International Journal of PSYCHOLOGICAL RESEARCH

RESEARCH ARTICLE

Vol 17, N° 2
https://revistas.usb.edu.co/index.php/IJPR
ISSN 2011-2084
E-ISSN 2011-7922

Relationship Between Self-efficacy and Attention using QEEG with Students from IUE

Relación entre la autoeficacia y la atención medida mediante QEEG entre estudiantes de la IUE

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Abstract.
Self-efficacy is related to the judgments and beliefs that a person has about him or her own capability to achieve goals, in which she or he also needs to be able of planning, organizing, and executing tasks to achieve that milestone. In this study, we are investigating if attention has a relevant role in self-efficacy.

The participants were students at Institución Universitaria de Envigado (N=25), aged between 18 and 40 years old. They filled out the informed consent, the General Self-Efficacy Scale (GSS), Digits and Symbols (DS), the Brief Attention Test (BTA), and the Theta-Beta ratio (TBR) using EEG at points C3-C4 of the cerebral cortex.

The results were as follows: mean GSS, 31.56 (SD=4.5) (max. 40 points); mean DS direct score, 45.16 (SD=8.6) (max. 120 points); mean total BTA, 9.4 (SD = 3.31) (max. 20 points); mean TBR C3 eyes open, 5.5 (SD = 1.7); TBR C4 eyes open, 5.2 (SD = 2). A negative correlation was found between the TBR C4 eyes open and the result of the Digits and Symbols DS test, which was statistically significant, using Spearman correlation, (–.529); however, there was no significant correlation between GSS self-efficacy and the three measures of attention (DS, BTA, QEEG).

The conclusion of this study is that there is no clear statistically significant relationship between high self-efficacy and a high level of attention. However, a significant negative correlation was found between the DS test and the QEEG measures, which indicates that the neurophysiological technique of attentional measurement is related to the psychometric measurement.

Resumen.
La autoeficacia está relacionada con los juicios propios y creencias que una persona tiene sobre sí misma; no es suficiente con alcanzar metas, es necesario creerse capaz de planear, organizar y ejecutar tareas para alcanzarlas. En este estudio, indagamos si la atención tiene un papel relevante en la autoeficacia.

Los participantes fueron estudiantes de la IUE (N=25), con edades entre 18 y 40 años. Firmaron el consentimiento informado y llenaron: la Escala de Autoeficacia General (EAG), Dígitos y Símbolos (DS), el Test Breve de Atención (BTA); se registró la relación Theta-Beta (TBR) mediante EEG en los puntos C3-C4 de la corteza cerebral.

Los resultados fueron: EAG media fue 31.56 (SD=4.5) (máx. 40 puntos), DS puntaje directo promedio 45.16 (SD=8.6) (máx. 120 puntos), BTA total promedio 9.4 (SD=3.31) (máx. 20 puntos), TBR C3 ojos abiertos media 5.5 (SD=1.7), TBR C4 ojos abiertos media 5.2 (SD=2). Se encontró una correlación negativa entre la TBR C4 ojos abiertos y el resultado de la prueba Dígitos y Símbolos DS el cual fue estadísticamente significativo usando la correlación de Spearman (-.529); pero no hubo correlación significativa entre la autoeficacia EAG y las tres medidas de la atención (DS, BTA, QEEG).

La conclusión de este estudio es que no hay una relación estadísticamente significativa entre alta autoeficacia y un alto nivel de atención; mientras que, si se encontró una correlación negativa significativa entre la prueba DS y las medidas QEEG, que indica que la técnica neurofisiológica de medición atencional está relacionada con la psicométrica.

Keywords.
Self-Efficacy, Attention Control, QEEG, Theta-to-Beta Ratio.
Palabras Clave.
Autoeficacia, control atencional, QEEG, relación theta-beta.

OPEN ACCESS

Manuscript received: 30-10-2023
Revised: 19-03-2024
Accepted: 26-04-2024

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Declaration of data availability: All relevant data are within the article, as well as the information support files.

Conflict of interests: The authors have declared that there is no conflict of interest.

How to Cite:
López Rios, E. (2024). Relationship Between Self-efficacy and Attention using QEEG with Students from IUE. *International Journal of Psychological Research*, *17*(2), 3–13. https://doi.org/10.21500/20112084.7255

1. Introduction

1.1 Self-efficacy

Self-efficacy is a concept created by Canadian psychologist Albert Bandura, for whom "it refers to the beliefs one has in organizing and executing courses of action required to produce an attainment" (1997, p. 3).

A key aspect of self-efficacy lies in the fact of "judging oneself capable", that is, it is not about whether a person is capable of performing or achieving a goal, but rather that the individual judges and self-perceives the power to do so.

Bandura identifies four sources of the beliefs that build self-efficacy (1997), which are not presented in isolation, as they can interact with each other. These sources are 1) Direct experiences, 2) Vicarious or observational experiences, 3) Verbal persuasion, and 4) Physiological activation.

Physiological activation considers factors such as emotions, physical activity as a possibility of generating information that affects efficacy, cognitive processing, among other (1997, p. 106). Physiological activation is most directly related to the regulation of brain activity and connects with the possibilities that QEEG has to provide useful information in this regard.

Self-efficacy has been widely studied. Taking studies such as that of Capri et al. (2012) and that of Boswell (2012) as examples, self-efficacy is an important variable in the academic life of university students. In the first study, a positive relationship was found between self-efficacy and life satisfaction, and a negative relationship between self-efficacy and exhaustion and cynicism. This suggests that students with high self-efficacy may experience less stress and enjoy their university life more. In the second study, an inverse relationship was found between the attitude of academic entitlement and self-efficacy for university work, suggesting that students with low self-efficacy might use the attitude of academic entitlement as a coping strategy to protect their self-esteem in the case of academic failure. Overall, these findings suggest that self-efficacy is an important variable that can influence the way students experience their university life.

1.2 Attention and QEEG

Angelidis et al. (2016) argue that there is a growing interest in the theta-beta ratio as it is closely related to attentional control. The interest lies in the fact that accumulated evidence points to the theta-beta ratio as a reliable biological marker for attention.

Experimentally, the study they proposed investigated whether the relationship between the frontal ratio of the theta/beta frequency bands (TBR) in the electroencephalogram (EEG) and executive cognitive control (and specifically attentional control) in healthy adults is consistent and reliable. The results indicate that there is a significant negative association between the TBR and attentional control, and that the reliability of the TBR is high. The findings suggest that frontal TBR could be used as a reliable biomarker for prefrontal executive cognitive control (Angelidis et al., 2016). Putman et al. (2010) also concluded that the TBR is closely related to attentional control.

Although the study of Putman et al. (2014) focused on the effects of CPA-type anxious stress (cognitive performance anxiety), a result of this research is that it replicated the negative relationship between the theta/beta ratio and attentional control, that is, when attention is high, this ratio decreases.

The brain areas related to attention are generally the prefrontal cortex, where executive functions are performed, and the sensorimotor cortex, where motor action planning, and its sequencing over time and in a logical manner, occur. In the International 10-20 system, the points over the skull that cover these areas are Fp1, Fp2, Fpz, F1, F2, Fz for the frontal cortex and C3, C4, and Cz for the sensorimotor cortex. Generally, the TBR tends to be higher and more relevant at all these points ; these are the points where attention is usually measured with QEEG and for the purposes of training with Neurofeedback, in which the intervention protocols are executed (Demos, 2005).

1.3 Self-efficacy and attention

The background linking self-efficacy with attention is extensive and varied when attention is measured through psychometric tests. It is worth mentioning that, in the review of the literature on these studies, there is a conceptual diversity with respect to the self-efficacy being studied, that is, the theoretical construct of self-efficacy is not unique: there are many ways to measure self-efficacy and, from a theoretical point of view, there are different aspects that are included or excluded depending on the author and the field of research. Thus, there is academic self-efficacy, general self-efficacy, counseling self-efficacy; even, there are specific self-efficacy scales in the field of health and medicine. Taking this situation into account, for the present referential framework, the specific theoretical models of medicine were not considered; whereas preference was given to those models of self-efficacy in the fields of psychology and education.

The correlational study conducted by Coetzer et al. (2009) showed a negative correlation between Attention Deficit Disorder (ADD) and self-efficacy.

In studying self-efficacy for self-regulated learning (SESRL) in the correlational research of, it was found that adolescent girls with Attention Deficit Hyperactivity Disorder (ADHD) have less self-efficacy than those without ADHD (Major et al., 2013). Thus, it is maintained that in self-reports of inattention that score high, there is a negative correlation with less optimistic self-efficacy beliefs.

Cho et al. (2015) presents a very extensive correlational study in which reading abilities, attention, and self-efficacy were assessed from a sample of 1695 fourth-grade students from 17 schools in the United States. Evidence shows there is a positive correlation between attention and self-efficacy.

Counseling self-efficacy, the study by Bentley and Cashwell (2009) argues that this self-efficacy is very relevant for the development of the counseling process and that the most important skills for successful counseling are sustained attention and empathy.

1.4 Self-efficacy and QEEG

Very little research has been conducted on the relationship between self-efficacy and attention when measured by QEEG, specifically with the TBR.

In the quasi-experimental study conducted by Nazer et al. (2018), they concluded that self-efficacy is a psychological state, an internal perception; only through the execution of tasks over time can the subject establish whether there has been any change in their perception of efficacy.

On the contrary, Harris et al. (2019) found, after 16 sessions of Neurofeedback training in 11 students, that the results of the academic self-efficacy test scores showed a gradual increase during the course of the training. This is interesting because it apparently contradicts the previous study, which can open discussions both methodologically and in terms of effectiveness itself.

1.5 Objectives and Hypothesis

The main objective is to describe and analyze the relationship between self-efficacy, attention, and the functioning of brain waves at points C3 and C4 of the sensorimotor cortex in a group of students from the IUE. This includes measuring attention through the theta/beta ratio using QEEG, a measurement that is complemented by the application of psychometric tests of attention and self-efficacy.

The evidence shows that self-efficacy is better when attention is also better; this is found in studies that measure attention with psychometric tests. However, there is very little research when self-efficacy is related to attention when measured by QEEG. If the theta/beta ratio is a good marker of attention, then it is reasonable to hypothesize that when self-efficacy is high, it is expected that attention measured psychometrically will also be high, and, consequently, the theta/beta ratio will be low.

2. Methodology

2.1 Participants

The sample consisted of 25 participants conveniently selected among the students of the Psychology program and other careers who wished to collaborate in the study. The defined inclusion criteria were a) being an active student of the institution, b) agreeing to participate and sign the informed consent, and c) being between 18 and 40 years of age. The exclusion criteria were a) having a diagnosis of Schizophrenia,; b) having one or more diagnosed neuropsychiatric diseases or disorders (bipolar affective disorder, depression), c) being on psychiatric medication that affects memory and processing speed, and d) having any of the following neurological conditions: epilepsy, stroke, brain trauma, temporomandibular joint disorder.

2.2 Measurements

2.2.1 Demographic Information

Sociodemographic information was collected through a questionnaire and consisted of the following variables: a) gender, b) current semester, c) years of schooling, d) educational level, e) socioeconomic status, f) marital status, g) age, h) having children, i) engaging in sports or physical activity, j) frequency of physical activity, k) working (in the last 3 months), and l) cumulative Credit Average.

2.2.2 General Self-efficacy Scale

The psychometric test used to measure self-efficacy was the General Self-Efficacy Scale by Baessler and Schwarcer (GSS), Chilean validation, due to the documented availability of its psychometric properties. The Spanish adaptation contains 10 items with 4-point Likert-type response scales. The internal consistency of the test obtained by Cid et al. (2010) in their validation study of the scale was $\alpha = .84$. The possible minimum score is 10, and the maximum is 40; the test covered a population of 360 people between the ages of 15 and 65; the mean is 34.1 and the standard deviation is 4.84.

2.2.3 Attentional Test

The Symbol Digit Modalities Test (SDMT) was used, which is a symbol substitution test; it allows for the assessment of attention and processing speed. The test consists of a series of symbols that the person must replace with numbers according to the key provided (Smith, 1982).

During the execution, each participant was given 90 seconds to complete the test, and the number of correct substitutions made during that time was scored. For the transformation of the scores, the norms provided by Arango (2015) were used, converting the raw scores to scaled scores. Finally, the standardized score and the percentile corresponding to the participant's age group will be reported.

2.2.4 Brief Test of Attention (BTA)

The Brief Test of Attention (BTA) is a psychometric tool used to assess an individual's attention and concentration capacity; it was created in 1989 by David Schretlen (1996). This test consists of a series of simple tasks that measure the subject's ability to pay attention to specific stimuli over a short period of time.

The BTA is a brief examination commonly used in the clinical assessment of patients with attention disor-

ders and attention deficits, although it has been used for other disorders as well (Arango, 2015, p. 164). The test consists of a list of letters, numbers, and symbols that are presented to the subject for a brief period of time. The participant must identify and recall the stimuli presented on the list in the correct order.

The BTA is a useful tool for assessing individuals' attention capacity in everyday situations. Additionally, it is a quick and easy test to administer that provides valuable information about a person's attention capacity. Overall, the BTA is a reliable and validated psychometric test that can be used in both clinical and educational settings to measure an individual's attention and concentration ability.

2.2.5 Brain Map (QEEG)

For the brain mapping, the two-channel NeuroBit Optima 2 equipment was used. The setup used for each participant was as follows: the ground or common electrode was placed at the Fpz point; to collect data from point C3, two electrodes were connected, the active one at C3 and the reference at A1 (left earlobe); to collect data from C4, the active sensor was placed at C4 and the reference at A2 (right earlobe).

The choice of C3-C4 points is due to the fact that they are the most common points within Neurofeedback protocols to train functions such as attention.

2.3 Procedure

The objective and scope of the study was explained to each participant . They were informed about the instruments to be used for data collection. The inclusion and exclusion criteria were validated.

First, they filled out the sociodemographic information form; second, the self-efficacy test; third, the Digit-Symbol attention test; and fourth, the BTA test.

Finally, the brain mapping was carried out, with the following procedure:

The two-channel NeuroBit Optima 2 equipment was used using the setup described above. Before taking the samples, the areas were prepared with conductive gel and paste to affix the electrodes.

Before each mapping, it was verified that the impedance did not exceed the manufacturer's recommended level, which is notified by the BioExplorer software.

With BioExplorer, the EEG data were saved in the following manner: a) Segment 1: 1 minute with eyes open; b) Segment 2: 1 minute while reading; c) Segment 3: 1 minute with eyes closed.

A design in BioExplorer was used to calculate the quotient of the Theta and Beta bands, followed by the average of this quotient. The average is the value with which the statistical analysis was conducted to determine the relationships. At the end of each segment, the average value of the Theta-Beta ratio was recorded.

3. Results

3.1 Descriptive Analysis

Out of the total of 25 participants in the study, 21 were women (84%) and 4 men (16%). The majority were from the Psychology program, where the proportion of women is much higher than that of men, which reflects the reality in the composition of students for this career with respect to gender distribution. The distribution of participants by program was: 2 from the Law program (8%) and 23 from the Psychology program (92%).

3.2 Descriptive Analysis of Variables of Interest (Attention and Self-Efficacy)

In Table 2 we see the descriptive statistics of the variables of interest and the Cumulative Credit Average (CCA). These variables of interest refer to the results of the instruments used in the research —psychometric tests, questionnaires, and brain mapping—, which were used to objectively measure variables such as attention and self-efficacy. To carry out these measurements, 22 brain mappings were performed, and 25 participants took the psychometric tests, with 3 individuals not present for the mapping.

Within the literature of QEEG and Neurofeedback, it is established that the normal values of the Theta-Beta Ratio (TBR) correspond to a proportion of 2:1. The closer the quotient of the two amplitudes approaches 1, the better the concentration, with 2 to 2.5 being normal, and values greater than 3 considered a slow-wave disorder and presumed ADD (Demos, 2005, p. 153; Lubar et al., 1995). The TBR averages for this study were between 3.9 and 5.5, values that, in the light of QEEG and Neurofeedback literature, indicate inadequate and suboptimal brain activity functioning and even suggest scores that could be associated with symptoms of Attention Deficit Disorder (ADD) as long as there is a clinical correlation directed by neurology. Since the current study does not have clinical correlation, the results can only be interpreted as suggestive of suboptimal brain activity indicative of a low attention level.

On the other hand, for the mean values of the physiological data in C3 and C4 that are in Table 2, it is expected that the TBR will improve when moving from eyes open to reading, because attention is engaged in a complex operation; when moving to eyes closed, the ratio will improve even further. This progression in the reduction of the ratio was maintained in the study, which, as seen in Table 2, went from 5.5 with eyes open to 3.9 with eyes closed in the left hemisphere and from 5.2 with eyes open to 3.9 with eyes closed in the right hemisphere.

In summary, the statistical results of the study compared with normative models tell us that in the GSS and BTA tests, the performances of the participants are below the averages; in QEEG, participants, on average, have much higher Theta-Beta ratios, suggesting

Table 1

Sociodemographic Characteristics of Sample

Variable	Category	Frequency	Percentage
Gender	Femenine	21	84
	Masculine	4	16
Career	Law	2	8
	Psychology	23	92
Current semester	2	1	4
	3	2	8
	5	8	32
	6	2	8
	8	2	8
	9	6	24
	10	4	16
Marital status	Single	20	80
	Married	2	8
	Widowed	1	4
	Divorced	2	8
Has children	Yes	4	16
	No	21	84
Engages in sport or physical activity	Yes	14	56
	No	11	44
Physical activity frequency (times per week)	0	11	44
	1	2	8
	2	3	12
	3	4	16
	4	1	4
	5	2	8
	6	2	8
Educational level	High school	13	52
	Technical	7	28
	Technologist	3	12
	Undergraduate/Bachelor's degree	2	8
	N	Average	Standard deviation
Years of schooling	25	16.6	2.4
Age	25	25.8	6.5

Table 2

Descriptive Statistics

Variable	N	Min	Max	Average	Std dev.	Normative AVG
Cumulative Credir Average (CCA)	22	3.40	4.60	3.95	.31	
C3 eyes open (C3EO)	22	3.3	10.5	5.5	1.74	
C3 reading (C3R)	22	3.1	7.7	4.6	1.12	
C3 eyes close (C3EC)	22	1.7	9.5	3.9	1.68	
C4 eyes open (C4EO)	22	1.3	10.6	5.2	2.07	
C4 reading (C4R)	22	2.4	8.0	4.2	1.36	
C4 eyes close (C4EC)	22	1.7	10.7	3.9	1.95	
Self-efficacy Direct score (GSS)	25	21.0	39.0	31.5	4.58	34.1
Digit-Symbol Direct score (DSPD)	25	31.0	66.0	45.1	8.69	29.41
BTA N test direct score (BTANPD)	25	1.0	8.0	5.0	1.95	6.3
BTA L test direct score (BTALPD)	25	2.0	8.0	4.4	1.87	6.3
BTA Total direct score. (BTATPD)	25	3.0	15.0	9.4	3.31	12.9

suboptimal modulation; in the Digit-Symbol test, finally, they showed outstanding results, with the average being much higher than the normative averages.

3.3 Bivariate Analysis (Association between Attention and Self-Efficacy)

In Table 3, the results of the Spearman correlation are presented, which was used to analyze possible associations between self-efficacy, academic average, and attentional measurements both psychometric and neurophysiological.

Age correlated negatively with TBR at C4EO (−.565) and C4R (−.531), that is, as age increases, the TBR tends to decrease, which can be interpreted as an improvement in brain physiology that correlates with attentional performance as the subject ages and reaches higher stages of neurodevelopment, understood in the context of a young university population. This is impor-

Table 3

Spearman Correlation

Variable		AGE	CCA	C3EO	C3R	C4EO	C4R	GSS	DSPD	BTANPD	BTALPD	BTATPD
	Coef. correlation	1.000	−.156	−.329	−.385	−.565**	−.531*	.439*	.416*	.248	.046	.200
AGE	Sig. (bilateral)		.489	.134	.077	.006	.011	.028	.039	.232	.828	.338
	N	25	22	22	22	22	22	25	25	25	25	25
	Coef. correlation	−.156	1.000	.189	.228	.150	.311	−.164	.349	.034	.114	.104
CCA	Sig. (bilateral)	.489		.413	.321	.517	.171	.466	.111	.880	.613	.645
	N	22	22	21	21	21	21	22	22	22	22	22
	Coef. correlation	−.329	.189	1.000	.468*	.812**	.507*	−.333	−.310	.131	.359	.265
C3EO	Sig. (bilateral)	.134	.413		.028	.000	.016	.130	.160	.563	.101	.234
	N	22	21	22	22	22	22	22	22	22	22	22
	Coef. correlation	−.385	.228	.468*	1.000	.474*	.719**	−.368	−.110	.279	.497*	.471*
C3R	Sig. (bilateral)	.077	.321	.028		.026	.000	.092	.626	.208	.019	.027
	N	22	21	22	22	22	22	22	22	22	22	22
	Coef. correlation	−.565**	.150	.812**	.474*	1.000	.774**	−.241	−.529*	.252	.377	.351
C4EO	Sig. (bilateral)	.006	.517	.000	.026		.000	.281	.011	.257	.084	.109
	N	22	21	22	22	22	22	22	22	22	22	22
	Coef. correlation	−.531*	.311	.507*	.719**	.774**	1.000	−.217	−.208	.374	.529*	.534*
C4R	Sig. (bilateral)	.011	.171	.016	.000	.000		.332	.354	.086	.011	.010
	N	22	21	22	22	22	22	22	22	22	22	22
	Coef. correlation	.439*	−.164	−.333	−.368	−.241	−.217	1.000	.029	.163	−.095	.070
GSS	Sig. (bilateral)	.028	.466	.130	.092	.281	.332		.891	.436	.651	.740
	N	25	22	22	22	22	22	25	25	25	25	25
	Coef. correlation	.416*	.349	−.310	−.110	−.529*	−.208	.029	1.000	.273	−.042	.149
DSPD	Sig. (bilateral)	.039	.111	.160	.626	.011	.354	.891		.186	.842	.477
	N	25	22	22	22	22	22	25	25	25	25	25
	Coef. correlation	.248	.034	.131	.279	.252	.374	.163	.273	1.000	.486*	.852**
BTANPD	Sig. (bilateral)	.232	.880	.563	.208	.257	.086	.436	.186		.014	.000
	N	25	22	22	22	22	22	25	25	25	25	25
	Coef. correlation	.046	.114	.359	.497*	.377	.529*	−.095	−.042	.486*	1.000	.862**
BTALPD	Sig. (bilateral)	.828	.613	.101	.019	.084	.011	.651	.842	.014		.000
	N	25	22	22	22	22	22	25	25	25	25	25
	Coef. correlation	.200	.104	.265	.471*	.351	.534*	.070	.149	.852**	.862**	1.000
BTATPD	Sig. (bilateral)	.338	.645	.234	.027	.109	.010	.740	.477	.000	.000	
	N	25	22	22	22	22	22	25	25	25	25	25

Note. *Significant ($p < .05$); **Very significant ($p < .01$). Abbreviations: CCA: Cumulative Credit Average; EO: Eyes Open; R: Reading; EC: Eyes Closed; GSS: General Self-Efficacy Scale Direct Score; DSDS: Digit-Symbol Direct Score; BTANDS: BTA Form N Direct Score; BTALDS: BTA Form L Direct Score; BTATDS: BTA Total Direct Score (the sum of DS of forms N and L).

tant because it is also documented in the literature (Demos, 2005, p. 94). Age also correlated positively with the direct score in GSS (.439): the older the age, the better the general self-efficacy. Finally, age correlated positively with performance on the Digit-Symbol test (.416), where the older the age, the better the performance in sustained and alternating attention.

The TBR at C4EO correlated negatively with performance on the Digit-Symbol test (−.529), indicating that when a subject has better performance in sustained and alternating attention measured psychometrically, there is also an electrophysiological record during eyes open that correlates with attentional functioning that is closer to optimal.

Lastly, it was found that C3R correlated positively with BTALPD (.497), as well as with BTATPD (.471); C4R correlated positively with BTALPD and BTATPD (.529 and .534, respectively). These results are unexpected because it was anticipated that a lower TBR (better attention) would yield better performance on the BTA test. The results obtained lead to some possibilities: a) that the test is difficult or has a very low ceiling for our population; or b) there is a relationship between the BTA results and the high values in the TBR, which would require a specific design to investigate it and thus draw conclusions afterwards.

4. Discussion

The objective of this study was to analyze the relationship between self-efficacy, attention, and the functioning of brain waves at points C3 and C4.

The hypothesis that attention measured with QEEG negatively correlated with the result of the psychometric measurement of sustained and selective attention on the Digit-Symbol test (−.529) was confirmed, that is, as the direct score of the psychometric test increases, the TBR decreases, meaning that better psychometric results are related to better attention, which is reflected in the decrease of the theta-beta ratio. The correlation between these two measures is consistent with evidence that supports the theta-beta ratio as a reliable marker for physiologically measuring attention (Angelidis et al., 2016); General self-efficacy showed no Spearman correlation with either the psychometric attention tests or QEEG.

The positive correlation between TBR at C3R with BTALPD (.497) and with BTATPD (.471); TBR at C4R with BTALPD and BTATPD (.529 and .534, respectively) are unexpected because they contradict the basic idea that a lower TBR (better attention) would correspond with better performance on the BTA test. It is possible that the low performance on the BTA test is somehow related to this, meaning that the scores were so low that they mathematically showed correlation with the TBR, which increases both simultaneously. It is also hypothesized that the type of attention measured by the BTA does not coincide with the attention manifested in the Theta-Beta ratio.

The Cumulative Credit Average (CCA) did not correlate with the results of self-efficacy (GSS) or attention (QEEG, DS, BTA). This result highlights that the academic average of the IUE students included in this study might not be a behavioral correlate of attentional functioning and self-efficacy. This conclusion is made considering that on many occasions the weighted grade of academic performance becomes an artificial measurement and does not reliably describe academic performance, the specific skills achieved in the areas of study, and the processes that occurred in it (Baird, 1985; Grant, 2018; Mackinnon, 1962; Villarroel, 2012). Another hypothesis generated from this finding is that since self-efficacy has to do with a subjectivity that falls on the own judgment of feeling capable or competent, then it could be that subjectively a person does not feel self-efficacious and that this diminished self-assessment leads them to increase efforts to achieve more objectives as a reactive measure against performance anxiety, resulting in presenting better academic performances than those subjects with more self-confidence and better results in questionnaires that evaluate the perception of self-efficacy. The findings of this research would be supporting the hypothesis of Nazer et al. (2018) in which they maintain that self-efficacy is a psychological state and that only through the continuous performance of tasks over time, the individual can determine if they have experienced any change in their perception of efficacy.

In this research, it was expected to find that high self-efficacy would correlate with high attention. However, the results of this study did not account for this relationship. A possible explanation for this result is that self-efficacy, and specifically self-efficacy measured by the General Self-Efficacy Scale, takes into account elements such as persistence, problem-solving, continuous effort, emotional stability, and self-confidence to complete tasks, and such characteristics of self-efficacy involve attention. As indicated in the results of this work, the participants of this study showed suboptimal modulations in the Theta-beta ratios. Therefore, possibly inattention and distractibility are elements that not only make it difficult to complete tasks and achieve objectives, but also influence the ability to plan and coordinate the necessary activities to take action (Young et al., 2007).

The results of this research in light of QEEG suggest alterations in attention in all participants, that is, the C3-C4 points have levels of modulation and functioning that are not adequate. Although the theta-beta ratio is a widely used marker in assessment, in the clinical application of these measurements it is not the only one considered, but a brain mapping is carried out, which includes at least 19 points on the skull and the application of more specific instruments to make the best decision regarding diagnosis and intervention.

For future research, the following improvements can be proposed: first, explore with new studies how ADD manifests among IUE students to determine whether or not it is underdiagnosed. Second, include within the variables to be considered nutrition, as nutritional deficits prevent the nervous system from functioning properly (Heaney, 2003; Hibbeln & Gow, 2014), and it has even been associated with ADHD (Bloch & Qawasmi, 2011; Hyman, 2018; Perera et al., 2012).

Based on the experience of this research, some recommendations arise. First, the construct of self-efficacy is very broad, so it would be really important to explore other psychometric tests to measure it with greater specificity. Second, choose an alternative attention test to the BTA to measure sustained and selective attention. Third, include nutrition and sleep quality as a variable to investigate; sleep is absolutely essential for the activation of various processes, such as body repair. Fourth, there is much more information that can be gathered by doing the same mapping, the TBR is one of many useful data that can be obtained, for example: interhemispheric coherence (the degree of similarity of two contralateral points), dominant frequency, alpha peak, BAT triad (verify the fundamental asymmetries) (Budzynski et al., 2008).

5. Remark

This article is part of the research work to qualify for the degree in Psychology, titled "Relationship between self-efficacy and level of attention, measured in the sensorimotor cortex at points C3-C4 in a group of IUE students between 18 and 40 years of age", conducted in 2023.

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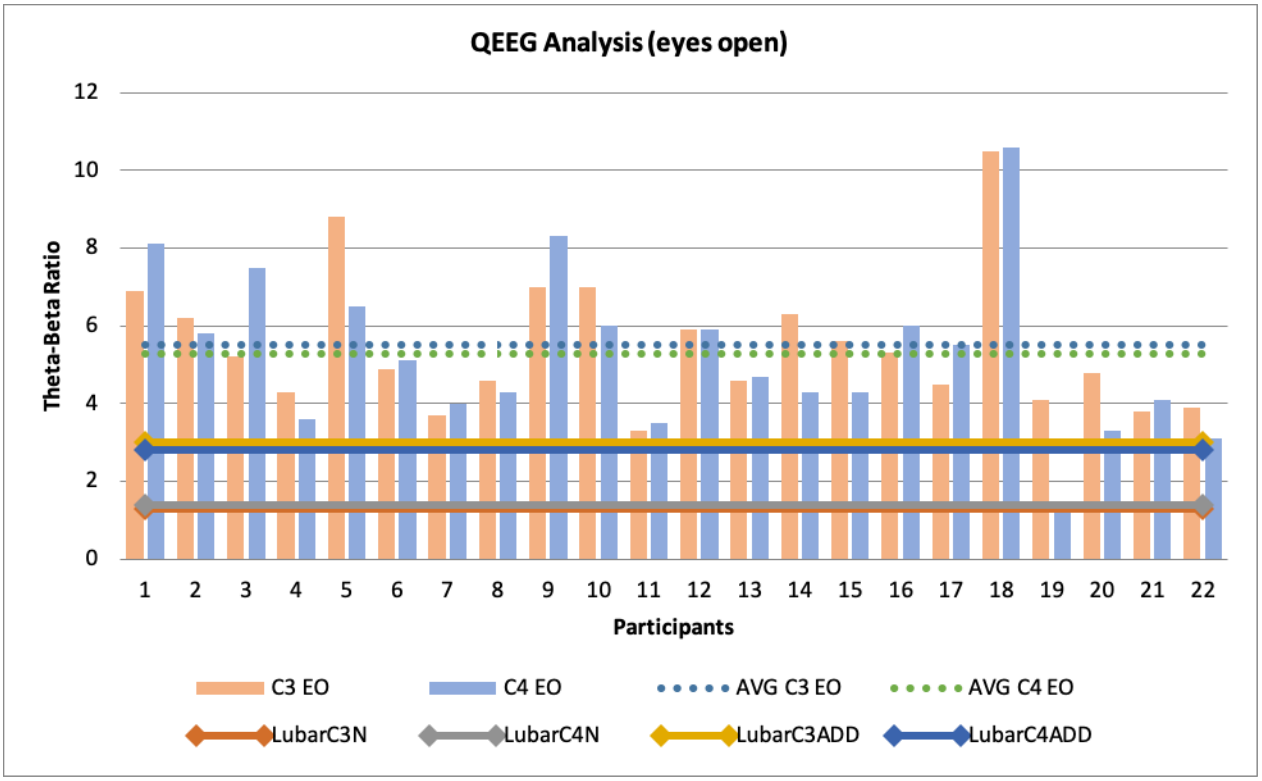
Appendix

Figure 1

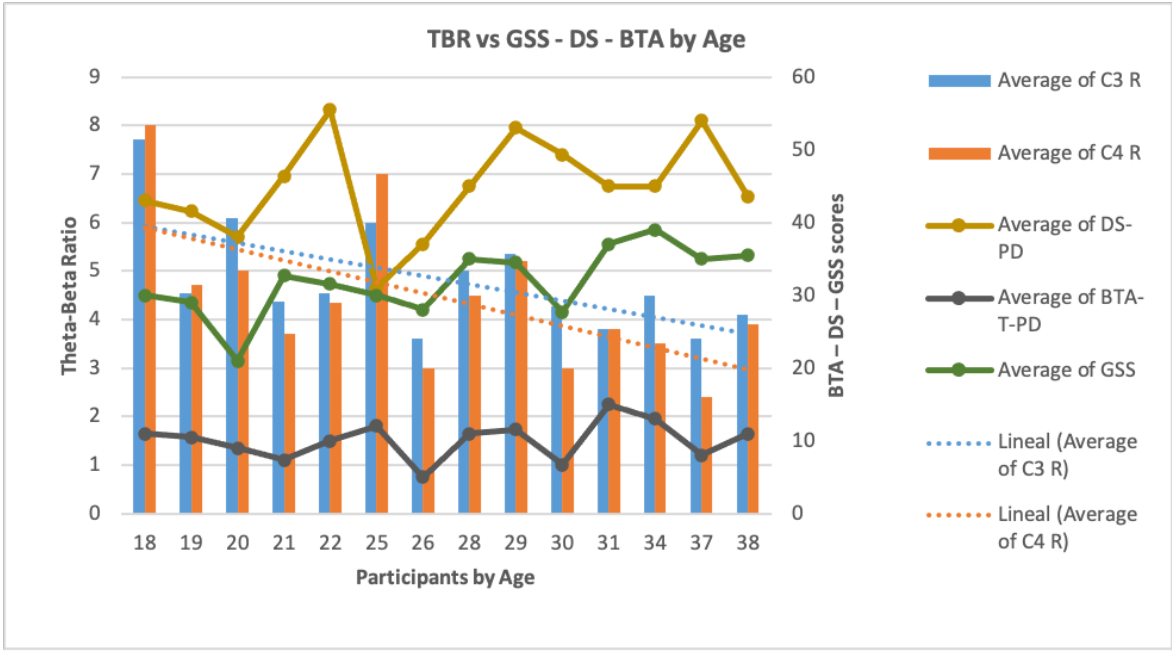
QEEG Analysis by Participant



Note. In the bars, the value of the TBR C3-C4 eyes open (EO) is found; the horizontal dotted lines at the top represent the average TBR of the participants, and for comparative purposes, the values from the study by Lubar (1995) are included, where the TBR averages of the group diagnosed with ADD are in yellow and blue (LubarC3ADD, LubarC4ADD, respectively); and also the TBR averages of the non-ADD diagnosed group in gray and orange (LubarC3N, LubarC4N, respectively).

Figure 2

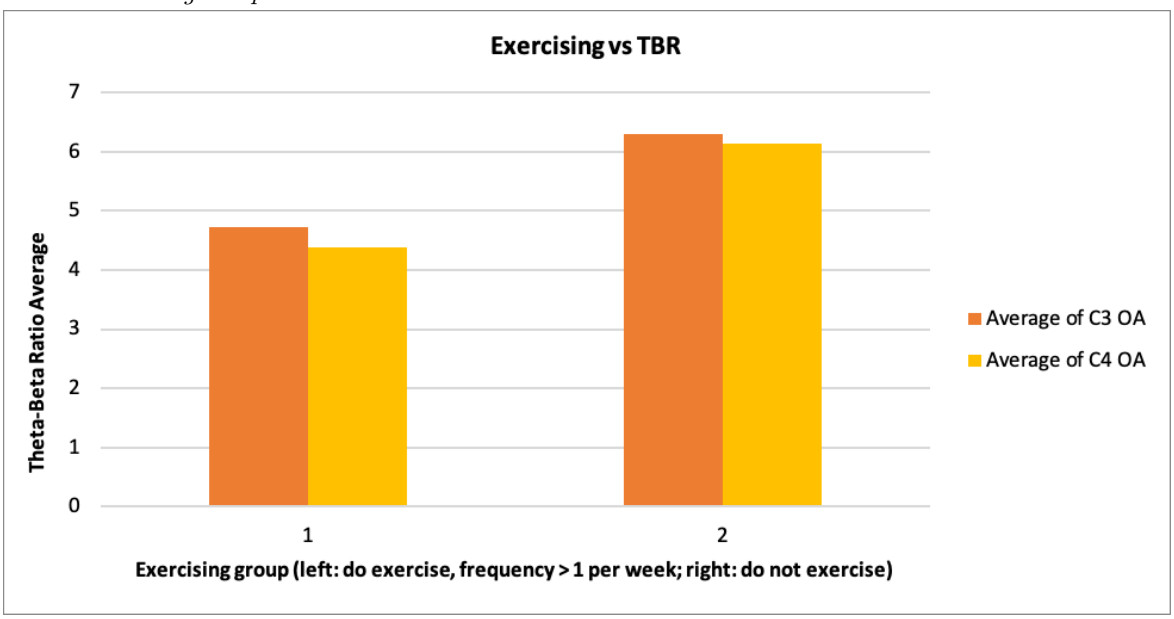
TBR Analysis: Comparing Average Scores of Self-Efficacy Scale (GSS), Digits-Symbols (DS), Brief Test of Attention (BTA), Grouped by Age



Note. In the bars are the average of the TBR for C3-C4 while reading (R); the dotted lines represent the linear trend for C3 and C4, which shows that as age increases, the TBR decreases and attention improves. In gray, the average value of the BTA test that does not reflect a clear trend. In green, the behavior of the GSS where it can be seen that as age increases, self-efficacy is higher; likewise, there is also a tendency to improve performance on the Digit-Symbol test as age increases.

Figure 3

TBR and exercising comparison



Note. One of the variables included in the study was the weekly frequency of physical activity among participants. Group 1 bars represent participants who engage in physical activity at least once a week; compared with group 2, those who do not exercise. It shows us how the average values of the TBR (eyes open) are lower among those who engage in physical activity.