Article

The Level of Self-Esteem May Influence the Effect of Positive Self-Statements. An EEG Alpha Asymmetry Pilot Study

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Abstract: (1) Background: Affirmative statements are widely recognized as a reliable tool that enhances personal resources to manage life demands, including stress-coping and emotional adaptability. However, recent data suggest that contrary effects can be obtained regarding the global self-esteem level. The current study focused on an approach for recognizing affirmation-induced responses in electroencephalographic (EEG) alpha asymmetry. (2) Methods: EEG data were collected from a total of 45 males (16–20 years) on a baseline condition and compared to EEG data produced when listening to positive self-statements, regarding self-esteem as a covariate. (3) Results: The study revealed relative left-frontal alpha asymmetry, indicating an approach-related motivational state, and right alpha asymmetry in parieto-temporal regions, indicating lower anxiety. This increased with higher self-esteem scores, with a more prominent moderation effect in experimental conditions. These results support and extend previous reports suggesting an adverse effect of positive self-statements for people with lower global self-esteem. (4) Conclusions: Positive self-statements may produce a differing physiological effect regarding an individual's global self-esteem level, with an adverse effect for people with lower self-esteem scores. These data highlight the need to consider differentiation of psychological approaches between people with higher and lower self-esteem levels.

Keywords: EEG alpha asymmetry; self-esteem; positive self-statements

1. Introduction

Self-esteem reflects an overall subjective assessment of personal worth [1]. High self-esteem is associated with happiness, serenity, success, and fulfilment. Low self-esteem is theoretically and empirically associated with a range of psychological difficulties (e.g., eating disorders, social anxiety) but has been especially linked to depressive symptoms [2]. Scientific research has already established that low self-esteem is not only an important indicator, but also a causing factor of depression (and not vice versa) [2]. Hence, it is crucial to develop effective methods improving self-esteem in order to build an emotional reserve, thereby reducing the hazard of the onset of depressive disorder.

Psychological intervention often uses positive self-statements, which are widely believed to be a universal tool for enhancing mood and self-esteem [3–5]. Positive self-statements are sentences that draw attention to the positive aspects of oneself. Their goal is to improve self-esteem through the repetition of positive sentences. According to some psychologists, sentences repeated many times are expected to play a similar role as empowerment given by important adults in childhood.

Recently, self-esteem has been explored as a potential mediator [3] and moderator [4,5] of the effectiveness of positive self-statements as interventions for change in health behaviors and mood enhancement. It has been suggested that repeating positive self-statements may be beneficial for people with high self-esteem but has no effect or even a negative one for those with low self-esteem levels [4]. To date, much remains unknown about the direct physiological effect of affirmative self-statements regarding self-esteem. Although self-esteem is one of the most popular constructs of individual differences in psychology, there is little research to date on the relationship between self-esteem and psychophysiological activity. An important physiological finding in this regard is the relative activity of the left side in the prefrontal cortex when experiencing positive emotions and the higher relative activity of the right side when experiencing negative emotions related to withdrawal.

Analysis of electroencephalographic alpha rhythm data is one of the most widely recognized investigative tools of brain neurophysiology. It is generally accepted that electroencephalography (EEG) alpha power (8–12 Hz) is inversely correlated with cortical activity. Brain alpha asymmetry is believed to display a relatively stable pattern but can also be situationally cued, such as by an emotional state [6]. Previous findings indicated a higher relative left-sided activity in the prefrontal cortex during the experience of positive approach-related emotions and approach-oriented motivational state. On the contrary, a higher relative right-sided activity was observed during the experience of an avoidance-oriented and more negative withdrawal related motivational and affective states [7,8]. Several EEG studies also investigated the relationship between self-esteem and behavioral/personality traits. In the study of De Raedt et al. [9], explicit self-esteem acted as a partial mediator in the path from EEG alpha asymmetry to depressive symptoms, while the study of McGregor et al. [10] supported a motivational interpretation of high self-esteem as a factor of resilient but also zealous and anti-social tendencies. The participants with high self-esteem in a situation with uncertain threat reacted with heightened relative left-frontal (F7/F8) EEG activity, which is a common neural marker of resilient approach-motivation. Alpha asymmetry in the posterior cingulate was also found to be associated with positivity personality trait [11,12].

It was recently suggested that an emotionally-valenced condition can provide a more reliable image of individual differences regarding EEG alpha asymmetry than during resting state [13].

According to this, it may be assumed that alpha asymmetry should be influenced by positive self-statements more in individuals with lower self-esteem, and thus, these statements are more challenging for them.

The aim of this study is to answer the question of whether positive self-statements are related to the alpha band asymmetry pattern and whether there are differences between people with higher self-esteem and lower self-esteem.

In addition to baseline EEG (eyes closed), we proposed a stimulation condition: listening to recordings of self-affirmative statements. The possible interaction of condition (rest vs. experimental condition) and self-esteem allows us to decide (1) whether self-esteem level can predict trait-like brain asymmetry pattern and (2) its potential role in processing self-affirmative statements. We hypothesized that individuals with higher self-esteem would present little to no change in lower left-frontal alpha asymmetry when listening to affirmative statements and relative greater left-frontal alpha activity regardless of condition.

Due to the fact that an increasing amount of research in the field of qEEG distinguishes between the low alpha (8–10 Hz) and high alpha (11–12 Hz) bands, we evaluated whether there were also differences in these bands depending on the self-esteem level, both in rest and experimental conditions. A lower alpha band (8–10 Hz) was selected as it is believed to reflect general cortical activity and is deemed to be representative of attention and emotional processes [14,15]. To control the specificity of results taken from the lower alpha band, the upper alpha band (10–12 Hz), which is believed to be representative of both affective and cognitive performance [14,15], was also assessed.

2. Materials and Methods

The study group was a convenient sample and consisted of forty-five healthy male volunteers aged 16–20 (18.8 $\pm$ 1.1 years) with normal BMI (22.2 $\pm$ 1.4 kg/m^2). Age was confirmed by the birth date from the identity card and BMI was calculated from measured weight and height. The decision to recruit only men for the study was dictated by previous studies on alpha asymmetry, according to which the asymmetry is influenced by age and gender (in particular: menstrual cycle phase in females). To minimize the problem, only men were selected.

The inclusion criteria included: male sex, age between 16 and 25 years, at least 8 years of education.

The exclusion criteria were as follows: Beck Depression Inventory score > 9 points, State-Trait Anxiety Inventory for trait anxiety (STAI-T) > 52 points, Raven Progressive Matrices Test < 20 points, and any of following included in questionnaire (self-report): intellectual disability, chronic diseases, any history of brain damage, any history of mental disorders, any history of psychological intervention or meditation practice, drugs or supplements intake, heavy nicotine use (smoking > 5 cigarettes per day, at least 3 times per week), heavy caffeine use (> 300 mg/day), being left-handed (confirmed with both self-report and observation), traumatic life events within 12 months.

Participants were fully informed about the experimental procedure. All subjects provided written informed consent, and the protocol was approved by the Ethics Committee of the Institute of Psychology, Kazimierz Wielki University, Bydgoszcz, Poland (Permit No. 001/2014), according to the Declaration of Helsinki.

2.1. Procedure

The participants were invited to the laboratory in the afternoons. The experimental sessions took approximately 1 h to complete and were always conducted between 3 p.m. and 7 p.m. Participants were asked to sleep as usual, refrain from intense activity the day before, not consume alcohol from the night before and avoid stressful situations. Additionally, they were instructed to drink only water and to not smoke or take any stimulants 2 h prior to the session. The protocol started with a 15 min introductory phase to allow the participants to adapt to the laboratory setting.

Participants who were selected according to the inclusion criteria completed a demographic questionnaire and the Rosenberg Self-Esteem Scale [16]. After filling in the questionnaires and measurement of weight and height for BMI calculation, subjects were equipped with electrocaps and stayed at rest with eyes closed for about 5 min. EEG measures were then collected for at least 3 min in rest condition (eyes-closed) followed by 3 min in experimental condition. The experimental condition consisted of listening to a 3 min recording (male voice) with eyes closed, which contained nine self-affirmative sentences (such as: "I am a special, wonderful person"). Participants were instructed to listen carefully to the sentences and encouraged to repeat each thought in their mind. Additionally, participants were advised to observe any distracting thoughts, feelings or sensations without judging, evaluating or elaborating on them.

2.2. Psychological Data—Self-Esteem

Self-esteem was measured by the Rosenberg Self Esteem Scale (SES). It is a 10-item test, scored on a four-point Likert scale, ranging from "strongly agree" to "strongly disagree" for both positive and negative feelings about the self. A mean score was calculated for each participant, with higher scores representing higher self-esteem. The scale is believed to be one-dimensional, showing good reliability and validity across a range of populations (Cronbach alpha = 0.87; [16]). A median was split by the group's self-esteem level (LOW = 28 or less points in SES vs. HIGH: 29 or more points in SES).

2.3. EEG Data

EEG was recorded with qEEG equipment (Mitsar-201 amplifier) with 19 electrodes with 250 Hz sampling rate in the 0.3–70 Hz frequency range (Scale: 50 mcV/cm, speed—30 mm/s, time constant—0.3 s, low frequency filter—30 Hz).

Recorded results were referred and analyzed as average reference montage.

The analysis was made after eliminating artifacts resulting from movements, large scale muscle tension, sweat, and large eye movements. Vertical and horizontal eye movement artifact correction was done by means of Independent Component Analysis (ICA). ICA is an information maximization algorithm that derives spatial filters by blind source separation of the EEG signals into temporally independent and spatially fixed components.

EEG data were collected from the 19 monopolar electrodes sites (Fz, Cz, Pz, Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1, and O2) according to the International 10/20 System. Impedances for EEG electrodes were below 5 kΩ. For rest and experimental conditions, EEG recordings were split into 60-s and 2-s segments and power spectra were computed via Fast Fourier Transform (FFT) using a Hamming window (50% taper) and then averaged to yield the mean power spectrum. The EEG power spectral density in lower (low alpha band, 8–10 Hz) and upper (high alpha band, 10–12 Hz) alpha band was extracted for each electrode. The EEG data were log-transformed to approximate a normal distribution. Asymmetry was defined as the functional difference between the left and right hemisphere and measured the difference in absolute amplitude which exists between the homologous electrodes located on these hemispheres. Hence, alpha asymmetry was calculated as: [ln (Right mean alpha power density) − ln(Left mean alpha power density)] for each frequency band. Greater asymmetry scores reflect relatively greater left than right brain activity (which is the inverse of alpha).

2.4. Statistical Analysis

Descriptive statistics were used to indicate the characteristics of the participants. To evaluate the effect of self-esteem level on upper and lower alpha asymmetry, the repeated-measures general linear model (GLM) was performed considering AREA (brain areas represented by electrode pairs: Fp1/Fp2 (Frontal 1 area), F3/F4 (Frontal 2 area), F7/F8 (Frontal 3 area), C3/C4 (Central area), P3/P4 (Parietal area), T3/T4 (Temporal 1 area), T5/T6 (Temporal 2 area), O1/O2 (Occipital area), and CONDITION (resting vs. experimental) as repeated measures and the level of self-esteem (number of points in SES scale) as continuous between-subjects variable. To compare alpha asymmetries in all eight areas between groups of low and high self-esteem, repeated-measures ANOVA was performed considering CONDITION (resting vs. experimental) as repeated measures and SELF-ESTEEM LEVEL (high vs. low) as a between-group factor. Statistical analysis was performed using STATISTICA 13.1 (Statsoft, Poland). The levels of significance were set at $p \leq 0.05$ for all statistical analyses.

3. Results

First, the mean results of alpha asymmetry in the subgroups are distinguished, and the level of self-esteem in rest and experimental conditions are presented. The data are shown in Table 1.

The t-Student test showed that low self-esteem level was associated with greater asymmetry in the rest condition, in the Frontal 3 area as well as Temporal 1 and Temporal 2 area, than in the high self-esteem group. On the other hand, in the experimental measurement, low level self-esteem was associated with significantly higher asymmetry in the frontal areas of Fp1–Fp2, F3–F4, F7–F8 and in the parietal area of P3–P4.

Further analyes were carried out in division into low alpha band (8–10 Hz) and high alpha band (11–12 Hz).

Table 1. Alpha band (8–12 Hz) asymmetry, rest condition, experimental condition.

Area	Pair of Electrodes	Low Self-Esteem	High Self-Esteem	*p*
			Rest condition	
Frontal 1	Fp1/Fp2	−0.02 ± 0.05	−0.01 ± 0.03	ns
Frontal 2	F3/F4	−0.03 ± 0.04	−0.02 ± 0.06	ns
Frontal 3	F7/F8	−0.06 ± 0.05	−0.01 ± 0.06	<0.001
Central	C3/C4	−0.03 ± 0.07	0.02 ± 0.05	ns
Parietal	P3/P4	−0.01 ± 0.05	0.02 ± 0.04	ns
Temopral 1	T3/T4	0.05 ± 0.01	0.02 ± 0.01	<0.001
Temporal 2	T5/T6	0.04 ± 0.02	0.003 ± 0.01	<0.05
Occipital	O1/O2	0.05 ± 0.02	0.03 ± 0.03	ns
			Experimental condition	
Frontal 1	Fp1/Fp2	−0.03 ± 0.02	0.02 ± 0.01	<0.05
Frontal 2	F3/F4	−0.07 ± 0.03	0.04 ± 0.02	<0.001
Frontal 3	F7/F8	−0.04 ± 0.02	0.02 ± 0.01	<0.001
Central	C3/C4	0.03 ± 0.05	0.03 ± 0.07	ns
Parietal	P3/P4	0.09 ± 0.07	−0.01 ± 0.01	<0.001
Temopral 1	T3/T4	0.03 ± 0.05	−0.04 ± 0.06	ns
Temporal 2	T5/T6	0.05 ± 0.04	−0.04 ± 0.04	ns
Occipital	O1/O2	0.02 ± 0.05	−0.01 ± 0.03	ns

ns—not significant.

3.1. Alpha 8–10 Hz Asymmetry

The lower alpha asymmetry scores showed a significant main effect for self-esteem level ($F_{(1.43)} = 9.456$, $p = 0.007$, partial η2 = 0.180), condition ($F_{(1.43)} = 8.066$, $p = 0.007$, partial η2 = 0.158), and area ($F_{(7,301)} = 8.625$, $p < 0.001$, partial η2 = 0.167).

Moreover, significant condition × self-esteem ($F_{(1.43)} = 7.430$, $p = 0.009$, partial η2 = 0.167) and area × self-esteem ($F_{(7,301)} = 7.717$, $p < 0.001$, partial η2 = 0.152) interaction effects were observed. No significant condition × area and condition × area × self-esteem interactions were found. We observed a significant negative relationship between self-esteem level and temporal and parietal low band alpha asymmetries in both baseline and experimental conditions (see Table 2).

Table 2. A generalized linear model (GLM) of the effects of self-esteem on lower alpha (8–10 Hz) asymmetries at rest and in an experimental condition.

Between-Group Factor	Condition	Area		R^2	$β$	SE	CI		F	*p*
Level of self-esteem	Rest	FRONTAL 1	Fp1/Fp2	0.054	0.275	0.147	−0.021	0.570	3.510	0.068
		FRONTAL 2	F3/F4	0.039	0.247	0.148	−0.051	0.545	2.804	0.101
		FRONTAL 3	F7/F8	0.004	−0.164	0.150	−0.467	0.139	1.188	0.282
		CENTRAL	C3/C4	−0.023	0.027	0.152	−0.281	0.334	0.030	0.863
		TEMPORAL 1	T3/T4	0.142	−0.402	0.140	−0.684	−0.121	8.298	0.006
		TEMPORAL 2	T5/T6	0.294	−0.557	0.127	−0.812	−0.302	19.342	<0.001
		PARIETAL	P3/P4	0.329	−0.587	0.123	−0.836	−0.338	22.619	<0.001
		OCCIPITAL	O1/O2	−0.012	0.107	0.152	−0.199	0.412	0.494	0.485
Level of self-esteem	Experimental	FRONTAL 1	Fp1/Fp2	0.064	0.293	0.146	−0.001	0.587	4.043	0.051
		FRONTAL 2	F3/F4	0.070	0.302	.145	0.009	0.595	4.313	0.054
		FRONTAL 3	F7/F8	−0.018	0.070	0.152	−0.237	0.377	0.212	0.648
		CENTRAL	C3/C4	0.014	0.191	0.150	−0.111	0.493	1.634	0.208
		TEMPORAL 1	T3/T4	0.120	−0.374	0.141	−0.659	−0.089	6.986	0.011
		TEMPORAL 2	T5/T6	0.204	−0.471	0.135	−0.742	−.200	12.266	0.001
		PARIETAL	P3/P4	0.194	−0.461	0.135	−0.734	−0.188	11.578	0.001
		OCCIPITAL	O1/O2	−0.018	−0.074	0.152	−0.381	0.232	0.238	0.628

Namely, for lower alpha frequency ranges (8–10 Hz), higher self-esteem corresponded to lower relative right alpha asymmetry in temporal and parietal regions regardless of the conditions, and this relationship was slightly stronger in the rest (eyes closed) condition (see Figure 1).
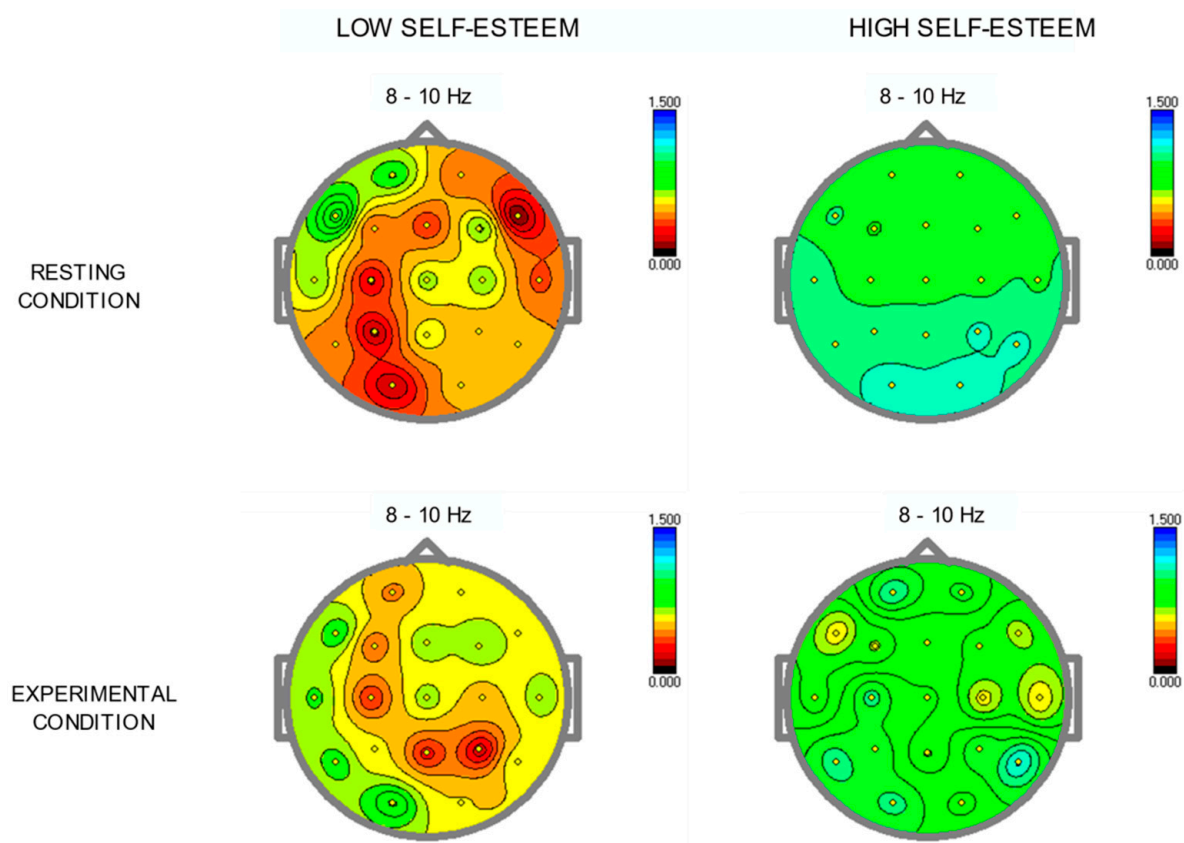
Figure 1. Low band alpha power (lnP) comparison between participants with lower (< 29 points) and higher (29 or more points) self–esteem levels, according to median split, for rest and experimental conditions.

In order to better illustrate the differences, the group was divided in relation to median into groups with high and low self-esteem. A median split by the group's self-esteem level (LOW = 28 or less points in SES vs. HIGH: 29 or more points in SES) enabled to illustrate differences in alpha asymmetry in both study conditions (Figure 1).

The significant differences between groups were observed in temporal (Temporal 1 and Temporal 2 areas) and parietal (Parietal area) regions in the rest condition (all $p < 0.001$) as well as during the experimental condition (all $p < 0.05$). Furthermore, we observed significant differences in alpha asymmetries in mid-frontal (Frontal2 area) area in the experimental condition ($p = 0.030$) but not in the rest condition ($p = 0.055$). The significant time × group interaction was found for Frontal 3 area ($F_{(1.43)} = 6.378$, $p = 0.015$, partial η2 = 0.129), Temporal 1 ($F_{(1.43)} = 5.43$, $p = 0.024$, partial η2 = 0.112), and Temporal 2 ($F_{(1.43)} = 4.92$, $p = 0.031$, partial η2 = 0.102) areas. These results indicate that participants with high self-esteem showed relatively greater left-frontal activation, but only during experimental condition.

Because some asymmetry effects may not match strict left vs. right patterns, we have shown the results in Figure 1 using alpha power standardization instead of right−left subtraction.

3.2. Alpha 10–12 Hz Asymmetry

For high alpha band asymmetry scores, there was a significant main effect for condition ($F_{(1.43)}$ = 10.061, p = 0.003, partial η2 = 0.190) and area ($F_{(7.301)}$ = 19.027, p < 0.003, partial η2 = 0.307) but no effect for self-esteem ($F_{(1.43)}$ = 0.944. p = 0.337, partial η2 = 0.021).

Additionally, a significant interaction was observed for condition × self-esteem ($F_{(1.43)}$ = 12.098, p = 0.001, partial η2 = 0.220), area × self-esteem ($F_{(7.301)}$ = 14.385, p < 0.001, partial η2 = 0.251), condition × area ($F_{(7.301)}$ = 10.775, p < 0.001, partial η2 = 0.200) and condition × area × self-esteem ($F_{(7.301)}$ = 12.786, p < 0.0001, partial η2 = 0.229).

The models revealed significantly lower values of right alpha asymmetry in parietal areas (greater right parietal alpha) in the experimental condition. We also observed positive predictive values of self-esteem for frontal (Frontal 1, Frontal 2, Frontal 3 areas) and negative values for parietal high alpha asymmetries in both rest and experimental conditions.

Furthermore, there were significant negative predictive values of self-esteem for high alpha asymmetry in the temporal area (Temporal 2 area) in the experimental condition (see Table 3).

Table 3. A generalized linear model (GLM) of the effects of self-esteem on upper alpha (10–12 Hz) asymmetries at rest and in an experimental condition.

Between-Group Factor	Condition	Area		R^2	$β$	SE	CI		F	p
Level of self-esteem	Rest	FRONTAL 1	Fp1/Fp2	0.300	0.562	0.126	0.308	817	19.874	<0.001
		FRONTAL 2	F3/F4	0.359	0.611	0.121	0.368	855	25.652	<0.001
		FRONTAL 3	F7/F8	0.293	0.556	0.127	0.301	812	19.265	<0.001
		CENTRAL	C3/C4	0.039	0.247	0.148	−0.051	545	3.787	0.102
		TEMPORAL 1	T3/T4	0.016	−0.197	0.150	−0.498	105	1.732	0.195
		TEMPORAL 2	T5/T6	0.046	0.260	0.147	−0.037	557	3.107	0.085
		PARIETAL	P3/P4	0.293	−0.556	0.127	−0.811	−300	19.209	<0.001
		OCCIPITAL	O1/O2	0.056	0.278	0.146	−0.017	574	3.607	0.064
Level of self-esteem	Experimental	FRONTAL 1	Fp1/Fp2	0.414	0.654	0.115	0.421	886	32.100	<0.001
		FRONTAL 2	F3/F4	0.524	0.731	0.104	0.522	941	49.491	<0.001
		FRONTAL 3	F7/F8	0.443	0.675	0.112	448	902	36.017	<0.001
		CENTRAL	C3/C4	−0.007	0.127	0.151	−0.178	432	0.703	0.406
		TEMPORAL 1	T3/T4	−0.020	−0.057	0.152	−0.364	250	0.139	0.711
		TEMPORAL 2	T5/T6	0.291	−0.554	0.127	−0.810	−298	190.019	<0.001
		PARIETAL	P3/P4	0.354	−0.607	0.121	−0.852	−363	250.107	<0.001
		OCCIPITAL	O1/O2	0.007	0.171	0.150	−0.133	474	1.288	0.263

After a median split by the group's self-esteem level (LOW = 28 or less points in SES vs. HIGH: 29 or more points in SES), we observed significant differences between groups in prefrontal, frontal, and parietal areas (Frontal 1, Frontal 2, Frontal 3 areas and Parietal area), all p <0.010 in both study conditions and significant differences in temporal (Temporal 2) area only in the experimental condition (p = 0.003) but not at rest (p = 0.435). The significant time × group interaction was found for Frontal 1 ($F_{(1.43)}$ = 7.16, p = 0.005, partial η2 = 0.142) and Temporal 2 area ($F_{(1.43)}$ = 6.24, p = 0.016, partial η2 = 0.126).

Because some asymmetry effects may not match strict left vs. right patterns, we have shown the results in Figure 2 using alpha power standardization instead of right−left subtraction.
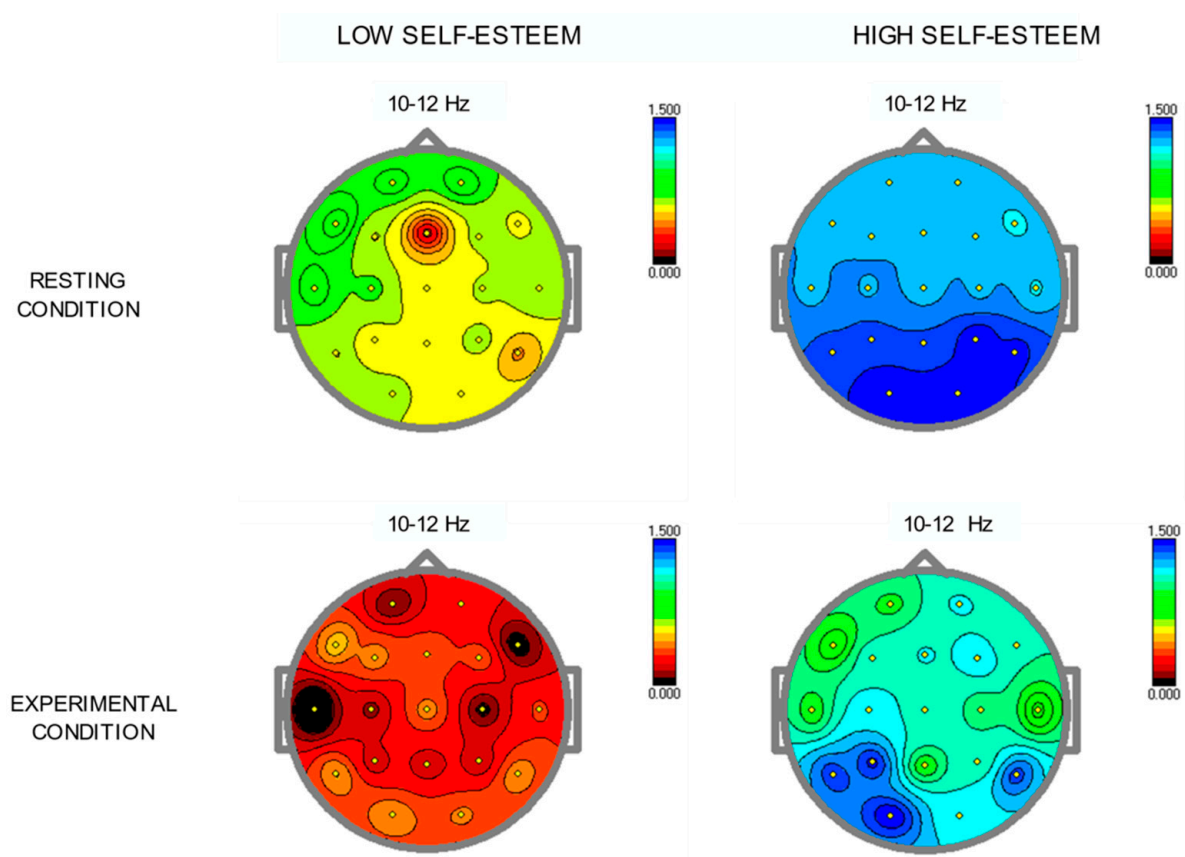
Figure 2. High band alpha power (lnP) comparison between participants with lower (< 29 points) and higher (29 or more points) self –esteem levels, according to median split, for rest and experimental condition.

4. Discussion

This study revealed the importance of self-esteem for alpha asymmetry, particularly in parietal and temporal regions. To the best of our knowledge, this is the first study examining this trait with regard to lower (8–10 Hz) and higher (10–12 Hz) alpha frequency range and not only frontal brain areas. The importance of differentiating frontal alpha asymmetry and lower and upper alpha bands is often underestimated and may be helpful in revealing subtle variances. In the current study, we have found evidence that the moderation effect of self-esteem is more prominent in the higher alpha frequency range (10–12 Hz). Self-affirmative statements have only a marginal effect on alpha asymmetry changes in the lower alpha band but seem influential on high band alpha asymmetry. Furthermore, frontal alpha asymmetry is affected by self-esteem only in high alpha bands. Low alpha has been postulated to reflect a diffuse attentional and brain-state phenomenon, while high alpha is postulated to reflect more localized and task-specific cognition [14]. After median split, we could reveal that alpha asymmetry in the lower frequency range is relatively stable in the group with lower levels of self-esteem but changes (in Frontal 3, Temporal 1, and Temporal 2 areas) in the group with higher self-esteem. This may imply that such sentences induce unpleasant stimuli for those with low self-esteem [17]. Nevertheless, based on the changes observed in upper alpha asymmetries, it may be supposed that cognitive−affective processing, rather than solely affective processing, should be considered when referring to the overall effect of positive self-statements on brain alpha asymmetry.

Frontal alpha lateralization exhibits implications for cognitive processing: it is assumed that greater left than right alpha asymmetry is indicative of better verbal performance, whereas greater right than left alpha asymmetry corresponds to spatial executive function tasks [18]. The current data provide a substrate for a cognitive−emotional/motivational loop, revealing that emotional/motivational processing seems to influence executive task disposition involving the same hemisphere [19]; however, the mechanism of this process is not fully understood.

Language processing (verbal stimuli) is represented in the left hemisphere, whereas right hemisphere dominance has been shown to be designated for processing tonal or prosodic information, which correspond to verbal or emotional stimuli. Prefrontal, frontal, and parietal regions of the scalp are also related to working memory, with a special concern to the latter in males [19]. The effect on the upper alpha activity in these areas is most likely related to verbalizing affirmations, since participants were encouraged to repeat given positive self-statements in their minds. This verbal rehearsal seems likely to be the main source generating greater left-frontal−cortical asymmetry and thus the main effect of greater left alpha. It may be assumed that higher self-esteem facilitates undertaking this challenge; however, no measure of participants' effectiveness has been applied.

A considerable body of evidence provides support for strong associations between the degree of frontal alpha asymmetry and individual differences regarding motivational direction [20]. The motivation model is based on two basic systems associated with two distinct neural circuits in the frontal cortex. One is engaged in approach behaviors and another in avoidance behaviors, which is reflected in resting EEG frontal alpha power. The left-lateralized approach (greater right than left alpha asymmetry) motivational system is linked to reactions leading to reward, or emotions and behaviors leading to access desired goals. Conversely, relatively greater right frontal activation (i.e., an increase of left alpha power) suggests a response leading to avert an expected threat or retribution [21,22]. In addition to the widely described relationship between frontal alpha lateralization and approach/avoidance systems, some recent work has indicated that frontal alpha asymmetry can be associated with the supervisory control system [21,22]. Greater left than right frontal alpha asymmetry in the rest condition has been related to behavioral inhibition, and left-frontal activation (greater right than left alpha power) has corresponded to the sensation-seeking trait [22,23].

Feelings of worthlessness, with which low self-esteem is associated, may be an early indicator or a prospective risk factor for depression [24]. Conversely, positive self-esteem is widely regarded as a safeguard for mental health [25]. Left hypoactivation is broadly understood as an indicator of dysfunction of the prefrontal cortex as well as susceptibility to unpleasant emotions and motivational deficit [20–23]. Some clinical studies have also examined the importance of central parietal and temporal areas, but for now, only central areas are proven to be connected with anxious apprehension, and data for temporal and parietal areas remain unclear [26].

In this light, it is not surprising that higher appreciation of self in this study corresponded to greater resting right prefrontal and frontal hypoactivity (relatively higher right frontal alpha power) and right parietal hyperactivity (relatively lower alpha in right parietal areas of the cortex), which seems to indicate a specific pattern "protecting" mental health. Frontal and parietal asymmetries are associated with emotional regulation, i.e., the ability to properly modulate emotions in response to environmental changes.

Interestingly, even stronger associations were observed in an experimental condition presented in this study, which may suggest that the beneficial potential of listening to self-affirmative statements enhances along with a greater feeling of self-worth. On the other hand, the lower the self-esteem, the more "unpleasant" positive self-statements are to an individual's brain, which is reflected in decreased alpha asymmetry. One reason for these effects is that for every conscious intention, there are many unconscious beliefs or feelings that conflict with it that will be called into battle. In regard to people with low self-esteem, these beliefs may include a negative picture of self-worth. Recent therapeutic approaches recommend tracing those beliefs back to their origins to release or transform them [27]. Research suggests that working with beliefs and removing anything blocking conscious intention could increase the chance of the effectiveness of affirmative self-statements [27].

The study revealed that relative left-frontal alpha asymmetry, indicating an approach-related motivational state, and right alpha asymmetry in parieto-temporal regions, indicating lower anxiety, increased with higher self-esteem scores, with a more prominent moderation effect in experimental conditions. These results support and extend previous

reports suggesting an adverse effect of only positive self-statements (without, i.e., tracking dysfunctional thoughts/beliefs, visualization with emotional engagement, etc.) for people with lower global self-esteem.

5. Limitations

The size and homogeneity (the exclusion of females, narrow age limits) of the present study sample limits the ability to generalize our research findings. Moreover, we used only short, previously invalidated experimental tasks. It raises a need for replication in larger, more diverse samples with regard to gender and age and the use of other relevant affective tasks that have been shown to reliably elicit approach or avoidance motivation. The other limitation of our study is the lack of subjective task-related ratings of participants, i.e., whether they perceived the task as pleasant or unpleasant. The current study did not involve any tool to measure post-experiment mood or task perception; thus, the emotional and cognitive correlates of the experiments are almost entirely hypothetical. Additionally, apart from self-esteem and controlled trait anxiety, no other individual differences, particularly personality traits, were assessed; therefore, it is indistinct whether the effects observed were connected with self-esteem per se or any other trait. In conclusion, we wish to highlight that the current study is a pilot study, and the result should be interpreted as preliminary.

It is more difficult to align the present findings with previous findings in literature, since in EEG alpha asymmetry research, traditionally, only the full alpha band is investigated. Accordingly, interpreting upper alpha effects of left-frontal activation as approach motivation may not be entirely correct.

6. Conclusions

The current study supports the hypothesis that positive self-statements may produce a different physiological effect regarding an individual's global self-esteem level and even an adverse effect for people with lower self-esteem scores. These data highlight the need to consider differentiation of psychological approaches between people with higher and lower self-esteem levels. Importantly, it is shown that there are differences in the analyzed asymmetry in the alpha sub-bands (low: 8–10 Hz, high:11–12 Hz), and although the sub-band analysis approach is less popular, it is worth paying attention to it in further analysis.

In the current study, we found evidence that the moderation effect of self-esteem was more prominent in the higher alpha frequency range (10–12 Hz). Self-affirmative statements had only a marginal effect on alpha asymmetry changes in the lower alpha band but seemed influential on high band alpha asymmetry. Furthermore, frontal alpha asymmetry was affected by self-esteem only in high alpha bands.

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