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Electrophysiological Correlates Of Difficulties In Emotional Regulation: An Event Related Potentials Study.

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ELECTROPHYSIOLOGICAL CORRELATES OF DIFFICULTIES IN EMOTIONAL REGULATION: AN EVENT RELATED POTENTIALS STUDY

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ABSTRACT
Emotion regulation (ER) is an ongoing process wherein each person manages their emotional responses in accordance with contextual demands. Difficulties in ER can significantly impact an individual's mental health and lead to a range of psychological problems. Previous studies have demonstrated a correlation between resting electrophysiological brain activity (EEG) and difficulties in ER and between event related potentials (ERP) and ER strategies. However, the relationship between difficulties in ER and ERPs activity have not been examined yet. In order to realize a first exploratory approach to link these variables, we utilized a classical oddball paradigm to elicit a classical ERP component (termed P3). Then, we examined the correlation between both the amplitude and latencies of the P3 component and scores on the Difficulties in Emotion Regulation Scale (DERS). We found significant positive correlations between the Difficulties in Emotional Awareness subscale of the DERS and P3 amplitude, as well as between the Lack of Emotional Control subscale and P3 latency, which indicates that greater difficulties in ER are positively related to reduced cognitive performance and slower mental speed. These results represent a novel attempt to link ERP activity with different levels of difficulties in ER.

Keywords
Emotion Regulation - DERS - ERP - EEG

RESUMEN
CORRELATOS ELECTROFISIOLÓGICOS DE LAS DIFICULTADES EN LA REGULACIÓN EMOCIONAL: UN ESTUDIO DE POTENCIALES RELACIONADOS CON EVENTOS
La regulación emocional (RE) es un proceso continuo mediante el cual las personas ajustan sus respuestas emocionales en base a las demandas contextuales. Estudios previos han demostrado una correlación entre la actividad cerebral en reposo (EEG) y las dificultades en la RE, así como entre los potenciales relacionados con eventos (ERP) y las estrategias de RE. Sin embargo, la relación entre las dificultades en la RE y la actividad de los ERP no ha sido explorada. Para realizar un primer acercamiento exploratorio a estas variables, utilizamos un paradigma clásico de "oddball" obteniendo un componente de ERP denominado P3. Luego examinamos la correlación entre la amplitud y las latencias del componente P3 y las puntuaciones en la Escala de Dificultades en la Regulación Emocional (DERS) y sus cinco subescalas. Encontramos correlaciones positivas significativas entre la subescala de Desatención Emocional y la amplitud del P3, así como entre la subescala de Descontrol Emocional y la latencia del P3, lo que indica que mayores dificultades en la RE están positivamente relacionadas con un rendimiento cognitivo reducido y una velocidad mental más lenta. Estos resultados representan un intento novedoso de vincular la actividad de los ERP con diferentes grados de dificultades en la RE.

Palabras clave
Regulación Emocional - DERS - ERP - EEG

Emotion Regulation and Electrophysiology:
Emotion regulation (ER) is an ongoing process wherein individuals manage their emotional responses in accordance with contextual demands (Cole et al., 1994; Thompson, 1991). This regulation involves assessing and adjusting emotions, particularly in terms of intensity and duration, and difficulties in this process can lead to emotional dysregulation (Cole et al., 1994). Such dysregulation may serve as symptoms or contribute to the development of various psychopathologies, including depression, anxiety disorders, PTSD, and substance abuse disorders (Berking & Wupperman, 2012; Aldao et al., 2010; Joormann & Stanton, 2016; Cisler et al., 2010; Bardeen et al., 2013; Tull et al., 2018; Berking et al., 2011; Dingle et al., 2018).
Various electrophysiological correlates of the ER process have been previously identified. Real-time functional magnetic resonance imaging (rt-fMRI) has been suggested as a neurofeedback treatment for difficulties in ER (Linhartová et al., 2019). EEG data have also been linked to ER processes; for instance, Deveney & Pizzagalli (2008) observed significant modulation of the P3 amplitude in response to aversive stimuli after teaching different ER strategies. This modulation reflects increased cortical activity associated with successful top-down control over emotional dysregulation. Similarly, Zhang et al. (2020) found

a correlation between scores on the Difficulties in Emotion Regulation Scale (DERS) and frontal alpha asymmetry (FAA) in resting-state EEG data, indicating higher difficulties in ER for individuals with higher FAA.

Despite existing correlations between difficulties in ER and EEG data, and some studies exploring ER strategies through ERPs, no research has investigated individual differences related to difficulties in ER using ERPs. In a novel effort to address this relationship, we examined the correlation between total DERS scores and its subscales with P3 component (latency and amplitude). These findings represent a novel attempt to understand how difficulties in ER manifest in cortical activity. Future research could further explore this relationship to identify biomarkers or neural signatures associated with specific aspects of emotional dysregulation. Such insights could inform the development of targeted interventions, including neurofeedback or cognitive-behavioral therapies.

Methods:

The study involved 35 participants (26 Females, 9 Males) aged between 18 and 34 years (M = 23.4 ± 3.91 years) with normal or corrected-to-normal vision and no history of psychiatric or neurological disorders or medication intake during the experiment. Ethical approval was obtained from the local Ethics Committee (code: #001220523), and all participants provided informed consent following the 1964 World Medical Association Declaration of Helsinki and its later amendments.

Stimuli

For the oddball task, we used green and blue squares (6.3° of visual angle) as standard and oddball stimuli respectively.

EEG recordings

Electrophysiological activity was recorded using 20 cap-mounted tin electrodes (19 active electrodes and one ground electrode, extended international 10/20 system, Electro-Cap International Inc.). Additionally, three electrodes were attached for measuring vertical and horizontal eye movements and as a reference. Recording was conducted using an AKONIC BIOPC system (as in Andreau et al., 2019; 2021). Electrode impedances were maintained below 10 kO, and EEG signals were sampled at 256 Hz with an analog filter of 0.1-100 Hz and low-pass filtered offline at 30 Hz (6 dB/Octave).

Participants completed the Edinburgh Handedness Inventory (EHI) (Oldfield, 1971) to ascertain their handedness and the Difficulties in Emotion Regulation Scale (DERS) (Gratz & Roemer, 2004) to measure emotion regulation problems. The DERS, in its Spanish adaptation (Hervás & Jodár, 2008), consisted of 28 items scored on a 5-point Likert scale, with higher scores indicating greater difficulties in emotion regulation across five subscales: Lack of Emotional Control, Non-Acceptance of negative emotions, Inability to engage in goal-directed behaviors when distressed, Difficulties in Emotional Awareness, and Emotional Clarity.

The procedure involved participants signing an informed consent form, completing the EHI and DERS on a PC, and being fitted with the EEG cap and auxiliary electrodes. During EEG recording, participants performed a visual oddball task presented on a 19-inch LCD computer monitor using PsychoPy software. The task comprised four blocks of 30 trials each, where participants responded to blue (oddball) squares by pressing the spacebar. Oddball stimuli occurred 20% of the time, totaling 24 trials per participant. Instructions were given to minimize blinking or eye movement during stimulus presentation, and rest periods were provided between task blocks for movement and communication with experimenters.

Preprocessing:

EEG pre-processing and ERP analysis were conducted using EEGLAB (v2019_0) following the laboratory's pipeline (Raggi et al., 2023). ERP data were time-locked to the onset of the target stimulus, with epoch length set to 1000ms (-200 pre-stimulus and 800ms post-stimulus). A 200ms pre-cue baseline correction was applied. Ocular artifacts were corrected using the ADJUST ICA-based correction algorithm (Mognon et al., 2011). Epochs containing other artifacts were identified through visual inspection and excluded from the analysis. For P3 latency analysis, the fractional area latency measure was utilized, owing to its effectiveness in handling broad components isolated by means of a difference wave, which may lack a clear maximum (Hansen & Hillyard, 1980; Kiesel et al., 2008; Luck, 2014). On the other hand, P3 amplitude was defined as the average activity occurring between 450 and 650 ms.

Results:

Oddball task

All subjects responded near ceiling (M=99.7%, SD= 0.68%) and within the normal range of RT (M=0.472, SD=0.071, Min= 316ms, Max= 638ms).

P3 and DERS correlations

As a control measurement, we used Jamovi (Version 2.03) to perform a Shapiro-Wilk normality test to assert that DERS scores had a normal distribution ($W = 0.98$, $p = 0.92$). As a result, Pearson's correlation tests were performed to examine the relationship between DERS total scores, its five subscales, and P3 amplitudes and latencies in electrodes fz, cz, and pz (Luck, 2014). A significant positive correlation was found between high scores on Difficulties in Emotional Awareness subscale and increased P3 amplitudes in electrode pz ($r = 0.34$, $p<0.05$). In addition, a significant positive correlation was found between higher Lack of Emotional Control subscale scores and slower P3 latencies in electrode fz ($r = 0.33$, $p<0.05$).

Discussion:

The purpose of the present study was to investigate the relationship between difficulties in the ER process and electrophysiological activity using ERP's. Therefore, we correlated scores in DERS (and its subscales) with P3 amplitude and latency in order to find any specific association between them.

All subjects performed above 95% in the oddball task and their reaction times were between normal boundaries, meaning that they were correctly solving the task. We then proceed to calculate the P3 component and perform different correlations. As a result we found a significant positive correlation between high scores on Difficulties in Emotional Awareness subscale and increased P3 amplitudes in electrode pz which is typically the one that presents the highest P3 amplitudes (Luck, 2014). Emotional Awareness has been described as the capacity to focus attention on emotional processes, as well as becoming aware of and valuing them. A high score in this scale would imply the existence of greater difficulties in this domain, while lower scores show less difficulties. Since P3 amplitude is sensitive to the amount of attentional resources engaged during task performance (Polich, 2012), meaning that amplitudes are larger when subjects devote more effort to a task (Luck, 2014). The existence of a positive correlation between Difficulties in Emotional Awareness scores and P3 amplitude could potentially indicate that subjects with more Difficulties in Emotional Awareness might require the involvement of greater attentional resources to resolve a simple task, such as the one present in the experiment.

In addition, a significant positive correlation was found between higher Lack of Emotional Control subscale scores and slower P3 latencies in electrode fz which might be related to frontal cortex functions such as cognitive execution (Funahashi & Andreau, 2013). As previous studies also found (Zhang et al., 2020), our results seem to indicate the existence of a relationship between Lack of Emotional Control and electrophysiological activity. These findings might imply that a Lack of Emotional Control is related to reduced cognitive performance capabilities and mental speed, although this relationship should be further studied.

In conclusion, this study revealed interesting associations between two DERS subscales and ERP activity (amplitude and latency). However, it is crucial to acknowledge that the study's limited sample size (n=35) increases the likelihood of random type II error and therefore the sample might not be representative of the population. The results should be replicated in a future experiment to increase external validity. Furthermore, it is important to clarify that this study could be considered as an initial exploration into the possible links between ERP activity and difficulties in ER.

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