedal et al., 2011). However, processing of emotions in the brain can be different based on the emotional stimuli modality (i.e., auditory vs visual) or explicitness of stimuli (i.e., implicit vs explicit emotional perception) too (Knyazev, Slobodskoj-Plusnin, & Bocharov, 2010).

The conscious experience of the emotion (i.e., feeling) in an important component of emotion and emotional processing (Fabrega, 2000). Not only is consciousness important for functional aspects of emotion, but also for those brain structures that are involved in "emotional processing" and "consciousness regulation" such as brainstem nuclei and midline cortices (Tsuchiya & Adolphs, 2007). Emotional processing of the brain occurs in both explicit (i.e., conscious) and implicit (i.e., subconscious) way. Findings from disorders marked with emotional abnormalities (i.e, depression, post-traumatic stress disorder) suggest that processing of emotional information is consistent in both conscious and subliminal states (Nejati, Salehinejad, & Sabayee, 2018). Similarly, it is shown that EEG components of emotional processing during hypnotic and conscious states are similar in high-susceptible people (Depascalis, 1994). However, studying the valence of emotion (i.e., sadness or happiness) and its association with

electrophysiological correlates in depressed individuals during conscious and hypnotic states still needs further investigation. This is specifically important to see whether electrophysiological components of positive emotional processing in depression is consistent or not during both conscious and hypnotic levels.

The present study, therefore, aims to investigate how experiencing a positive emotion (i.e., happiness) in two different levels of consciousness affect the electrophysiological functioning of the brain in depressed individuals compared to healthy control. Based on previous findings about emotional processing of brain that revealed an increase in the Beta activity during processing of positive emotion, we expect to see an increase in beta activity in the right temporal lobe in both depressed and healthy individuals (Hypothesis 1). Furthermore, based on frontal alpha asymmetry in depression, we expect to see an increase of alpha activity in the right frontal lobe in depressed individuals during resting EEG (Hypothesis 2).

2. Material and methods

2.1. Participants

Fifty individuals were initially recruited for this study. Ten participants were excluded after the initial screening due to low scores on the Stanford Hypnotic Susceptibility Scale (SHSS). The forty individuals (Mean age = 25.55, SD = 4.39) were classified in two groups of depression (N = 20, 10 females) and healthy control (N = 20, 10 females). Participants in both groups were initially screened for level of susceptibility based on their scores on SHSS and were matched based on gender, age, and educational level. Participants in the depression group were recruited from the local university Mental Health Clinic and their depressive symptoms were diagnosed according to DSM-5 criteria confirmed by the participant's scores on the Beck Depression Inventory (BDI-II) (Beck, Ward, & Mendelson, 1961; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Inclusion criteria for depression group were: (1) age from 18 to 40 years, (2) not to be on antidepressant or other psychotropic medications or psychotherapy during the study (3) moderate to severe depression score based on BDI (scores from 20 and higher); (4) no other psychological, mental or neurological disorders; (5) scoring 8 or higher on the SHSS. The fourth and fifth criteria were applied to control group too. The study was conducted according to the Declaration of Helsinki ethical standards and approved by the Institutional Review Board and the Ethical Committee at the Univesity of Tehran. All participants had normal or corrected to normal vision and gave their written informed consent before participation and were free to withdraw from the experiment upon request. Demographic data are shown in Table 1.

2.2. Measures

2.2.1. Beck depression inventory (BDI-II)

Depression symptoms were assessed using the BDI-II (Beck, Ward, Mendelson et al., 1961, 1961b). The BDI-II is a self-reported 21-item self-report inventory about how the subject has been feeling in the last week and each question has four answers ranging in intensity. It is

Table 1
Demographic data of participants.

Variables	Group	N	Mean	SD	Min	Max
Age	depressed	20	25.10	4.15	19	31
	healthy	20	26	4.63	19	35
Hypnosis susceptibility	depressed	20	8.85	1.08	8	11
	healthy	20	9.03	1.23	8	11
Depression	depressed	20	22.85	2.23	18	28
	healthy	20	9.20	5.17	2	17

SD = standard deviation.

designed to be administered to people aging from 13 and higher. Respondents rate the severity of each symptom on a 0 (absent) to 3 (most severe) scale. Total scores range from 0 to 63 and scores from 29 and higher are indicative of moderate to severe depressive symptoms. BDI-II cutoff scores indicate different levels of depression (i.e., 0–13 = "minimal," 14–19 = "mild," 20–28 = "moderate," and 29–63 = "severe". The BDI-II has demonstrated adequate reliability and validity (Smarr & Keefer, 2011). The BDI-II version used in this study was in the native language of participants with adequate test-retest reliability ($r = 0.74$), internal consistency (Cronbach's α = 0.87) and validity values (Habibollah, Ramin, Narges, & Narges, 2005). It takes around 5–10 min to complete.

2.2.2. Stanford Hypnotic Susceptibility Scale-Form C (SHSS:C)

Measuring hypnotic suggestibility is recommended for improving the methodological rigor of hypnosis research (Jensen et al., 2017). Accordingly, we used the SHSS:C to measure the hypnotic suggestibility of subjects prior to the experiment. The SHSS:C (Weitzenhoffer & Hilgard, 1996) is a standardized 12-item measurement of people's response to suggestions following a hypnotic induction. It was initially generated in two forms of A and B and the latest version which is commonly used is the form C. The SHSS:C consists of 12 dichotomously scored items including direct ideomotor (e.g., arm heaviness), challenge motor (e.g., arm immobilization), and cognitive-perceptual (e.g., auditory hallucination) suggestions. The SHSS:C items are offered in order of increasing difficulty and total scores range from 0 to 12 with higher scores indicative of higher susceptibility. The procedure lasts approximately 45 min, starting with a unified interpretational set and eye-closure induction. During the task, each suggestion is carried out successfully, as judged by the hypnotist according to objective criteria, and is noted as passed and counted as one point. The SHSS:C used in this study was in the native language of participants with adequate test-retest reliability ($r = 0.75$) and internal consistency (Cronbach's α = 0.80) (Taslimbakhsh, Sadeghi, Sadeghi, & Ahmadi, 2017).

2.3. Positive emotion arousal and hypnosis induction

In order to induce positive emotion (i.e., happiness) we used a 2-min audio clip. Previous EEG studies usually used video-clips or funny pictures (i.e., pictures of laughter) for inducing positive emotions and happiness in participants (Huang et al., 2016; Koelstra et al., 2010; Liu et al., 2018). Here we used the audio version of the same stimuli because our studies required participants to respond to emotional arousal in the hypnotic state, in addition to the conscious state, where their eyes should be closed. The clip included a mix of funny conversations from TV shows, "laughter" sounds and funny soundtracks from movies and cartoons. In order to evaluate the level of the funniness of the audio clip, seventeen individuals who did not participate in the study and were blind to study rational evaluated the clip in a 0 to 5 Likert scale with 0 scores indicative of "Not funny at all" and 5 indicative of "So funny". Almost 80% of evaluations rated the audio clip funny.

For inducing hypnosis, we used the standard procedure suggested in the Handbook of Hypnotic Suggestion (Hammond, 1990). Specifically, a particular hypnotic transcript which had the same time length as the 2-min audio clip was written by researchers. The hypnosis procedure had three major stages in all of which the subjects' eyes were closed: first, subjects were hypnotized according to the suggested instruction (Hammond, 1990). Secondly, the main stage was begun afterward in which participants were in the deep trance state for 2 min. At this stage, subjects were suggested to retrive funny memories or hear the laughter sounds. This stage took as long as the audio clip. Finally, participants were dehypnotized in 30–45 seconds.

2.4. EEG recordings

Electroencephalogram (EEG) was recorded by the Telepat-104 24-channel EEG system and by the Mitsar 21-channel EEG system (Mitsar, Russia). Nineteen silver-chloride scalp electrodes (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, and O2) were placed according to the 10–20 international system. EEG data was offline re-referenced to the average signal and was bandpass filtered between 0.5 and 30 Hz. Earlobe electrodes were used as reference ones and the ground electrode was placed at Fpz. Impedance was kept below 10 kΩ. EEG was continuously recorded on the hard disc. EEG was recorded in Eyes closed resting states, at least for three and a half minutes for every period. No eyeblink artifacts were recorded because during the whole experiment subjects' eyes were closed. However, epochs with an excessive amplitude of non-filtered EEG and/or excessive high and slow frequency activity were automatically marked and excluded from further analysis. The horizontal and vertical eye movements, low-voltage electrode movements, low-voltage EMG, and cardiac artifacts were removed from the raw EEG recording. Raw EEG data were recorded and stored for offline analysis using WinEEG software.

The EEG data was filtered by a bandpass Butterworth filter order six. The order was specified based on previous studies (Hekmatmanesh, Wu, Li, Nasrabadi, & Handroos, 2019; Hekmatmanesh et al., 2017). The selected edges of the bandpass filter were 0.5–30 Hz to remove offset and high power of EMG signals. Butterworth is an IIR filter that causes phase distortion. To avoid phase distortion "filtfilt" function in Matlab software was used. The capability of this function is passing the EEG signal through the filter two times, first the signal is passed from beginning to the end and for the second time the signal is passed from end to the beginning (Oppenheim, 1999). Through this approach, the phase distortion is removed from the signal. The target frequency bands were Alpha and Beta at the frequency ranges of 8–12 and 16–30 Hz, respectively.

2.5. Procedure

Participants in both groups were seated in a comfortable chair in a quiet room. All participants were in a normal and relaxed state with no signs of substantial deviations. Each subject had two-time EEG recordings: once during listening to an audio clip in a conscious state (including resting state EEG) and once during hypnotic state and in both states subjects' eyes were closed (including resting state EEG). The order of exposure to experimental stimuli (i.e., conscious sessions vs hypnotic session) was randomized across participants. After attachment of electrodes, task instructions were given for each respective session. During conscious state and after installation of the EEG cap, first resting EEG was recorded during which subjects were asked to close their eyes and stay relaxed for 210 s. After resting state and while subjects' eyes were kept close, subjects listened to the 2-min audio clip which was supposed to induce happiness while their EEG was recording. Auditory stimuli were presented via customary computer loudspeakers. Subjects rated the funniness of the auditory clip at the end of the experiment session. During the hypnotic state and after installation of the EEG cap, the hypnotic induction was carried out by an expert psychologist who was blind to the grouping information of the participants. After successful hypnotic induction, two suggestions were carried out during hypnosis. The first suggestion asked subjects to sit calm and relaxed on the chair for 210 s (rest state EEG). Afterward, the positive emotion or happiness suggestion was carried out for 2 min. In the end, the subjects opened their eyes and this was the end of the experiment.

2.6. Statistical analysis

Data analyses were conducted using MATLAB (MathWorks, Inc., Natick, Massachusetts) and the statistical package SPSS for Windows, version 21.0 (IBM, SPSS, Inc., Chicago, IL). In order to examine changes of EEG patterns during resting state and positive emotion induction at two levels of consciousness (i.e., conscious and hypnotic state), we employed a two-way mixed analysis of variance (ANOVA) with group
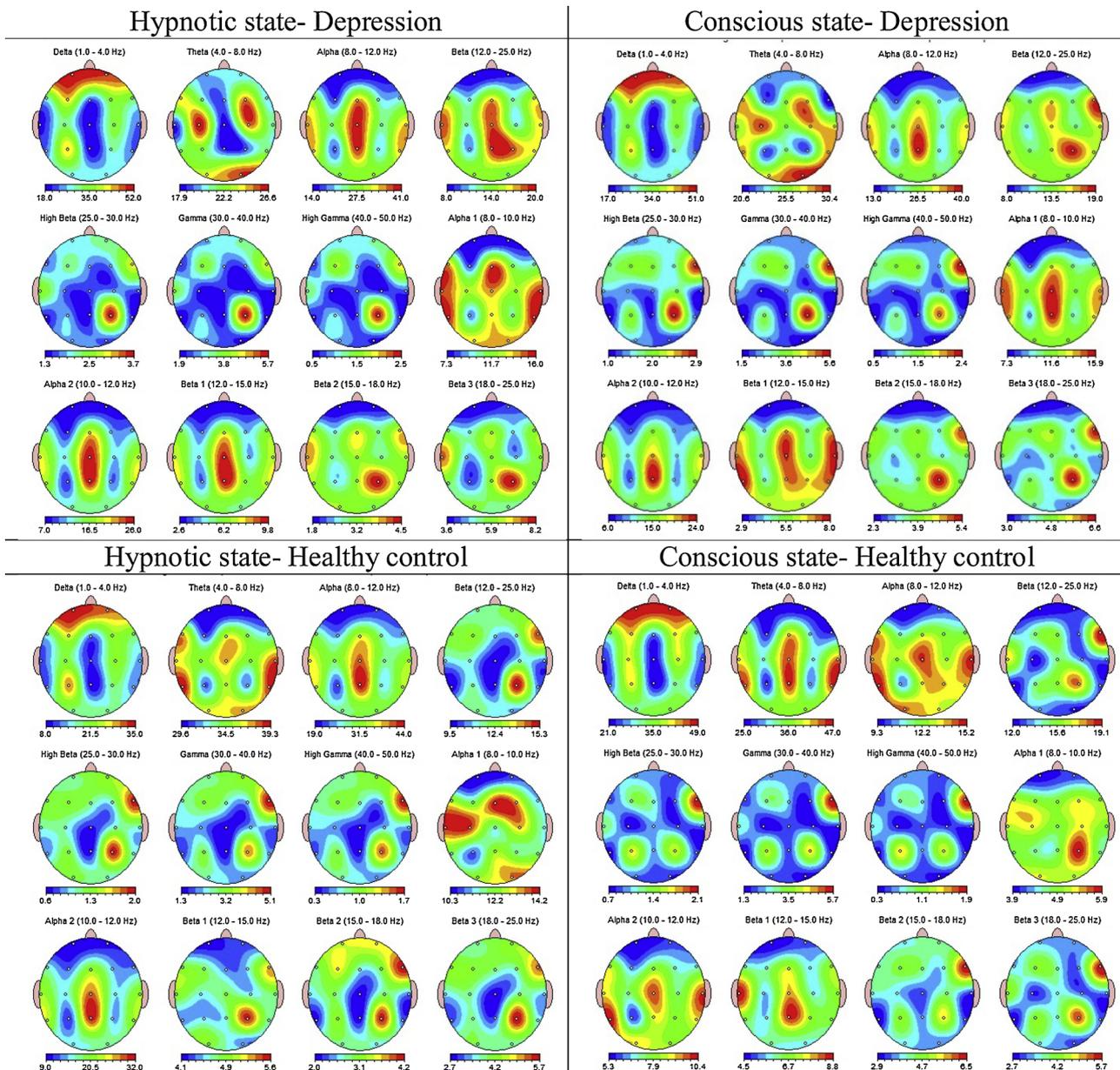
Fig. 1. Power spectrum maps of EEG Delta, Theta, Alpha and Beta bands during hypnotic and conscious states in depression and control groups. The experience of happiness was not significantly different during hypnotic and conscious states.

(depression, healthy) and consciousness (hypnotic, conscious) as between-subjects factors and time as the within-subjects factor. Our analyses of variance met linear assumptions. The normality and homogeneity of variance of data were confirmed using Shapiro-Wilk and Levin tests respectively. Additionally, in order to compare alpha band activity between depressed individuals and healthy control during resting EEG pattern, we employed a t-test. The normal distribution of the data was confirmed by the Shapiro-Wilk test. A significance level of $p < 0.05$ was used for all statistical comparisons.

3. Results

Data overview including means and standard deviation of EEG spectral power (0 to 50 HZ) showed significant difference in the EEG spectral power during experiencing happiness in both groups (Fig. 1). ANOVA results showed a significant main effect of time (i.e., rest-state recording vs happiness experience recording) on the EEG spectral power in all recorded sites. In other words, experiencing positive

emotion (i.e., happiness) during both conscious and hypnotic states led to a significant increase in the EEG spectral power obtained from the 0 to 30 HZ frequency bands. No significant interaction effect of time x group and time x consciousness were observed indicating that the increase of EEG spectral power occurred in both depressed and healthy individuals under both hypnotic and conscious experience of happiness. Results are shown in Table 2.

We also evaluated whether experiencing happiness during hypnotic and conscious states, as an independent variable, could change EEG power in the beta band of temporal areas. ANOVA results showed a significant interaction effect of time (rest EEG vs task EEG) and group ($F = 9.82$, $p < 0.01$) indicating that the changes in the beta power were significantly lower in depressed individuals compared to healthy control. Moreover, the main effects of time ($F = 21.49$, $p < 0.01$) was also significant indicating that experiencing happiness in the hypnotic and conscious states led to a significant increase of temporal beta power in both depressed and healthy individuals with a significantly higher increase in the healthy group. Nevertheless, no significant interaction

Table 2
ANOVA results for effects of experiencing happiness on EEG spectral power (0–30 HZ) of brain areas in depressed and healthy individuals.

Brain area	Source	df	F	sig
right prefrontal	Time	1	7.49	**0.01**
	Time*group	1	4.04	0.52
	Time*consciousness	1	0.71	0.40
	Time*group*consciousness	1	1.90	0.17
left prefrontal	Time	1	33.29	**0.01**
	Time*group	1	0.78	0.38
	Time*consciousness	1	5.48	0.25
	Time*group*consciousness	1	1.88	1.78
right frontal	Time	1	12.06	**0.01**
	Time*group	1	0.59	0.44
	Time*consciousness	1	0.36	0.54
	Time*group*consciousness	1	0.94	0.33
left frontal	Time	1	36.73	**0.01**
	Time*group	1	7.05	0.12
	Time*consciousness	1	3.83	0.06
	Time*group*consciousness	1	1.77	0.19
right temporal	Time	1	32.46	**0.01**
	Time*group	1	1.19	0.05
	Time*consciousness	1	0.15	0.70
	Time*group*consciousness	1	0.01	0.96
Left temporal	Time	1	16.50	**0.01**
	Time*group	1	5.25	0.28
	Time*consciousness	1	0.99	0.32
	Time*group*consciousness	1	0.44	0.51
right parietal	Time	1	26.17	**0.01**
	Time*group	1	0.24	0.60
	Time*consciousness	1	1.33	0.25
	Time*group*consciousness	1	1.65	0.21
left parietal	Time	1	28.21	**0.01**
	Time*group	1	0.50	0.48
	Time*consciousness	1	0.30	0.58
	Time*group*consciousness	1	2.08	0.15
right occipital	Time	1	7.58	**0.01**
	Time*group	1	6.05	0.19
	Time*consciousness	1	1.14	0.29
	Time*group*consciousness	1	1.32	0.25
left occipital	Time	1	23.65	**0.01**
	Time*group	1	0.02	0.88
	Time*consciousness	1	0.26	0.61
	Time*group*consciousness	1	1.35	0.25

Note: Time refers to measurement time during rest (Resting state EEG) and emotional experience.

Table 3
ANOVA results for effects of experiencing happiness on temporal EEG spectral power in depressed and healthy individuals.

Brain area	Source	df	F	sig
Temporal	Time	1	7.49	**0.01**
	Time*group	1	4.04	0.52
	Time*consciousness	1	0.71	0.40
	Time*group*consciousness	1	1.90	0.17

Note: Time refers to measurement time which was during rest (Resting state EEG) and emotional experience.

effect of time and consciousness were found ($F = 1.29$, $p = 0.27$) indicating that experiencing happiness under both the hypnotic and conscious states similarly increased temporal beta power. Results are shown in Table 3.

Additionally, we compared the frontal alpha band of depressed individuals and healthy controls during resting state EGG using the independent *t*-test (Fig. 2). Results show no significant differences in the frontal alpha power between depressed and healthy individuals in the right ($t_{(1, 38)} = 1.67$, $p = 0.10$) and left ($t_{(1, 38)} = 0.73$, $p = 0.46$) hemispheres. Results are shown in Table 4.

4. Discussion

In this study, we investigated the effects of experiencing happiness during hypnotic and conscious states on brain electrophysiological functioning in a sample of depressed individuals compared to healthy controls. Results showed that experiencing happiness, either via hypnotic suggestion during hypnotic state or via an auditory clip in conscious state, significantly increased EEG spectral power in both depressed and healthy individuals. Specifically, we observed an increase in the right temporal beta activation during hypnotic and conscious states for both depressed and healthy individuals. However, the amount of right temporal beta band increase was significantly higher in healthy individuals. Lastly, our results showed no significant difference between depressed and healthy individuals in the right frontal alpha band during the resting state.

The primary finding of our study implicates that experiencing happiness affects brain functioning similarly during both hypnotic and conscious state. In line with this, it was shown that imaginary sensory experience compared to real hearing the experience of the stimulus, generated a similar effect on highly susceptible individuals to hypnosis (Szechtman, Woody, Bowers, & Nahmias, 1998). All subjects in our study were highly susceptible to hypnosis too which might explain the similar effect of the hypnotic and conscious experience of happiness on EEG spectral power in both groups. This makes more sense as previous studies have shown that cognitive functioning especially attentional processes are stronger in high-susceptible individuals and can be enhanced more than low-susceptible individuals following hypnotic suggestion (Crawford, 1994; Iani, Ricci, Baroni, & Rubichi, 2009). Therefore, experiencing happiness via hypnotic suggestion can be experienced like real by these individuals.

The increase of beta power in the temporal area and specifically right hemisphere after experiencing happiness is consistent with previous findings. A higher beta activity in the right temporal areas for emotional stimuli compared to neutral stimuli has been documented in previous studies (Müller, Keil, Gruber, & Elbert, 1999). Neuroimaging and EEG studies showed that perception of happy facial expressions elicited beta-band (14–30 Hz) oscillatory activity in the right and left temporal regions (Jabbi et al., 2015). Similarly, in a study with combined EEG and functional magnetic resonance imaging (fMRI) approach, it was found that while the frontal area is involved in the processing of all emotions, the temporal region of participants is more involved in the processing of positive emotions (Trautmann-Lengsfeld, Domínguez-Borràs, Escera, Herrmann, & Fehr, 2013). The most relevant case in accordance with our study comes from a study which investigated the effects of happy and sad emotions on EEG activity in high and low susceptible individuals to hypnosis (Crawford, Clarke, & Kitner-Triolo, 1996). With regard to the beta band activity, it was shown that happy pictures significantly induced more beta band activity in the right temporal, parietal and frontal areas only in highly susceptible individuals. In our study, however, we found an increase in beta band activity in the temporal area which could be due to the auditory nature of the stimuli. It is of note that although both groups had a significant increase in the right temporal beta activity, the level of increase was significantly higher in healthy subjects compared to depressed ones. Depressed individuals are less sensitive to positive stimuli which is well-documented in previous studies (Armstrong & Olatunji, 2012; Katharina et al., 2018) and is associated with lower EEG oscillatory (Bocharov, Knyazev, & Savostyanov, 2017). This could explain their lower EEG spectral power during happiness experience.

Regarding the alpha band activity, our results did not show an increase of alpha activity during resting state EEG in depressed individuals which seems to be inconsistent with previous findings. Previous EEG studies in individuals with severe depression showed a
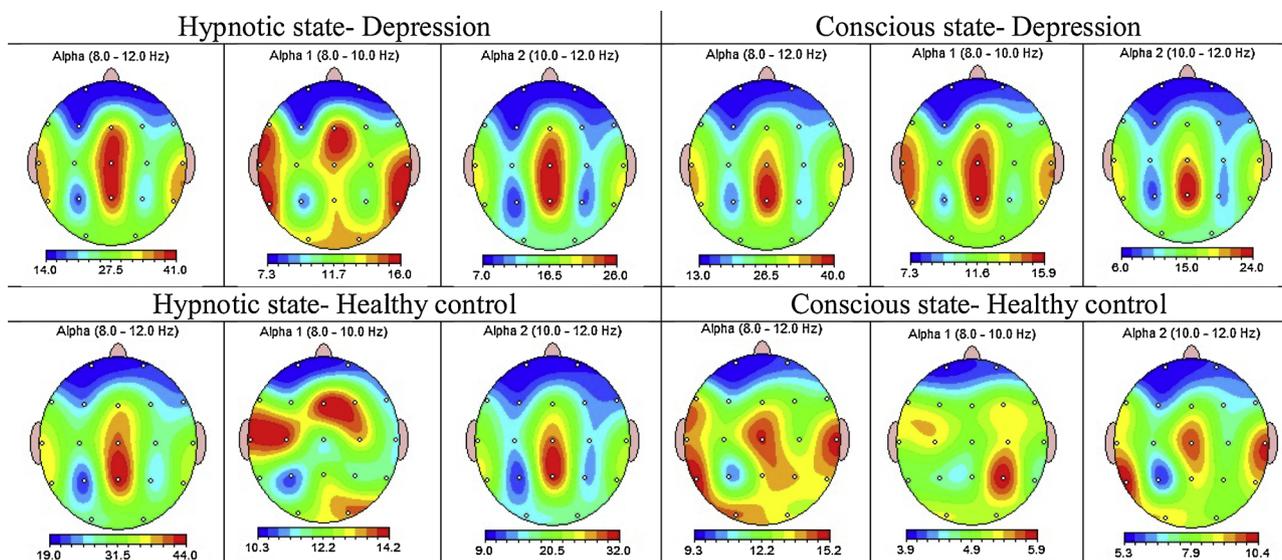
Hypnotic state- Depression

Alpha (8.0 - 12.0 Hz) | Alpha 1 (8.0 - 10.0 Hz) | Alpha 2 (10.0 - 12.0 Hz)

14.0 27.5 41.0 | 7.3 11.7 16.0 | 7.0 16.5 26.0

Conscious state- Depression

Alpha (8.0 - 12.0 Hz) | Alpha 1 (8.0 - 10.0 Hz) | Alpha 2 (10.0 - 12.0 Hz)

13.0 26.5 40.0 | 7.3 11.6 15.9 | 6.0 15.0 24.0

Hypnotic state- Healthy control

Alpha (8.0 - 12.0 Hz) | Alpha 1 (8.0 - 10.0 Hz) | Alpha 2 (10.0 - 12.0 Hz)

19.0 31.5 44.0 | 10.3 12.2 14.2 | 9.0 20.5 32.0

Conscious state- Healthy control

Alpha (8.0 - 12.0 Hz) | Alpha 1 (8.0 - 10.0 Hz) | Alpha 2 (10.0 - 12.0 Hz)

9.3 12.2 15.2 | 3.9 4.9 5.9 | 5.3 7.9 10.4

Fig. 2. Power spectrum maps of EEG Alpha band during hypnotic and conscious states in depression and control groups. The Alpha band increase in both groups during hypnotic but not in the conscious state.

Table 4

t- *t*-test results of frontal alpha activation during resting EEG in depressed and healthy groups.

Brain area	Group	Mean	SD	*df*	*t*	*sig*
Right frontal	depressed	0.003	0.005	1, 38	1.67	0.10
	healthy	0.002	0.001			
Left frontal	depressed	0.004	0.005	1, 38	0.73	0.46
	healthy	0.002	0.002			

relatively higher alpha activation especially in the frontal brain areas compared to healthy individuals. Another study in 237 patients with severe depression found that major depression with melancholia was significantly associated with higher alpha activation in the right hemisphere compared to depression without melancholia (Quinn, Rennie, Harris, & Kemp, 2014). Similarly, it was shown that alpha EEG asymmetry was significantly higher in patients with major depression than healthy participants at pre-treatment which was significantly associated with increased behavioral inhibition and negative emotion (Gollan et al., 2014). We need to note that most of these were conducted on patients with severe depression while our study mostly included moderately depressed individuals and this might be one reason why we did not find significant frontal alpha asymmetry in the depression group. Moreover, a recent meta-analysis about frontal alpha asymmetry in depression found there are many studies that failed to report such asymmetry and recent studies reported contradicting results which might question alpha asymmetry in depression compared to non-depressed people (van der Vinne, Vollebregt, & Arns, 2016).

Taken together, results of our study suggest that experiencing a positive emotion is associated with an increase of beta activation in the temporal lobe and specifically right temporal area. Moreover, it seems that the brain processes happiness in both conscious and hypnotic states the same way. Nevertheless, results of the present study should be interpreted based on the hypnotic susceptibility of subjects. All subjects in our study were highly susceptible individuals which can have a different impact on the electrophysiological functioning of the brain compared to low and moderate susceptible individuals. Our study had several limitations such as including moderately depressed individuals. This is specifically concerned with our non-significant difference in the frontal alpha asymmetry in the depressed group which is well-documented in previous studies mostly in severe depression. Moreover, the study was single-blind and it is possible that the experimenter effect

influenced data especially during hypnotic states. Thirdly, no neutral and unpleasant stimuli were included in the experimental stimuli which makes it difficult to understand whether the obtained effects are actually due to the pleasantness of the stimuli. The reason we did not include neutral or unpleasant stimuli was to keep hypnotic not so long. Lastly, interpreting the findings should be based on this notion that depression is a trait activity and happiness experience is a state activity which can be associated but their differences at electrophysiological processing level should be considered.

Conflicts of interest

None of the authors have potential conflicts of interest to be disclosed.

Acknowledgments

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