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Neural Process of Emotional Valence Quality in Extraversion: Localisation, Components and Specific Electrodes Analyses

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The process of emotion is greatly influenced by people's personalities. This study aimed to determine the interaction between extraversion continuum (extravert, ambivert, and introvert) and the process of emotion from different valence quality of visual stimuli (high, moderate, low). Potential participants had their extraversion trait screened using the Extraversion-Five-Factor Nonverbal Personality Questionnaire (E-FF-NPQ). Ninety participants (30 for each group of personality) enrolled in this study. In the Event-Related Potential (ERP) session, participants' emotion was evoked by a series of pictures (visual stimuli) from the International Affective Picture System (IAPS) with different valence qualities (high, moderate, low). No significant interaction between extraversion continuum and valence quality was observed at component level of analysis. However, several specific electrodes revealed significant interaction – P3 latency (p=0.03) and F8 amplitude (p=0,02) of N200 and Cz latency of P300 (p=0.02). Low-resolution brain electromagnetic tomography (sLORETA) revealed almost similar pattern of N200 and P300 localisation in the high valence state, particularly among extraverts. At the very least, a minor difference between extravert and non-extravert could be expected with careful consideration of cultural and methodological bias.

Keywords: Event-related potential; extraversion; emotional valence; visual perception

I. INTRODUCTION

Personality encompasses the distinct variations in cognitive processes, emotional experiences, and behavioural tendencies that are observed among individuals (American Psychological Association 2020). The study of personality has emerged as a captivating subject within the fields of psychology and neuroscience due to its demonstrated impact on various domains of an individual's life, including academic performance (Furnham *et al.*, 2013; Komarraju *et al.*, 2011; Marcela 2015), occupational outcomes (Grant, 2013; Mount *et al.*, 1998; Neal *et al.*, 2012), and overall well-being (Gale *et al.*, 2013; Jylhä *et al.*, 2010). Extraversion is a personality trait that is extensively recognised and studied in the field of psychology. The topic of personalities is extensively examined in prominent theoretical frameworks, including the Five Factor Model (McCrae & Costa, 1999; Matthews *et al.*, 2009; Zvolensky *et al.*, 2015) and Eysenck's Theories of Personalities (Eysenck, 1994). Extraversion involves an individual's level of sociability and assertiveness (McCrae & Costa, 1987), along with their inclination towards seeking stimulation and experiencing delight (Cervone & Pervin, 2013). Extraverted personalities can be categorised into three distinct qualities. At the uppermost range of the extraversion continuum lies the personality trait known as extraversion. Individuals exhibiting this feature can be characterised as friendly, active, and talkative, deriving gratification from interpersonal interactions (Feist & Feist, 2008). The introvert characteristic can be characterised as the antithesis of the extravert trait, since it entails a tendency for individuals to

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*Corresponding author's e-mail: nasirff@usm.my exhibit reserved, silent, and aloof behaviours. The ambivert trait refers to a personality feature that encompasses both introverted and extroverted tendencies, with the individual exhibiting either attribute depending on the specific context (Cohen & Schmidt, 1979).

Subjective well-being refers to the individual's subjective evaluation of their happiness, fulfilment, and overall quality of life (Diener & Suh, 2000). Research has shown that extraverts tend to consistently report higher levels of subjective well-being compared to individuals who are not extraverted (Yuan *et al.*, 2012). Individuals who have extraverted personality traits tend to experience positive or satisfying states more frequently. According to the Affective Reactive Hypothesis (ARH), individuals who exhibit extraverted traits tend to display more pronounced responses to pleasant and rewarding stimuli in comparison to those who do not possess extraverted characteristics (Oerlemans & Bakker, 2014). Based on Reinforcement Sensitivity Theory (RST), it has been suggested that the extravert trait is associated with a combination of an increased behavioural activation system (BAS) and a reduced behavioural inhibition system (BIS), whereas introversion is linked to a reduced BAS and an elevated BIS (Maltby *et al.*, 2017). Individuals exhibiting elevated levels of the Behavioural Activation System (BAS) tend to have a pronounced response to stimuli that are appetitive and pleasurable in nature. According to Barrós-Loscertales *et al.* (2010), there is evidence suggesting that a high Behavioural Activation System (BAS) may impede the influence of the Behavioural Inhibition System (BIS), which is responsible for regulating responses to aversive or unpleasant stimuli. The utilisation of the event-related potential (ERP) methodology has been extensively employed within the realm of neuroscience, particularly in the investigation of emotional processes. The phenomenon is referred to is a time-locked electroencephalography (EEG) activity, which has the ability to record brain activity associated with cognitive processes. This activity is utilised as a means of comprehending neurobiological dysregulation and assessing neurotransmission (Luck, 2014).

An electroencephalogram (EEG) has been used to differentiate extraversion traits (Georgiev *et al.*, 2014). The pleasant and unpleasant experience has been simulated in many studies by presenting stimuli with different qualities of emotional valence (Altmann *et al.*, 2012) to the subjects. Stimuli with high valence were used to elicit positive emotion, resulting in a pleasant experience, while low valence stimuli did the opposite. Olofsson *et al.* (2008) discovered that visual stimuli with varying valence ratings, such as those included in the International Affective Picture Systems (IAPS) (Rupp *et al.*, 2014; Schupp *et al.*, 2012; Styliadis *et al.*, 2014), had the ability to alter ERP components. Aside from that, the ERP method uses source localisation analysis to find the most active or intense parts of the brain (Jatoi *et al.*, 2014) so that the effects of extraversion and valence can be studied more. Hence, in order to investigate potential variations in the response of distinct extraversion traits to positive or negative experiences, we employed event-related potentials (ERPs) to examine the differential processing of emotional visual stimuli with varying valence qualities (pleasant, neutral, and unpleasant) among individuals exhibiting different levels of extraversion (extravert, ambivert, and introvert).

II. MATERIALS AND METHOD

A. Participants' Characteristic and Personality Screening

The participants were selected using a convenience sampling method. Their extraversion traits were assessed with the Malay version of the Five Factor-Non-verbal Personality Questionnaire (FF-NPQ) (specifically the Extraversion Subscale) as stated in the studies conducted by Ab Rashid *et al.* (2018) and Paunonen *et al.* (2001). Then, they were asked to evaluate the five-item illustrations in the Malay version of the FF-NPQ (specifically, the Extraversion Subscale). These illustrations depicted behaviours associated with extraversion constructs. Meanwhile, they were required to rate each illustration using a seven-point Likert scale, where 1 represented "extremely unlikely" and 7 represented "extremely likely." Finally, they were categorised into three distinct groups, namely extraverts, ambiverts, and introverts, using predetermined thresholds: 17–35 for extraverts, 10–16 for ambiverts, and 5–9 for introverts. The psychometric property of the scale has been reported elsewhere (Ab Rashid *et al.*, 2018). Ninety participants (60% female) agreed to participate. The Chinese race (56%) represented a large proportion of the sample. The mean age of the participants was 22.51 (±1.96) years old, with about 80% of them graduated with bachelor's degrees from the local universities. All participants had similar conditions of laterality (right-handedness); however, 40% of them reported being left-eye dominant. Some participants had vision problems that were corrected with glasses or contact lenses. The 30 participants were divided into three groups depending on their personality traits: extraversion (mean = 22.27, ±4.24), ambiversion (mean = 12.07, ±1.84), and introversion (mean = 7.67, ±5.25). The Extraversion-Five Factor-Personality Questionnaire (E-FF-NPQ) revealed statistically significant variations in personality ratings across these three groups [F (2, 87) = 103.22, $p<0.05$].

B. *Visual Stimuli*

The images selected for this study were obtained from the International Affective Picture Systems (IAPS) (Lang *et al.* 1997). Each image in the IAPS database was given a rating for its valence value. The rating ranges from one, which is very unpleasant, to seven, which is very pleasant. We divided the valence rating into three groups as follows: high (7-9), moderate (4 to < 7), and low (1 to < 4) (Cano *et al.*, 2009; Lang *et al.*, 1997). A purposeful sampling technique was employed to select ten images for each valence group. The themes of the selected images were diverse, including nature, people, buildings, and so on. The IAPS identification number for the selected images for each group is as follows: high (1610, 2035, 2156, 2222, 5001, 5260, 5910, 7270, 7502, 8090), moderate (1230, 2025, 2056, 2092, 2681, 5301, 5520, 5665, 7004, 7300), and low (1280, 2278, 2312, 3550, 6313, 6840, 7520, 8485, 9101, 9831).

C. *Event-Related Potential Recording*

The visual stimuli were given using E-Prime version 2.0 software developed by Psychology Software Tools, Inc. in Sharpsburg, Pennsylvania, USA. Data gathering was conducted using Net Station software, developed by Electrical Geodesics, Inc. in Eugene, Oregon, USA. The participants were situated in a room with subdued lighting and soundproofing, positioned at a distance of 100 cm from a monitor where the stimuli were displayed. During the recording, a sensor network consisting of HydroCell sensors with 128 channels of varying sizes was utilised.

Prior to displaying each stimulus slide to the participant, two pre-stimulus slides were shown. The first pre-stimulus slide featured a fixation mark consisting of a white cross symbol (+) centred on a black background. This fixation slide had a duration of 500 ms and served the purpose of directing the participant's attention to the screen's centre. Following the fixation slide, there was a blank slide, which was essentially an empty black slide lasting for 800 ms. The blank slide aimed to prepare the participant for the upcoming stimulus slide. The stimulus slide, which contained the IAPS images, followed the blank slide and remained on the screen for 2000 ms. This sequence of presenting stimuli was repeated a total of ninety times, with each selected IAPS image appearing in random sequences three times on the monitor **(Illustrated in Figure 1)**.

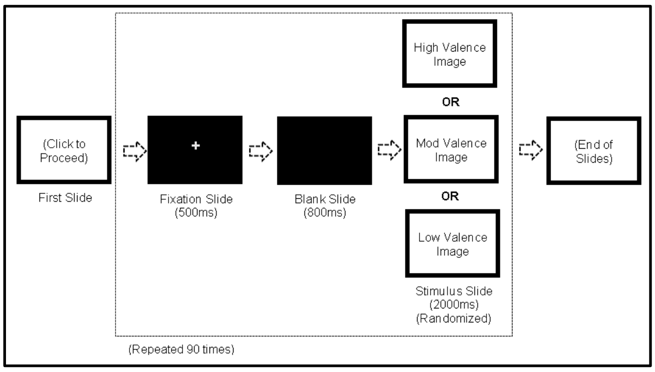

Figure 1. Event-related potential schematic procedure.

In this study, the EEG was conducted by capturing data from nineteen specific electrodes. These electrodes were positioned according to the 10/20 method, and their locations were designated as follows: Fp1, Fp2, F3, F4, F7, F8, Fz, C3, C4, Cz, T3, T4, T5, T6, P3, P4, Pz, O1, and O2 (Acharya *et al.*, 2016).

D. *Component Extraction and Analysis*

The ERP components were extracted using the EGI Net Station 5.3 software through a series of steps. Initially, the raw EEG recordings underwent a bandpass filter, restricting the frequency range to 0.30–50.00 Hz. Segmentation was precisely aligned to 100 ms before and 1000 ms after the stimulus onset, with automatic removal of ocular artefacts (such as eye blinks and eye movements) and other motion-related artefacts. If any segment exhibited an amplitude difference exceeding 400V, it was identified as a bad channel. Data were considered unreliable if approximately 20% of EEG recordings had bad channels across all segments. In this phase, interpolation was employed to substitute bad channels with signals recorded by nearby functional electrodes to eliminate noisy data. Subsequently, separate averaging was carried out to enhance the signal-to-noise ratio, followed by the conversion of data to the 10–20 EEG montage and subsequent baseline correction. Finally, the data were consolidated and averaged to reduce inter-subject variability. The raw data corresponding to the selected ERP components were then extracted.

The continuous event-related potential (ERP) data was analysed using Statistical Package for the Social Sciences (SPSS) version 26. A two-way mixed design analysis was conducted to examine the impact of personality (extraversion, ambiversion, and introversion) and valence qualities (high, moderate, and low) on the amplitude and latency of the ERP components associated with emotional valence processing. The assumption of sphericity was assessed, and the degrees of freedom for the F ratio were adjusted using the Huynh-Feldt method. Furthermore, where deemed suitable, the multivariate tests of Pillai's Trace were employed.

The study also conducted a source localisation analysis to identify the specific region of the brain exhibiting the greatest intensity when participants saw visual stimuli. This research utilised the sLORETA tool within the Net-Station 5.3 software. The regions exhibiting the greatest intensity, as quantified in nanoamperes (nA), were those that experienced the highest level of activation and hence produced the most substantial electromagnetic signals (Ali *et al.*, 2020; Jatoi *et al.*, 2014). The Brodmann Area classification and its corresponding anatomy structures that can be viewed through sagittal view, coronal view, and axial view were reported. The localisation analysis was done for N200 and P300 concerning both independent variables groups of extraversion traits and valence qualities.

III. RESULT

We only interested to look at the interaction effect between the extraversion continuum (extraversion, ambiversion, and introversion) and emotional valence processing of ERP components at different levels (low, moderate, and high), thus, all results are based on the interaction effect from the two-ways mixed design analysis. For this purpose, the 19 electrodes in each component of N200 and P300 were analysed.

At the component level of analysis (Table 1 and 2), the interaction effects between the emotional valence substrates (for both amplitude and latency) and the extraversion continuum were not significant.

Table 1. Interaction effect between the emotional valence substrate (amplitude) and personality: Component level analysis.

		Amplitude (Mean±SD)[1]			**F**	**Partial eta squared**	***P***
		H	**M**	**L**			
N200	E	2.2 ±5.1	2.2 ±4.9	2.0 ±4.8	1.5	0.0	0.19
	A	2.0 ±4.4	1.8 ±4.1	1.9 ±4.0			
	I	1.8 ±4.1	1.7 ±3.8	1.9 ±4.6			
P300	E	3.0 ±4.8	3.3 ±4.1	3.1 ±4.4	1.3	0.0	0.29
	A	2.6 ±7.4	2.6 ±4.6	2.6 ±4.1			
	I	2.2 ±5.0	2.28 ±3.8	2.6 ±5.5			

SD = Standard Deviation; 1. Unit in Microvolt (μv)
H=High, M=Moderate, L=Low
E=Extravert, A=Ambivert, I=Introvert

Table 2. Interaction effect between the emotional valence substrate (Latency) and personality: Component level analysis.

		Latency (Mean±SD)[1]			**F**	**Partial eta squared**	***P***
		H	**M**	**L**			
N200	E	274 ±68	273 ±71	275 ±68	1.5	0.0	0.20
	A	271 ±66	275 ±65	272 ±67			
	I	277 ±68	272 ±69	269 ±70			
P300	E	503 ±135	495 ±140	489 ±144	1.7	0.0	0.16
	A	497 ±136	505 ±139	498 ±138			
	I	490 ±135	503 ±136	488. ±136			

SD = Standard Deviation; 1. Unit in Milliseconds
H=High, M=Moderate, L=Low
E=Extravert, A=Ambivert, I=Introvert

However, when the analysis was carried out specifically at the electrode level (i.e. C3, C4, Cz, F3, F4, F7, F8, Fp1, Fp2, Fz, O1, O2, P3, P4, Pz, T3, T4, T5, and T6, for each component–N200 and P300), the interaction effects between the emotional valence substrates and the extraversion continuum were discovered at several electrodes (Table 3) as below:

(1) P3 electrode (latency) of N200 component [F(4, 174) = 2.8, p = 0.03, partial eta squared = 0.06]

(2) Cz electrode (latency) of P300 component [F(4, 174) = 3.0, p = 0.02, partial eta squared = 0.07]

(3) F8 electrode (amplitude) of N200 component [F (3.6, 157) = 3.1, p = 0.02, partial eta squared = 0.07].

Table 3. Interaction effect between the emotional valence substrate and personality: Electrode level analysis.

		Mean ± SD[1]			**F**	**Partial eta squared**	***P***
		H	**M**	**L**			
P3-N200[1]	E	290 ±66	247 ±63	282 ±61	2.8	0.1	0.03 *
	A	277 ±62	293 ±58	289 ±71			
	I	273 ±73	295 ±64	285 ±69			
Cz-P300[1]	E	607 ±69	538 ±103	590 ±111	3.0	0.1	0.02 *
	A	579 ±107	557 ±112	597 ±88			
	I	527 ±117	579 ±114	555 ±117			
F8-N200[2]	E	0.5 ±3.7	1.5 ±6.3	0.6 ±3.2	3.1	0.1	0.02 *
	A	0.7 ±1.9	0.0 ±2.1	0.0 ±1.7			
	I	0.5 ±3.0	0.0 ±2.7	1.7 ±4.2			

SD = Standard Deviation; 1. Latency in Milliseconds; 2. Amplitude in Microvolt (μv); *p<0.05
Note: Other electrodes are not significant.
H=High, M=Moderate, L=Low
E=Extravert, A=Ambivert, I=Introvert

Table 4 displays the source localisation information in extravert, ambivert and introvert as a result from the high valence experience. Several important findings are highlighted:

1. The broadman area index for both ERP components indicated a similar pattern. Extravert indicated the biggest coverage area followed by ambivert and introvert.
2. The intensity index for both ERP components also indicated a similar pattern. Extravert indicated the highest intensity followed by ambivert and introvert.
3. The temporal lobe area played a major role in the emotional valence processing as manifested by both components (N200, P300) in extravert, ambivert and introvert. Extravert exhibited a similar anatomical section in P300 and N200. However, ambivert and introvert indicated the involvement of anatomical section other than displayed in extravert.

Table 4. Source localisation of N200 and P300 in extravert, ambivert and introvert in high valence state.

		Personality		
		Extravert	**Ambivert**	**Introvert**
N200	Location	53, -74, 8	53, -46, -27	60. -53. -20
	Intensity	0.094 nA	0.060 nA	0.043 nA
	Brodmann Area (BA)	BA39	BA37	BA20
	Anatomy	Middle Temporal Gyrus, Temporal Lobe	Fusiform Gyrus, Temporal Lobe	Inferior Temporal Gyrus, Temporal Lobe
P300	Location	53, -74, 8	60. -53. -20	46, -74, -13
	Intensity	0.077 nA	0.048 nA	0.040 nA
	Brodmann Area (BA)	BA39	BA20	BA19
	Anatomy	Middle Temporal Gyrus, Temporal Lobe	Inferior Temporal Gyrus, Temporal Lobe	Middle Occipital Gyrus, Occipital Lobe

nA: nanoAmpere (nA)

IV. DISCUSSION

Understanding human behaviour has been a central focus of researchers for many years, with personality being a major area of interest. According to American Psychological Association (APA) (2020), it is believed that an individual's personality exerts a significant influence over their thought, emotions, and behaviour patterns. In addition, personality is believed to be a factor in the consistency of an individual's behaviour (Feist & Feist, 2008). Given the broad impact of personality on an individual's behaviour and its enduring nature, it is not surprising to observe its far-reaching effects, spanning diverse domains such as academic performance (Komarraju *et al.*, 2011), and susceptibility to psychological disorders (Haas *et al.*, 2008).

The ERP modality is frequently employed in research investigating extraversion (Roslan *et al.*, 2017) and the processing of emotional images (Olofsson *et al.*, 2008). This study aims to examine the correlation between extraversion traits and emotional stimuli by utilising extraversion traits and the valence quality of visual stimuli as the independent variables. The objective is to determine if there is a significant interaction between these variables that impacts the amplitudes and latencies of specific event-related potential (ERP) components. Although our overall findings did not provide support for the hypothesis of an interaction between the spectrum of extraversion and the processing of emotional valence, our analysis at the electrode level revealed significant emotional valence processes influenced by the extraversion spectrum. Specifically, we observed significant impacts on several electrodes, including P3 latency and F8 amplitude of N200, as well as Cz latency of P300. As compared to other electrodes, the F8-N200 amplitude showed significant interaction with the extraversion continuum. The partial eta squared value of 0.066 indicates that this interaction appears to exhibit a moderate effect size, as per Cohen's 1988 classification. These values are considerably smaller when contrasted with the significant results' partial eta squared reported in other related studies (i.e., Rozenkrants & Polich, 2008), or eta squared values (Olofsson & Polich, 2007; Yuan *et al.*, 2012). The insignificant of majority electrodes in this study, perhaps, mirrored the previous documentation, i.e. (Rozenkrants & Polich, 2008). The variability in findings concerning the impact of emotional valence on ERP amplitude can be ascribed to various factors. Additionally, each component of the ERP corresponds to distinct phases of emotional processing, leading to variations in amplitude measurements driven by different aspects of the study designs.

The majority of individual electrodes for the P300 component did not yield statistically significant results. However, a specific electrode, Cz (representing latency), did exhibit a significant interaction with the valence quality variable. This finding aligns with prior studies that have demonstrated the influence of valence on the P300 component (Olofsson & Polich, 2007; Rozenkrants & Polich, 2008; Yuan *et al.*, 2012). The inconsistency in results regarding the impact of emotional valence on modulating ERP amplitude for the P300 component mirrors the variability observed in earlier latency findings. One contributing factor is the substantial influence of task relevance on P300 amplitude. This might elucidate why studies showing significant valence modulation often incorporated specific tasks targeting participant engagement. In contrast, our study employed passive viewing, in line with previous research indicating that valence-dependent effects are less pronounced in passive viewing studies (Olofsson *et al.*, 2008). This difference in valence effects on the P300 component may be attributed to the smaller and less consistent P300 waveform observed during passive viewing compared to active tasks, highlighting the importance of task relevance in the P300 component (Bennington & Polich, 1999).

The lack of significant results for most electrodes could potentially find an explanation in the Affective Reactive Hypothesis (ARH). According to the ARH, extraversion traits primarily impact emotional valence in the context of positive stimuli or pleasant experiences, as suggested by Oerlemans & Bakker (2014). This notion appears to be supported by a study conducted by Canli *et al.* (2001). If extraversion traits exclusively influence the perception of high-valence images, it becomes less likely for a statistically significant interaction to emerge, as the remaining two groups within the valence quality variable are unaffected.

This study is based on the assumption that extraverts frequently report higher levels of subjective well-being than non-extraverts. However, the current ERP study encounters limitations in explaining this assertion, primarily due to constraints related to the visual stimuli used. In prior research, extraverts have been suggested to exhibit a stronger response than introverts, particularly in the case of appetitive stimuli, such as the pursuit of rewards (Smillie *et al.*, 2012). These appetitive stimuli are believed to activate the positive aspect of extraversion, encouraging motivation for reward pursuit and facilitating goal-directed behaviour (Inglis *et al.*, 2018). Additionally, the positive impact of these experiences is likely enhanced when the rewarding activities involve social interactions with others (Oerlemans & Bakker, 2014). Furthermore, it has been proposed that extraverts not only have heightened responses to positive stimuli but also maintain positive affect for longer durations through mood regulation (Lischetzke *et al.*, 2012). This habitual mood maintenance results in a slower decline of positive mood following its initiation and a propensity to experience positivity even in ambivalent situations (Lischetzke & Eid, 2006). However, it is important to note that measuring these effects was beyond the scope of this study.

While ERP latency parameters are often overlooked and receive less attention in ERP literature (Olofsson *et al.*, 2008; Olofsson & Polich, 2007; Rozenkrants & Polich, 2008; Fishman *et al.*, 2011; Roslan *et al.*, 2017; Yuan *et al.*, 2012), we observed a significant interaction effect in the latency parameter, specifically indexed by P3-N200 and Cz-P300. Typically, latency is a relatively minor consideration in ERP studies, and only a few known factors have been suggested to influence ERP latency readings. One of these factors is age, with studies proposing a U-shaped effect, where latency is higher in very young and very old individuals but lower in young adults and adults (Mueller *et al.*, 2008). This phenomenon is believed to be related to changes in selective attention and working memory as individuals age (Finnigan *et al.*, 2011; Pinal *et al.*, 2015; Reuter *et al.*, 2019). Given that this study involved participants from the same age group, the influence of age on latencies is expected to be minimal. Certain disorders have also been linked to alterations in ERP latencies, such as attention deficit hyperactivity disorder (ADHD) (Fisher *et al.*, 2011) and multiple sclerosis (Whelan *et al.*, 2010). However, since our study included generally healthy participants, it is unlikely that these disorders significantly impacted the ERP latencies.

The source localisation process aimed to identify regions with the highest intensity, based on Brodmann area classification and anatomical features. Among the ERP components, extraversion traits, and valence quality, Brodmann area 37 consistently emerged as the most prominent area. This area displayed the highest intensity for the N200 in ambiverts. Furthermore, both the N200 extravert and P300 extravert also showed source localisation in area 37, specifically in cases involving low valence. Brodmann area 37, also known as the occipitotemporal gyrus, primarily functions in language and visual processing (Strotzer, 2009). This area extends into the fusiform gyrus, which is closely associated with memory circuitry and complex visual functions, including facial recognition (Trans Cranial Technologies, 2012). It's worth noting that Brodmann area 37 is part of the ventral stream system, alongside areas 17, 18, and 19, and plays a key role in distinguishing and identifying visual shapes and objects (Ardila *et al.*, 2015; Hebart & Hesselmann, 2012). On the other hand, for moderate valence, the N200 introvert and P300 introvert exhibited their highest intensity in Brodmann area 36, specifically in the parahippocampal gyrus of limbic lobe and uncus. Brodmann area 30 is thought to be associated with visual attention, while Brodmann area 36 is suggested to play a role in emotion perception (Strotzer, 2009). These findings may provide insights into why these areas exhibited the highest intensity in certain categories. In addition, Brodmann area 31, which corresponds to the cingulate gyrus within the limbic lobe, emerged as the region with the highest intensity. Area 31 is believed to be involved in tasks such as familiar face recognition, visuospatial imagery, and the retrieval of episodic memory (Strotzer, 2009).

Brodmann area 20, situated within the inferior temporal gyrus of the temporal lobe, exhibited the highest intensity during the high valence condition of the P300 in ambiverts. This region is believed to be involved in memory functions and various visual processes, including high-level visual processing and the integration of visual elements (Trans Cranial Technologies, 2012). Furthermore, area 20 is thought to contribute to the attribution of emotional significance to visual stimuli, such as facial expressions and colours, as part of its visual association processes (Strotzer, 2009). Additionally, two other Brodmann areas within the temporal lobe displayed high intensity. Brodmann area 38, also known as the temporopolar area within the superior temporal gyrus, served as the localised source for the low-valence P300 in introverts. This area has been suggested to play a significant role in emotional processing, encompassing functions related to emotional attachment, processing of emotional images, experiencing emotional states, and responding to aversive stimuli (Trans Cranial Technologies, 2012). It appears to connect visceral emotional responses to processed stimuli (Olson *et al.*, 2007). Brodmann area 39, known as the angular area, was identified as the highest intensity region for both high and low-valence P300 in extraverts. This area also engages in visual processing tasks like face recognition and reading (Strotzer, 2009). Furthermore, it is associated with visuospatial processing and attention to spatial imagery (Trans Cranial Technologies, 2012).

For the P300 in ambiverts during the moderate valence condition, the orbital gyrus of the frontal lobe, specifically Brodmann area 11, exhibited the highest intensity. While this area is typically associated with olfactory functions and social behaviour, it has been suggested to have a role in decision-making processes related to reward (Trans Cranial Technologies, 2012).

Overall, the results of the source localisation analysis point to regions within the temporal lobe, occipital lobe, and limbic lobe as having the highest intensity, except for one category that exhibited a frontal lobe area. While the precise functions of these areas remain to be precisely determined, there is a consensus that they are involved in various aspects of information processing. These functions include visual processing, facial recognition, emotional processing, attention, and memory, all of which align with the participants' affective responses to the emotional visual stimuli presented. Some studies have suggested that when neural activation occurs as a result of processing emotional visual stimuli, three key factors—emotional valence, arousal, and attention—each independently contribute to increased activity in the visual cortex and temporal region. These influences work in concert throughout the process of visual analysis (Lane *et al.*, 1999).

This study has important clinical implications that can improve different aspects of psychological and therapeutic treatment. The findings add to our understanding of how personality qualities, such as extraversion, influence emotional processing, with implications for a number of clinical domains. Finding out a person's extraversion degree, for example, during therapy could help them come up with better techniques to control their emotions. Including personality tests, such as extraversion scores, in psychological examinations could provide a more complete picture of emotional responses, making clinical diagnoses and developing tailored treatment plans easier. Furthermore, increased knowledge of cultural and methodological implications on the differences between extraverts and non-extraverts emphasises the importance of doctors navigating potential biases across different groups. Furthermore, the study's finding of specific brain regions associated with different methods of processing emotions, as explained by sLORETA, provides potential for developing targeted neurofeedback interventions that could help people, particularly extraverts, better manage their emotions.

Several limitations are present in this study. First, classifying images based on valence into only three categories (high, moderate, and low) may oversimplify the perception of emotional inputs. Many studies take a more complex approach, further categorising pleasant and unpleasant stimuli as high- or low-valence evaluations. Because strong valence-related ERP effects may show only in certain subcategories, such as high unpleasant stimuli, when grouped into a general unpleasant stimuli category, this simplification risks losing subtle effects. Second, the study's usage of a very limited number of distinct images (30 total, with 10 per valence group) falls short of comparable research's larger image counts (usually 15 or more photos per category). While employing more distinct images reduces the potential influence of stimulus repetition on ERP measurements, it does lengthen the viewing session, which may present practical issues. Finally, while the study's passive viewing strategy is appropriate for evaluating emotional responses, it raises questions regarding participants' continuous attention throughout the session. Adding interactive slides at random intervals to assure participant involvement, as done in previous studies, could improve attention retention during passive viewing periods and is worth further investigation.

V. CONCLUSION

The neural substrates responsible for the emotional valence process in extraversion appear to be localised in a relatively limited brain region as reflected by a few electrodes in the parietal, frontal and central parts, with a significant level of p less than 0.05. Nevertheless, the notion that extraverts exhibit heightened sensitivity to highly valence emotional visual stimuli and resistance to those with low valence remains somewhat inconclusive. The elicitation of positive effects in extraverts seems to be influenced by additional factors, including the presence of rewarding stimuli, social context, and mood regulation. Furthermore, the specific pattern of emotional valence observed in this study prevents any definitive conclusions regarding the interplay between extraversion and visual stimuli featuring varying valence qualities.

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VII. REFERENCES

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