Universidade de Aveiro Departamento de Educação e Psicologia
Ano 2018

ANA TERESA AMADOR PEREIRA

O PAPEL DO NEUROTICISMO NO PROCESSAMENTO EMOCIONAL: EVIDÊNCIAS DE ESTUDOS COMPORTAMENTAIS E PSICOFISIÓLOGICOS

THE ROLE OF NEUROTICISM IN EMOTIONAL PROCESSING: EVIDENCE FROM BEHAVIOURAL AND PSYCHOPHYSIOLOGICAL STUDIES

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Tese apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Psicologia, realizada sob a orientação científica da Doutora Isabel Maria Barbas dos Santos, Professora Auxiliar do Departamento de Educação e Psicologia da Universidade de Aveiro e co-orientação do Doutor Carlos Fernandes da Silva, Professor Catedrático do Departamento de Educação e Psicologia da Universidade de Aveiro

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Dedico este trabalho à minha família e aos meus amigos.

o júri

presidente

Prof. Doutora Ana Isabel Couto Neto da Silva Miranda
Professora Catedrática da Universidade de Aveiro

Prof. Doutor Fernando Ricardo Ferreira Santos
Professora Auxiliar da Universidade do Porto

Prof. Doutora Sara Margarida Soares Ramos Fernandes
Professora Auxiliar da Universidade Portucalense Infante D. Henrique

Prof. Doutora Maria de Fátima Jesus Simões
Professora Associada com Agregação da Universidade da Beira Interior

Doutora Josefa das Neves Simões Pandeirada
Equiparada a Investigadora Auxiliar da Universidade de Aveiro

orientador

Prof. Doutora Isabel Maria Barbas dos Santos
Professora Auxiliar da Universidade de Aveiro

agradecimentos

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palavras-chave

Neuroticismo, word-face Stroop, conflito emocional, face, palavras, ERP, P1, N170, EPN, N450, Conflict SP

resumo

No nosso quotidiano somos confrontados com situações nas quais múltiplos estímulos competem pela nossa atenção, tendo que escolher a qual deles atender. Com o objetivo de selecionar a informação importante e ignorar ou inibir os estímulos distractores, o nosso sistema cognitivo baseia-se, não só em mecanismos emocionais e atencionais mas também em características pessoais. Assim sendo, neste trabalho, pretendemos explorar a influência do neuroticismo no processamento do conflito emocional, com uma tarefa na qual dois estímulos emocionais competem entre si. O neuroticismo é um traço de personalidade associado a ansiedade, depressão, vulnerabilidade, perturbações de humor, regulação emocional enfraquecida e dificuldades na inibição de informação distractora. A capacidade de resolução do conflito emocional foi testada através da apresentação de palavras emocionais sobrepostas em faces emocionais numa tarefa *word-face Stroop*, na qual foram usadas palavras positivas, negativas e neutras e faces de alegria, raiva, medo, nojo, tristeza e neutras. Assim, as palavras podiam ser congruentes ou incongruentes com a expressão emocional da face (e *vice-versa*), gerando efeitos de facilitação ou interferência, respetivamente. Foi pedido aos participantes para avaliarem a valência – positiva, negativa ou neutra – de palavras e faces, em tarefas separadas. O nosso objetivo foi comparar o processamento explícito e implícito de diferentes expressões faciais. Para tal, foram utilizados potenciais evocados no sentido de investigar as dinâmicas temporais do conflito.

Os resultados apontaram para maiores efeitos de interferência em participantes com elevado neuroticismo em comparação com participantes com baixo neuroticismo. Nos participantes com elevado neuroticismo, foi encontrado um efeito facilitador do processamento implícito de faces negativas na avaliação da valência de palavras negativas – estímulos congruentes – que foi mais forte em caras de medo, apontando para a sua saliência e relevância neste grupo de participantes. Relativamente ao conflito emocional causado por palavras e faces emocionais, encontrámos efeitos de interferência das palavras emocionais nas faces emocionais e o contrário. Na tarefa de avaliação da valência das faces, além de efeitos de congruência e de facilitação do reconhecimento de faces de alegria e nojo, encontrámos também efeitos de facilitação e interferência de palavras emocionais nas condições de tristeza e medo. Na tarefa de avaliação da valência das palavras, encontrámos efeitos de facilitação de caras de medo e raiva na avaliação da valência de palavras negativas, mas apenas encontrámos efeitos de interferência das caras de raiva, visto que as de medo parecem não interferir com a avaliação da valência de palavras positivas.

O neuroticismo influenciou todos os potenciais evocados analisados neste trabalho. Mais ainda, foram encontradas influências da saliência e valência emocional, em ambas as tarefas, na P1. Por fim, verificámos que os potenciais evocados N170, EPN, N450 e *Conflict SP* foram modulados pelo conflito emocional.

O presente trabalho apresenta dados importantes acerca da influência do neuroticismo no conflito emocional, nas suas dinâmicas temporais e no processamento implícito e explícito de faces e palavras que podem ajudar-nos a compreender os enviesamentos emocionais de pessoas com elevado neuroticismo.

keywords

Neuroticism, word-face Stroop, emotional conflict, faces, words, ERP, P1, N170, EPN, N450, Conflict SP

abstract

In everyday life, we face situations where multiple stimuli are presented, sometimes competing, and we are required to choose which ones to attend. In order to select the important information from the environment and ignore or inhibit the distracting stimuli, our cognitive system often relies on emotional and attentional mechanisms and is also influenced by individual characteristics. Therefore, in this work, we proposed to study the influence of neuroticism on the processing of emotional conflict, based on a task where two emotional stimuli are competing for processing. Neuroticism is a personality trait associated with anxiety, depression, vulnerability to mood disorders, poor emotional regulation and difficulties in inhibiting the distracting information. We tested participants' ability to solve emotional conflict by presenting them emotional words superimposed on emotional faces in a word-face Stroop task. We used positive, negative and neutral words and happy, angry, fearful, disgusted, sad and neutral faces. Thus, words could be either congruent or incongruent with the facial expression (and *vice-versa*), generating facilitation or interference effects, respectively. Participants were asked to make valence judgements – positive, negative or neutral – of faces and words, in different tasks. We aimed to compare the explicit and implicit processing of different facial expressions and we used event-related potentials to study the temporal dynamics of the conflict.

Results suggested that high neuroticism participants suffered more interference effects than low neuroticism participants. A facilitation effect of the implicit processing of negative faces on negative word valence assessment – congruent stimuli – in high neuroticism participants was also found and was stronger for fearful faces suggesting its emotional salience and relevance for these subjects. In relation to the emotional conflict caused by emotional words and faces, we found interference effects from emotional words in emotional faces and the opposite. In the face valence assessment task, along with congruency effects and a facilitation of happy and disgusted face recognition, we found facilitation and interference effects of emotional words in sadness, fear and disgust conditions. In the word valence assessment task, we found facilitation effects of fearful and angry faces in the assessment of negative words, but only found interference effects from angry faces, since fearful faces seemed not to interfere with positive word valence assessment.

Neuroticism influenced all ERPs analysed in this work. We also found an influence of stimuli's emotional valence and salience, in both tasks, in P1. Moreover, N170, EPN, N450 and Conflict SP were modulated by emotional conflict.

The present work provides important findings regarding the influence of neuroticism in the emotional conflict, its temporal dynamics and the implicit and explicit processing of faces and words that can help to understand the cognitive and emotional biases of high neuroticism individuals.

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LIST OF ABBREVIATIONS

16 PF .... Sixteen Personality Factor Questionnaire
ACC .... Anterior Cingulate Cortex
Ag/AgCl .... Silver/Silver Chloride
ANEW .... Affective Norms for English Words
ANOVA .... Analysis of Variance
Conflict SP .... Conflict Slow Potential
CP .... Centro-Parietal sites
d. f. .... Degrees of freedom
dlPFC .... dorsolateral PreFrontal Cortex
EEG .... Electroencephalography
EPN .... Early Posterior Negativity
EPQ .... Eysenck Personality Questionnaire
ERN .... Error-Related Negativity
ERP .... Event-Related Potential
FEI Face Database .... Face Database from the *Centro Universitário da Fundação Educacional Inaciana*
FFA .... Fusiform Face Area
FFM .... Five-Factor Model of Personality
fMRI .... functional Magnetic Resonance Imaging
FVA .... Face Valence Assessment
GES .... Goal Engagement System
KDEF .... Karolinska Directed Emotional Faces
LGN .... Lateral Geniculate Nucleus
LH .... Left Hemisphere
LPC .... Late Positive Complex
LPP .... Late Positive Potential
M .... Mean
MDD .... Major Depressive Disorder
NEO PI-R .... Revised NEO Personality Inventory
PFC .... PreFrontal Cortex
PICS .... Psychological Image Collection at Stirling
POs .... Parieto-Occipital sites
Ps .... Parietal sites

PVA .... Positive Valence Advantage
RH .... Right Hemisphere
SD .... Standard Deviation
SE .... Standard Error
SPSS .... Statistical Package for the Social Sciences
STG .... Superior Temporal Gyrus
vEAP .... very Early Anterior Positivity
VES .... Valence Evaluation System
vlPFC .... ventrolateral PreFrontal Cortex
WFS .... Word-Face Stroop
WVA .... Word Valence Assessment

CHAPTER 1: LITERATURE REVIEW

INTRODUCTION

The work carried out and described in the present thesis is divided in six chapters. The first chapter encompasses the Literature Review and is divided in five topics of interest. In this chapter we will present the main theories and findings related to our objectives. We will describe the emotional and attentional mechanisms that underlie the processing of emotional conflict, present the major findings and theories of the emotional processing of faces and words, and introduce the Stroop effect. Then, various Stroop-like tasks will be presented: the emotional Stroop, the picture-word Stroop, and the word-face Stroop that was used in our experiments to test the automaticity processing of words and faces. Next, we will briefly outline the history behind the Five-Factor Model of Personality and introduce in more detail the neuroticism personality trait. Next, we will present the relation between neuroticism and cognitive and emotional conflicts.

In Chapters II, III, and IV, three experiments will be described in detail and for each one we will present a brief introduction to the experiment, its methods, results, and discussion.

In Chapter V, we will discuss all results described in Chapters II, III and IV and we will also draw conclusions and final remarks about this work.

EMOTION AND ATTENTION

In everyday life, we need to adapt to changes and demands in the environment. We need to attend to the relevant information and inhibit the irrelevant in order to prevent an information overload and strategically select the correct response required by a particular situation. Our cognitive system often relies on emotion to decide which stimuli we attend to, approach or avoid first. So, emotions play an important role in this selection process because they give preferential access to some essential information, modify perception, manage attention and actions and are responsible for the communication of socially relevant information. Emotional stimuli, like emotional words, faces or pictures attract more attention than neutral ones because they are more salient and, therefore, activate the amygdala and other limbic structures responsible for a fast evaluation and response to emotional stimuli, specially the threatening ones (Bayer, Sommer, & Schacht, 2012; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Damásio, 2003; Egner, Etkin, Gale, & Hirsch, 2008; Eimer, Holmes, & McGlone, 2003; Jimura, Konishi, & Miyasshita, 2009; Kissler, Herbert, Winkler, & Junghofer, 2009; Lang, Bradley, & Cuthbert, 1998; Lang, Bradley, & Cuthbert, 2005; Lang & Davis, 2006; MacLeod & MacDonald, 2000; Pratto & John, 1991; Rellecke, Palazova, Sommer, & Schacht, 2011; Schacht & Sommer, 2009; Schupp et al., 2004; Vuilleumier, 2005; Vuilleumier, Armony, Driver, & Dolan, 2001; Yiend, 2010; Zhu & Luo, 2012).

Emotional responses depend on stimulus properties, task demands, attention and individual characteristics (Okon-Singer, Lichtenstein-Vidne, & Cohen, 2013; Yiend, 2010). The expression of these responses includes three reaction systems: expressive and evaluative language, psychophysiological changes (somatic and autonomic systems) and behaviour (Lang et al., 1998). The influence of stimulus properties in emotional responses can be explained by the type of stimuli and its emotional value. There is a wide variety of stimuli commonly used in emotional studies – faces (real or schematic), words, music, sounds, pictures, films, voices – that differ in their processing neural circuits, duration, sensorial dimension, physical characteristics, just to name a few (Okon-Singer et al., 2013; Yiend, 2010). On the other hand, there are several factors that can determine the emotional value of a stimulus, namely basic emotions (Ekman & Oster, 1979; Oatley & Jenkins, 1996b), arousal and valence dimensions (Russell, 1980), approach-avoidance dimensions (Lang et al., 1998) and relevance (Okon-Singer et al., 2013).

According to the pioneer work of Charles Darwin (1897) and, more recently, Paul Ekman (1992), there are a set of basic emotions that are present across cultures and species: happiness, anger, fear, surprise, disgust and sadness. These emotions share some characteristics with other emotions, such as rapid onset, short duration, unbidden occurrence, automatic appraisal mechanism and coherence among responses. However, they have unique features that differentiate them from others: distinctive universal signals (emotional expression), emotion-specific physiology, universals in antecedent events (the context in which the emotion occurs is similar across cultures) and presence in other primates.

Stimuli value can be evaluated not only by specific emotions or categories but also by their arousal and valence dimensions – the valence-arousal approach (Posner, Russell, & Peterson, 2005; Russell, 1980). The Circumplex Model of Affect suggests that emotions can vary along two axes: arousal (ranging from deactivation to activation, expresses the sensation of energy or stimulus intensity) and valence (ranging from unpleasant to pleasant, expresses positive or negative feelings towards the stimuli) (Gerber et al., 2008; Posner et al., 2005; Russell, 1980). Typically, the more extreme the stimulus valence, the more arousing it will be (Bradley, Codispoti, Cuthbert, & Lang, 2001; Lang, Bradley, & Cuthbert, 1999; Mikels et al., 2005; Soares, Comesaña, Pinheiro, Simões, & Frade, 2012); nevertheless, Ito, Cacioppo, and Lang (1998) found strong correlations between arousal and negative stimuli and weak correlations between arousal and positive stimuli. Okon-Singer et al. (2013) suggested that when the emotional stimuli is relevant to the task, its valence may be more decisive to subjects' performance; in turn, when the emotional stimuli is not relevant to the task, arousal can play a more important role than valence, that is, the higher the stimulus arousal, the higher its interference in the current task (Osinsky, Gebhardt, Alexander, & Hennig, 2012). The valence component of this model had substantial influence in the motivated attention model of affect and its approach and avoidance dimensions. Several authors (Lang et al., 1998; Mauer & Borkenau, 2007) affirmed that affects are organized into two motivational systems in our brain: appetitive and defensive/aversive. They can be characterized by behavioural responses of approach to positive, appetitive stimuli and withdrawal, avoidance to aversive, threatening stimuli, respectively, that are essential behaviours for survival. According to this approach, our emotional system is organized in positive (pleasant: happiness, pleasure, contentment) and negative (unpleasant: anger, fear, sadness, gloom, depression) states. Two distinct activations are generated from the segregation between positive and negative emotions and appetitive and aversive motivational forces – the positivity offset (allows the exploratory behaviour, optimism and hope) and the negativity bias (sensitivity for negative information, stronger and faster physiological, cognitive, emotional and social reactions or responses to negative compared to positive and neutral stimuli; it helps to avoid threatening events in the environment) (Cacioppo & Gardner, 1999; Lang et al., 1998).

At last, the emotional value of a stimulus also depends on its relevance, which is influenced by individual differences and context demands. The greater the stimulus relevance, the greater its influence on a subject's performance (Okon-Singer et al., 2013). Regarding the influence of task demands and attention on emotional responses, Okon-Singer et al. (2013) claimed that attention and cognitive overload play an important role in this process. Posner and Petersen (1990) proposed three subsystems of attention: orienting, detecting and alerting. The first one describes the attentional orienting process: disengaging (inhibit or withdraw attention from a current location), shifting (shift attention to another location) or engaging (maintain attention to the new location). The second is related to the detection of signals for focal (conscious) processing and the third refers to the maintenance of a vigilant/alert state. Some researchers have also identified an executive system responsible for monitoring and controlling other attentional subsystems which are also related to solving emotional conflict (Eysenck & Derakshan, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007; Luo, Feng, He, Wang, & Luo, 2010; Yiend, 2010; Zhu & Luo, 2012).

Due to stimulus proprieties (described above) our attention is captured by emotional rather than neutral stimuli; emotional stimuli can even increase the psychophysiological state of alert. So, emotional stimuli influence attention but attention processes also modulate emotional processing (Okon-Singer et al., 2013; Posner & Petersen, 1990). Another proof of the interaction between emotional and attentional systems is the study of cognitive overload in emotional processing. When our cognitive system is overloaded with information, the activity in brain areas responsible for emotional processing decrease and the activity in brain areas responsible for cognitive and executive control increase, that is, the emotional response can be attenuated under high cognitive load. This process results in higher interference of emotional distractors due to the inability of the executive control system to maintain the processing priority of the relevant emotional stimuli (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Okon-Singer et al., 2013; Pessoa, 2008; Vuilleumier, 2005).

Finally, individual characteristics such as personality, mood and psychological disorders, can also influence emotional responses (Okon-Singer et al., 2013). These influences will be discussed in the following chapters.

1. EMOTIONAL FACE PROCESSING

Compared to other stimuli, faces are highly significant biologically, emotionally and socially for all human beings, across all cultures. Faces give important information about the emotional state of an individual, therefore they are a fundamental source of communication (Adolphs, 2002; Eimer & Holmes, 2007; Ekman, 1992; Ekman & Oster, 1979; Fox & Zougkou, 2011). Humans are highly effective in facial emotion recognition, especially if it is salient, distinctive or/and threat related (Fox & Zougkou, 2011; Schupp et al., 2004).

Bruce and Young (1986) proposed a model for face processing (see Figure 1) in which identity recognition and facial emotion recognition are two separate processes. Facial recognition begins with the structural coding, that is, the perceptual processing of the face, its configuration and features. These view-centered descriptions are the basis for expression analysis, facial speech analysis and directed visual processing that will be conducted to the cognitive system for further and more conceptual analysis. At the same time, the expression-independent descriptions will activate the facial recognition units which will allow the person's recognition or identity by comparing the stored structural codes to the ones belonging to the face we are seeing at the moment. Then, the facial information reaches the person's identity nodes that contain all the information we have stored about a given person. There is one node for each person we know and that node can be assessed without activating the facial recognition units, that is, we can recognize a person by other characteristics (their voice, for instance). The following step is to name the face that we are seeing. Then, all information will be conducted to the cognitive system for further analysis.

Another model for face processing was proposed by Haxby, Hoffman, and Gobbini (2000) (Figure 2). This neuroanatomical model suggests that face processing is divided into two systems: a core system which is responsible for face visual analysis and an extended system which is responsible for further processing which includes several neural systems. The perceptual features of the face are analyzed in the inferior occipital cortex; this information is then divided into the mutable and immutable facial characteristics for further and separate analysis in specific neural regions. All the connections between neural structures are bidirectional which allows the bilateral flow of information.

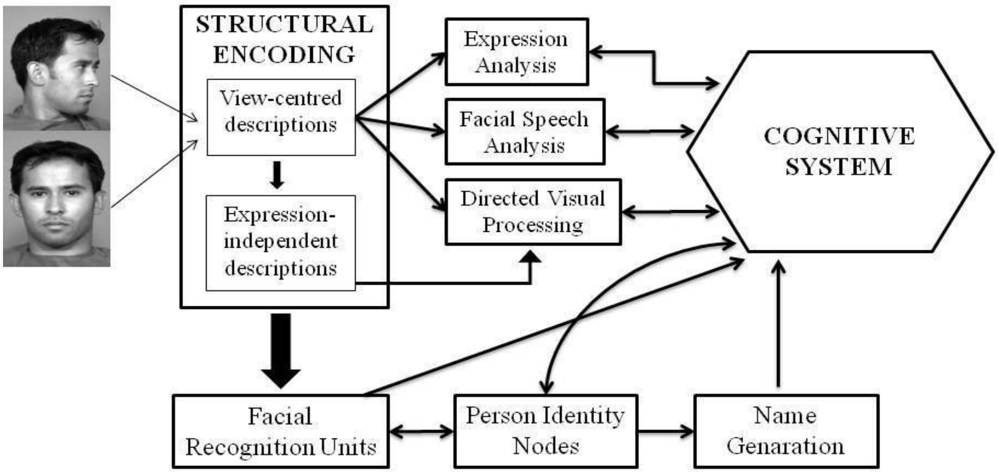


Figure 1: A functional model for face processing. Reprinted from British Journal of Psychology, 77, V. Bruce & A. Young, Understanding face recognition, p. 305, Copyright (2018), with permission from John Wiley and Sons.

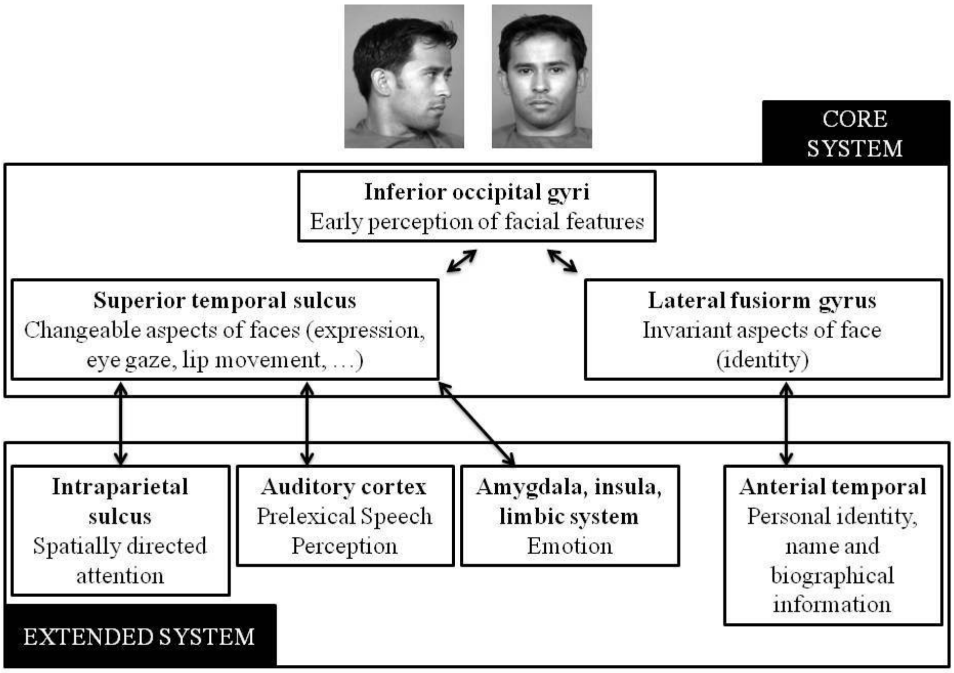


Figure 2: A neuroanatomical model for face processing Reprinted from *Trends in Cognitive Sciences*, 4, J. V. Haxby, E. A. Hoffman, & M. I. Gobbini, The distributed human neural system for face perception, p. 230, Copyright (2018), with permission from Elsevier.

Adolphs (2002) brought together both models of face processing in order to explain facial expression recognition (Figure 3). Facial emotional recognition begins with the initial processing of the face (Adolphs, 2002; Eimer & Holmes, 2007; Hole & Bourne, 2010). Several studies point to a strong influence of stimuli physical features and valence in early processing stages (100 – 200 ms), that is, stimuli are processed according to their valence and emotional salience is one of the first information extracted from them (Olofsson, Nordin, Sequeira, & Polich, 2008; Vuilleumier, 2005). Evidence comes from P1 analysis. P1 is a positive wave, peaking approximately between 100 – 130 ms, in occipital locations and it is observed in response to all visual stimuli because it is task and goal independent (Luck & Kappenman, 2012); it is sensitive to the processing of the physical features and valence of the stimuli, to attentional manipulations and even to the subject's state of arousal (Batty & Taylor, 2003; Luck, 2005; Luck, Woodman, & Vogel, 2000; Pourtois, Grandjean, Sander, & Vuilleumier, 2004; Van Strien, Langeslag, Strekalova, Gootjes, & Franken, 2009). Some studies showed higher P1 amplitude evoked by negative compared to positive and neutral stimuli, indicating higher sensibility and attention allocation to negatively valenced stimuli, giving them processing priority (Batty & Taylor, 2003; Delplanque, Lavoie, Hot, Silvert, & Sequeira, 2004; Holmes, Nielsen, & Green, 2008; Huang & Luo, 2006; Olofsson et al., 2008; Pourtois et al., 2004; Schupp et al., 2004). Eimer and Holmes (2007), for instance, reported higher P1 positivity for fearful compared to neutral faces at 120 ms. Rellecke et al. (2011), however, claim more positive P1 amplitudes for happy than for neutral faces.

Then, at approximately 170 ms after onset, a more detailed processing takes place in order to build a facial representation that will allow identity and facial emotion recognition. The N170 is a negative deflection found in occipito-temporal brain regions, peaking between 120 – 220 ms (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Eimer & Holmes, 2007; Luck, 2005); it has been associated with face processing in general (it is found even in implicit face processing, when faces must be ignored, or when they are not the target of the task) and with the beginning of structural face encoding processes (Holmes, Vuilleumier, & Eimer, 2003; Luck, 2005; Pratt, 2012; Rossion & Jacques, 2012). N170 amplitude tends to be more negative and right lateralized for face *versus* non-face stimuli (Bentin et al., 1996; Rossion & Jacques, 2012). The N170 is also sensitive to attentional processes (Holmes et al., 2003). Some studies showed a modulation of this event-related potential (ERP) by facial expression. Blau, Maurer, Tottenham, and McCandliss (2007) found that fearful faces evoked larger N170 amplitudes than neutral faces and Batty and

Taylor (2003) found the same results for fearful faces compared to all other facial emotions. In this last study, the N170 component appeared later for fearful, sad and disgust faces compared to neutral, happy and surprised faces. Rossignol, Philippot, Douilliez, Crommelinck, and Campanella (2005) also found a larger N170 for fearful faces only compared to happy faces. There is also evidence for a more enhanced N170 for angry compared to happy and neutral faces (Batty & Taylor, 2003; Hajcak, Weinberg, MacNamara, & Foti, 2012). Marinkovic and Halgren (1998) discovered a higher N170 amplitude for happy than sad and neutral faces. At around this temporal window (160 ms), Eimer and Holmes (2002), Holmes et al. (2003), Eimer et al. (2003) and Eimer and Holmes (2007) found higher positivity in fronto-central sites for emotional compared to neutral faces.

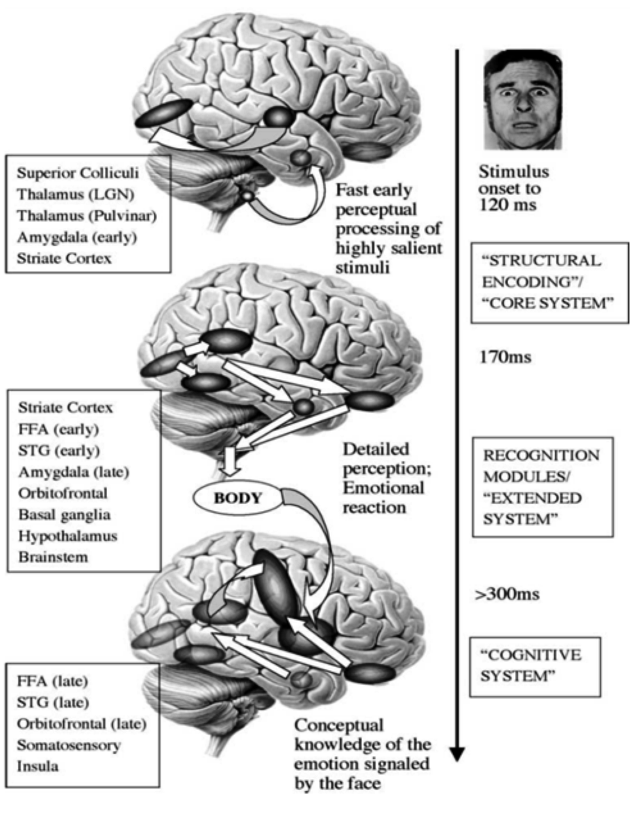


Figure 3: Model of facial expression recognition (LGN – Lateral Geniculate Nucleus; FFA – Fusiform Face Area; STG – Superior Temporal Gyrus). Reprinted from Behavioral and Cognitive Neuroscience Reviews, 1, R. Adolphs, Recognizing emotion from facial expressions: Psychological and neurological mechanisms, p. 52, Copyright (2018), with permission from SAGE Publications.

Eimer et al. (2003) also found higher negativity in posterior sites, between 220 – 320 ms for fear compared to neutral faces. In this time window, an important ERP component is frequently found – the Early Posterior Negativity (EPN) – a relative negativity found at occipito-temporal sites (Citron, 2012; Hajcak et al., 2012; Junghöfer, Bradley, Elbert, & Lang, 2001; Rellecke et al., 2011). It reflects attentional processes towards emotional stimuli, implicit and automatic emotional processing, being sensitive to stimuli emotional content (Bayer et al., 2012; Citron, 2012; Hajcak et al., 2012; Junghöfer et al., 2001; Kissler et al., 2009; Schacht & Sommer, 2009; Schupp et al., 2004). The EPN is also involved in the rapid detection, attentional and processing priority of the face (Eimer & Holmes, 2007; Holmes et al., 2008) and is more negative for negative faces compared to positive and neutral faces (Holmes et al., 2008; Rellecke et al., 2011; Schupp et al., 2004). There is also evidence for a more negative EPN for emotional compared to neutral faces (Eimer et al., 2003; Hajcak et al., 2012; Schacht & Sommer, 2009).

According to the face processing model proposed by Adolphs (2002), in later stages, our brain compares the stored information about the emotional and social significance of the face and all the conceptual knowledge that we have about it with the information of the facial expression we are facing, and attention is allocated to some of its characteristics. Finally, we generate a conscious representation of the facial emotion, feelings about the internal emotional state of the face we are seeing and strategically control thoughts and actions towards that face (Adolphs, 2002; Eimer & Holmes, 2007). In these later stages, EEG (Electroencephalography) potentials like the LPC[1] (Late Positive Complex) related to superior cognitive stages of stimuli processing and enhanced encoding of facial expressions, can appear. This late potential begins at approximately 300 ms after stimuli onset and can be found at centro-parietal sites. It is sensitive to attentional manipulations, to stimuli emotional content and its motivational salience, being larger for emotional compared to neutral stimuli (Cuthbert et al., 2000; Hajcak et al., 2012; Hinojosa, Carretié, Valcárcel, Méndez-Bértolo, & Pozo, 2009; Schacht & Sommer, 2009; Schupp et al., 2004). Several studies found evidence of a larger LPC elicited by unpleasant compared to pleasant pictures (Briggs & Martin, 2009; Hajcak et al., 2012; Huang & Luo, 2006; Ito et al., 1998) and Williams, Palmer, Liddell, Song, and Gordon (2006) and Schupp et al. (2004) found higher LPC amplitudes specifically for fearful and angry (threatening) faces. In turn, Batty

[1] LPC can also be called LPP (Late Positive Potential) or P3b

and Taylor (2003) found higher mean amplitudes for neutral faces, significant lower mean amplitudes for angry faces and a tendency for fearful and disgust faces, in an implicit face processing task, in the 360 – 390 ms time window. These discrepancies can de due to differences in task demands. But, we do know that angry and fearful faces have high arousal and intrinsic relevance and, consequently, they can capture more attention and engage in more elaborative processing in later stages (Beall & Herbert, 2008; Rellecke et al., 2011; Schupp et al., 2004; Stenberg, Wiking, & Dahl, 1998).

As stated by several psychophysiological and behavioural studies, both angry and fearful faces signal danger but have contrasting functions: fearful faces help to protect us from threat because they trigger defense or withdrawal responses; angry faces, in turn, are emotions that serve to confront or eliminate a threat and, therefore can also trigger defense or withdrawal responses. They both are important to survival because they help us to avoid threatening events through fight or flight behaviours. Sad faces also represent negative emotions, but with low arousal, that can signal loss, depression, sorrow, regret, among other negative feelings. Sadness serves to prevent future losses and to activate social support. The difference between angry and sad faces is the fact that angry faces often represent revolt, insurgence against the cause of the negative feelings, while sad faces represent conformity. Disgusted faces, in turn, signal repulsion, aversion and repugnance and serve to reject or repel the stimuli that caused the negative feelings, protecting people from biological or psychological contamination (Beall & Herbert, 2008; Oatley & Jenkins, 1996a, 1996b; Rellecke et al., 2011; Schupp et al., 2004; Zhang, Liu, Wang, Chen, & Luo, 2014b). Several studies point to an early detection and rapid processing of negative faces (especially the threatening – angry and fear) compared to neutral and happy ones both in implicit and explicit face processing tasks (Cremers et al., 2010; Eastwood, Smilek, & Merikle, 2003; Fox et al., 2000; Schupp et al., 2004). However, other studies claim that happy faces are the most recognizable facial expressions, even if presented for a few milliseconds (Calvo & Lundqvist, 2008; Calvo & Beltrán, 2013; Montagne, Kessels, De Haan, & Perrett, 2007). Happy faces are positive facial expressions which show high arousal with survival value since they are important to pro-social behaviour (incentive to achieve a given goal, create and maintain relationships) and mating (Beall & Herbert, 2008; Oatley & Jenkins, 1996a, 1996b).

2. EMOTIONAL WORD PROCESSING

Language, both spoken and written, is a human invention and its fundamental unit is the word; letters are the written symbols through which we "translate" the phonemes of the spoken language to graphemes. Word recognition becomes easier and we become more proficient at word reading throughout training in recognizing symbols based on their features. So, we can identify words by their letters and letters by their features (Whitney, 1998b). However, we do not identify written words letter-by-letter. Actually, we are more proficient in recognizing letters in a word than in a string of letters with no meaning (a non-word), even if the word stimuli is presented briefly – the word superiority effect (Rastle, 2007; Whitney, 1998b).

The word superiority effect was the starting point for the development of the interactive-activation model of visual word recognition proposed by McClelland and Rumelhart (1981) and Rumelhart and McClelland (1982). In this model (see Figure 4) there are various levels – low (letter features) and high (words) – that activate and inhibit each other so that letters can influence word identification and words can influence letter identification. The first level – features – represents a combination of nodes that contain all features that letters can present. The second – letters – includes nodes for all the letters and the positions they can occupy in a word. The higher level is made of word nodes. So, when a string of letters is presented to a subject, the feature level is activated. Then, in that level, all the feature nodes that are consistent with the string of letters become more active and the nodes that are inconsistent are inhibited. Then, the information passes to the subsequent level – the letter unit. In this unit, only letters with features identified in the previous levels are activated. The same processes occur in all levels. When information arrives to the word level, there are a set of activated words that can correspond to the word presented. The one that is more active is selected. If there is a competition between words, another process takes place: a frequency-ordered serial search is made to find the best candidate for the presented word. The interactive nature of this model promotes bottom-up along with top-down processing which can explain the word superiority effect (McClelland & Rumelhart, 1981; Rastle, 2007; Rumelhart & McClelland, 1982; Whitney, 1998a, 1998b).

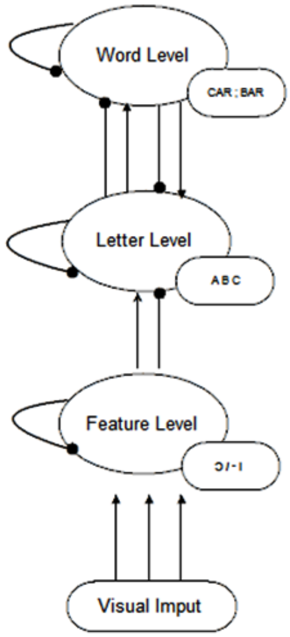


Figure 4: The Interactive-activation model of visual word recognition proposed by McClelland and Rumelhart. Excitatory pathways are represented by lines with arrows and inhibitory pathways are represented by lines with small black circles. Reprinted from Psychological Review, 89, D. E. Rumelhart & J. L. McClelland, An interactive model of context effects in letter perception: II. The Contextual enhancement effect and some tests and extensions of the model, p. 62, Copyright (2018), with permission from APA.

Emotional words can express or induce emotional states (Scott, O'Donnell, Leuthold, & Sereno, 2009) but contrary to the facial emotional perception where emotional information is easily extracted because faces are biological and socially relevant stimuli, the emotional meaning of a word is symbolic and it is learned by training (Frühholz, Jellinghaus, & Herrmann, 2011; Rellecke et al., 2011; Schacht & Sommer, 2009). Nevertheless, some authors suggest that the perceptive input can be enough to recognize emotional characteristics (like emotional valence) before semantic associations (Hofmann, Kuchinke, Tamm, Võ, & Jacobs, 2009; Rellecke et al., 2011). The semantic meaning of the word is extracted at approximately 200 ms after word onset (Frühholz et al., 2011; Posner & Abdullaev, 1999). Nonetheless, there are ERP components that can be found before this time window in response to written words. Scott et al. (2009), for instance, asked participants to identify a word as a real word or a non-word. They found a higher P1 for emotional compared to neutral words. Additionally, several studies showed higher P1 amplitude evoked by negative and threatening words compared to pleasant words (Bar-Haim, Lamy, & Glickman, 2005; Bernat, Bunce, & Shevrin, 2001; Li, Zinbarg, & Paller, 2007; Sass et al., 2010; Taake, Jaspers-Fayer, & Liotti, 2009; Thomas, Johnstone, & Gonsalvez, 2007). The same results described above were found for the N1 wave, a negative deflection at occipito-parietal sites, peaking generally between 135 – 150 ms after stimuli onset (Hajcak et al., 2012; Hofmann et al., 2009; Luck, 2005; Pratt, 2012; Scott et al., 2009). At about 180 ms after onset, Herbert, Kissler, Junghöfer, Peyk, and Rockstroh (2006) found higher amplitudes for emotional compared to neutral adjectives. This time window is consistent with the N170. In turn, Montalan et al. (2008) found that negative adjectives elicited higher N170 amplitudes compared to positive ones, also suggesting a word emotional valence modulation of the N170 component (Luck, 2005). In the next time window, between 180 – 200 ms, a positive deflection called P2 can be observed at anterior and central scalp sites (Hajcak et al., 2012; Luck, 2005). This ERP component is sensitive to selective attention and affective evaluation and it is enhanced for emotional than for neutral stimuli, including words (Hajcak et al., 2012; Herbert et al., 2006). Some authors, however, claim that P2 amplitude is higher for unpleasant than for pleasant stimuli (words included) (Bernat et al., 2001; Carretié, Martín-Loeches, Hinojosa, & Mercado, 2001a; Carretié, Mercado, Tapia, & Hinojosa, 2001b). Emotional differences in word processing were found in the 200 – 300 ms time window, both in N2 and in EPN waves: emotional high arousing words evoked higher negativity at posterior sites than neutral low arousing words (Bayer et al., 2012; Citron, 2012; Kissler, Herbert, Peyk, & Junghofer, 2007; Scott et al., 2009). Some authors, in turn, claim higher amplitudes and longer latencies for positive compared to negative or threatening words (Hinojosa, Méndez-Bértolo, & Pozo, 2010; Sass et al., 2010).

Perhaps the most studied ERP component in language studies is the N400 wave which is a negative deflection, peaking between 380 – 500 ms at central-parietal sites; it lasts approximately 300 ms and it is lateralized in the right hemisphere. The N400 wave is related to semantic expectations, context and/or (in)congruency (Luck, 2005; Swaab, Ledoux, Camblin, & Boudewyn, 2012). It also indexes how deep is the word processing, i.e., the smaller the N400 amplitude, the easier the word processing. Since emotional words are easier to process than neutral words, Sass et al. (2010), for instance, found higher N400 amplitude for neutral compared to emotional words.

The P3 wave is a large positive deflection, peaking between 300 – 500 ms post stimulus and reflects resource allocation, stimuli evaluation and attentional, motivational and memory processes (Citron, 2012; Hajcak et al., 2012; Luck, 2005; Polich, 2012). It is task-dependent and is modulated by internal biological and external cognitive factors (Luck, 2005; Polich, 2012). Emotional words also modulate amplitude and latency of the P3: some studies reported higher amplitudes and longer latencies elicited by negative, threatening words compared to neutral and positive words (Bernat et al., 2001; Sass et al., 2010), while others reported enhanced amplitudes for emotional compared to neutral words (Herbert, Junghofer, & Kissler, 2008). The differences could be associated with different task demands.

Finally, the LPP, which is usually found in centro-parietal sites, as has been described before, reflects elaborate, controlled and complex stimuli processing, motivational relevance, stimuli evaluation and emotional processing (Bayer et al., 2012; Citron, 2012; Cuthbert et al., 2000; Fischler & Bradley, 2006; Hajcak et al., 2012; Schacht & Sommer, 2009; Schupp et al., 2004). Several studies found higher LPP amplitudes for emotional than for neutral words (Bayer et al., 2012; Carretié et al., 2008; Fischler & Bradley, 2006; Herbert et al., 2006; Hinojosa et al., 2010; Schacht & Sommer, 2009). Again, depending on task demands, more positive LPP amplitudes can be observed for positive compared to negative words (Bayer et al., 2012; Herbert et al., 2008; Herbert et al., 2006; Kissler et al., 2009) or for negative compared to neutral and positive words (Bernat et al., 2001; Gootjes, Coppens, Zwaan, Franken, & Van Strien, 2011; Hofmann et al., 2009).

Regarding behavioural results, generally there is a facilitation effect for emotional compared to neutral word identification (Scott et al., 2009). Nonetheless, some authors claim a superiority effect of positive compared to negative words, maybe due to the fact that positive words are more frequent than negative and neutral words (Bayer et al., 2012; Scott et al., 2009; Stenberg et al., 1998). On the contrary, Matthews, Pitcaithly, and Mann (1995), in a primed lexical decision task, found faster reaction times for negative compared to positive and neutral words. This discrepancy can be due to differences in task demands and/or word arousal level. In fact, negative words can elicit a more extensive processing and can require more cognitive resources, leading to a slower categorization (Pratto & John, 1991; Stenberg et al., 1998), but they can be detected and processed faster due to automatic vigilance and negativity bias mechanisms (Bayer et al., 2012; Pratto & John, 1991; Scott et al., 2009; Taylor, 1991). Taylor (1991) proposed the Mobilization-Minimization hypothesis that states that when an emotional stimulus is presented, the stimulus' arousal and valence are detected. Negative valence stimuli are generally more arousing because they have environmental significance – they can anticipate danger – so our body needs to react faster. Thus, if we encounter a high arousing negative stimulus, it would be recognized faster and would initiate a rapid physiological response – the mobilization stage. This stage can cause enhancement or disruption responses that are accompanied by increased neural processing. The mobilization stage is followed by the minimization stage: internal responses (physiological and cognitive) are provided in order to reduce the impact of negative stimuli (Scott et al., 2009; Taylor, 1991).

3. EMOTIONAL AND COGNITIVE CONFLICT – THE STROOP EFFECT

Sometimes the environmental ambiguity challenges us with simultaneous and competitive stimuli that can lead to different outcomes or behaviours generating emotional or cognitive conflict. This particular situation requires cognitive control, i.e., decision strategies and complex action coordination to suppress or inhibit irrelevant information and/or magnify relevant information processing (Botvinick et al., 2004; Botvinick, Braver, Barch, Carter, & Cohen, 2001; Clayson & Larson, 2011; Clayson & Larson, 2013; Ma, Liu, Zhong, Wang, & Chen, 2014; Ovaysikia, Tahir, Chan, & DeSouza, 2010; Shen, Xue, Wang, & Qiu, 2013; Soutschek & Schubert, 2013; Vivekananth, Sood, Kumaran, & Srivastava, 2013; Vuilleumier, 2005; Xue, Ren, Kong, Liu, & Qiu, 2015). Cognitive control relies on two processes: regulative control and evaluative control. Regulative control processes occur in areas of the dorsolateral PreFrontal Cortex (dlPFC) and ventrolateral PreFrontal Cortex (vlPFC) and include implementation of top-down control, allocation of control resources and attention, maintenance of task context and ability to override task unsuitable responses. On the other hand, evaluative control processes help to monitor performance of conflict or mistakes, signal the need to change control implementation and give feedback about that control. Usually, evaluative control occurs in the Anterior Cingulate Cortex (ACC) (Larson, Clayson, & Clawson, 2014; Ridderinkhof, van der Wildenberg, Wijnen, & Burle, 2004). Thus, the process of conflict solving involves the constant monitoring of the distracting information (Cohen, Aston-Jones, & Gilzenrat, 2004). The emotional valence and arousal of this distracting information affects the control mechanism of emotional conflict. Emotional salient stimuli, especially the ones related to danger or threat, are particularly effective in creating conflict, because they interfere more with current cognitive processing (Beall & Herbert, 2008; Botvinick et al., 2001; Etkin et al., 2006; Stenberg et al., 1998; Yang et al., 2016).

One of the most common tasks used in the laboratory to study cognitive conflict, attention, emotion and automaticity processes is the Stroop task (MacLeod, 1991, 1992; MacLeod & Dunbar, 1988; Stroop, 1935). John Ridley Stroop, in 1935, made a series of three experiments demonstrating the reading interference effect on colour naming. In the first experiment he showed participants two lists of coloured words: one in which coloured words were written in red, blue, green, brown and purple (the words and the colours were never coincident, that is the word “red” was never written in the colour red) and another where coloured words were written in black. The subject’s task was to read the list of words. He found no significant differences in reading time between the two lists of words. In experiment 2, Stroop presented two lists again: one with a series of squares printed in different colours (the same used in experiment one) and another equal to the first list presented in experiment 1. This time, participants were asked to name the colour in which a sequence of squares or a given word was printed. Participants took 74% more time to name the colours of the list of words than the list of squares. The third experiment was equal to the previous, but instead of squares, John Stroop used a list of swastikas and added a training variable – participants read the same list on different days. The reason why squares were replaced with swastikas was to introduce a white background in the figure so it would become more similar to written letters or words. After eight days of practice, participants showed a reduction of the interference effect of the colour word in colour naming but an increase of interference effects of colour in word reading (Stroop, 1935). With these three experiments Stroop proved that word reading was faster than colour naming and that the colour in which the word was written did not interfere in its reading. Most importantly, he showed that when participants were asked to name the colour of an incongruent colour word, a large interference effect emerged (Stroop, 1935). Numerous studies were conducted based on the original Stroop’s tasks. Modern versions of this task present colour-word pairs alone instead of in a list of words and include congruent colour-word pairs (the word presented has the same meaning than the word print colour - the word “red” written in red). In this case, participants have no problem to name the colour. The conflict and, consequently, the interference effect are generated when the lexical meaning of the word is incongruent with the colour in which it is written (the word “red” written in blue). Participant’s response in incongruent trials is slower than in congruent ones because reading is a faster and more automatic process than naming the colour of the word (MacLeod, 1991, 1992; MacLeod & Dunbar, 1988; MacLeod & MacDonald, 2000; Phaf & Kan, 2007).

Miller and Cohen (2001) explained the conflict generated by Stroop tasks by the Guided Activation Theory – a connectionist model – of cognitive control. This theory proposes stimulus units, associative units, verbal response units and control units (see Figure 5). The units are connected forming pathways between them. If no instructions are given, subjects will respond to the most familiar or salient stimuli – the word – regardless of the (in)congruency of the stimuli. Thus, without instructions, the word "blue" presented in red or presented in blue will lead to the same verbal outcome – "blue". However, if asked to, subjects will attend and respond to the weaker dimension of the stimuli, showing a form of controlled, voluntary attention. So, the question that remains to be answered is what process or mechanism do we rely on to give the right answer when we are asked to name the colour of an incongruent stimuli? In a resting state, all units have low activity and are connected to the associative units. If we add task demand units to the model, we will have a colour-naming unit (which is connected to the associative unit in the colour-naming pathway) and a word-reading unit (which is connected to the associative unit in the word-reading pathway). Interference occurs when conflicting information simultaneously activates both pathways. If the subject is asked to name the colour of the written word, the colour-naming unit will be activated. This unit will then activate the associative units in the colour-naming pathway biasing and promoting the activity along the colour-naming pathway (even though it is the weaker pathway) while attenuating the activity flow in the word-reading pathway. A response is given when an output from the associative unit exceeds a certain threshold (Cohen et al., 2004; MacLeod & MacDonald, 2000).

This connectionist proposal is in line with another model proposed by Desimone and Duncan (1995) – the Biased Competition Theory – that states that there are different representations in our brain that compete for expression. The function of attention is to choose which information we are going to process, that is, the attention biases and favours one representation over the competing others. Attention can, therefore, be captured by environmental stimuli (relevant and competing stimulus features) – bottom-up, stimulus-driven or exogenous processes – or driven by the observer (control mechanisms acting on stimulus representations) – top-down, goal-directed or endogenous processes (Cohen et al., 2004; MacLeod & MacDonald, 2000; Yiend, 2010). Allocation of attention to one stimulus at the expense of others is the result of a series of top-down and bottom-up processes applied to the competing information.

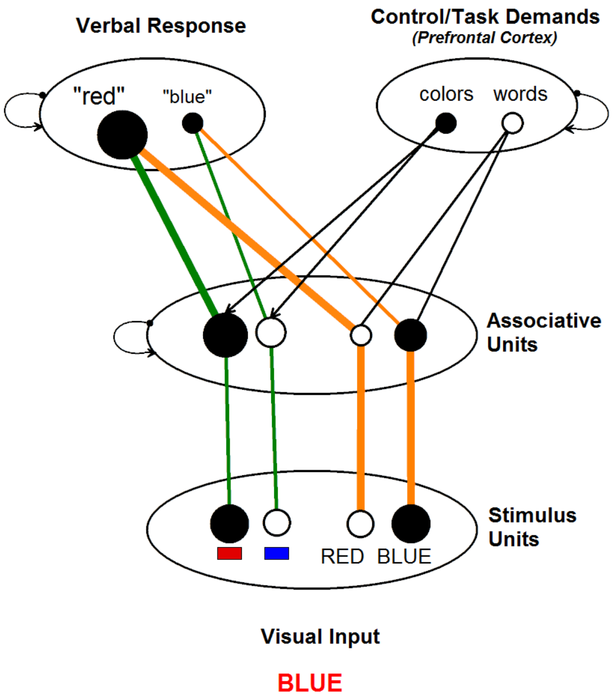


Figure 5: Miller and Cohen's Guided Activation Theory applied to the Stroop task (adapted from Cohen et al. (2004)). The circles represent processing units and the filled circles represent active units that are larger if more active. Green lines represent the colour-naming pathway and orange the word-reading pathway. The larger the line, the stronger the connection between units. Mutual inhibition between units occurs in associative, control and verbal response layers and is represented by half circles with black dots. When an incongruent stimulus is presented (BLUE), the red colour unit and the blue word unit are activated. Although the red word unit was not activated, the connection to associative units is strong in the resting (no instructions) state. Then, information flows to associative units that are influenced by control units – task demands – favouring the colour-naming units (represented by bigger circles). Consequently, the colour-naming pathway is also primed and become stronger, empowering the verbal response "red". Reprinted from, Cognitive Neuroscience of attention, 1, J. D. Cohen, G. Aston-Jones & M. S. Gilzenrat, A systems-level perspective on attention and cognitive control – Guided activation, adaptive gating, conflict monitoring and exploitation versus exploration, p. 73, Copyright (2018), with permission from Guilford Publications.

Information processing models suggest that controlled and automatic processes manage information. If attention and control are required for processing a stimulus or performing a task, a controlled process is being carried out (Cohen et al., 2004; MacLeod & MacDonald, 2000). In turn, a stimulus is automatically processed when it can be handled without attention: we are not aware of it or its influence on our cognitive system, it requires minimal attentional resources, less effort to detect or process, it can be processed with no intention, that is, it is easier to process than to inhibit its processing (Bargh, 1984; Beall & Herbert, 2008; Cohen et al., 2004; MacLeod &

MacDonald, 2000; Stenberg et al., 1998; Yiend, 2010). Yiend (2010) made a distinction between innate and acquired automatic processes. The innate automaticity occurs in biologically prepared stimuli processing and the other is acquired throughout intensive practice and repetition. So, in this perspective, automatic processes should be carried out fast, effortlessly, with little amount of resources and independently of other processes; it would not therefore cause any interference in other concurrent and simultaneous processes. However, the word reading process still causes interference in colour naming. Furthermore, some researchers are defying the automaticity of stimulus processing by claiming that all processes require attention to some degree (Cohen et al., 2004). So, a new perspective was adopted to explain these results: automatic processes are fast and unconscious but not totally insensitive to interference (Phaf & Kan, 2007) and they do require attention even in a smaller amount (MacLeod & MacDonald, 2000).

The Conflict Monitoring Theory states that when two or more competitive information need to be processed, attended and responded to, a conflict is generated (Botvinick et al., 2001). This conflict can influence behaviour, especially if emotion is involved (Botvinick et al., 2004; Yiend, 2010). According to this theory, and in order to solve conflict, our brain relies on attentional control mechanisms to amplify the relevant information, inhibit (or minimize the interference of) the irrelevant one or use a combination of both (Figure 6). The Conflict Monitoring Hypothesis also suggests that there are specific brain areas that process conflict and response competition (Botvinick et al., 2004). With Miller and Cohen's Guided Activation Theory of cognitive control as the starting point, we can explain the Conflict Monitoring Theory by adding a conflict monitor (that occurs in the ACC) that will enhance activation of the task-demand units, producing more top-down control, suppressing and inhibiting the task-irrelevant units and pathways, hence reducing the conflict (Botvinick et al., 2004; Cohen et al., 2004; Egner et al., 2008; Etkin et al., 2006). The conflict detection and monitoring proposed by the theory, monitors information processing, evaluates task demands, and promotes adjustments in attention and control mechanisms that can prevent or reduce conflict (Botvinick et al., 2004; Botvinick et al., 2001; Larson et al., 2014). Therefore, the processing of incongruent trials is faster when incongruent stimuli are preceded by other incongruent stimuli and slower when they are preceded by congruent stimuli. That is, conflicting trials may generate an anticipatory conflict control mechanism which facilitates the conflict resolution of the following incongruent trial. Hence, there are high conflict resolution trials (two consecutive incongruent stimuli) that leads to a more rapid and effective conflict resolution and low conflict resolution trials (an incongruent stimulus preceded by a congruent stimulus) that leads to a slower conflict resolution (Botvinick et al., 2001; Etkin et al., 2006; Favre, Polosan, Pichat, Bougerol, & Baciu, 2015; Vivekananth et al., 2013).

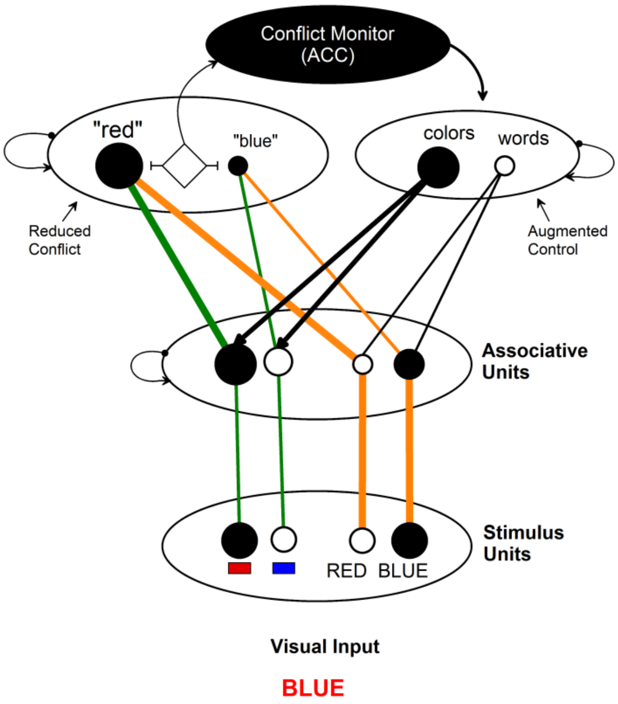


Figure 6: Miller and Cohen's guided activation theory with a conflict monitoring mechanism carried out by the ACC. The conflict monitor – ACC – detects conflict and provides more top-down control. As a result colour naming units at the associative layer become more active and therefore the conflict is reduced. Reprinted from, Cognitive Neuroscience of attention, 1, J. D. Cohen, G. Aston-Jones & M. S. Gilzenrat, A systems-level perspective on attention and cognitive control – Guided activation, adaptive gating, conflict monitoring and exploitation versus exploration, p. 81, Copyright (2018), with permission from Guilford Publications.

Along with this theory of conflict monitoring, other mechanisms can also be involved to ensure conflict resolution. One of these mechanisms is the inhibition of activation: the Activation-Suppression Hypothesis. This hypothesis suggests a selective inhibition of a behavioural response activated by irrelevant stimuli. When a stimulus is presented together with distractors we immediately start to process the entire scene. Eventually, we activate direct responses to that scene. The inhibition mechanism will select the response processes related to direct responses, inhibiting them in order to prevent them from taking place; thus, the relevant responses, the ones that we want or were instructed to give, can be performed. This selective inhibition takes time to become effective (Ridderinkhof et al., 2004).

3.1. EMOTIONAL STROOP

Based on the original Stroop task, the emotional Stroop uses emotional words presented in different colours. The subject's task is to identify the colour of the emotional word, while ignoring its meaning (Avram, Balteş, Miclea, & Miu, 2010; Dresler, Mériau, Heekeren, & van der Meer, 2009; Frings, Englert, Wentura, & Bermeitinger, 2009; MacLeod, 1991, 1992; MacLeod & Dunbar, 1988; Phaf & Kan, 2007; Taake et al., 2009; Thomas et al., 2007). The introduction of emotional words diverts the attention from the relevant information because people are incapable of ignoring the emotional meaning of the word. As a consequence, reaction times for emotional and especially negative words are slower than for neutral words (Citron, 2012; Dresler et al., 2009; Gootjes et al., 2011; MacLeod, 1991, 1992; MacLeod & Dunbar, 1988; Mathews & MacLeod, 1985; Mogg, Mathews, & Weinman, 1989; Pratto & John, 1991; Taake et al., 2009; Thomas et al., 2007). Some authors claim that reaction times for negative words are slower than for positive words (Pratto & John, 1991) and that subjects with high anxiety, high neuroticism and depression have even larger response latencies (Canli, 2004; Epp, Dobson, Dozois, & Frewen, 2012; Taake et al., 2009). These results can also be found in reading, word naming and lexical decision tasks and can be explained by the automatic vigilance effect – a pre-attentive mechanism that responds to negative or threatening stimuli which interrupts the current cognitive task (Algom, Chajut, & Lev, 2004; Cothran, Larsen, Zelenski, & Prizmic, 2012).

Thomas et al. (2007) explored the ERPs during an emotional Stroop task in order to observe if threatening stimuli had preferential processing. They conducted two experiments: the word relevant task – participants were asked to evaluate the presented word as threatening or non-threatening – and the colour relevant task – judge the colour in which the word was written. In the word relevant task, they found higher P3 amplitudes for threatening compared to neutral words. In the colour relevant task, they found higher P2 amplitudes, in the right hemisphere, elicited by threatening compared to neutral words. These results can indicate a more intense processing of threatening words, especially in the right hemisphere, that is, the emotional processing can be more lateralized in the right hemisphere, particularly the processing of negative stimuli (Oatley & Jenkins, 1996a, 1996b; Thomas et al., 2007). Regarding P3 results, Thomas and collaborators suggested a negativity bias in the processing of threatening words related to their emotional salience and their evolutionary importance.

Other important findings in the time course of the emotional Stroop task were found by Gootjes et al. (2011). They found a more positive N400 and a higher LPP evoked by negative compared to neutral words that can reflect facilitation in the processing of negative words (Gootjes et al., 2011; Taake et al., 2009). Franken, Gootjes, and van Strien (2009) found an enhanced EPN for emotional compared to neutral words. Another study (Taake et al., 2009) showed a more negative AN380, at fronto-central sites, elicited by threatening words in high anxiety subjects. These subjects also showed a positive peak, at approximately 60 ms after onset, elicited by threatening words – the vEAP (very Early Anterior Positivity). Taake et al. (2009) associated this potential with a very early emotional salience processing of the word. In this study, threatening faces also elicited a more enhanced P1 in high anxiety subjects compared to positive faces, corroborating the results found by Bar-Haim et al. (2005) and Li et al. (2007). These results point to an early detection of stimuli emotional valence and relevance and also to difficulties in attentional control by high anxiety participants which can determine consequent approach or avoidance behaviour (Bayer et al., 2012; Taake et al., 2009).

Although the introduction of emotional words causes interference in colour naming, some authors claim that the emotional Stroop task does not cause a real emotional conflict because emotional words and the colour in which the word is written represent different dimensions (semantic and perceptual) and one of them does not have emotional content. That is, the two responses generated by this paradigm do not directly compete with each other (Algom et al., 2004; Chechko et al., 2013; Etkin et al., 2006; Haas, Omura, Constable, & Canli, 2006).

3.2. PICTURE-WORD STROOP

Another example of Stroop-like tasks is the picture-word paradigm in which a word is superimposed on a picture and the participant has to name or categorize either the word or the picture, while ignoring the irrelevant information. The word can be congruent (the word “baby” placed on a picture of a baby), incongruent (the word "baby" placed on a picture of a car) or semantically associated with the picture (the word "accident" superimposed on an ambulance picture) (Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Greene & Fei-Fei, 2014; Greenham, Stelmack, & Campbell, 2000; Houwer & Hermans, 1994; MacLeod, 1991; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007; Smith & Magee, 1980). Words have privileged access to lexical information and images have privileged access to semantic memory. Thus, participants' performance is better when they are asked to name words (images do not interfere with word reading) and when they are asked to categorize pictures (words do not interfere with picture categorization). On the other hand, pictures interfere with word categorization and words interfere with picture naming. If the distracting word shares the same semantic category as the picture (the word "leg" presented in a picture of an arm), the interference will be higher (Glaser & Düngelhoff, 1984; Glaser & Glaser, 1989; Greenham et al., 2000; Houwer & Hermans, 1994; Smith & Magee, 1980). These results point to a more controlled attentional processing of pictures compared to a more automatic processing of words (Greenham et al., 2000).

Greenham et al. (2000) presented congruent, incongruent and semantically related picture-word pairs to participants and asked them to name words and pictures in separate tasks. They also had to perform a control task in which they had to name pictures and words individually. They found that compared to individual word naming, in the attended-word task, participants showed a negative fronto-central N280. This component was also found in the attended-picture task. N280 is thought to be related to the N2 family which reflects stimulus classification, discrimination and identification of relevant stimulus and task requirements (Hillyard & Anllo-Vento, 1998). Thus, if the N280 wave was only found in picture-word stimuli and not in the individual presentation, this component can be related to the process of extracting and identifying the task relevant and ignoring task irrelevant information in complex stimuli – the attended and non-attended stimuli (Greenham et al., 2000). No differences were found between the N450 elicited in individual naming and in the attended-word task. This N450 was larger for attended words than for attended pictures and it was not elicited in picture naming individually. This result points to an influence of the distractor word in picture naming, that is, words are automatically processed despite the instructions to ignore them.

In a different approach to this paradigm, Xu et al. (2015) asked participants to categorize an emotional face, embedded in a fearful or in a happy related scene, as fearful or happy. They found that facial categorization was faster when the scene was congruent with the face. They also found a larger N170 for congruent compared to incongruent stimuli. Regarding N2 amplitudes, they were larger for incongruent than congruent conditions. These two components may reflect conflict monitoring within a picture-word Stroop task (Xu et al., 2015).

3.3. WORD-FACE STROOP

The Word-Face Stroop (WFS) task is used to study the conflict generated by the emotional incompatibility between affective faces and affective words, and automaticity effects. In this task, words are superimposed between the eye and the nose area of a face. Both words and faces can represent neutral, positive or negative emotions. Usually, participants are required to evaluate either the word or the face valence. The conflict is generated when faces and words present different valence emotions. Unlike the original Stroop paradigm that only studies the conflict between cognitive and perceptual processes, the WFS investigates attention and emotional bias as well as emotional information inhibition. Although this paradigm has been widely used, there are slight differences in task demands: participants may be asked to make valence judgments of faces (Başgöze, Gönül, Baskak, & Gökçay, 2015; Beall & Herbert, 2008; Egner et al., 2008; Frühholz et al., 2011; Haas, Omura, Constable, & Canli, 2007; Hu, Liu, Weng, & Northoff, 2012; Stenberg et al., 1998) or words (Beall & Herbert, 2008; Frühholz et al., 2011; Haas et al., 2006, 2007; Keedwell et al., 2016; Stenberg et al., 1998; Strand, Oram, & Hammar, 2012; Yang et al., 2016), identify the emotional category of faces (Avram et al., 2010; Chechko et al., 2013; Cothran et al., 2012; Egner et al., 2008; Etkin et al., 2006; Favre et al., 2015; Ovaysikia et al., 2010; Shen et al., 2013; Strand et al., 2012; Worsham, Gray, Larson, & South, 2015; Xue et al., 2016; Xue et al., 2015; Zhu & Luo, 2012; Zhu, Zhang, Wu, Luo, & Luo, 2010) or words (Baggott, Palermo, & Fox, 2010; Ovaysikia et al., 2010; Zhu et al., 2010) or identify the sex/gender of the faces (Egner et al., 2008; Krebs, Boehler, De Belder, & Egner, 2013; Osinsky et al., 2012; Xue et al., 2016) or words (Keedwell et al., 2016). If the task requires any kind of face judgment, we must inhibit the conflicting semantic information from the word. On the other hand, if the word is the target, we must suppress the emotional information from the face to avoid conflict and give a correct response. If we have to attend to the face, the incongruent information of the word activates an emotional representation that is incompatible with the one formed by the face. These two representations will compete for the same processing resources, thus creating conflict (Egner et al., 2008; Etkin et al., 2006). So, the emotional conflict is generated because two automatic processes of stimuli with incongruent valence are competing for a response (Avram et al., 2010; Basgöze & Gökçay, 2008; Beall & Herbert, 2008; Clayson & Larson, 2013; Ovaysikia et al., 2010; Phaf & Kan, 2007; Zhu et al., 2010). From the moment we learn to read fluently, the reading process becomes automatic. It is unintentional; we are required to make more effort to inhibit reading than to read. However, words represent emotions on a symbolic level (MacLeod, 1991). On the other hand, emotion can be extracted directly from facial expressions and emotional facial recognition requires little attention probably because faces are an evolutionary-prepared stimuli with biological significance (Baggott et al., 2010; Beall & Herbert, 2008; Rellecke et al., 2011) that we can detect quickly and efficiently, even if we are not aware of its presence (Adolphs, 2002; Calvo & Lundqvist, 2008; Palermo & Coltheart, 2004). If both processes are automatic, one must be more salient than the other, otherwise the emotional conflict could not be solved.

Overall, the literature about the WFS paradigm claims that incongruent trials (the source of emotional conflict) originate slower and less accurate responses compared to congruent ones because conflict trials require a more extensive/complex processing. This (in)congruency effect occurs not only when valence judgment is required but also when participants need to answer to the emotional category or gender of faces or words (Avram et al., 2010; Baggott et al., 2010; Basgöze & Gökçay, 2008; Başgöze et al., 2015; Beall & Herbert, 2008; Cothran et al., 2012; Egner et al., 2008; Haas et al., 2006, 2007; Hu et al., 2012; Krebs et al., 2013; Osinsky et al., 2012; Ovaysikia et al., 2010; Shen et al., 2013; Stenberg et al., 1998; Strand et al., 2012; Vivekananth et al., 2013; Worsham et al., 2015; Zhu et al., 2010).

When words are the target, that is, when participants are asked to make word valence judgments while ignoring emotional faces, the influence of faces in this judgment process is clear: faces make it more difficult to evaluate words (slower reaction times and lower accuracy). This can indicate that facial expression discrimination is processed before word valence when both stimuli are presented simultaneously (Beall & Herbert, 2008; Strand et al., 2012) and that the emotional reaction to faces is stronger (they elicit more psychophysiological arousal) compared to words (Lees, Mogg, & Bradley, 2005). However, when faces are the target, there is no consensus about the influence of word valence. Some researchers argue that the interference effect disappears, that is to say that affective words do not interfere with face processing (Stenberg et al., 1998; Strand et al., 2012), while others allege that word valence processing interferes with face valence processing (Cothran et al., 2012) but the interference effect is smaller than when words are the target (Beall & Herbert, 2008). Nonetheless, altogether, the evidence seems to suggest that face valence processing is faster and more automatic than word valence processing, that information about the emotional content of the word is processed later than the emotional content of the face and that there is a magnified processing of faces when they are the target but an inability to inhibit or suppress face processing when they are used as the distractor stimuli (Baggott et al., 2010; Basgöze & Gökçay, 2008; Beall & Herbert, 2008; Chechko et al., 2013; Clayson & Larson, 2013; Compton, 2003; Frühholz et al., 2011; Halgren, Baudena, Heit, Clarke, & Marinkovic, 1994a; Halgren et al., 1994b; Isaac et al., 2012; Shen et al., 2013; Stenberg et al., 1998; Strand et al., 2012; Vivekananth et al., 2013; Zhu & Luo, 2012; Zhu et al., 2010).

Regarding the differences between facial emotions in WFS paradigm, Stenberg et al. (1998) argued that there must be a positive valence advantage (PVA) in face and word processing because stimuli with positive faces were processed faster than stimuli with negative faces, positive words were evaluated faster than negative words and when positive faces and words were presented simultaneously, the PVA was even bigger. Stenberg et al. (1998) made three experiments where participants were presented with positive, negative and neutral words superimposed in happy, angry and neutral faces (in the first experiment), sad, happy and pseudo faces (in the second experiment) and angry, sad, disgust, happy and neutral faces (in the third experiment); in all experiments participants were asked to assess word valence. Indeed, positive words were evaluated faster than negative words regardless of the emotion displayed by the face (sadness, anger, disgust, happiness or neutral). The authors claimed that this is probably due to the fact that negative stimuli are processed slower and therefore its categorization is delayed. In fact, the PVA (also called happy superiority effect or positive bias) has been found in other studies (Başgöze et al., 2015; Fox & Zougkou, 2011; Hu et al., 2012). On the other hand, some researchers claim that negative stimuli are detected faster than positive stimuli – threat superiority effect (Fox & Zougkou, 2011; Hansen & Hansen, 1988; Pratto & John, 1991; Taylor, 1991). Cacioppo and Gardner (1999) suggested that the positivity bias is associated with the processing of low arousing stimuli and the negativity bias or the threat superiority effect may be more likely in stimuli with high arousal ratings. This is the reason why some authors even suggest that the positivity bias is almost limited to positive words, while the negative bias is more frequently found in other negative stimuli (Cacioppo & Gardner, 1999; Hinojosa et al., 2009; Hinojosa et al., 2010; Olofsson et al., 2008; Schacht & Sommer, 2009). Differences in personality traits are a variable that can determine if we attend more to positive or negative stimuli because of its influence in attention allocation to emotional salient stimuli. For instance, subjects with high levels of extroversion are more reactive to positive stimuli while subjects with high neuroticism or anxiety ratings are more reactive to negative stimuli, specially the threatening ones (Canli et al., 2001; Fox & Zougkou, 2011). The difference between happy and threat superiority effects can also rely on task demands. If more complex stimuli are presented, a more complex cognitive approach is necessary because there is an information and processing overload and negative stimuli will occupy more resources resulting in longer response latencies (Basgöze & Gökçay, 2008; Başgöze et al., 2015; Chechko et al., 2013; Egner et al., 2008; Etkin et al., 2006; Hu et al., 2012; Stenberg et al., 1998; Strand et al., 2012; Taylor, 1991; Zhu et al., 2010). That is the case of the WFS, where we have two different emotional representations in our brain competing for the same resources.

In their first experiment Stenberg et al. (1998) found that congruent negative stimuli (negative words and angry faces) took longer to evaluate than all other stimuli (including the ones with neutral faces). These results could be explained by the fact that negative stimuli tend to elicit more cognitive activity and negative threatening faces capture more attention, therefore it could be more difficult to withdraw or suppress attention. In the remaining experiments and especially in the last one (where sad, angry, disgusted, happy and neutral faces were presented) no differences between negative facial expressions were reported (Stenberg et al., 1998). In turn, Beall and Herbert (2008) found that angry faces induced more interference than sad faces in word valence assessment but they found no differences between the amount of interference caused by angry and happy expressions. One possible explanation for these results might be that emotional conflict resolution relies more on arousal than on valence (Beall & Herbert, 2008; Vuilleumier, 2005). The circumplex model of affect places happiness in the positive valence dimension while anger and sadness fall in the negative valence dimension. On the other hand, anger and happiness are high arousing emotions whereas sadness falls in the low arousal pole of the model (Posner et al., 2005; Russell, 1980).

Thus, it is possible that high arousing emotional faces require more cognitive resources to inhibit the response and withdraw attention from the faces (Keedwell et al., 2016) even if they lead to different behaviour: approach in the case of happiness and withdrawal in the case of anger. Still, both emotions are more important to survival than sadness, as a result they can be more automatically processed and consequently can cause more interference. Sadness, on the other hand, is a non-threatening and low arousing emotion that can induce either approach or avoidance behaviours but is not essential for survival, resulting in slower processing and less interference (Beall & Herbert, 2008).

Regarding incongruent stimuli, Beall and Herbert (2008) found greater interference effects of happy faces in negative word valence assessment than negative (sad) faces in positive word valence assessment. The same result was found by Yang et al. (2016) but, in this case, with fearful faces. Beall and Herbert (2008) also found a more automatic processing of emotional faces compared to emotional words. Concerning trials with neutral faces, Stenberg et al. (1998) verified that participants judged positive word valence faster in congruent trials compared to trials with neutral faces and that positive word judgment was faster than negative word judgment in trials with neutral faces. However, Haas et al. (2006) found that participants took longer to evaluate word valence in congruent trials (both positive and negative) than in neutral trials (trials with neutral faces and neutral words).

Cothran et al. (2012) asked participants to verbally categorize facial emotions as angry, fearful, happy, sad or surprised, while ignoring the superimposed words: angry, sad, happy, fear, surprise and "XXXX" (control). They found higher interference in reaction times for negative compared to positive words and to control. Specifically, the words "angry" and "sad" caused slower responses to emotional faces than the word "happy". Regarding error rates, participants were less accurate evaluating negative than positive emotional faces. The authors explained these results by the automatic vigilance effect: more errors and higher reaction times were obtained in response to negative stimuli. Negative stimuli have the power to capture attention and are detected first but then, it is more difficult to withdraw attention even if it is an irrelevant stimulus and was supposed to be ignored.

In a different approach to the Stroop task, Frühholz et al. (2011) presented participants fearful and neutral faces and negative and neutral words colored in blue, green or red, on a grey background. Participants had to perform two tasks: a "colour naming task" where participants had to identify the colour in which the stimuli were presented (while ignoring their meaning) and an "emotional judgment task" where participants were asked to identify stimuli valence while ignoring the colour. Participant's performance was better (faster reaction times and fewer errors) in the "colour naming task". Regardless of the task, participants were faster judging stimuli with faces compared to stimuli with words. Neutral faces were more correctly judged than fearful faces in the "emotional judgment task". The authors explained these results with the fact that although emotional stimuli are prioritized in emotional processing and therefore can facilitate the task, they can also attract so much attention that they can interfere with other tasks. Negative faces, in this case, fearful faces, can capture attention in a way that can worsen task performance (Frühholz et al., 2011; Stenberg et al., 1998).

ERPs are a useful tool to study the temporal aspects of all psychological processes, including the emotional conflict. They measure the salience/intensity – amplitude – and speed/efficiency – latency – of brain processes, and are sensitive to stimuli emotional features (Luck, 2005; Luck et al., 2000). In Frühholz et al. (2011) study, negative stimuli (fearful faces and negative words) revealed higher N170 and EPN amplitudes compared to neutral stimuli. Specifically, fearful faces revealed higher N170 and EPN amplitudes compared to neutral faces, and negative words elicited higher EPN amplitudes, in the left hemisphere, and only during the "emotional judgment task", that is, when words were explicitly processed. The left N170 was affected by fearful faces in both tasks while the right N170 was affected by negative stimuli only in the "colour naming task". The LPP was also affected by negative material: higher amplitudes in the left LPP were found in response to negative faces and words in the "colour naming task", that is, when negative material was implicitly processed; and negative words elicited an enhanced right LPP during the "emotional judgment task". These results point to a strong influence of fearful faces on the N170, EPN and LPP regarding the attentional focus, that is, the emotional value of fearful expressions seems to be processed implicitly and explicitly.

Zhu et al. (2010) presented fearful and happy faces together with the words "happy" and "fear" superimposed. In their first experiment, the participant's task was to categorize the face as fearful or happy, while ignoring the written words. In the second experiment, they presented the same stimuli and asked participants to categorize words as "happy" or "fear", while ignoring the face. They found more negative N170 amplitudes in conflict trials than in congruent trials when participants were asked to categorize faces. Contrariwise, when participants were asked to assess words, in incongruent trials, N170 amplitudes were less negative than in congruent trials. Zhu and collegues suggested that the explicit processing of faces evoked a more pronounced N170 and the suppression of face processing (in the task where participants needed to ignore faces and respond to words – face implicit processing) evoked a less pronounced N170, in conflict trials. Baggott et al. (2010) also found a more negative N170 for incongruent trials, in a WFS task, where participants were asked to categorize angry, fearful, sad and neutral faces, with words related to sadness, anger and fear, superimposed. Compared to neutral, emotional trials also elicited an enhanced N170. This ERP component was only found in the right hemisphere, in electrode P8. These results point to an early processing of conflicting information: at approximately 170 ms after onset, the information about the emotional category of the facial expression had already been processed and the emotional category of the word must have been already processed too, otherwise, the (in)congruency between both information would not generate the differences found in the N170. Thus, N170 amplitude appears to be able to index the processing of the relevant stimuli and the suppression of the task-irrelevant information (Baggott et al., 2010; Zhu et al., 2010).

Shen et al. (2013) and Xue et al. (2015) presented happy and fearful faces with the words “happy” and “fear” superimposed and asked participants to categorize the face as happy or fearful, while ignoring the words. They found a negative deflection between 350 and 550 ms after onset in fronto-central sites, in response to incongruent compared to congruent trials that correlated with the interference effect (Larson et al., 2014). These results were also found by Xue et al. (2016), Osinsky et al. (2012) and West, Jakubek, Wymbs, Perry, and Moore (2005). This negative deflection resembled the N450 – a fronto-central negativity, peaking between 400 and 500 ms after stimulus onset, possibly originated in the ACC – that is related to conflict detection, monitoring and resolution (Larson et al., 2014; Liotti, Woldorff, Perez, & Mayberg, 2000; Ma et al., 2014; Osinsky et al., 2012; Shen et al., 2013; West et al., 2005; Xue et al., 2016; Xue et al., 2015). West et al. (2005), Osinsky et al. (2012), Shen et al. (2013) and Xue et al. (2015, 2016) also found a positive deflection between 700 and 800 ms after stimulus onset, more pronounced for incongruent compared to congruent trials, in posterior parietal sites, that resembled the Conflict Slow Potential (Conflict SP). This ERP component generally follows the N450 in conflict paradigms and is related to an increased recruitment of cognitive resources, enhanced top-down control, monitoring, adaptation (adjustments for correct task performance), response selection and conflict resolution (Larson et al., 2014; Larson, Kaufman, & Perlstein, 2009; Liotti et al., 2000; Osinsky et al., 2012; Shen et al., 2013; West et al., 2005; Xue et al., 2016; Xue et al., 2015).

With the same stimuli and task, Zhu and Luo (2012) also found a larger C1 potential, elicited by fearful compared to happy faces. The C1 ERP component usually peaks at approximately 50 – 100 ms after stimuli onset in posterior sites and is sensible to stimulus parameters like spatial frequency or contrast (Luck, 2005; Pratt, 2012). Since the differentiation of happy and fearful faces occurs at approximately 100 ms after stimuli onset and the conflict detection often occurs 200 ms after stimuli onset, fearful faces do not seem to interfere with the conflict. Fearful faces appear to have a prioritized processing in the executive attention system, a subcortical and fast path with connections to the amygdala (Baggott et al., 2010; Frühholz et al., 2011; Larson et al., 2014; Van Veen & Carter, 2002; Williams, Morris, McGlone, Abbott, & Mattingley, 2004; Xue et al., 2016; Zhu & Luo, 2012; Zhu et al., 2010).

THE FIVE-FACTOR MODEL OF PERSONALITY

Personality can affect crucial processes of the human cognition, especially the ones that are involved in emotional cognitive conflicts, such as emotion and attention, which, as has been proved hitherto, can be investigated with the WFS paradigm (Haas et al., 2007; Wiebe & Smith, 1997). According to Hampson (1988), there are four assumptions in order to define the personality concept: personality is stable, internal, consistent and different. Personality is relatively stable, it can have short-term fluctuations but in adulthood it has a core of continuity and stability. Personality is also an internal process, that is, it is not a phenomenon that we can directly observe. Although, we can infer some personality characteristics by observing other's behaviour or reflecting on our own. Consistency refers to the fact that because our personality is stable, our behaviour will be consistent, which allows for a certain degree of predictability. At last, personality definition must account for individual differences, that is, what makes a person unique and different from all others (Hampson, 1988).

According to the trait theorists, the basic element of personality is the trait – internal factors/elements, stable characteristics, bipolar dimensions, general dispositions, patterns of thoughts, actions/behaviours or feelings, that differentiate people and can be used to assess or explain behaviour (Hampson, 1988; Johnson, 1997). The personality traits are part of a group of basic tendencies which also encompasses genetics, physical characteristics, cognitive capacities, physiological drives and focal vulnerabilities. These capacities or dispositions interact with characteristic adaptations (such as language, social skills, attitudes, beliefs, goals, habits, preferences, relationships…), self-concept, objective biography (life course) and external influences (education, relations, family, culture…) through dynamic processes resulting in one's psychological functioning. Personality traits may, therefore, influence dynamic processes such as cognitive and emotional mechanisms (Canli, 2008; McCrae & Costa, 1996).

Over the years, many theories have been attempting to establish the basic elements that can explain personality functioning and its implications. Among them, the most consensual is the well-known "Big Five" approach or the Five-Factor Model of Personality (FFM)[2]. This model encompasses all the characteristics described above and claims that there are five traits that underlie the human personality – neuroticism, extraversion, openness to experience, agreeableness and conscientiousness (Amin, Constable, & Canli, 2004; Costa & McCrae, 2000; Geen, 1997; McCrae & Costa, 1996; Pereira, 2009; Saucier & Goldberg, 1996).

1. THE FIVE-FACTOR MODEL OF PERSONALITY

Literature about personality traits can be found as early as in Ancient Greece but it was in the 1930's that it began to be studied as a personality model. The origins of the "Big Five" go back to that time with the work of Gordon Allport and Raymond Cattell (Wiggins & Trapnell, 1997). Allport and Odbert listed all words associated with

[2] Although these two approaches are not fully equal, the essential guidelines are very similar. The "Big Five" Model is more theoretical whereas the FFM is a more quantitative approach. The research in the FFM is based on the search for the biological foundations of personality traits.

personal attributes and psychological functioning and found 4500 personality traits reasonably stable and permanent. Based on Allport and Odbert's studies, Catell used a meticulous quantitative method and reduced the 4500 personality traits to 35 standard clusters – facets – and then he developed the Sixteen Personality Factor Questionnaire (16 PF) which can evaluate the 16 primary trait constructs he had found. Another model of personality that largely influenced the "Big Five" approach was Eysenck's personality model. Initially with only two bipolar personality traits – neuroticism and extraversion – the model accounted for four personality types (the combination of the two dimensions). Later, in the 1970's, a new trait was introduced – psychoticism – and a questionnaire to measure these traits was created – the Eysenck Personality Questionnaire. Finally, in 1958, Tupes and Christal found five factors that could define personality and explain its individual differences: surgency/extraversion, agreeableness, conscientiousness, emotional stability and culture (McAdams, 2009b, 2009c; Wiggins & Trapnell, 1997).

The FFM model has been changing over the years due to the extensive research in this area (Wiggins & Trapnell, 1997). The more recently and supported approach defends that personality is composed by the following bipolar traits: neuroticism (vs. emotional stability) – easily upset, maladjusted, not calm; extraversion (vs. introversion) – assertive, energetic, talkative; agreeableness (vs. antagonism) – cooperative, good-natured, trusting; conscientiousness (vs. impulsivity) – dependable, orderly, responsible; and openness to experience (vs. closeness to experience) – imaginative, independent-minded, intellectual (Amin et al., 2004; Costa & McCrae, 2000; Geen, 1997; Malouff, Thorsteinsson, & Schutte, 2005; McAdams, 2009a; McCrae & Costa, 1996; Samuel & Widiger, 2008; Saucier & Goldberg, 1996).

According to Costa and McCrae (1997; 1996), personality consists of a complex system defined by personality traits – dimensions of individual differences in tendencies – and the dynamic processes by which they affect our psychological functioning (patterns of thoughts, feelings and actions). These authors supported the FFM and proposed a division of the five personality traits in six facets each and developed the NEO PI-R (Revised NEO Personality Inventory) to evaluate the five factors and respective facets that define personality (see Table 1). This questionnaire includes items about habits, attitudes, relationships, preferences and social skills (Costa & McCrae, 1997; McCrae & Costa, 1996). The five domains and respective facets have behavioural, genetic and cross-cultural support (Canli, 2004, 2008; Fox & Zougkou, 2011; McCrae & Allik, 2002; Yamagata et al., 2006) and are related to important life adaptations and outcomes, such as longevity, career success, physical and psychological health (Costa & McCrae, 1997; Judge, Bono, Ilies, & Gerhardt, 2002; Judge, Higgins, Thoresen, & Barrick, 1999; Martin & Friedman, 2000; McCrae & Costa Jr, 1997; Ozer & Benet-Martinez, 2006; Paunonen, Haddock, Forsterling, & Keinonen, 2003; Samuel & Widiger, 2008).

Table 1: Domains and facets of the NEO PI-R Inventory by Costa and McCrae (2000)

Neuroticism	Extraversion	Openness to Experience	Agreeableness	Conscientiousness
Anxiety	Warmth	Fantasy	Trust	Competence
Hostility	Gregariousness	Aesthetics	Straightforwardness	Order
Depression	Assertiveness	Feelings	Altruism	Dutifulness
Self-consciousness	Activity	Actions	Compliance	Achievement striving
Impulsiveness	Excitement seeking	Ideas	Modesty	Self-discipline
Vulnerability	Positive emotions	Values	Tender-mindedness	Deliberation

Among these personality traits, neuroticism and extroversion are the most studied in psychology (Costa & McCrae, 1997).

2. NEUROTICISM

Neuroticism is a normative personality dimension represented in a continuum raging between emotional stability and instability; it is related with the way that an individual reacts under pressure and his/her ability to overcome stressful situations (Denissen & Penke, 2008). It is a predisposition to experience negative emotions, anxiety, gloom and pessimism (Costa & McCrae, 2000; Wiebe & Smith, 1997) and it is related to negative affect (Canli, 2004; Cremers et al., 2010; Haas, Constable, & Turhan, 2008; Rafienia, Azadfallah, Fathi-Ashtiani, & Rasoulzadeh-Tabatabaiei, 2008). It is a personality dimension with a genetic component that affects mood, cognition, emotion, attention, behaviour and other psychological and neurobiological processes

(Canli, 2004; Fox & Zougkou, 2011; McAdams, 2009a). Similar to the trait, each of the facets are evaluated on a continuum. So, people with high ratings of anxiety are worried, tense and anxious; on the contrary, people with low anxiety ratings deal with problems in a calmer and more relaxed way. The hostility facet is characterized by anger and frustration or friendship and moderation in individuals with high or low scores on this facet, respectively. In turn, depression, as a facet of neuroticism, is a normative personality characteristic related with feelings of sadness or gloom; hence, people that score high in depression show more frequently symptoms of guilt and despair. Secure and confident individuals present low scores in the self-consciousness facet, while at the opposite pole of the spectrum, individuals are ashamed, anxious and shy in their social interactions. The impulsiveness facet evaluates resistance to temptation and self-control; therefore, people with high impulsivity have less self-control and can experience, more frequently, feelings of regret. Lastly, individuals high in vulnerability have more difficulties in becoming independent because, when they face stressful situations, they often panic; less vulnerable individuals are more resistant even under pressure or in stressful situations (Costa & McCrae, 2000). In conclusion, individuals high in neuroticism are more psychologically reactive than individuals with low neuroticism (Cremers et al., 2010; Norris, Larsen, & Cacioppo, 2007; Reynaud, El Khoury-Malhame, Rossier, Blin, & Khalfa, 2012).

In general, individuals with high levels of neuroticism have more tendency to experience feelings of anxiety, anger, unhappiness, distress, stress, worry and inferiority (Schwebel & Suls, 1999); they are more vulnerable (Fjell, Walhovd, Meling, & Johansen, 2005), have more difficulties in controlling impulses and coping with stress and have more unrealistic ideas (Costa & McCrae, 2000). Typically, people high in neuroticism are more reactive to stressors owing to the fact that they are more sensible to negative cues in the environment, considering them as threatening (Costa & McCrae, 1997, 2000; Denissen & Penke, 2008; Fjell et al., 2005; Haas et al., 2007; Mauer & Borkenau, 2007; Norris et al., 2007; Perlman et al., 2009; Reynaud et al., 2012; Wiebe & Smith, 1997; Wright et al., 2006). Specifically, neuroticism and anxiety have been associated with a processing bias towards negative or threatening information, namely towards sad, fearful and angry faces, threatening words and unpleasant pictures, reflected by a hyper vigilance (faster detection and processing and difficulties in withdrawing attention) to that stimuli (Berggren & Derakshan, 2013; Bradley, Mogg, Falla, & Hamilton, 1998; Bradley & Lang, 1999; Campanella et al., 2002; Cremers et al., 2010; Fox & Zougkou, 2011; Mogg, Garner, & Bradley, 2007; Rafienia et al., 2008; Rossignol et al., 2005; Surcinelli, Codispoti, Montebarocci, Rossi, & Baldaro, 2006). There is also evidence linking high neuroticism with poor emotional regulation, avoidance temperament, negative affection (behaviour inhibition system), psychopathology and difficulties in solving emotional and cognitive conflicts (Bienvenu et al., 2001; Bienvenu et al., 2004; Canli, 2004; Cremers et al., 2010; Haas et al., 2008; Haas et al., 2006, 2007; Huang et al., 2009; Malouff et al., 2005; Mauer & Borkenau, 2007; McAdams, 2009a; Ormel, Rosmalen, & Farmer, 2004; Reynaud et al., 2012; Samuel & Widiger, 2008). Contrariwise, individuals with low neuroticism levels are emotionally more stable, calm, relaxed, reliable and self-controlled, have a more constant mood and are capable of facing a stressful situation without getting so upset or disturbed. These individuals are usually less reactive to any kind of stimuli compared to high neuroticism individuals (Costa & McCrae, 2000; Schwebel & Suls, 1999). Low neuroticim has also been linked to less susceptibility to distraction (Wallace & Newman, 1998).

High neuroticism and anxiety influence the affective response to facial expressions: higher attentional allocation, faster detection and recognition of negative faces, like angry (Bradley et al., 1998; Mogg & Bradley, 1999; Mogg et al., 2007), sad (Perlman et al., 2009; Stewart, Ebmeier, & Deary, 2005) and fearful faces (Fox, 2002; Mogg et al., 2007; Perlman et al., 2009; Richards et al., 2002; Rossignol et al., 2005; Surcinelli et al., 2006). Cooper, Rowe, and Penton-Voak (2008), asked participants to identify facial emotions and found that they were more accurate and took less time recognizing happy faces compared to other facial expressions. In this study, no differences were found among the negative facial expressions – angry, fearful, disgusted and sad faces – in accuracy, but disgusted and sad faces were identified faster than angry and fearful faces. Haas et al. (2008) and Jimura et al. (2009) proved a correlation between neuroticism and the visualization of sad faces: the higher the neuroticism, the higher the medial prefrontal cortex activation and the temporal pole activity, respectively, during the presentation of sad faces, compared to neutral, happy and fearful faces.

Subjects with high neuroticism and anxiety show higher responsiveness to stimuli emotional content and a bias towards emotional stimuli, especially negative ones (Bishop, 2007; Bradley & Lang, 1999; Haas et al., 2008; Holmes et al., 2008; Rossignol et al., 2005). Perlman et al. (2009) claim that high neurotic people tend to attend to the most informative and activating face feature – the eyes – and that low neurotic people do not show this behaviour for so long. So, people with higher neuroticism scores can perceive an emotionally salient image as more threatening and with more emotional content than people with low neuroticism scores. Thus, personality cannot only be related to how people interpret and think about what they see or hear, but also to the information they will attend first.

Neuroticism also influences emotional word processing, given the fact that high neuroticism and anxiety subjects tend to be more sensitive to negative valence words (Canli, 2004; De Pascalis, Strippoli, Riccardi, & Vergari, 2004; Gotlib, McLachlan, & Katz, 1988; Richards, French, Johnson, Naparstek, & Williams, 1992).

Holmes et al. (2008) found a more pronounced P1 ERP component evoked by fearful faces in anxious compared to non-anxious subjects and claimed that it can be related to a mechanism of attentional vigilance to negative material – the threat evaluation system. Mathews and Mackintosh (1998) affirmed that this system biases selective attention and processing resources towards threatening material. They allege that this evaluation system can have a lower activation threshold for anxious compared to non-anxious individuals and that higher activations of the threat evaluation system can lead to stronger representations and attentional processing of threat related stimuli (Holmes et al., 2008; Mathews & Mackintosh, 1998). Mogg and Bradley (1998) proposed a similar model – the cognitive motivational analysis – that suggests a "valence evaluation system" (VES) instead of a threatening evaluation system. When a stimulus exceeds certain thresholds, the "goal engagement system" (GES) interrupts the current task and guides attentional resources to that stimuli. People high in anxiety have a more sensitive VES and, therefore perceive/evaluate stimulus as more threatening (Mogg & Bradley, 1998; Yiend, 2010).

THE NEUROTICISM TRAIT AND THE DYNAMICS OF COGNITIVE AND EMOTIONAL CONFLICTS

Neuroticism affects the functioning of the amygdala, hippocampus, prefrontal cortex (PFC), dlPFC and ACC (Cremers et al., 2010; Fox & Zougkou, 2011; Haas et al., 2007; Whittle, Allen, Lubman, & Yücel, 2006). Some of these brain areas are also related to the detection (Zhu et al., 2010), monitoring (Egner et al., 2008; Etkin et al., 2006; Soutschek & Schubert, 2013; Vivekananth et al., 2013) and resolution (Egner et al., 2008; Etkin et al., 2006; Vivekananth et al., 2013; Yang et al., 2016) of the emotional cognitive conflict and to attentional control (Canli, 2004; Dalgleish, 2004; Haas et al., 2007; Hillyard & Anllo-Vento, 1998). These brain areas are also responsible for the integration of emotional and cognitive information (Cremers et al., 2010; Dalgleish, 2004; Gerber et al., 2008; Pessoa, 2008). Moreover, the amygdala is also involved in several emotional and attentional processes, like modulation of attentional and perceptive resources, implicit face processing (Haas et al., 2007) and preferential processing of emotional stimuli for rapid responses to possible threats in the environment (Dalgleish, 2004; Vuilleumier et al., 2001). Emotional salient faces (Breiter et al., 1996; Emery & Amaral, 2000) and words (Isenberg et al., 1999; Scott et al., 2009) also activate the amygdala and other limbic structures (Egner et al., 2008; Emery & Amaral, 2000). So, if neuroticism affects all brain areas described above, it seems likely that neuroticism will play a major role in emotional/cognitive conflicts and that individuals with high neuroticism scores will have more difficulties in processing conflict (Frühholz, Prinz, & Herrmann, 2010; Haas et al., 2006, 2007). This claim was demonstrated by Haas et al. (2006, 2007). They found that neuroticism was highly correlated with amygdala and subgenual anterior cingulate activation during conflict trials. These two areas are involved in conflict resolution and monitoring (Egner et al., 2008; Etkin et al., 2006; Haas et al., 2006, 2007; Vivekananth et al., 2013). Moreover, the anxiety facet of neuroticism was associated with higher response latency in incongruent trials, indicating larger attentional bias. These results can be due to the fact that high neuroticism individuals can interpret the incongruent trials and consequently the emotional conflict as more arousing and, therefore, there is more activation in the amygdala (Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000; Haas et al., 2006, 2007). Since this structure is also related with modulation of threat and faster responses to negative emotional stimuli, this can be one of the reasons why individuals high in neuroticism are more vigilant to negative stimuli (Eisenberger, Lieberman, & Satpute, 2005; Haas et al., 2007; Whalen, 1998).

Patients with major depressive disorder (MDD) usually experience bias toward negative information, lower accuracy in emotional recognition and impairment in cognitive inhibition (Strand et al., 2012). Chechko et al. (2013) and Strand et al. (2012) confirmed that patients with MDD, performing WFS tasks, showed less accurate and longer response times than control subjects judging incongruent trials, which indicates that they are more affected by the Stroop interference effect. However, Başgöze et al. (2015) in a WFS task where participants had to evaluate word valence (neutral, negative or positive), while ignoring emotional faces (happy, sad and neutral) found that, regarding negative words, healthy patients made more errors in incongruent stimuli (negative word valence assessment of stimuli with happy faces) while MDD patients made more errors in congruent negative stimuli. Keedwell et al. (2016) also found slower reaction times, for both MDD and control subjects, when they had to evaluate a positive word superimposed on an angry face. Since MDD patients and individuals with high avoidance temperament respond more slowly when distractive material is negative (Başgöze et al., 2015; Hu et al., 2012; Mauer & Borkenau, 2007; Siegle, Steinhauer, Thase, Stenger, & Carter, 2002; Wang et al., 2008) and mood disorder patients have higher negative attentional emotional bias (Keedwell et al., 2016), this could point to more difficulties in withdrawing attention from angry faces (Mauer & Borkenau, 2007; Stenberg et al., 1998).

Moreover, in a colour-naming facial Stroop, where happy, angry, sad and neutral faces were presented, participants induced with sad mood took more time to identify the colour of angry than happy faces and also took longer to name the colour of neutral faces (Isaac et al., 2012). Neutral faces are ambiguous and can be interpreted as more negative depending on individual differences in personality (Cooney, Atlas, Joormann, Eugène, & Gotlib, 2006; Isaac et al., 2012; Keedwell et al., 2016; Somerville, Kim, Johnstone, Alexander, & Whalen, 2004). So, the difficulty in withdrawing attention from neutral faces could be due to the fact that they are more ambiguous or because they were interpreted as more negative.

Contrary to healthy subjects that showed a positive superiority effect, MDD patients showed a lack of positive bias in WFS tasks, proved by the fact that they made more errors than healthy subjects in assessing word valence in stimuli with happy faces (Strand et al., 2012). In addition, Hu et al. (2012), in a WFS task where the subjects had to evaluate face valence while ignoring the words, revealed that positive words did not affect the processing of negative faces in MDD patients as they did in healthy subjects. The authors proposed that MDD patients did not interpret positive stimuli as so positive and, therefore, those stimuli stopped producing conflict and interference (Hu et al., 2012; Strand et al., 2012).

Mauer and Borkenau (2007) presented happy, angry and neutral faces, in four different colours. Participant's task was to identify the colour in which faces were printed. They found that participants with high avoidance temperament (high anxiety and neuroticism) were slower in identifying colours of angry faces than happy and neutral faces. These results point to a higher interference of negative material in colour naming in high avoidance temperament individuals. Together with the previous results, we can infer that high arousing stimuli, especially the negative ones, interfere more with the current task and cause even more performance impairment in subjects with high anxiety and neuroticism, maybe because these stimuli may require more attentional resources (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; MacLeod, Mathews, & Tata, 1986; Osinsky et al., 2012; Stenberg et al., 1998; Taylor, 1991).

The Attentional Control Theory (Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009; Eysenck, Derakshan, Santos, & Calvo, 2007; Eysenck & Derakshan, 2011) explains the effects of anxiety on attention and cognitive performance in tasks involving information inhibition, shifting and updating. The inhibition function is responsible for the resistance to interference from task irrelevant stimuli. The authors suggest that subjects with high anxiety have more difficulties in suppressing the irrelevant information and therefore are more susceptible to distraction and probably that is why they have more difficulties in solving emotional and cognitive conflict. According to the model, the shifting function is responsible for flexibly allocating attention to the current relevant task. Individuals with high anxiety levels also show difficulties in flexibly shifting their attention from one aspect of the task to another or between demands from various tasks. At last, anxiety also influences the updating function, because it can reduce the ability to update and monitor the information in working memory and has been associated with higher ERN (Error-Related Negativity) amplitude in Stroop Tasks. The ERN is a negative deflection at central and frontal sites, peaking at approximately 50 ms after an incorrect response and reflects error detection and monitoring – an incorrect response or a conflict between the response that the subject wanted to give and the one he/she actually gave (Luck, 2005). In conclusion, high levels of anxiety can increase the recruitment of cognitive resources to solve a demanding task, overloading the subject and possibly affecting its performance on the task, especially when inhibition and shifting are necessary (Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009; Eysenck et al., 2007; Eysenck & Derakshan, 2011; Osinsky et al., 2012).

Regarding ERPs, Taake et al. (2009), in an emotional Stroop study, found an early effect of threatening words: an augmented early anterior positivity, peaking at 60 ms, in high anxious individuals, which suggests an early processing of word salience modulated by anxiety and a general attentional bias that facilitates the detection of threatening stimuli. High arousing irrelevant stimuli, like threatening words or faces, attract attention and interfere with the relevant task through avoidance processes and/or augmented processing, especially in high anxiety or high neuroticism subjects (Carretié et al., 2001a; Carretié et al., 2001b; Metzger, Orr, Lasko, McNally, & Pitman, 1997; Osinsky et al., 2012; Thomas et al., 2007).

Hereupon, the dysfunctional processing of the emotional conflict shown by subjects with high neuroticism can be due to a lack of top-down cognitive control and difficulties in focus on the task, probably because the attention is oriented to the emotional distractor.

OVERVIEW

The main objective of this thesis is to study the influence of the neuroticism personality trait on the processing of emotional conflict. For that purpose we used the Word-Face Stroop (WFS) paradigm, a modified version of the traditional Stroop task in which words with different valences are superimposed on faces also with different valences. We aim to study the conflict generated by words and faces, that is, we will investigate the influence of emotional and neutral words on valence categorization of faces and the effects of different emotional expressions in faces on word valence assessment, in three separate experiments. We are also interested in the temporal neural dynamics of conflict processing, and as such we will use ERPs along with behavioural measures – reaction time and accuracy ratings – in order to understand how conflict information is processed and how it is modulated by neuroticism. ERPs will also be useful to investigate the discrepancies between the explicit and implicit processing of different facial expressions, either positive – happy – or negative – anger, fear, sadness, and disgust.

To our knowledge, no study so far has investigated these effects as globally and holistically as we tried to do. Firstly, we only know of one study that presented the same facial expressions as we did (Hu et al., 2012) while also presenting positive and negative words selected according to their valence ratings. However, in this study, only faces were assessed and no electrophysiological data was collected. The majority of the studies only tested one task similar to one of ours (i.e., either face valence assessment or word valence assessment): only in Zhu et al. (2010), and Beall and Herbert (2008) were participants asked to performed both tasks. Only Abbassi, Kahlaoui, Wilson, and Joanette (2011), Zhu and Luo (2012), Zhu et al. (2010), Frühholz et al. (2011), Xue et al. (2016), Osinsky et al. (2012), and Strand et al. (2012) used ERPs in a WFS task similar to ours. Additionally, the majority of research with this paradigm only used two emotional expressions and their names in order to study conflict/interference effects (Chechko et al., 2013; Egner et al., 2008; Ovaysikia et al., 2010; Shen et al., 2013; Soutschek & Schubert, 2013; Xue et al., 2016; Yang et al., 2016; Zhu & Luo, 2012; Zhu et al., 2010). More importantly, only Haas et al. (2007) used this paradigm to study the influence of the neuroticism trait in emotional conflict using functional magnetic resonance imaging (fMRI). Hence, this thesis intends to provide a broader picture of the interference effects of faces in words and *vice-versa*, by filling the gaps we found in the state of the art and, most importantly, to understand how neuroticism can affect our conflict assessment, monitoring, and resolution.

CHAPTER II: EMOTIONAL CONFLICT BETWEEN EMOTIONALLY VALENCED WORDS AND FACES IN A WORD-FACE STROOP TASK

INTRODUCTION

The aim of the present chapter is to extend the understanding about the interference between words and faces with different emotional content in a word-face Stroop task and how the personality trait neuroticism is associated with this process. For this porpuse, we conducted the present experiment using positive, negative and neutral words superimposed on positive (happy faces), negative (angry, disgusted, sad and fearful faces) and neutral faces in a valence categorization task. Participants judged both word and face valence.

We predict that incongruent/conflict trials will produce larger interference effects (less accuracy and longer reaction times) than congruent trials in both tasks. According to Cothran et al. (2012) results, we anticipate that positive faces will be evaluated faster and more accurately than negative and neutral faces. Regarding the word valence assessment (WVA) task, we expected that more arousing faces (fearful, angry, and happy) would cause more interference than less arousing faces (neutral and sad) (Beall & Herbert, 2008; Stenberg et al., 1998; Yang et al., 2016). Since only two studies, Hu et al. (2012) and Stenberg et al. (1998), used disgusted faces in their tasks, and no meaningful results were found, we could not make any predictions for these stimuli.

Regarding neuroticism, we hipothesize that neuroticism scores will correlate positively with reaction times and negatively with accuracy in incongruent stimuli, indicating more interference effects in subjects with high neuroticism (Chechko et al., 2013; Haas et al., 2007; Keedwell et al., 2016; Mauer & Borkenau, 2007; Strand et al., 2012).

METHOD

1. PARTICIPANTS

Sixty-four graduate and undergraduate students from the University of Aveiro were recruited. Nine participants were excluded from the analysis due to performance accuracy being below chance level. Thus, the final sample was 55 participants (45 females) with a mean age of 22 years-old (SD = 3.99, range: 19 – 41 years). Regarding neuroticism scores, participants ranged from 49 (percentile 3) to 155 (percentile 99), with a mean of 90.33 (percentile 50). All participants were native European Portuguese speakers.

2. MATERIALS

The Portuguese version of the NEO – Personality Inventory-Revised (NEO PI-R) by Lima and Simões (Costa & McCrae, 2000) was used to assess neuroticism. The instrument consists of 240 items, distributed by five personality traits (domains) – neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. Each domain comprises 48 items also distributed by 30 facets (six for each domain). This personality inventory consists of statements that can be evaluated with a Likert scale of 5 points ranging from 0 (*strongly disagree*) to 4 (*strongly agree*). We used the neuroticism scale of the NEO PI-R to assess neuroticism scores of all participants. The Portuguese version of this scale has a Cronbach's alpha of .853, which points to a good internal consistency. In the present sample, the Cronbach's alpha was .830. Regarding convergent and discriminant validity, the neuroticism trait from the NEO-PI-R correlates significantly ($r = .75$, $p < .001$) with the neuroticism trait from the EPQ (Eysenck Personality Questionnaire) (Costa & McCrae, 2000).

Pictures of facial expressions of emotion were selected from five different databases: Face Database from the *Centro Universitário da Fundação Educacional Inaciana* (FEI Face Database) (Oliveira Junior & Thomaz, 2006), Pictures of Facial Affect (Ekman & Friesen, 1976), the Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt, & Öhman, 1998), the Psychological Image Collection at Stirling (PICS) and the Radboud

Face Database (Langner et al., 2010). A total of 432 faces were selected, being 72 faces per emotion: fear, anger, sadness, disgust, happiness and 72 neutral (half male and half female in each set). A black oval frame was placed over the face to cover background and hair cues and to homogenize the sample of images. In order to standardize the size of the images, photographs were resized to 285 (width) x 380 (height) pixels (resolution: 72ppi). All faces were saved as grey-scale picture files.

Four hundred and thirty-two words were selected based on their valence ratings from the adaptation of the ANEW (Affective Norms for English Words) for European Portuguese (Soares et al., 2012): 144 with positive, 144 with negative and 144 with neutral valence. Three one-way ANOVAs were conducted to analyse Valence, Word Frequency and Number of Letters between the selected sets of words. A main effect of Valence was found, $F(2, 429) = 8547.18$, $p < .001$, $\eta_p^2 = .98$: positive words ($M = 7.48$, $SD = 0.37$) were significantly more pleasant ($p < .001$) than negative ($M = 2.29$, $SD = 0.36$) and neutral words ($M = 5.14$, $SD = 0.24$). Negative words were significantly more unpleasant than neutral words ($p < .001$). No differences were found between the three sets regarding the Number of Letters, $F(2, 429) = 2.05$, $p = .130$, and Word Frequency, $F(2, 421) = 2.48$, $p = .090$.

Stimuli consisted of a face with a superimposed word placed over the nose area of the face (X = 50% and Y = 56% of the computer screen). As mentioned above, both words and faces could be positive, negative or neutral in valence. Therefore, stimuli could be congruent (the word and the face had the same emotional valence) or incongruent (the word and the face had different emotional valence) (see Figure 7 for an example of the stimuli used).

Figure 7: Examples of stimuli used in Experiment 1: a) congruent stimuli – the negative word "death" superimposed on a sad face; b) incongruent stimuli – the negative word "cancer" superimposed on a happy face.

3. PROCEDURE

Firstly, written consent was obtained from all participants. Participants were randomly allocated to one of four experimental conditions (16 participants per condition). Conditions differed in the negative facial expressions that were displayed (anger, disgust, fear and sadness). Positive (happy) and neutral faces were the same for all four conditions.

Four hundred and thirty-two stimuli were presented in random order and were divided into two experimental blocks (216 stimuli in each block). In one block, the participants' task was to assess the valence of the face and in the other block they were asked to assess the valence of the word. Each block had a total of 72 congruent stimuli (negative, positive and neutral) and 144 incongruent stimuli (positive faces combined with negative and neutral words, negative faces combined with positive and neutral words and neutral faces combined with negative and positive words). Each face was presented twice (once in each block) but there was no repetition of words. So, in the same experiment, participants saw one face, paired with a given word, in one block, as a target (i.e. participants were asked to judge face valence while ignoring the word – the face was the target and the word was the distractor), and the same face, paired with a different word, on the other block, as a distractor (i.e. participants were asked to judge word valence while ignoring the face – the face was the distractor and the word was the target). The answer was given on a computer keyboard and the options were the same on both tasks: 1 = negative; 2 = neutral; 3 = positive. Half of the participants evaluated the words first and the other half evaluated the faces first.

The experiment took place in an isolated testing room. Each trial began with a 750 ms white fixation cross, followed by the composite face-word stimulus presented in the centre of the screen that remained visible until the subject responded. The inter-trial interval was 500 ms. Screen background colour was black. Words were written in capital letters, in black, Arial and font size 25. All instructions were written on the computer screen. Stimuli were presented with E-Prime software (Psychology Software Tools, Pittsburgh, PA).

4. DATA ANALYSIS

Response accuracy and reaction times (RTs) were analysed with a 4 x 3 x 3 split-plot ANOVA. Emotion (negative facial expression: fear, disgust, anger and sadness) was the between-subjects factor. Face Valence (positive, negative and neutral faces) and Word Valence (positive, negative and neutral words) were within-subject factors. The split-plot ANOVAs were conducted separately for each task: face valence assessment (FVA) task and word valence assessment (WVA) task. Where necessary, degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity. Pairwise comparisons with *Bonferroni* corrections were also carried out when needed. Pearson correlations were used to test the association between neuroticism and all the variables. Marginal differences ($p < .070$) will be presented if relevant to our study objectives.

All data were analysed with SPSS, Version 20.0 (IBM Corp., 2011).

RESULTS

1. ACCURACY RESULTS

1.1. FACE VALENCE ASSESSMENT

The results from the 4 x 3 x 3 split-plot ANOVA conducted for face valence assessment are presented in Table 2.

The main effect of Face Valence was significant and post-hoc tests showed that the valence of positive faces was judged more accurately (M = 96.69%, SE = 0.64) than the valence of negative (M = 91.42%, SE = 1.11) and neutral faces (M = 91.84%, SE = 0.84, $p < .001$).

There was also a significant main effect of Word Valence. However, no significant differences in pairwise comparisons were found.

Concerning the interaction between Face Valence and Emotion (see Figure 8), multiple comparisons showed that participants made more errors when they were asked to evaluate the valence of sad faces compared to fearful (p = .009) and disgusted faces (p = .003). Participants were also less accurate in judging the valence of negative compared to positive (p < .001) and neutral (p = .001) faces in the sadness condition. In relation to the fear condition, valence judgments of positive faces originated higher accuracy compared to neutral faces (p = .002) and fearful faces (although it did not reach statistical significance in this last case). The results in the anger condition were similar: higher accuracy ratings for positive face valence evaluation than for negative (p = .032) and neutral (p = .013).

Table 2: Results from the 4 x 3 x 3 split-plot ANOVA for Face Valence Assessment analysis.

Effect	F	d. f.	*p*	η_p^2
Emotion	2.46	3, 51	.073	.13
Face Valence	**14.89**	**2, 102**	**<.001**	**.23**
Word Valence	**3.55**	**2, 102**	**.032**	**.07**
Emotion x Face Valence	**4.34**	**6, 102**	**.001**	**.20**
Emotion x Word Valence	**3.10**	**6, 102**	**.008**	**.15**
Face Valence x Word Valence	**6.55**	**4, 204**	**<.001**	**.11**
Face Valence x Word Valence x Emotion	0.89	12, 204	.557	.05

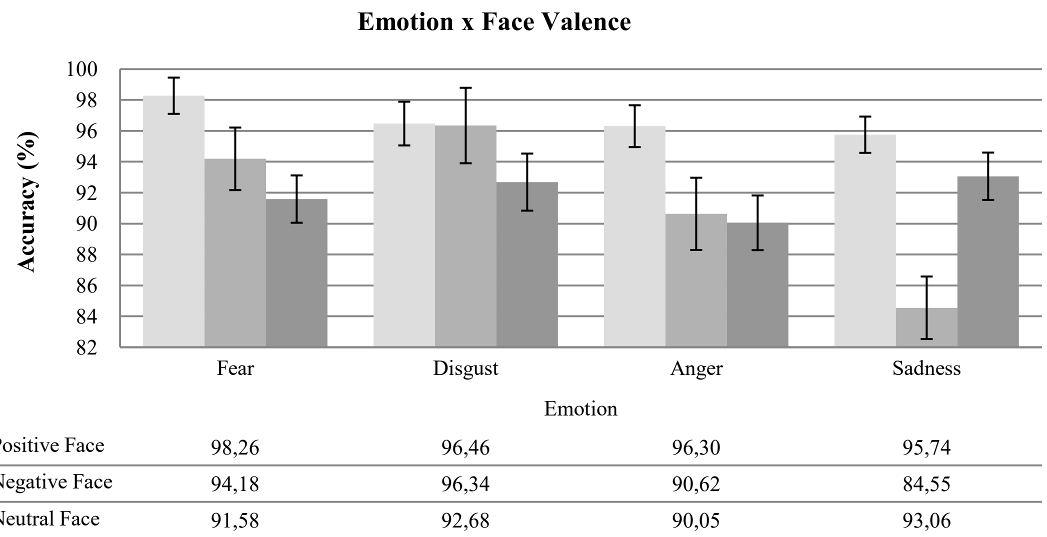
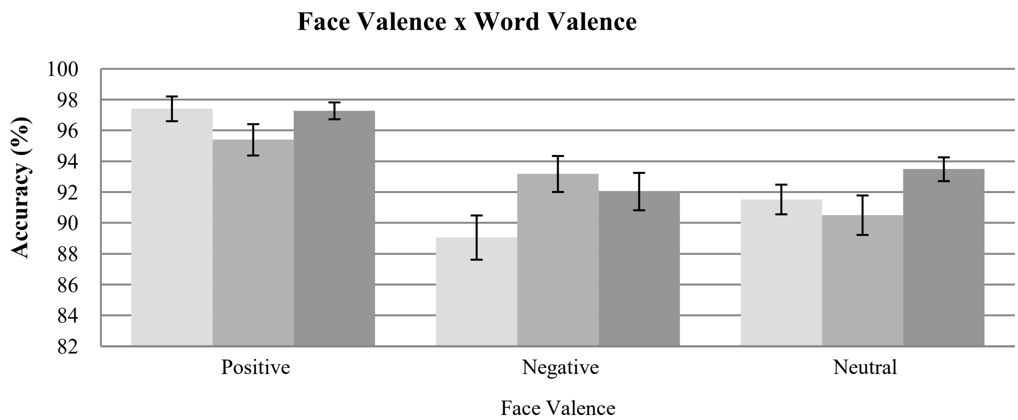


Figure 8: Percentage of correct responses plotted by Emotion and Face Valence conditions. Error bars represent standard errors.

Post-hoc tests conducted to investigate the significant interaction between Word Valence and Emotion showed that participants were less accurate in face valence assessment when faces were paired with positive words (*M* = 89.12%, *SE* = 1.75) than with negative (*M* = 93.40%, *SE* = 1.56, *p* = .007) and neutral words (*M* = 94.44%, *SE* = 1.25, *p* = .002) only in the anger condition. Furthermore, participants were more accurate judging face valence in the disgust (*M* = 96.34%, *SE* = 1.31) compared to the sadness (*M* = 91.32%, *SE* = 1.08, *p* = .028) condition but only when faces were paired with neutral words.

The interaction between Face and Word Valence is represented in Figure 9. Pairwise comparisons revealed some congruency effects: when participants were asked to evaluate the valence of congruent stimuli with happy faces, accuracy was higher compared to when happy faces were paired with negative words (*p* = .028) – incongruent stimuli. On the other hand, when negative faces were paired with positive words (incongruent stimuli), participant's accuracy was lower than when they were paired with negative words – congruent stimuli (*p* = .004) – or neutral words (*p* = .019). Furthermore, when participants were asked to evaluate face valence of stimuli with positive words, their accuracy was higher for positive faces than for negative and neutral faces (*p* < .001).



	Positive	Negative	Neutral
Positive Word	97,41	89,05	91,52
Negative Word	95,39	93,18	90,51
Neutral Word	97,28	92,04	93,49

Figure 9: Percentage of correct responses plotted by Face Valence and Word Valence conditions. Error bars represent standard errors.

1.2. WORD VALENCE ASSESSMENT

The results from the 4 x 3 x 3 split-plot ANOVA conducted for word valence assessment are presented in Table 3.

Table 3: Results from the 4 x 3 x 3 split-plot ANOVA for Word Valence Assessment analysis.

Effect	F	d. f.[a]	*p*	η_p^2
Emotion	0.76	3, 51	.524	.04
Face Valence	1.38	2, 102	.257	.03
Word Valence	**32.04**	**1.38, 70.10**	**<.001**	**.39**
Emotion x Face Valence	1.21	6, 102	.306	.07
Emotion x Word Valence	0.30	4.12, 70.10	.882	.02
Face Valence x Word Valence	0.62	4, 204	.650	.01
Face Valence x Word Valence x Emotion	**2.63**	**12, 204**	**.003**	**.13**

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The only main effect found was for Word Valence and post-hoc tests confirmed that participant's accuracy was higher when they had to evaluate the valence of negative (M = 92.41%, SE = 1.15) compared to positive (M = 89.67%, SE = 1.09, p = .022) and neutral (M = 79.55%, SE = 1.37, $p < .001$) words, regardless of the face valence. Moreover, the difference between word evaluation of positive and neutral words was also significant ($p < .001$).

To explore the interaction between Face Valence, Word Valence and Emotion, four 3 (Word Valence) x 3 (Face Valence) repeated measures ANOVAs were conducted, one for each Emotion. The main effect of Word Valence was found in all emotional conditions: fear – $F(1.22, 18.25) = 8.84$, $p = .006$, $\eta_p^2 = .37$; disgust – $F(1.11, 11.06) = 6.54$, $p = .024$, $\eta_p^2 = .40$; anger – $F(1.24, 13.66) = 9.62$, $p = .006$, $\eta_p^2 = .47$ and sadness – $F(2, 30) = 7.37$, $p = .002$, $\eta_p^2 = .33$. Post-hoc tests revealed that neutral words were evaluated more incorrectly (see Table 4) than negative words (fear: $p = .007$; disgust: $p = .054$; anger: $p = .003$; sadness: $p = .022$). Additionally, in the anger condition, the interaction between Face and Word Valence was significant, $F(4, 44) = 3.11$, $p = .024$, $\eta_p^2 = .22$. Pairwise comparisons showed that when participants had to evaluate the valence of words paired with angry faces, they made more errors assessing neutral (M = 75.35%, SE = 2.88) than positive (M = 92.01%, SE = 2.54, $p = .007$) and negative (M = 92.71%, SE = 2.82, *p* = .003) words. The interaction between Face and Word Valence was also significant in the sadness condition, *F*(4, 60) = 3.27, *p* = .017, η_p^2 = .18. Multiple comparisons showed that participants were again less accurate in judging word valence of neutral words (*M* = 78.39%, *SE* = 2.47) than emotional ones (positive: *M* = 89.58%, *SE* = 1.47, *p* = .002; negative: *M* = 92.45%, *SE* = 3.00, *p* = .003) but only when they were paired with happy faces. Furthermore, participants were more accurate in judging the valence of negative words superimposed in sad faces (*M* = 92.45%, *SE* = 1.87) than in happy (*M* = 83.59%, *SE* = 2.88, *p* = 002) and neutral (*M* = 80.99%, *SE* = 2.97, *p* = .021) ones – congruency effect.

Table 4: Means and standard errors of the main effect of Word Valence in all emotional conditions.

Emotional Condition	**Word Valence**	**Mean** (% of correct responses)	**Standard Error**
Fear	Positive	90.97	1.51
	Negative	92.97	1.54
	Neutral	80.99	2.89
Disgust	Positive	91.04	2.42
	Negative	91.79	2.37
	Neutral	79.29	3.06
Anger	Positive	89.70	2.57
	Negative	94.44	1.97
	Neutral	78.59	2.82
Sadness	Positive	86.98	2.24
	Negative	90.45	2.80
	Neutral	79.34	2.19

1.3. NEUROTICISM

In order to clarify the relation between Neuroticism and the remaining variables in this study we used Pearson correlations. A significant negative correlation emerged between Neuroticism and Face Valence Assessment of stimuli with neutral faces and negative words (*r* = -.34, *p* = .011): as Neuroticism increases the accuracy in the assessment of neutral faces paired with negative words decreases. Three positive correlations were also found: as Neuroticism increases, participant's accuracy also increases when they must evaluate positive words paired with neutral (*r* = .30, *p* = .027) and negative faces (*r* = .34, *p* = .011) and when they had to evaluate negative words presented with negative faces – congruent negative stimuli (*r* = .28, *p* = .043).

2. REACTION TIME RESULTS

In the following analysis only correct responses were considered.

2.1. FACE VALENCE ASSESSMENT

The results from the 4 x 3 x 3 split-plot ANOVA conducted for face valence assessment are presented in Table 5.

Table 5: Results from the 4 x 3 x 3 split-plot ANOVA for Face Valence Assessment analysis.

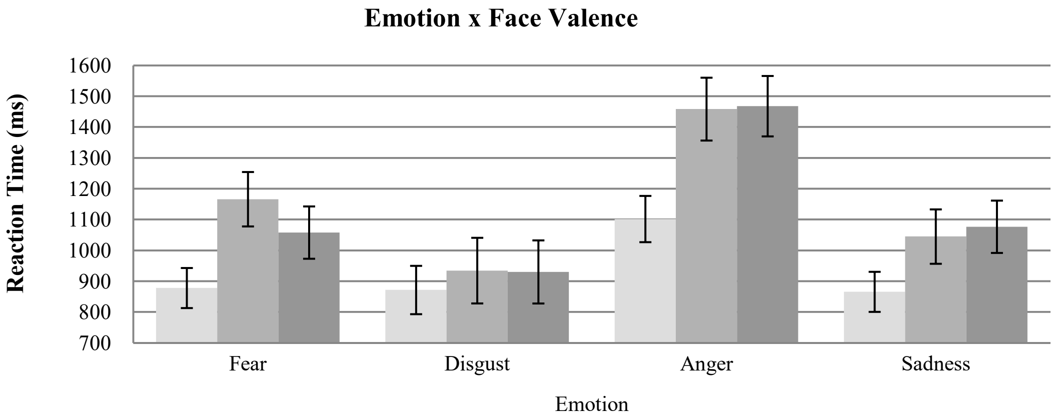
Effect	F	d. f.	*p*	η_p^2
Emotion	**4.77**	**3, 51**	**.005**	**.22**
Face Valence	**40.72**	**2, 102**	**<.001**	**.44**
Word Valence	0.28	2, 102	.757	.01
Emotion x Face Valence	**3.71**	**6, 102**	**.002**	**.18**
Emotion x Word Valence	2.14	6, 102	.055	.11
Face Valence x Word Valence	**2.45**	**4, 204**	**.047**	**.05**
Face Valence x Word Valence x Emotion	1.38	12, 204	.178	.08

A main effect of Emotion was found and post-hoc tests showed that participants' responses were slower in the anger condition (*M* = 1342.44 ms, *SE* = 86.18) than in the disgust (*M* = 911.93 ms, *SE* = 90.01, *p* = .007) and sadness (*M* = 995.57 ms, *SE* = 76.64, *p* = .022) conditions.

Regarding the main effect of Face Valence, pairwise comparisons showed that regardless of all other variables, participants were faster in evaluating the valence of happy faces (*M* = 929.07 ms, *SE* = 35.53) compared to negative (*M* = 1150.75 ms, *SE* = 48.27, *p* < .001) and neutral (*M* = 1132.97 ms, *SE* = 46.41, *p* < .001) faces.

In relation to the interaction between Face Valence and Emotion (see Figure 10), post-hoc tests showed that for all conditions except disgust, participants assessed the valence of positive faces faster than negative (fear: *p* < .001; anger: *p* < .001; sadness:

$p = .002$) and neutral (fear: $p = .003$; anger: $p < .001$; sadness: $p < .001$) faces. Furthermore, participants assessed angry faces slower than disgusted ($p = .005$) and sad ($p =. 021$) faces. Neutral face valence assessment was also slower in the anger condition compared to fear ($p = .016$), disgust ($p = .002$) and sadness ($p = .024$) conditions.

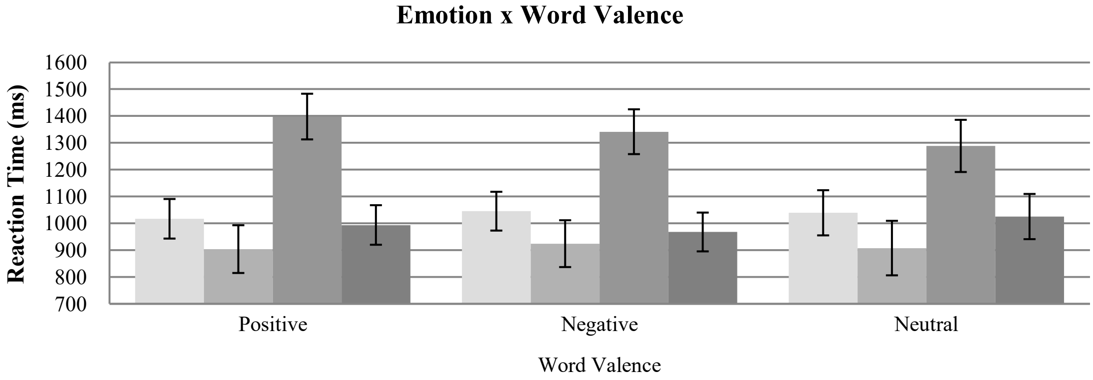


	Fear	Disgust	Anger	Sadness
Positive Faces	877,78	871,40	1101,61	865,47
Negative Faces	1165,88	934,31	1458,07	1044,71
Neutral Faces	1057,64	930,08	1467,63	1076,53

Figure 10: Reaction times plotted by Emotion and Face Valence conditions. Error bars represent standard errors.

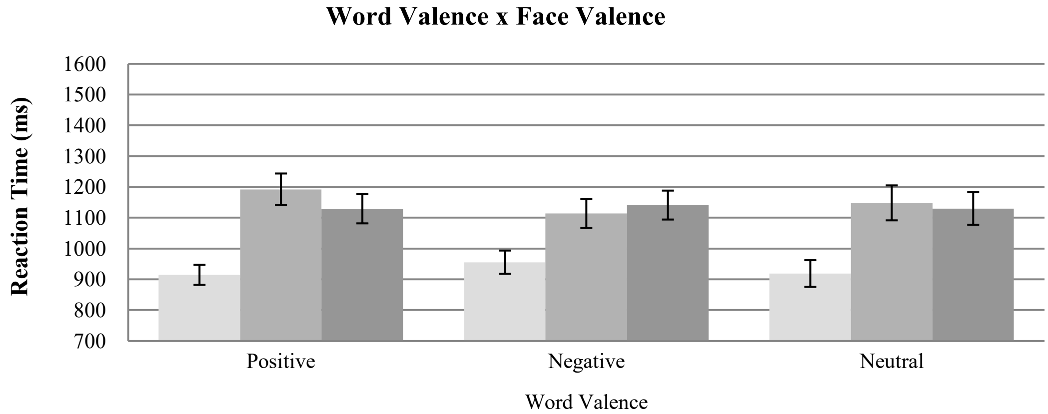
There was a marginally significant interaction between Word Valence and Emotion (see Figure 11). Multiple comparisons showed that in the anger condition participants were slower in response to faces paired with positive than with neutral words ($p = .011$). Moreover, participants' face valence evaluation of stimuli with positive words was slower in the anger condition than in all other conditions (fear: $p = .008$; disgust: $p = .001$; sadness: $p = .004$). The same happened in stimuli with negative words (disgust: $p = .007$; sadness: $p = .008$; fear: $p = .059$).

Finally, pairwise comparisons for the interaction between Face Valence and Word Valence (Figure 12) showed faster reaction times when positive words were superimposed on positive faces than when they were superimposed on negative and neutral ($p < .001$) faces – congruency effect.



	Positive	Negative	Neutral
Fear	1016,89	1045,19	1039,23
Disgust	903,87	924,21	907,72
Anger	1397,68	1341,27	1288,35
Sadness	993,80	967,72	1025,19

Figure 11: Reaction times plotted by Emotion and Word Valence conditions. Error bars represent standard errors.



	Positive	Negative	Neutral
Positive Faces	914,011	955,115	918,069
Negative Faces	1191,474	1113,185	1147,576
Neutral Faces	1128,691	1140,496	1129,723

Figure 12: Reaction times plotted by Word Valence and Face Valence conditions. Error bars represent standard errors.

2.2. WORD VALENCE ASSESSMENT

The results from the 4 x 3 x 3 split-plot ANOVA conducted for word valence assessment are presented in Table 6**.**

The only effect found in the reaction time analysis for word valence assessment was the main effect of Word Valence. Post-hoc tests confirmed that neutral words took more time to evaluate (*M* = 1360.34 ms, *SE* = 49.52) than emotional words (positive: *M* = 1193.56 ms, *SE* = 50.46, $p < .001$; negative: *M* = 1212.69 ms, *SE* = 55.25, $p = .004$), regardless of face valence.

Table 6: Results from the 4 x 3 x 3 split-plot ANOVA for Word Valence Assessment analysis.

Effect	F	d. f.[a]	*p*	η_p^2
Emotion	1.53	3, 51	.218	.08
Face Valence	0.35	1.43, 73.04	.636	.01
Word Valence	**12.43**	**1.63, 83.24**	**<.001**	**.20**
Emotion x Face Valence	0.59	4.30, 73.04	.681	.03
Emotion x Word Valence	0.67	4.90, 83.24	.642	.04
Face Valence x Word Valence	1.12	2.69, 137.03	.339	.02
Face Valence x Word Valence x Emotion	1.55	8.06, 137.03	.146	.08

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

2.3. NEUROTICISM

A negative correlation was found showing that high Neuroticism scores were associated to faster valence assessment of negative words superimposed on negative faces ($r = -.27$, $p = .044$).

DISCUSSION

As expected, a congruency effect was found, thus confirming results from the general literature on the WFS paradigm (Avram et al., 2010; Basgöze & Gökçay, 2008; Beall & Herbert, 2008; Chechko et al., 2013; Clayson & Larson, 2013; Shen et al., 2013; Stenberg et al., 1998; Strand, et al., 2012; Zhu et al., 2010), but only in the face valence assessment task. Positive and negative faces were easier to evaluate in congruent than in incongruent stimuli, as reflected by the interaction between Face Valence and Word Valence in the FVA task. Contrary to our predictions, we did not find congruency effects in WVA judgments. This result could be due to the methodological/task differences between our study and the ones described in Chapter I.

The positive valence advantage (Stenberg et al., 1998) was only found in the face valence assessment task – positive faces were evaluated faster and more accurately than negative and neutral faces. Conversely, in the WVA task negative words were more accurately assessed than positive and neutral words. These results are the opposite of what Stenberg et al. (1998) found in their experiments. However, they are congruent with results from Matthews et al. (1995), who claimed a faster response for negative than positive and neutral words in a lexical decision task. These results can also be explained by the fact that negative words might have been more arousing than positive: negative words, such as "rape", "murder" and "aggressive" may be perceived as more emotionally intense than "passion", "excitement", or "adventure" (the three most arousing words with negative and positive valence, respectively).

Additionally, when participants had to evaluate word valence, emotional words were evaluated faster than neutral words, supporting the idea that emotional material is processed first (Beall & Herbert, 2008; Herbert et al., 2006; Zhu et al., 2010).

In the WVA task, congruency effects were only found in the sadness block and only in negative word valence assessment, that is, participants evaluated negative words more accurately when presented with sad faces – congruent negative stimuli – than when they were paired with happy and neutral faces. This result is evidence that sad faces had a facilitation effect on negative word valence assessment, confirming results found by Stenberg et al. (1998) and Strand et al. (2012). In the same condition, when words were presented with happy faces, participants made more errors in neutral than in emotional (positive and negative) word valence assessment. Moreover, in the same task, but in the angry condition, participants evaluated emotional words more accurately than neutral words when paired with angry faces, which mean that angry faces had more interference effects on neutral than on emotional words. Both results showed that emotional word processing is easier than neutral. Furthermore, we hypothesized more interference effects from high arousing faces – angry, happy, and fearful – in word valence assessment, but we did not find evidence for this. This could be related with methodological differences, such as the use of five different facial expressions, words that did not match the names of the expressions presented, or the inclusion of neutral words and faces.

Regarding the FVA task, we found more accuracy in face valence assessment of fearful and disgusted compared to sad faces, and faster evaluation of disgusted and sad compared to angry faces. When combined, this could point to an easier identification of disgusted faces as negative facial expressions. In turn, in the sadness block, participants' evaluation of sad faces was impaired compared to the evaluation of happy and neutral faces, and stimuli with neutral words were assessed more incorrectly in the sad compared to the disgust condition. These results can indicate more difficulties in recognizing sad faces as a negative stimulus.

Finally, in the anger condition, in general, faces were evaluated more slowly than in all other blocks, especially neutral and happy faces. Moreover, participants were more accurate in face valence assessment when faces were paired with neutral and negative than with positive faces. Taken together these results suggest that implicit word processing can have more influence in the assessment of faces in the anger conditions than in all other emotional conditions. Moreover, positive words seem to interfere more than negative and neutral words in that judgment.

We expected that, as neuroticism scores increased, participants would be more susceptible to emotional conflict and to stimuli with negative faces (more salient, arousing, and threatening). Regarding accuracy, we found that higher scores in neuroticism were associated with more errors in face valence assessment of neutral faces paired with negative words; with higher accuracy in positive word valence assessment of stimuli with negative and neutral faces; and with higher accuracy in word valence assessment in negative congruent trials. In relation to reaction times, neuroticism was also associated with faster reaction times in negative word valence assessment of congruent trials. The first association indicates that, as neuroticism increases, the percentage of errors in face valence assessment of neutral faces paired with negative words also increases. This can suggest that high neuroticism participants suffered more interference from negative words and perhaps this interference caused a biased interpretation of neutral faces as more negative, thus generating more evaluation errors. In fact, some studies have suggested that, because neutral faces are ambiguous, they can be interpreted as more negative depending on individual differences in personality (Cooney et al., 2006; Isaac et al., 2012; Keedwell et al., 2016; Somerville et al., 2004). The second association established that, as neuroticism increased, higher accuracy in positive word valence assessment in incongruent trials was observed. This is a peculiar and unexpected result. We were expecting a negative correlation between task performance and neuroticism, that is, as neuroticism increased, accuracy in conflict trials would decrease. We could not find any explanation for this correlation.

Another important finding was that higher neuroticism scores were associated with higher accuracy and faster reaction times in word valence assessment of congruent negative stimuli. That is, negative faces can have a greater facilitation effect on negative word valence assessment in high neuroticism participants. With the exception of the correlation with positive word valence assessment in incongruent trials, the remaining results are in line with the literature that claims that high neuroticism subjects are more reactive to negative material, have a negative bias, and are more influenced by emotional conflict, which is compatible with our hypotheses (Berggren & Derakshan, 2013; Bradley et al., 1998; Bradley & Lang, 1999; Costa & McCrae, 1997, 2000; Cremers et al., 2010; Denissen & Penke, 2008; Fjell et al., 2005; Fox & Zougkou, 2011; Haas et al., 2008; Haas et al., 2007; Mauer & Borkenau, 2007; Mogg et al., 2007; Norris et al., 2007; Perlman et al., 2009; Rafienia et al., 2008; Reynaud et al., 2012; Rossignol et al., 2005; Surcinelli et al., 2006; Wiebe & Smith, 1997; Wright et al., 2006).

In sum, we were expecting that high arousing faces would produce more interference effects on word valence assessment. In the FVA task, a happy superiority effect was indeed found, supporting our hypothesis. We would expect to find longer reaction times and higher accuracy ratings in the evaluation of arousing negative faces – fear and anger, since they can capture more attention and are more easily and rapidly recognized than sad and disgusted faces. Fearful faces were evaluated more correctly than sad faces, but the effects regarding angry faces were confusing. Additionally, disgusted faces in this experiment were recognized as negative more accurately than sad faces, and faster than angry ones. This result is interesting because the few studies that introduced disgusted faces in WFS paradigms did not find meaningful results.

Chapter III: The Interference of Negative Facial Expressions in Word Evaluation in a WFS Task

INTRODUCTION

Since we could not find interference effects from negative facial expressions in the word valence assessment task in the last experiment, we conducted Experiment 2. In this experiment, we only used negative facial expressions and the participants were only asked to make word valence judgments. Words were selected based on their valence and arousal ratings. With this task we could focus directly on the influence of negative facial expressions and minimize the interference of word arousal (as it was matched between positive and negative words). We expected to shed light on the interference effects of each negative facial expression separately in word valence assessment. We expected more interference effects from more arousing facial expressions – angry and fearful faces – confirming the results obtained by Stenberg et al. (1998) and Beall and Herbert (2008). We also hypothesized lower accuracy and longer reaction times in positive word valence assessment – conflict trials.

In relation to the correlations with neuroticism, we expected high neuroticism to be related with better performance in congruent negative trials confirming our previous findings and also with more interference of negative facial expressions in incongruent trials (Chechko et al., 2013; Haas et al., 2007; Strand et al., 2012).

METHOD

1. PARTICIPANTS

Thirty graduate and undergraduate students were recruited at the University of Aveiro (10 males). Participants' ages varied between 18 and 47 years (*M* = 21.50, *SD* = 5.18).

Regarding neuroticism, participant´s scores ranged from 36 (percentile 1) to 130 (percentile 98), with a mean of 85.03 (percentile 50). All participants were native European Portuguese speakers.

2. MATERIALS

As in the previous experiment, the neuroticism scale of the Portuguese version of the personality inventory NEO PI-R (Costa & McCrae, 2000) was used to assess neuroticism. The Cronbach's alpha for this sample was .92.

Two hundred and eighty eight words were selected from the European Portuguese version of the ANEW (Soares et al., 2012), divided into three groups (with 96 words each) according to their Valence rating – positive ($M = 7.47$, $SD = 0.41$), neutral ($M = 4.63$, $SD = 0.36$) and negative ($M = 2.44$, $SD = 0.34$). Significant Valence differences between sets were confirmed, $F(2, 285) = 4384.45$, $p < .001$, $\eta_p^2 = .97$, and pairwise comparisons using the *Bonferroni* correction indicated that all sets differed from each other (all $p_s < .001$). Words were selected considering also their Arousal ratings, Word Frequency and Number of Letters (four to 11). As expected, a significant effect of Arousal was found, $F(2, 285) = 116.55$, $p < .001$, $\eta_p^2 = .45$). Emotional words were rated as more arousing (positive words: $M = 5.55$, $SD = 0.76$; negative words: $M = 5.79$, $SD = 0.61$) than neutral words ($M = 4.35$, $SD = 0.72$, $p < .001$). No differences were found between positive and negative words concerning Arousal ratings. Regarding the Word Frequency and Number of Letters, differences between sets were not found, $F(2, 285) = 2.48$, $p = .086$ and $F(2, 285) = 2.65$, $p = .072$, respectively.

Two hundred and eighty eight faces displaying negative emotions (anger, sadness, disgust and fear) were selected from the same databases used in Experiment 1 (Ekman & Friesen, 1976; Langner et al., 2010; Lundqvist et al., 1998; Oliveira Junior & Thomaz, 2006) and formatted in the same way.

As previously, a total of 288 composite stimuli were created overlapping words on faces: 96 congruent stimuli (negative faces and negative words), 96 incongruent stimuli (negative faces and positive words) and 96 neutral stimuli (negative faces and neutral words). In each condition (congruent, incongruent, and neutral) there were 24 stimuli corresponding to each of the four negative facial expressions.

All data was analysed with SPSS, Version 20.0 (IBM Corp., 2011).

3. PROCEDURE

Prior to the beginning of the experiment, all participants signed a consent form.

Each trial started with a white fixation cross on a black background for 750 ms. Then stimuli were presented in random order and remained on the screen until the participant responded. Inter-trial interval was 500 ms. Stimuli presentation was controlled by E- Prime software (Psychology Software Tools, Pittsburgh, PA).

The participant's task was to assess word valence using the computer keyboard: key 1 for negative valence, key 2 for neutral valence and key 3 for positive valence. Written instructions were given at the beginning of the experiment on the computer screen.

At the end of the experiment, all participants filled the neuroticism scale of NEO PI-R (Costa & McCrae, 2000).

4. DATA ANALYSIS

A repeated measures ANOVA was used to analyse the influence of Facial Emotion (4) and Word Valence (3) on participant's accuracy and reaction times. The *Greenhouse-Geisser* correction was applied to all sphericity violations. When needed, significant effects were further explored with multiple comparisons using *Bonferroni* corrections. To investigate the relation between Neuroticism, Facial Emotion and Word Valence, Pearson's correlation coefficient was used. Only marginal effects ($p < .070$) essential for the objectives of this study were reported.

RESULTS

1. ACCURACY RESULTS

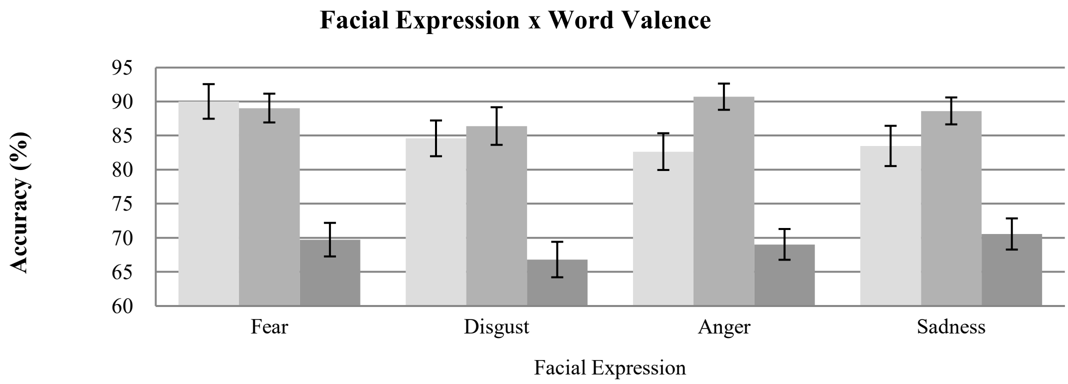
A main effect of Facial Expression was found, $F(3, 87) = 3.82$, $p = .013$, $\eta_p^2 = .12$. As can be seen in Table 7, participant's accuracy was overall higher for stimuli composed of fearful faces than for stimuli with disgusted faces ($p = .040$).

Table 7: Means and standard errors for accuracy analysis.

Variable		Mean (% of correct responses)	Standard Error
Facial Expression	Fear	82.92	1.63
	Disgust	79.26	1.57
	Anger	80.79	1.71
	Sadness	80.88	1.72
Word Valence	Positive	85.17	2.54
	Negative	88.68	1.93
	Neutral	69.02	2.14

There was also a main effect of Word Valence, $F(2, 58) = 27.87$, $p < .001$, $\eta_p^2 = .49$. Overall both types of emotional words were assessed more accurately than neutral words ($p < .001$).

The interaction between Word Valence and Facial Expression was significant, $F(6, 174) = 3.92$, $p = .001$, $\eta_p^2 = .12$. Post-hoc tests confirmed what can be observed in Figure 13: accuracy was better for stimuli with emotional words (negative and positive) than neutral words. In fact, this pattern was significant for all facial expressions: fear ($p < .001$), disgust ($p < .001$), anger ($p < .001$) and sadness (neutral and positive: $p = .002$; neutral and negative: $p < .001$). As can be seen in Figure 13, for all facial emotions except fear, participants showed a better performance (more accurate responses) in congruent compared to incongruent stimuli. However, this congruency effect was only significant in the anger condition ($p = .004$). Regarding stimuli with positive words, participant's assessment was significantly more accurate in the fear condition compared to all the other emotions (disgust and anger: $p = .001$; sadness: $p = .002$).



	Fear	Disgust	Anger	Sadness
Positive Words	90,00	84,58	82,64	83,47
Negative Words	89,03	86,39	90,69	88,61
Neutral Words	69,72	66,81	69,03	70,56

Figure 13: Percentage of correct responses plotted by Facial Expression and Word Valence conditions. Error bars represent standard errors.

1.1. NEUROTICISM

No significant correlations were found between neuroticism scores and accuracy in congruent, incongruent and neutral trials.

2. REACTION TIME RESULTS

In this analysis only reaction times from correct responses were considered.

Even though the main effect of Facial Expression did not reach significance, we can see in the Table 8 that reaction times were faster for stimuli with angry faces.

A main effect of Word Valence assessment was found, $F(2, 58) = 19.85$, $p < .001$, $\eta_p^2 = .41$ (see Table 8). Neutral valence judgments were significantly slower than positive and negative valence judgments ($p < .001$).

The interaction between Facial Expression and Word Valence was marginally significant, $F(3.85, 111.66) = 2.41$, $p = .055$, $\eta_p^2 = .08$. As can be seen in Figure 14, neutral word valence evaluation was slower than positive and negative valence evaluation when words were superimposed in fearful ($p < .001$ and $p = .002$, respectively), angry ($p = .003$ and $p = .016$, respectively) and sad faces ($p = .007$ and $p = .003$, respectively). In turn, when words were paired with disgusted faces, the results were different: positive words were assessed faster than negative (p = .021) and neutral (p = .003). On the other hand, RTs for negative word assessment were faster in the anger condition than in the disgust condition (p = .027). Regarding positive valence assessment, RTs were faster when positive words overlapped fearful and disgusted faces compared to sad faces (p = .006 and p = .022, respectively).

Table 8: Means and standard errors for reaction time analysis.

Variable		**Mean** (ms)	**Standard Error**
Facial Expression	Fear	1263.39	78.66
	Disgust	1300.38	73.94
	Anger	1227.86	74.78
	Sadness	1281.08	77.03
Word Valence	Positive	1189.45	71.15
	Negative	1223.41	81.46
	Neutral	1391.68	82.57

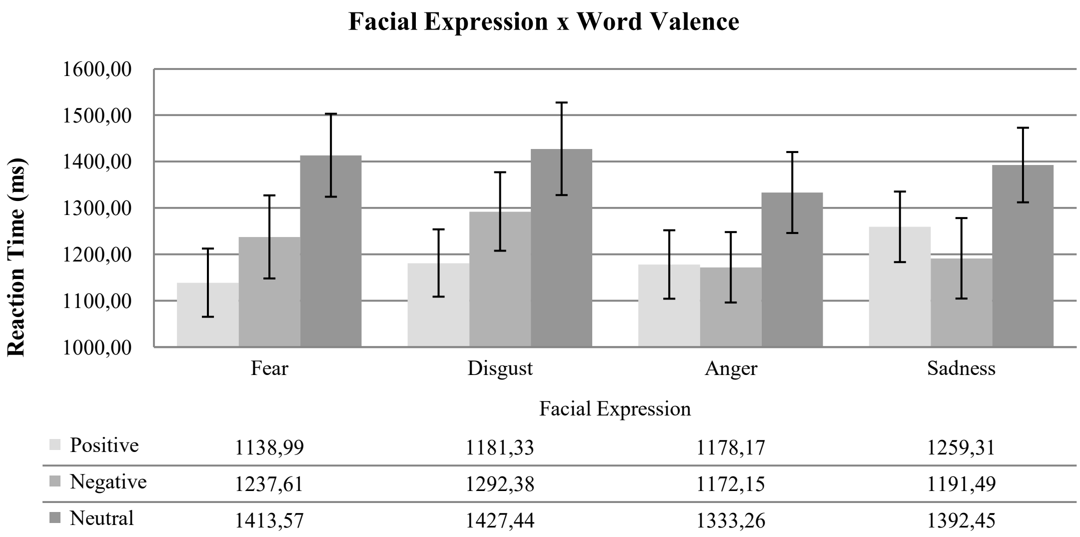


Figure 14: Reaction times plotted by Facial Expression and Word Valence Assessment conditions. Error bars represent standard errors.

2.1. NEUROTICISM

Finally, a negative correlation was found between Neuroticism and the assessment of neutral words paired with disgusted faces ($r = -.41$, $p = .024$): as neuroticism levels increased, the reaction times to these stimuli decreased.

DISCUSSION

A facilitation in valence judgments of emotional words was observed, reflected by faster reaction times and higher accuracy in emotional word valence assessment, confirming that it is easier to assess the valence of emotional stimuli than neutral stimuli (Beall & Herbert, 2008; Herbert et al., 2006; Zhu et al., 2010). This facilitation effect was significant for all conditions in accuracy analysis but in reaction time analysis, stimuli with disgusted faces showed a different pattern of results: participants judge positive words faster than negative and neutral words. Instead of congruency effects or facilitation processing of emotional compared to neutral words, disgusted faces seemed to interference less in positive than in negative or neutral word valence assessment. Although it is an odd result, this difference confirms the results found by Stenberg et al. (1998).

Regarding the effect of facial emotion, we found that word valence judgments were more accurate when words were paired with fearful faces than when they were paired with disgusted faces and, in incongruent trials, positive words were more correctly assessed when paired with fearful faces compared to all other facial emotions. Concerning reaction times, participants were faster in positive word valence assessment of stimuli with fearful and disgusted faces than sad faces. These results indicate that fearful faces did not interfere with word valence evaluation as much as disgust, sadness and anger. The literature suggests an early processing of fearful faces: they are easily and quickly recognizable, are highly arousing and signal threat in the environment (Adolphs, 2002; Batty & Taylor, 2003; Blau et al., 2007; Eimer & Holmes, 2002; Posner et al., 2005; Russell, 1980; Zhu & Luo, 2012). In fact, differences between happy and fearful faces were found in ERPs at about 60 – 90 ms (Zhu & Luo, 2012), 120 ms (Adolphs, 2002; Eimer & Holmes, 2002) and 170 ms (Batty & Taylor, 2003; Blau et al., 2007) after stimuli onset. Also, Zhu and Luo (2012) claimed that cognitive control and conflict monitoring occur at about 200 ms after stimulus onset, which means that fearful faces had already been differentiated at least from happy faces. They found a difference between these two facial emotions in C1 amplitude in a WFS task. These results had been associated with a priority in the processing of fearful faces compared to the processing of happy faces in our executive attentional system. Thus, fearful faces can be processed so fast and early that they probably failed to interfere in the word valence categorization process (Méndez-Bértolo et al., 2016; Öhman, 2005).

A congruency effect was found only for angry faces – there was a facilitation effect (higher accuracy) of angry faces in negative word assessment compared to positive word valence assessment. In disgust and sadness conditions these differences were observed but did not reached statistical significance. Together with the fact that negative word valence assessment was faster when angry compared to disgusted faces were presented it seems that angry faces have a facilitation effect on negative word valence assessment.

High neuroticism ratings were associated with faster neutral word valence assessment in stimuli with disgusting faces. We found that disgust faces did not seem to interfere with positive word valence judgment neither seem to facilitate negative word valence judgment. In this experiment only negative faces were included and participants did not have to categorize the valence of such faces, thus it was the implicit face processing that would create interference or facilitation effects. Because disgust faces are rarer in our everyday life and are visually more distinct compared to other negative facial emotions (Oatley & Jenkins, 1996a; Stenberg et al., 1998), we can presume that participants with high neuroticism as a mean to avoid the rare and negative face, focused their attention on neutral valence discrimination. Another explanation for this result can be related to the ambiguity of neutral material. As has been stated before, neutral material can be interpreted as negative depending on individual differences (Cooney et al., 2006; Isaac et al., 2012; Keedwell et al., 2016; Somerville et al., 2004). Thus, participants high in neuroticism could interpret neutral words as more negative and therefore the conflict ceased to exist leading to faster responses.

Regarding negative facial emotions, we found that fearful faces seem to be evaluated earlier in time and, therefore, do not interfere with the emotional conflict. Angry faces, in turn, seem to have a facilitation effect on congruent negative trials and contrary to our initial hypothesis, they do not interfere as much with positive word valence assessment. Disgusted faces showed lower interference effects on positive word valence assessment and, as fewer studies investigated this facial emotion in WFS tasks, we are still not sure what caused the effects found in this and in the previous experiment.

We also hypothesized more errors and longer reaction times for incongruent stimuli. Instead we found lower accuracy and longer reaction times for neutral compared to emotional word valence assessment. We only found congruency effects in word valence assessment of stimuli with angry faces.

In relation to the correlations with neuroticism, we did not find the associations between neuroticism and interference effects that we were expecting to find.

This study allowed us to clarify some differences between facial emotional expressions. However, we still did not find strong interference effects. Moreover, we also wanted to further explore the interference effects from positive and negative words on the explicit processing of face valence.

More importantly, in both studies reported so far, we only tested neuroticism associations with the remaining variables. It was our objective to compare groups of high and low neuroticism subjects. Furthermore, we wanted to improve our knowledge about the processes involved in emotional conflict by analysing psychophysiological measures, namely ERPs, in order to study the temporal dynamics of the WFS interference effects.

CHAPTER IV: BEHAVIOURAL AND PSYCHOPHYSIOLOGICAL CORRELATES OF EMOTIONAL CONFLICT IN A WFS TASK

INTRODUCTION

Results from previous chapters did not allow us to draw meaningful conclusions concerning the effects of the different negative facial emotions in word valence assessment and the effects of implicit processing of emotional words in face valence assessment. Most importantly, these experiments did not test for differences between high and low neuroticism participants' performance in WFS task. Hence, we conducted one more experiment with different participants, divided in two groups – high and low neuroticism – and we used electroencephalography (EEG) to study the temporal aspects of the WFS task. ERPs are electrophysiological measures with excellent temporal resolution that provide a continuous measurement of cognitive processing. That is, we can monitor online the cognitive processes that occur between stimuli presentation and response. Additionally, they can be very useful to determine the effects of experimental manipulations, even in the absence of a behavioural response (Luck, 2005). Therefore, we used both ERPs and behavioural responses – accuracy and reaction times – to obtain more information about the cognitive, emotional, and attentional processes that underlie the detection, monitoring, and resolution of the emotional conflict.

This last experiment is similar to the one described in Chapter II. However, in the present one, participants only performed one task. Moreover, all participants answered to all emotional conditions. In order to simplify the analysis and conclusions about the interference and facilitation effects of emotional words and faces, neutral faces and words were presented together, that is, no neutral words were superimposed on facial expressions and no neutral expressions were paired with emotional words.

As before, we predicted more accurate and faster responses to congruent compared to incongruent stimuli, especially in low neuroticism participants. We also predicted that angry and disgusted faces would generate more interference in incongruent trials and more facilitation in congruent trials (in the WVA task), since angry faces are highly arousing and disgusted faces had been easily recognized in the first experiment. Regarding fearful expressions, we hypothesized that they would generate facilitation effects in negative WVA and a lack of interference effects in positive WVA, since they are processed faster than other facial emotions. In the case of explicit face processing, we expected a facilitation effect from positive words on happy faces and from negative words on negative faces. We also expected to find accuracy and reaction time differences concerning interference effects between high and low neuroticism participants, especially regarding negative high arousing faces, namely fearful and angry in explicit and implicit processing.

Regarding ERP analysis, we anticipated differences in the P1 component for explicit and implicit fearful and happy face processing since differences in this time window had already been found between them (Eimer & Holmes, 2007). We also expected to find some differences in explicit and implicit negative word processing in this time window, based especially on the emotional Stroop literature. Concerning the emotional conflict, we expected to find evidence of conflict in the N170, EPN, N450, and Conflict SP. We hypothesized that the N170 would be more pronounced in the right hemisphere and in incongruent trials in the FVA task, and less pronounced in the WVA task, corroborating studies from Zhu et al. (2010), and Baggott et al. (2010). Regarding the EPN, we hypothesized more pronounced amplitudes in congruent compared to incongruent trials (Frühholz, Fehr, & Herrmann, 2009; Rampone, Makin, & Bertamini, 2014). As for the N450 (367 – 567 ms time window) and the Conflict SP (717 – 867 ms time window), we expected to find lower and higher mean amplitudes, respectively, in response to incongruent compared to congruent trials (Larson et al., 2014; Osinsky et al., 2012; Shen et al., 2013; West et al., 2005; Xue et al., 2016; Xue et al., 2015).

METHOD

1. PARTICIPANTS

One thousand, three hundred and twelve university students filled the neuroticism scale of the NEO-PI-R. From this initial sample 61 participants were excluded due to lack of contact information. Subjects that were on medication that could affect the results (for example anxiolytics or antidepressants) or had psychiatric or neurological disorders (like epilepsy, for instance) were excluded. Only native European Portuguese speakers were included. Thus, the final sample was selected from a pool of 1251 university students: 743 women, 488 men and 20 subjects that did not mention their sex with a mean age of 21.56 years (*SD* = 5.55; age range: 17 – 54).

Eighty participants were then selected on the basis of their neuroticism score. In the low neuroticism group, participants scores ranged from 31 to 59 (percentile 10) and in the high neuroticism group, participants scores ranged from 114 to 171 (percentile 80). From this sample, seven subjects were excluded from the final analysis for one of the following reasons: their response accuracy was lower than chance level, there were technical problems in signal acquisition or because they were left-handed. So, the final sample was composed of 36 men and 37 women with a mean age of 23.07 years (*SD* = 4.53, age range: 18 – 36). Participants were divided into two groups: one of 38 (20 women) with high neuroticism (*M* = 134.79 and *SD* = 16.73 in the neuroticism scale of the NEO-PI-R; age: *M* = 22.37; *SD* = 4.04; range: 18 – 36) and the other 35 (17 women) with low neuroticism (*M* = 47.63 and *SD* = 7.87 in the neuroticism scale of the NEO-PI-R; age: *M* = 23.83; *SD* = 4.95; Range: 18 – 36). Both groups significantly differed in their neuroticism score, $t(71) = -28.08$, $p < .001$, $\eta_p^2 = .67$) and did not differ in age, $t(71) = 1.37$, $p = .170$).

All participants had normal or corrected-to-normal vision and received 10€ (money or a gift voucher from a main commercial store) for their participation.

2. MATERIALS

The neuroticism scale of the Portuguese version of personality inventory NEO-PI-R by Lima and Simões (Costa & McCrae, 2000) was used to assess neuroticism. The Cronbach's alpha of this sample was .75.

Pictures of facial expressions of emotion were selected from the same databases that were used in the previous experiments (Ekman & Friesen, 1976; Langner et al., 2010; Lundqvist et al., 1998; Oliveira Junior & Thomaz, 2006). Four hundred and eighty faces were selected: 40 (20 females) for each negative emotion (fear, anger, sadness and disgust), 160 (80 females) positive (happy) and 160 (80 females) neutral faces. So as to facilitate the pairing process between faces and words, positive faces were randomly divided into two sets (SET A and SET B with 80 happy faces each) and neutral faces were randomly divided into four different sets (NEU 1, NEU 2, NEU 3 and NEU 4 with 40 neutral faces each). All faces were formatted in the same way as in previous experiments.

Four hundred words were selected from the adaptation of the ANEW for European Portuguese (Soares et al., 2012): 80 neutral, 160 positive and 160 negative. Words were divided into two sets (SET 1 and SET 2). One-way ANOVAs were conducted to compare the three groups of words in each set for Valence, Arousal, Word Frequency, Number of Letters and Syllables.

Results from SET 1 analysis are described in Table 9. Regarding Valence, multiple comparisons using the *Bonferroni* correction revealed that positive words were more pleasant ($M = 7.66$, $SD = .031$) than neutral ($M = 5.07$, $SD = 0.12$) and negative ($M = 2.26$, $SD = 0.30$) words and that negative words were more unpleasant than neutral words (all $p_s < .001$). In relation to Arousal, emotional words had significantly higher arousal (positive words: $M = 5.50$, $SD = 1.00$; negative words: $M = 5.80$, $SD = 0.67$) than neutral words ($M = 4.11$, $SD = 0.73$, $p < .001$). Positive and negative words did not differ from each other. Although the main effect of Word Frequency was significant, post-hoc tests did not reveal any differences between the three groups of words.

Table 9: Results from the ANOVAs examining differences between positive, negative and neutral words from SET 1.

Effect	F	d. f.	*p*	η_p^2
Valence	**7634.35**	**2, 197**	**< .001**	**.99**
Arousal	**58.01**	**2, 196**	**.042**	**.37**
Word Frequency	**3.22**	**2, 196**	**.042**	**.03**
Number of Letters	1.73	2, 197	.180	.02
Number of Syllables	2.39	2, 197	.094	.02

Regarding SET 2 (see results in Table 10), positive words had higher valence ratings ($M = 6.67$, $SD = 0.37$) than neutral ($M = 5.03$, $SD = 0.13$) and negative words ($M = 2.84$, $SD = 0.28$) and negative words were significantly more negative than neutral words (all $p_s < .001$). In relation to Arousal, emotional words were more arousing (positive words: $M = 5.24$, $SD = 0.50$; negative words: $M = 5.49$, $SD = 0.71$) than neutral words ($M = 4.16$, *SD* = 0.86) ($p < .001$). Positive and negative words did not differ in Arousal ($p = 0.58$). Positive, negative and neutral words did not differ in Word Frequency, Number of Letters and Number of Syllables.

Table 10: Results from the ANOVAs examining differences between positive, negative and neutral words from SET 2.

Effect	F	d. f.	*p*	η_p^2
Valence	**3292.58**	**2, 197**	**< .001**	**.97**
Arousal	**54.47**	**2, 197**	**< .001**	**.36**
Word Frequency	1.27	2, 195	.282	.01
Number of Letters	2.48	2, 197	.087	.03
Number of Syllables	2.64	2, 197	.074	.03

3. PROCEDURE

Firstly, the neuroticism scale of NEO-PI-R was administered to a sample of 1312 university students using paper and computer forms. Then, after excluding some participants (see details in the Participants' section), 80 students were selected based on their neuroticism score: the highest and the lowest scores of the distribution.

The sets of words and faces were combined to pseudo-randomize presentation order into eight different experiments with four blocks each. Each block consisted of 200 stimuli: 80 congruent (40 with positive words and positive faces and 40 with negative words and negative faces), 80 incongruent (40 with positive words superimposed on negative faces and 40 with negative words superimposed on positive faces) and 40 neutral (neutral words and neutral faces). Each participant saw the same words twice but they were superimposed on different faces. Emotional faces were also seen twice but were paired with different words. Neutral faces were never repeated, i.e., participants never saw the same neutral face twice. Each version of the experiment described in Table 11 was programmed for word and face valence assessment, i.e., there was a Version 1 for word valence assessment and the same Version 1 programmed for face valence assessment.

It should be noted that each participant only performed one version of the experiment (Version 1, 2, 3 or 4) with four blocks each (one block for each negative facial emotion:

sadness, anger, disgust and fear). The same version of the experiment could be used for word or for face valence assessment. The participants were randomly assigned to one of the tasks (half of the participants evaluated word valence and the other half evaluated face valence).

Table 11: Block organization per version of the experiment.

Block	Positive Faces	Emotional Words	Neutral Faces
Version 1			
Sadness	SET A	SET 1	NEU 1
Anger	SET B	SET 2	NEU 2
Disgust	SET B	SET 1	NEU 3
Fear	SET A	SET 2	NEU 4
Version 2			
Sadness	SET B	SET 2	NEU 4
Anger	SET A	SET 1	NEU 3
Disgust	SET A	SET 2	NEU 2
Fear	SET B	SET 1	NEU 1
Version 3			
	The same stimuli as in Version 1 but with a different response mapping		
Version 4			
	The same stimuli as in Version 2 but with a different response mapping		

Notes: SET A: 40 female positive faces + 40 male positive faces

SET B: 40 female positive faces + 40 male positive faces

SET 1: 80 positive, 80 negative and 40 neutral words

SET 2: 80 positive, 80 negative and 40 neutral words

NEU 1, 2, 3, 4: 20 female faces + 20 male faces

All blocks in each experiment were presented in random order. Participants were randomly distributed by the eight versions of the experiment considering their neuroticism level and sex.

The experiment took place in an isolated room inside the laboratory. After the preparation for EEG recordings, instructions were presented on the computer screen. Participants were asked to assess the valence of words or faces pressing the keys 1, 2 or 3 on the computer keyboard (Version 1 and 3: 1 = negative; 2 = neutral; 3 = positive valence; Version 2 and 4: 1 = positive; 2 = neutral; 3 = negative valence). Each trial started with a

500 ms white fixation cross on a black background, followed by the stimuli that remained on the screen until the subject's response up to a maximum of 3000 ms. The inter-trial interval was variable (range: 750 – 1200 ms, M = 1000 ms).

The EEG was acquired using an Easy-Cap with Ag/AgCl sintered electrodes. We used the *Neuroscan* software (Scan 4.3) for EEG acquisition, *Neuroscan* software (Scan 4.4) for EEG data analysis and the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) for stimuli presentation and recording of responses.

Behavioural and ERP data were analyzed with SPSS, Version 20.0 (IBM Corp., 2011).

4. PSYCHOPHYSIOLOGICAL RECORDING PROCEDURES, DATA REDUCTION AND ANALYSIS

EEG was acquired from 40 channels (FP1, FPz, FP2, F7, F3, Fz, F4, F8, FC3, FC1, FCz, FC2, FC4, T7, C3, C1, Cz, C2, C4, T8, CP3, CP1, CPz, CP2, CP4, P7, P5, P3, Pz, P4, P6, P8, PO7, PO3, POz, PO4, PO8, O1, Oz, O2) located according to the international 10-20 system. The reference was placed on the tip of the nose. Vertical and horizontal electrooculogram were recorded above and below the left eye and from the outer canthi of both eyes, respectively. Impedance was kept below 5 kΩ.

An offline bandpass filter of 0.1 to 30 Hz was applied to the data of each participant. Segments with artifacts were rejected from the analysis following the automatic correction of ocular movements implemented in Scan 4.4. The EEG was segmented in epochs of 1050 ms (150 ms pre-stimuli to 900 ms post-stimuli). Then, the baseline was corrected, using the mean amplitudes of the 150 ms pre-stimuli.

Separate grand averages were computed for both tasks (face and word valence assessment) and facial emotion (blocks of sadness, anger, disgust and fear), high and low neuroticism and all (in)congruency conditions (congruent condition with negative faces and words, congruent condition with positive faces and words, incongruent condition with positive faces and negative words and incongruent condition with negative faces and positive words).

Based on the literature and on the visual analysis of the grand averages (see Appendix), we decided to analyse peak amplitude and peak latency of three ERP waves

(P1, N170 and EPN) and the mean amplitude of two post-stimulus time windows: 367 – 567 ms, consistent with the N450 time window, and 717 – 867 ms, consistent with the Conflict SP time window, in different electrode sites. These were the time windows where these potentials were more conspicuous, after visual inspection of the grand average waveforms. The P1 was calculated in the time window between 97 and 137 ms in occipital sites (O_1 and O_2). The N170, on the other hand, was assessed between 147 and 207 ms time window in parietal and parieto-occipital sites ($P_5/_6$, $P_7/_8$ and $PO_7/_8$). Lastly, the EPN was assessed between 217 and 317 ms also in parietal and in parieto-occipital sites ($P_5/_6$, $P_7/_8$, $PO_3/_4$ and $PO_7/_8$). Regarding the mean amplitude of the time windows selected, based on the visual inspection of the grand averages, we opted to analyse the electrodes $CP_1/_2$, $CP_3/_4$, $P_3/_4$, $P_5/_6$, $PO_3/_4$ and $PO_7/_8$ between 367 and 567 ms post-stimuli (N450), and $P_3/_4$, $P_5/_6$, $PO_3/_4$ and $PO_7/_8$ in the 717 – 867 ms time window post-stimulus (Conflict SP).

Regarding the behavioural data, an arcsine transformation was applied to accuracy data to normalize the distribution and to homogenize the variances. Accuracy and reaction times were analysed with 2 x 4 x 2 x 2 split-plot ANOVAs with Neuroticism (high or low) as between-subjects factor and Emotion (fear, disgust, anger and sadness), Word Valence (positive and negative) and Face Valence (positive and negative) as within-subjects factors. Neutral congruent trials were not included in the statistical analysis.

ERP data (mean amplitude, peak latency and peak amplitude) were also analysed with split-plot ANOVAs, similar to the ones described for behavioural data, with Region and/or Hemisphere (depending on the analysis) as additional within-subjects factors.

As in the first experiment, all analyses were conducted for word and face valence assessment tasks separately. The marginal effects (p < .070) important to our objectives were reported. All marginal effects involving either Hemisphere or Region were not reported.

When needed, the *Greenhouse-Geisser* correction was used for sphericity violations and the *Bonferroni* correction was applied in pairwise comparisons.

RESULTS

1. BEHAVIOURAL RESULTS

1.1. ACCURACY RESULTS

1.1.1. Face Valence Assessment

The 2 x 4 x 2 x 2 split-plot ANOVA (see Table 12 for details) revealed a marginal main effect of Neuroticism, which is relevant to the aim of our study. Participants with low neuroticism scores tended to judge face valence more accurately (M = 94.75%, SE = 1.60) than participants with high neuroticism scores (M = 91.13%, SE = 1.46).

Table 12: ANOVA results from the accuracy analysis of the Face Valence Assessment task.

Effect	F	d. f.	p	η_p^2
Neuroticism	3.98	1, 31	.055	.11
Emotion	2.33	3, 93	.080	.07
Face Valence	**25.17**	**1, 31**	**< .001**	**.45**
Word Valence	0.06	1, 31	.802	.00
Emotion x Neuroticism	0.57	3, 93	.638	.02
Face Valence x Neuroticism	0.00	1, 31	.986	.00
Word Valence x Neuroticism	0.76	1, 31	.391	.02
Emotion x Face Valence	**6.20**	**3, 93**	**.001**	**.17**
Emotion x Word Valence	0.25	3, 93	.864	.01
Face Valence x Word Valence	**7.51**	**1, 31**	**.010**	**.20**
Emotion x Face Valence x Neuroticism	0.55	3, 93	.651	.02
Emotion x Word Valence x Neuroticism	0.73	3, 93	.534	.02
Face Valence x Word Valence x Neuroticism	1.07	1, 31	.309	.03
Emotion x Face Valence x Word Valence	**3.67**	**3, 93**	**.015**	**.11**
Emotion x Face Valence x Word Valence x Neuroticism	0.59	3, 93	.622	.02

Regarding the main effect of Face Valence, post-hoc tests confirmed that participants were more accurate in positive (M = 96.09%, SE = 0.76) than in negative (M = 89.79%, SE = 1.78) face valence judgments.

The interaction between Emotion and Face Valence was significant. As can be seen in Figure 15, disgust was the only emotion condition in which the assessment of positive faces was not significantly more accurate than the assessment of negative faces (fear, anger and sadness: $p < .001$). Moreover, participants assessed disgust faces overall more accurately than angry ($p = .004$) and sad ($p = .007$) faces.

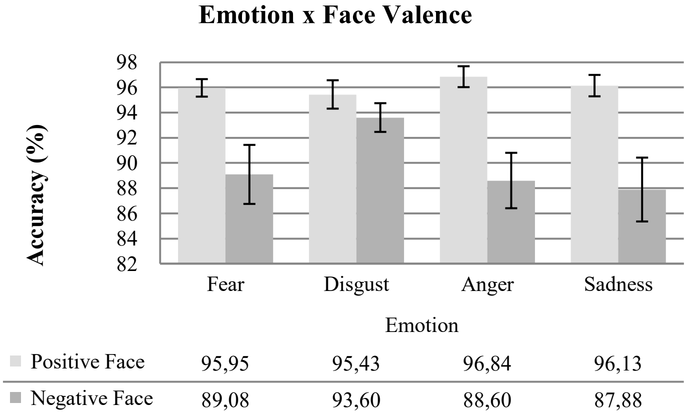


Figure 15: Percentage of correct responses, in the Face Valence Assessment task, plotted by Emotion and Face Valence conditions. Error bars represent standard errors.

Figure 16 represents the significant interaction between Face and Word Valence. Pairwise comparisons demonstrated that when participants were asked to evaluate positive face valence, they were more accurate in congruent than in incongruent stimuli ($p = .045$) – congruency effect. This effect was also confirmed in negative face valence assessment ($p = .030$).

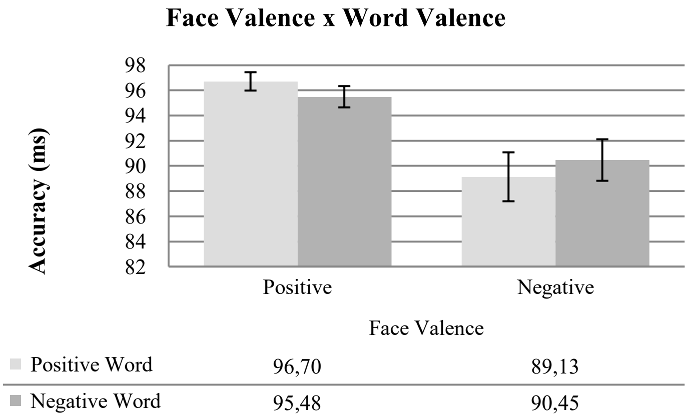


Figure 16: Percentage of correct responses, in the Face Valence Assessment task, plotted by Face and Word Valence conditions. Error bars represent standard errors.

In order to explore the interaction between Emotion, Face Valence and Word Valence, 2 new repeated measures ANOVAs were conducted with Emotion (4 levels) and Word Valence (2 levels) as within-subjects factors, separately for each Face Valence (positive and negative). There were no significant effects in positive face valence assessment. In turn, in negative face valence assessment, a main effect of Emotion was found, $F(3, 96) = 5.84$, $p = .001$, $\eta_p^2 = .15$. Post-hoc tests revealed that disgust was the easiest facial emotion to evaluate (disgust: $M = 93.52\%$, $SE = 1.13$; anger: $M = 88.37\%$, $SE = 2.20$, $p = .003$; sadness: $M = 87.61\%$, $SE = 2.54$, $p = .005$; fear: $M = 88.83\%$, $SE = 2.35$, $p = .085$). The main effect of Word Valence was also significant, $F(1, 32) = 5.25$, $p = .029$, $\eta_p^2 = .14$, and post-hoc tests confirmed the congruency effect: participants' accuracy was higher when they were asked to evaluate negative facial valence in congruent ($M = 90.23\%$, $SE = 1.68$) than in incongruent ($M = 88.94\%$, $SE = 1.94$) stimuli.

1.1.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 split-plot ANOVA are presented in Table 13.

The interaction between Face and Word Valence was significant (see Figure 17) and multiple comparisons revealed congruency effects: participant's accuracy in evaluating negative word valence was higher in congruent stimuli than in incongruent stimuli ($p < .001$). Furthermore, when participants were asked to evaluate the valence of words superimposed on negative faces (regardless of the facial expression), they were more accurate in negative (congruent) than in positive (incongruent) word valence assessment ($p = .010$).

To explore the interaction between Emotion, Face Valence and Word Valence, four new 2 (Word Valence) x 2 (Face Valence) repeated measures ANOVAs were conducted, one for each emotional condition. The interaction between Word and Face Valence was significant in the fear, disgust and sadness conditions – $F(1, 37) = 7.80$, $p = .008$, $\eta_p^2 = .17$, $F(1, 37) = 22.03$, $p < .001$, $\eta_p^2 = .37$ and $F(1, 37) = 5.54$, $p = .024$, $\eta_p^2 = .13$, respectively. Regarding the fear condition, negative word valence evaluation was more accurate in congruent ($M = 91.05\%$, $SE = 1.48$) than in incongruent stimuli ($M = 87.03\%$, $SE = 1.73$, $p = .014$) – congruency effect. In relation to the disgust condition, when participants were assessing the valence of positive words, they were more accurate in congruent

(M = 91.05%, SE = 1.27) than in incongruent stimuli (M = 82.63%, SE = 2.06, p = .001). Moreover, participant’s valence judgment of negative words was better in congruent (M = 91.11%, SE = 1.66) than in incongruent stimuli (M = 85.79%, SE = 1.97, p = .001). Concerning the sadness condition, no significant effects were found in post-hoc tests.

Table 13: ANOVA results from the accuracy analysis of the Word Valence Assessment task.

Effect	**F**	**d. f.** [a]	***p***	η_p^2
Neuroticism	0.36	1, 35	.551	.10
Emotion	0.21	1.32, 46.32	.714	.01
Face Valence	0.46	1, 35	.505	.01
Word Valence	0.92	1, 35	.345	.03
Emotion x Neuroticism	1.31	1.32, 46.32	.269	.04
Face Valence x Neuroticism	0.37	1, 35	.546	.01
Word Valence x Neuroticism	1.61	1, 35	.213	.04
Emotion x Face Valence	1.31	3, 105	.274	.04
Emotion x Word Valence	0.10	2.19, 76.63	.922	.00
Face Valence x Word Valence	**20.63**	**1, 35**	**< .001**	**.37**
Emotion x Face Valence x Neuroticism	1.01	3, 105	.392	.03
Emotion x Word Valence x Neuroticism	0.94	2.19, 76.63	.404	.03
Face Valence x Word Valence x Neuroticism	0.02	1, 35	.889	.00
Emotion x Face Valence x Word Valence	**5.21**	**3, 105**	**.002**	**.13**
Emotion x Face Valence x Word Valence x Neuroticism	2.15	3, 105	.099	.06

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

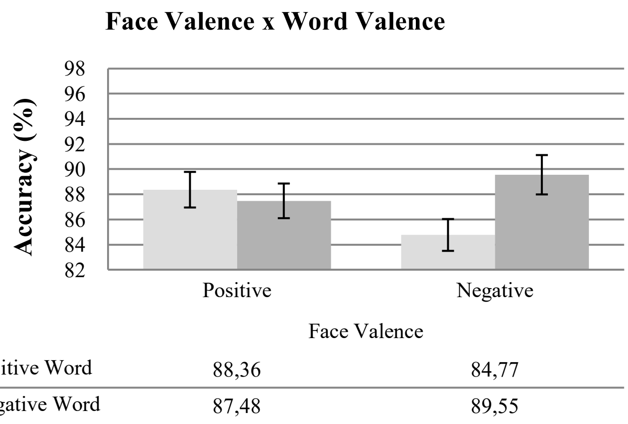


Figure 17: Percentage of correct responses, in the Word Valence Assessment task, plotted by Face Valence and Word Valence conditions. Error bars represent standard errors.

1.2. REACTION TIME RESULTS

1.2.1. Face Valence Assessment

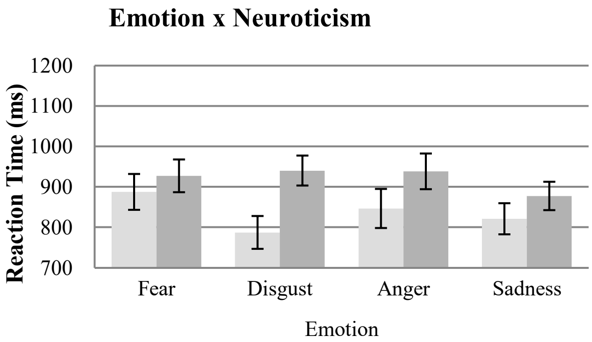
The 2 x 4 x 2 x 2 split-plot ANOVA revealed a significant main effect of Emotion (see Table 14 for details): a tendency was found for a slower face valence judgment in the fear condition (*M* = 907.09 ms, *SE* = 30.01) than in the sadness condition (*M* = 849.07 ms, *SE* = 26.02, *p* = .094).

Table 14: ANOVA results from the reaction time analysis of the Face Valence Assessment task.

Effect	F	d. f.	*p*	η_p^2
Neuroticism	2.64	1, 31	.114	.08
Emotion	**3.19**	**3, 93**	**.027**	**.09**
Face Valence	**52.60**	**1, 31**	**< .001**	**.63**
Word Valence	0.16	1, 31	.692	.01
Emotion x Neuroticism	**2.87**	**3, 93**	**.041**	**.09**
Face Valence x Neuroticism	1.25	1, 31	.272	.04
Word Valence x Neuroticism	0.63	1, 31	.434	.02
Emotion x Face Valence	**9.55**	**3, 93**	**< .001**	**.24**
Emotion x Word Valence	0.27	3, 93	.844	.01
Face Valence x Word Valence	**22.63**	**1, 31**	**< .001**	**.42**
Emotion x Face Valence x Neuroticism	0.57	3, 93	.636	.02
Emotion x Word Valence x Neuroticism	1.08	3, 93	.361	.03
Face Valence x Word Valence x Neuroticism	1.26	1, 31	.270	.04
Emotion x Face Valence x Word Valence	1.35	3, 93	.264	.04
Emotion x Face Valence x Word Valence x Neuroticism	0.51	3, 93	.679	.02

Concerning the main effect of Face Valence, post-hoc tests showed that positive face valence assessment (*M* = 817.34 ms, *SE* = 24.09) was faster than negative face valence assessment (*M* = 938.61 ms, *SE* = 30.55).

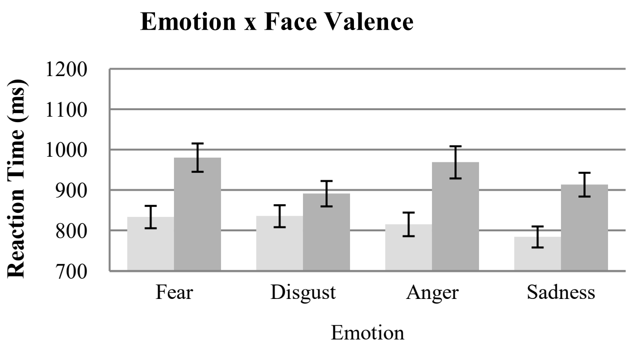
An interaction between Emotion and Neuroticism was found and it is represented in Figure 18. Multiple comparisons showed that participants with low neuroticism scores assessed face valence in fear conditions slower than in disgust conditions (*p* = .009). In turn, high neuroticism participants showed a tendency to evaluate face valence slower in disgust than in sadness conditions (*p* = .068). Furthermore, and only in disgust conditions, low neuroticism participants assessed face valence faster than high neuroticism subjects (p = .009).



	Fear	Disgust	Anger	Sadness
Low Neuroticism	887,25	787,10	846,31	820,83
High Neuroticism	926,93	940,02	938,05	877,30

Figure 18: Reaction times, in the Face Valence Assessment task, plotted by Emotion and Neuroticism conditions. Error bars represent standard errors.

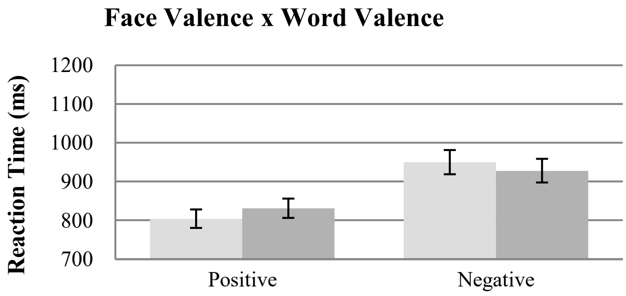
Regarding the interaction between Emotion and Face Valence (see Figure 19), post-hoc tests showed that for all emotional conditions, positive face valence judgments were faster than negative face valence judgments (fear: $p < .001$; disgust: $p = .011$; anger: $p < .001$; sadness: $p < .001$). On the other hand, when participants were asked to evaluate the valence of positive faces, they were slower in disgust conditions than in sadness conditions (p = .049). On the contrary, face valence judgments of negative faces were faster in stimuli with disgusted faces compared to fearful (p = .002) and angry ones (p = .007).



	Fear	Disgust	Anger	Sadness
Positive Faces	833,63	835,76	815,54	784,42
Negative Faces	980,55	891,37	968,82	913,72

Figure 19: Reaction times, in the Face Valence Assessment task, plotted by Emotion and Face Valence conditions. Error bars represent standard errors.

Concerning the interaction between Face and Word Valence (see Figure 20), multiple comparisons confirmed the congruency effects: when participants were assessing positive face valence, reaction times were faster in congruent than in incongruent stimuli (p = .001). In turn, when they were judging negative face valence, congruent stimuli had faster reaction times than incongruent stimuli (p = .014). Moreover, face valence assessment of stimuli with positive words was slower when paired with negative compared to positive faces (p < .001).



	Positive	Negative
Positive Words	803,90	949,58
Negative Words	830,77	927,65

Figure 20: Reaction times, in the Face Valence Assessment task, plotted by Face Valence and Word Valence conditions. Error bars represent standard errors.

1.2.2. Word Valence Assessment

As can be seen in Table 15, the main effect of Word Valence was significant: positive words were evaluated faster (M = 1066.99 ms, SE = 27.30) than negative words (M = 1101.46 ms, SE = 28.82).

The interaction between Face Valence and Word Valence was significant (see Figure 21). Multiple comparisons showed that when participants were assessing positive words, they were faster in congruent than in incongruent stimuli (p < .001) – congruency effect. The same happened with negative word valence assessment: congruent stimuli elicited a lower reaction time than incongruent stimuli (p < .001).

Table 15: ANOVA results from the reaction time analysis of the Word Valence Assessment task.

Effect	F	d. f.	*p*	η_p^2
Neuroticism	2.57	1, 35	.118	.07
Emotion	1.17	3, 105	.325	.03
Face Valence	0.19	1, 35	.996	.00
Word Valence	**6.46**	**1, 35**	**.016**	**.16**
Emotion x Neuroticism	0.98	3, 105	.406	.03
Face Valence x Neuroticism	0.00	1, 35	.996	.00
Word Valence x Neuroticism	0.55	1, 35	.465	.02
Emotion x Face Valence	1.06	3, 105	.368	.03
Emotion x Word Valence	0.44	3, 105	.727	.01
Face Valence x Word Valence	**72.57**	**1, 35**	**< .001**	**.68**
Emotion x Face Valence x Neuroticism	0.40	1, 105	.755	.01
Emotion x Word Valence x Neuroticism	1.53	3, 105	.210	.04
Face Valence x Word Valence x Neuroticism	0.35	1, 35	.557	.01
Emotion x Face Valence x Word Valence	**6.49**	**3, 105**	**< .001**	**.16**
Emotion x Face Valence x Word Valence x Neuroticism	0.67	3, 105	.573	.02

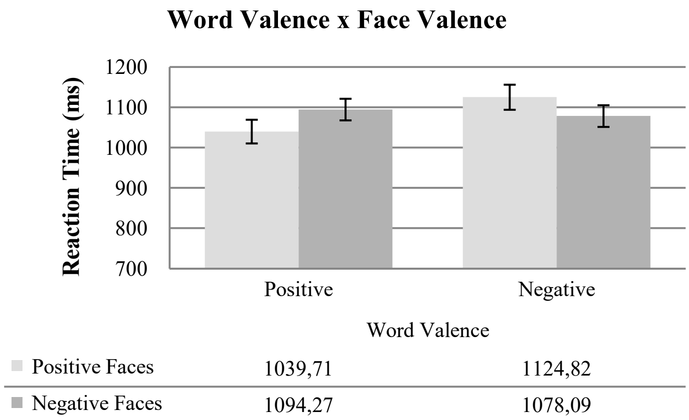


Figure 21: Reaction times, in the Word Valence Assessment task, plotted by Word Valence and Face Valence conditions. Error bars represent standard errors.

In order to explore the significant interaction between Emotion, Face Valence and Word Valence, four new 2 (Face Valence) x 2 (Word Valence) repeated measures ANOVAs were conducted, one for each Emotion. The main effect of Word Valence was significant in fear, disgust and sadness conditions, $F(1, 37) = 5.22$, $p = .028$, $\eta_p^2 = .12$, $F(1, 37) = 4.40$, $p = .043$, $\eta_p^2 = 0.11$ and $F(1, 37) = 6.95$, $p = .012$, $\eta_p^2 = .16$, respectively.

For these three emotional conditions, positive word valence assessment was faster (fear: $M = 1055.05$ ms, $SE = 38.69$; disgust: $M = 1098.40$ ms, $SE = 36.09$; sadness: $M = 1025.27$ ms, $SE = 30.65$) than negative word valence assessment (fear: $M = 1093.36$ ms, $SE = 36.75$; disgust: $M = 1134.59$ ms, $SE = 37.38$; sadness: $M = 1071.87$ ms, $SE = 33.49$). The interaction between Face Valence and Word Valence was significant for all emotional conditions and pairwise comparisons revealed several congruency effects. In the fear condition, $F(1, 37) = 9.20$, $p = .004$, $\eta_p^2 = .20$, when participants were assessing negative word valence, they were faster in congruent ($M = 1075.25$ ms, $SE = 37.19$) than in incongruent stimuli ($M = 1111.46$ ms, $SE = 37.70$, $p = .016$). Moreover, positive words paired with positive faces – congruent – were evaluated faster ($M = 1039.55$ ms, $SE = 41.19$) than negative words paired with positive faces ($p = .001$). In relation to the disgust condition, $F(1, 37) = 54.19$, $p < .001$, $\eta_p^2 = .20$, positive valence assessment in congruent stimuli was faster ($M = 1055.46$ ms, $SE = 35.00$) than in incongruent stimuli ($M = 1141.34$ ms, $SE = 39.41$, $p < .001$). This congruency effect was also observed in negative word valence assessment: reaction times were lower when negative words were superimposed on negative faces ($M = 1088.10$ ms, $SE = 34.74$) compared with positive faces ($M = 1181.08$ ms, $SE = 41.55$, $p < .001$). In the anger condition, $F(1, 36) = 12.29$, $p = .001$, $\eta_p^2 = .26$, congruency effects were confirmed by multiple comparisons: negative word valence assessment was faster in congruent ($M = 1081.30$ ms, $SE = 31.36$) than in incongruent stimuli ($M = 1121.09$ ms, $SE = 40.68$, $p = .046$). Furthermore, stimuli with positive faces were assessed faster when paired with positive ($M = 1061.43$ ms, $SE = 40.00$) than with negative words ($p = .005$). Concerning the sadness condition, $F(1, 37) = 17.80$, $p < .001$, $\eta_p^2 = .33$, the congruency effect was only observed in positive word valence assessment that occurred faster ($M = 993.80$ ms, $SE = 32.77$) than negative ($M = 1082.01$ ms, $SE = 34.90$, $p < .001$) when words were paired with positive faces.

2. ELECTROPHYSIOLOGICAL RESULTS

In this section, we will present ERP data from the analysis of peak amplitude and latency of P1, N170 and EPN waves as well as mean amplitudes of the 367 – 567 ms (N450) and 717 – 867 ms (Conflict SP) time windows.

2.1. P1

This section is divided in peak amplitude and peak latency. For each of these ERP measures, two 2 (Neuroticism) x 4 (Emotion) x 2 (Word Valence) x 2 (Face Valence) x 2 (Hemisphere) split-plot ANOVAs were conducted, for face and for word valence assessment tasks.

2.1.1. Peak Amplitude

2.1.1.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 split-plot ANOVA conducted to analyze P1 peak amplitude elicited in the face valence assessment task are presented in Table 16.

Table 16: ANOVA results from the analysis of P1 peak amplitude for the Face Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.04	1, 29	.851	.00
Emotion	0.30	3, 87	.827	.01
Word Valence	**6.09**	**1, 29**	**.020**	**.17**
Face Valence	0.05	1, 29	.818	.00
Hemisphere	0.40	1, 29	.531	.01
Emotion x Neuroticism	0.17	3, 87	.917	.01
Word Valence x Neuroticism	0.04	1, 29	.833	.00
Face Valence x Neuroticism	0.11	1, 29	.739	.00
Hemisphere x Neuroticism	1.97	1, 29	.171	.06
Emotion x Word Valence	0.56	2.12, 61.38	.585	.02
Emotion x Face Valence	0.80	2.22, 64.35	.467	.03
Word Valence x Face Valence	0.31	1, 29	.582	.01
Emotion x Hemisphere	1.23	3, 87	.305	.04

Word Valence x Hemisphere	1.98	1, 29	.170	.06
Face Valence x Hemisphere	0.07	1, 29	.799	.00
Emotion x Word Valence x Neuroticism	1.07	2.12, 61.38	.351	.04
Emotion x Face Valence x Neuroticism	0.48	2.22, 64.35	.639	.02
Word Valence x Face Valence x Neuroticism	0.66	1, 29	.424	.02
Emotion x Word Valence x Face Valence	1.82	2.33, 67.68	.163	.06
Emotion x Hemisphere x Neuroticism	1.63	3, 87	.188	.05
Word Valence x Hemisphere x Neuroticism	0.20	1, 29	.661	.01
Emotion x Word Valence x Hemisphere	0.09	3, 87	.968	.00
Face Valence x Hemisphere x Neuroticism	3.62	1, 29	.067	.11
Emotion x Face Valence x Hemisphere	0.36	3, 87	.786	.11
Word Valence x Face Valence x Hemisphere	0.43	1, 29	.520	.01
Emotion x Word Valence x Face Valence x Neuroticism	0.42	2.33, 67.68	.693	.01
Emotion x Word Valence x Hemisphere x Neuroticism	0.09	3, 87	.968	.00
Emotion x Face Valence x Hemisphere x Neuroticism	0.66	3, 87	.577	.02
Word Valence x Face Valence x Hemisphere x Neuroticism	0.53	1, 29	.473	.02
Emotion x Word Valence x Face Valence x Hemisphere	**6.41**	**3, 87**	**.001**	**.18**
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.15	3, 87	.332	.04

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

There was a significant effect of Word Valence: P1 peak amplitude was higher for face valence assessment of stimuli with negative words (M = 6.15 μV, SE = 0.73) compared to stimuli with positive words (M = 5.59 μV, SE = 0.70).

The interaction between Emotion, Word Valence, Face Valence and Hemisphere was significant. In order to explore this interaction, eight 2 (Word Valence) x 2 (Face Valence) repeated measures ANOVAs were conducted for emotion and hemisphere separately, i.e., for all emotional conditions in the right and in the left hemisphere. The main effect of word valence was significant only in the disgust condition for both hemispheres, $F(1, 34) = 4.42$, $p = .043$, $\eta_p^2 = .12$ and $F(1, 34) = 4.56$, $p = .040$, $\eta_p^2 = .12$ in the left and right hemisphere, respectively. The results resembled the main effect of Word Valence found in the main split-plot ANOVA.

2.1.1.2. Word Valence Assessment

A 2 x 4 x 2 x 2 x 2 split-plot ANOVA was conducted to analyze P1 peak amplitude elicited by word valence assessment (see the results in Table 17).

The main effect of Hemisphere was significant: word valence assessment elicited higher P1 peak amplitude in O_1 (M = 10.09 µV, SE = 0.76) than in O_2 (M = 9.09 µV, SE = 0.85).

Table 17: ANOVA results from the analysis of P1 peak amplitude for the Word Valence Assessment task.

Effect	F	d. f. [a]	p	η_p^2
Neuroticism	0.23	1, 33	.631	.07
Emotion	0.80	2.44, 80.39	.475	.02
Word Valence	0.33	1, 33	.567	.01
Face Valence	0.61	1, 33	.441	.02
Hemisphere	**4.31**	**1, 33**	**.046**	**.12**
Emotion x Neuroticism	0.13	2.44, 80.39	.912	.00
Word Valence x Neuroticism	2.44	1, 33	.128	.07
Face Valence x Neuroticism	0.61	1, 33	.441	.02
Hemisphere x Neuroticism	0.63	1, 33	.432	.02
Emotion x Word Valence	0.54	3, 99	.656	.02
Emotion x Face Valence	1.52	3, 99	.215	.04
Word Valence x Face Valence	0.02	1, 33	.877	.00
Emotion x Hemisphere	1.96	2.35, 77.65	.140	.06
Word Valence x Hemisphere	0.00	1, 33	.985	.00
Face Valence x Hemisphere	0.00	1, 33	.953	.00
Emotion x Word Valence x Neuroticism	2.21	3, 99	.092	.06
Emotion x Face Valence x Neuroticism	0.83	3, 99	.479	.03
Word Valence x Face Valence x Neuroticism	0.43	1, 33	.517	.01
Emotion x Word Valence x Face Valence	0.95	3, 99	.419	.03
Emotion x Hemisphere x Neuroticism	0.14	2.35, 77.65	.902	.00
Word Valence x Hemisphere x Neuroticism	0.25	1, 33	.620	.01
Emotion x Word Valence x Hemisphere	1.92	3, 99	.132	.06
Face Valence x Hemisphere x Neuroticism	0.66	1, 33	.422	.02
Emotion x Face Valence x Hemisphere	0.08	2.32, 76.56	.931	.00
Word Valence x Face Valence x Hemisphere	0.33	1, 33	.567	.01
Emotion x Word Valence x Face Valence x Neuroticism	**2.74**	**3, 99**	**.047**	**.08**
Emotion x Word Valence x Hemisphere x Neuroticism	1.09	3, 99	.358	.03

Emotion x Face Valence x Hemisphere x Neuroticism	0.29	2.32, 76.56	.779	.01
Word Valence x Face Valence x Hemisphere x Neuroticism	0.12	1, 33	.730	.00
Emotion x Word Valence x Face Valence x Hemisphere	1.84	3, 99	.145	.05
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.40	3, 99	.756	.01

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

Aiming to explore the significant interaction between Emotion, Word Valence, Face Valence and Neuroticism, four new 2 (Word Valence) x 2 (Face Valence) x 2 (Neuroticism) split-plot ANOVAs were conducted, one for each Emotion. The only significant effects were found in the fear condition. The interaction between Word Valence and Neuroticism, $F(1, 36) = 4.61$, $p = .039$, $\eta_p^2 = .11$, was significant. Multiple comparisons revealed a more positive P1 elicited by the evaluation of negative ($M = 9.75$ µV, $SE = 1.13$) compared to positive ($M = 8.74$ µV, $SE = 1.08$) words, only in participants with low neuroticism ($p = .049$). The same pattern of results was found in the sadness condition but it did not reach statistical significance. The interaction between Word Valence, Face Valence and Neuroticism, in the fear block was also significant, $F(1, 36) = 11.76$, $p = .002$, $\eta_p^2 = .25$. In order to explore this result, we conducted one more split-plot ANOVAs for fear condition, with a 2 (Word Valence) x 2 (Face Valence) design, and we tested high and low neuroticism in separate. The interaction between Word and Face Valence, in the fear condition, was significant for participants with high and low neuroticism, $F(1, 18) = 4.72$, $p = .043$, $\eta_p^2 = .21$ and $F(1, 18) = 9.55$, $p = .006$, $\eta_p^2 = .35$, respectively. Multiple comparisons showed higher P1 amplitudes elicited by negative compared to positive word valence assessment of stimuli with happy faces ($p = .007$), in participants with low neuroticism (see Figure 22). Regarding participants with high neuroticism, negative word valence assessment of stimuli with negative faces elicited a higher P1 than the same evaluation in stimuli with positive faces ($p = .027$).

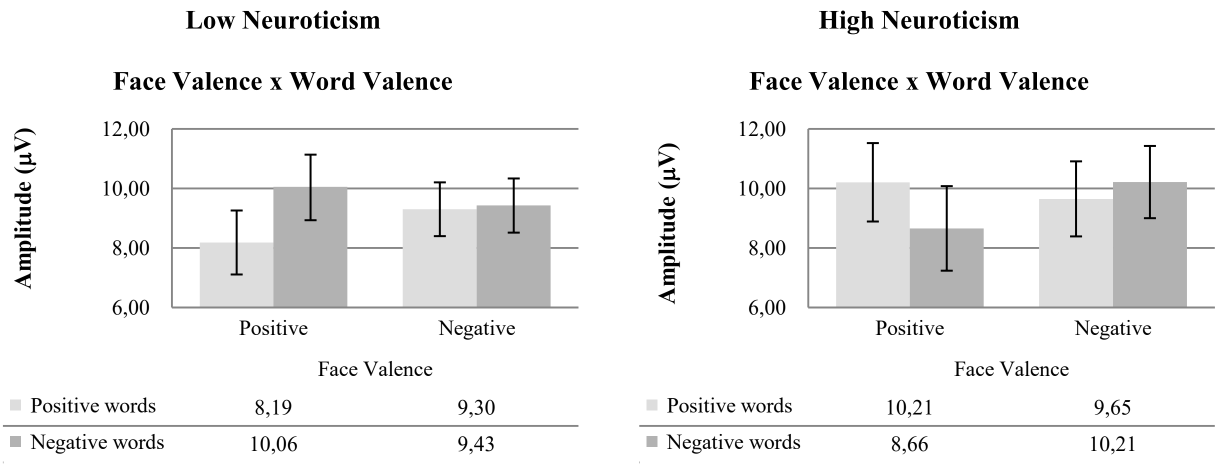


Figure 22: P1 peak amplitude, in the Word Valence Assessment task, plotted by Face Valence and Word Valence conditions. The graph on the left represents results from low neuroticism participants and the graph on the right represents results from the high neuroticism participants. Error bars represent standard errors.

2.1.2. Peak Latency

2.1.2.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 split-plot ANOVA conducted to analyze P1 peak latency elicited by face valence assessment are presented in Table 18.

Table 18: ANOVA results from the analysis of P1 peak latency for the Face Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.22	1, 30	.639	.01
Emotion	0.91	1.57, 47.11	.390	.03
Word Valence	**5.90**	**1, 30**	**.021**	**.16**
Face Valence	2.51	1, 30	.124	.08
Hemisphere	0.15	1, 30	.700	.01
Emotion x Neuroticism	0.39	1.57, 47.11	.627	.01
Word Valence x Neuroticism	2.22	1, 30	.146	.07
Face Valence x Neuroticism	3.24	1, 30	.082	.10
Hemisphere x Neuroticism	0.68	1, 30	.415	.02
Emotion x Word Valence	0.72	1.56, 46.64	.460	.02
Emotion x Face Valence	0.61	1.42, 42.65	.494	.02
Word Valence x Face Valence	0.00	1, 30	.961	.00
Emotion x Hemisphere	1.35	3, 90	.264	.04

Word Valence x Hemisphere	0.19	1, 30	.668	.01
Face Valence x Hemisphere	0.01	1, 30	.930	.00
Emotion x Word Valence x Neuroticism	1.16	1.56, 46.64	.313	.04
Emotion x Face Valence x Neuroticism	0.97	1.42, 42.65	.356	.03
Word Valence x Face Valence x Neuroticism	1.19	1, 30	.284	.04
Emotion x Word Valence x Face Valence	0.27	1.72, 51.57	.731	.01
Emotion x Hemisphere x Neuroticism	2.17	3, 90	.097	.07
Word Valence x Hemisphere x Neuroticism	0.29	1, 30	.867	.00
Emotion x Word Valence x Hemisphere	1.27	3, 90	.290	.04
Face Valence x Hemisphere x Neuroticism	0.75	1, 30	.395	.02
Emotion x Face Valence x Hemisphere	1.45	3, 90	.233	.05
Word Valence x Face Valence x Hemisphere	0.50	1, 30	.485	.02
Emotion x Word Valence x Face Valence x Neuroticism	1.00	1.72, 51.57	.363	.03
Emotion x Word Valence x Hemisphere x Neuroticism	0.33	3, 90	.803	.01
Emotion x Face Valence x Hemisphere x Neuroticism	0.46	3, 90	.714	.02
Word Valence x Face Valence x Hemisphere x Neuroticism	1.16	1, 30	.290	.04
Emotion x Word Valence x Face Valence x Hemisphere	0.26	1.90, 57.06	.761	.01
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.93	1.90, 57.06	.395	.03

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The only significant effect found was the Word Valence: face valence assessment of stimuli with positive words elicited a later P1 peak (M = 118.61 ms, SE = 1.93) than stimuli with negative words (M = 116.85 ms, SE = 1.98).

2.1.2.2. Word Valence Assessment

A 2 x 4 x 2 x 2 x 2 split-plot ANOVA was conducted to analyze P1 peak latency elicited by word valence assessment (see the results in Table 19). No significant results were found in the analysis.

Table 19: ANOVA results from the analysis of P1 peak latency for the Word Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.52	1, 33	.475	.02
Emotion	0.42	2.29, 75.67	.685	.01
Word Valence	1.34	1, 33	.256	.04
Face Valence	2.64	1, 33	.113	.07

Hemisphere	0.03	1, 33	.869	.00
Emotion x Neuroticism	0.73	2.29, 75.67	.503	.02
Word Valence x Neuroticism	0.09	1, 33	.767	.00
Face Valence x Neuroticism	1.88	1, 33	.180	.05
Hemisphere x Neuroticism	0.88	1, 33	.355	.03
Emotion x Word Valence	1.43	3, 99	.238	.04
Emotion x Face Valence	1.28	2.39, 78.77	.287	.04
Word Valence x Face Valence	2.17	1, 33	.150	.06
Emotion x Hemisphere	1.90	2.09, 68.86	.156	.05
Word Valence x Hemisphere	0.01	1, 33	.916	.00
Face Valence x Hemisphere	1.98	1, 33	.168	.06
Emotion x Word Valence x Neuroticism	0.72	3, 99	.545	.02
Emotion x Face Valence x Neuroticism	2.61	2.39, 78.77	.070	.07
Word Valence x Face Valence x Neuroticism	0.11	1, 33	.740	.00
Emotion x Word Valence x Face Valence	0.84	3, 99	.474	.03
Emotion x Hemisphere x Neuroticism	1.22	2.09, 68.86	.304	.04
Word Valence x Hemisphere x Neuroticism	0.89	1, 33	.353	.03
Emotion x Word Valence x Hemisphere	0.30	1.79, 59.19	.721	.01
Face Valence x Hemisphere x Neuroticism	2.04	1, 33	.163	.06
Emotion x Face Valence x Hemisphere	0.71	1.93, 63.52	.491	.02
Word Valence x Face Valence x Hemisphere	0.07	1, 33	.792	.00
Emotion x Word Valence x Face Valence x Neuroticism	0.43	3, 99	.730	.01
Emotion x Word Valence x Hemisphere x Neuroticism	1.52	1.79, 59.19	.228	.04
Emotion x Face Valence x Hemisphere x Neuroticism	0.83	1.93, 63.52	.436	.03
Word Valence x Face Valence x Hemisphere x Neuroticism	2.48	1, 33	.125	.07
Emotion x Word Valence x Face Valence x Hemisphere	0.20	1.98, 65.34	.817	.01
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.37	1.98, 65.34	.694	.01

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

2.2. N170

Peak amplitude and latency of the N170 ERP component were analyzed by 2 (Neuroticism) x 4 (Emotion) x 2 (Word Valence) x 2 (Face Valence) x 2 (Hemisphere) x 2 (Region) split-plot ANOVAs, conducted for Face and Word Valence Assessment tasks in separate. In both analyses, the Region variable had 2 levels: parietal (Ps) – the average of

P_7, P_5, P_6 and P_8 electrode sites– and parieto-occipital (POs) – the average of electrode sites PO_7 and PO_8.

2.2.1. Peak Amplitude

2.2.1.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse N170 peak amplitude elicited by Face Valence Assessment in parietal and parieto-occipital regions are presented in Table 20.

Table 20: ANOVA results from the analysis of N170 peak amplitude for the Face Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.52	1, 29	.478	.02
Emotion	1.45	3, 87	.234	.05
Word Valence	0.96	1, 29	.334	.03
Face Valence	0.63	1, 29	.434	.02
Hemisphere	**8.25**	**1, 29**	**.008**	**.22**
Region	0.02	1, 29	.897	.00
Emotion x Neuroticism	1.22	3, 87	.307	.04
Word Valence x Neuroticism	0.91	1, 29	.347	.03
Face Valence x Neuroticism	0.64	1, 29	.430	.02
Hemisphere x Neuroticism	0.08	1, 29	.776	.00
Region x Neuroticism	1.22	1, 29	.278	.04
Emotion x Word Valence	0.30	3, 87	.827	.01
Emotion x Face Valence	0.05	3, 87	.983	.00
Word Valence x Face Valence	0.00	1, 29	.987	.00
Emotion x Hemisphere	1.58	3, 87	.200	.05
Word Valence x Hemisphere	0.07	1, 29	.791	.00
Face Valence x Hemisphere	3.11	1, 29	.088	.10
Emotion x Region	**3.77**	**3, 87**	**.013**	**.12**
Word Valence x Region	1.82	1, 29	.188	.06
Face Valence x Region	**7.99**	**1, 29**	**.008**	**.22**
Hemisphere x Region	1.56	1, 29	.222	.05
Emotion x Word Valence x Neuroticism	0.19	3, 87	.901	.01
Emotion x Face Valence x Neuroticism	0.03	3, 87	.992	.00
Word Valence x Face Valence x Neuroticism	0.67	1, 29	.419	.02

Emotion x Word Valence x Face Valence	1.91	3, 87	.135	.06
Emotion x Hemisphere x Neuroticism	0.34	3, 87	.798	.01
Word Valence x Hemisphere x Neuroticism	0.41	1, 29	.526	.01
Emotion x Word Valence x Hemisphere	0.70	3, 87	.556	.02
Face Valence x Hemisphere x Neuroticism	0.09	1, 29	.772	.00
Emotion x Face Valence x Hemisphere	0.09	3, 87	.968	.00
Word Valence x Face Valence x Hemisphere	0.39	1, 29	.537	.01
Emotion x Region x Neuroticism	**4.21**	**3, 87**	**.008**	**.13**
Word Valence x Region x Neuroticism	0.95	1, 29	.337	.03
Emotion x Word Valence x Region	**2.82**	**3, 87**	**.044**	**.09**
Face Valence x Region x Neuroticism	1.03	1, 29	.318	.03
Emotion x Face Valence x Region	2.21	3, 87	.092	.07
Word Valence x Face Valence x Region	1.43	1, 29	.242	.05
Hemisphere x Region x Neuroticism	**8.33**	**1, 29**	**.007**	**.22**
Emotion x Hemisphere x Region	1.34	3, 87	.268	.04
Word Valence x Hemisphere x Region	1.03	1, 29	.320	.03
Face Valence x Hemisphere x Region	3.12	1, 29	.088	.10
Emotion x Word Valence x Face Valence x Neuroticism	0.07	3, 87	.978	.00
Emotion x Word Valence x Hemisphere x Neuroticism	0.74	3, 87	.533	.03
Emotion x Face Valence x Hemisphere x Neuroticism	1.23	3, 87	.305	.04
Word Valence x Face Valence x Hemisphere x Neuroticism	1.24	1, 29	.275	.04
Emotion x Word Valence x Face Valence x Hemisphere	0.28	2.33, 67.44	.787	.01
Emotion x Word Valence x Region x Neuroticism	2.50	3, 87	.065	.08
Emotion x Face Valence x Region x Neuroticism	0.52	3, 87	.673	.02
Word Valence x Face Valence x Region x Neuroticism	1.57	1, 29	.220	.05
Emotion x Word Valence x Face Valence x Region	1.79	3, 87	.155	.06
Emotion x Hemisphere x Region x Neuroticism	0.83	3, 87	.480	.03
Word Valence x Hemisphere x Region x Neuroticism	0.57	1, 29	.456	.02
Emotion x Word Valence x Hemisphere x Region	0.60	2.09, 60.70	.557	.02
Face Valence x Hemisphere x Region x Neuroticism	0.47	1, 29	.501	.02
Emotion x Face Valence x Hemisphere x Region	0.09	1.78, 51.61	.891	.00
Word Valence x Face Valence x Hemisphere x Region	1.18	1, 29	.287	.04
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.12	2.33, 67.44	.340	.04
Emotion x Word Valence x Face Valence x Region x Neuroticism	2.44	3, 87	.070	.08
Emotion x Word Valence x Hemisphere x Region x Neuroticism	0.78	2.09, 60.70	.469	.03
Emotion x Face Valence x Hemisphere x Region x Neuroticism	1.29	1.78, 51.61	.281	.04
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.41	1, 29	.529	.01

Emotion x Word Valence x Face Valence x Hemisphere x Region	0.75	2.25, 65.26	.493	.03
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	1.17	2.25, 65.26	.322	.04

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The main effect of Hemisphere was significant: a more negative N170 was found in the right (M = -9.38 µV, SE = 1.07) compared to the left hemisphere (M = -7.83 µV, SE = 0.99).

The interactions between Emotion and Region and between Face Valence and Region were significant but multiple comparisons did not show any significant result.

We conducted several analyses in order to explore the significant interactions between Emotion, Region and Neuroticism, and between Emotion, Word Valence and Site, although none of them showed any significant results.

The significant interaction between Hemisphere, Region and Neuroticism is not relevant to the objectives of this thesis, therefore it was not described.

2.2.1.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse N170 peak amplitude elicited by Word Valence Assessment in parietal and parieto-occipital regions are presented in Table 21.

Table 21: ANOVA results from the analysis of N170 peak amplitude for the Word Valence Assessment task.

Effect	**F**	**d. f.** [a]	***p***	η_p^2
Neuroticism	3.79	1, 33	.060	.10
Emotion	1.20	3, 99	.313	.04
Word Valence	0.01	1, 33	.913	.00
Face Valence	0.54	1, 33	.467	.02
Hemisphere	0.40	1, 33	.531	.01
Region	0.02	1, 33	.880	.00
Emotion x Neuroticism	2.61	3, 99	.056	.07
Word Valence x Neuroticism	0.52	1, 33	.476	.02
Face Valence x Neuroticism	0.76	1, 33	.389	.02
Hemisphere x Neuroticism	3.66	1, 33	.065	.10
Region x Neuroticism	0.92	1, 33	.345	.03
Emotion x Word Valence	1.25	3, 99	.297	.04

Emotion x Face Valence	1.58	3, 99	.200	.05
Word Valence x Face Valence	0.79	1, 33	.381	.02
Emotion x Hemisphere	0.05	3, 99	.985	.00
Word Valence x Hemisphere	0.03	1, 33	.583	.00
Face Valence x Hemisphere	0.00	1, 33	.971	.00
Emotion x Region	0.61	3, 99	.608	.02
Word Valence x Region	2.55	1, 33	.120	.07
Face Valence x Region	0.21	1, 33	.065	.01
Hemisphere x Region	2.81	1, 33	.103	.08
Emotion x Word Valence x Neuroticism	**3.05**	**3, 99**	**.032**	**.09**
Emotion x Face Valence x Neuroticism	0.30	3, 99	.828	.01
Word Valence x Face Valence x Neuroticism	0.26	1, 33	.617	.01
Emotion x Word Valence x Face Valence	0.48	3, 99	.694	.01
Emotion x Hemisphere x Neuroticism	0.60	3, 99	.618	.02
Word Valence x Hemisphere x Neuroticism	0.71	1, 33	.405	.02
Emotion x Word Valence x Hemisphere	0.82	3, 99	.485	.02
Face Valence x Hemisphere x Neuroticism	3.09	1, 33	.088	.09
Emotion x Face Valence x Hemisphere	**2.74**	**3, 99**	**.047**	**.08**
Word Valence x Face Valence x Hemisphere	0.62	1, 33	.435	.02
Emotion x Region x Neuroticism	1.65	3, 99	.182	.05
Word Valence x Region x Neuroticism	0.45	1, 33	.508	.01
Emotion x Word Valence x Region	0.06	3, 99	.981	.00
Face Valence x Region x Neuroticism	0.89	1, 33	.354	.03
Emotion x Face Valence x Region	**3.30**	**2.43, 80.01**	**.033**	**.09**
Word Valence x Face Valence x Region	0.51	1, 33	.480	.02
Hemisphere x Region x Neuroticism	0.07	1, 33	.800	.00
Emotion x Hemisphere x Region	1.93	3, 99	.130	.06
Word Valence x Hemisphere x Region	0.35	1, 33	.560	.01
Face Valence x Hemisphere x Region	0.34	1, 33	.563	.01
Emotion x Word Valence x Face Valence x Neuroticism	0.65	3, 99	.583	.02
Emotion x Word Valence x Hemisphere x Neuroticism	0.69	3, 99	.560	.02
Emotion x Face Valence x Hemisphere x Neuroticism	1.07	3, 99	.367	.03
Word Valence x Face Valence x Hemisphere x Neuroticism	2.35	1, 33	.135	.07
Emotion x Word Valence x Face Valence x Hemisphere	0.63	2.24, 73.95	.551	.02
Emotion x Word Valence x Region x Neuroticism	0.69	3, 99	.563	.02
Emotion x Face Valence x Region x Neuroticism	0.21	2.43, 80.01	.849	.01
Word Valence x Face Valence x Region x Neuroticism	0.47	1, 33	.499	.01
Emotion x Word Valence x Face Valence x Region	0.81	3, 99	.489	.02
Emotion x Hemisphere x Region x Neuroticism	0.41	3, 99	.746	.01

Word Valence x Hemisphere x Region x Neuroticism	1.16	1, 33	.289	.03
Emotion x Word Valence x Hemisphere x Region	1.55	3, 99	.206	.05
Face Valence x Hemisphere x Region x Neuroticism	0.02	1, 33	.888	.00
Emotion x Face Valence x Hemisphere x Region	0.17	1.91, 63.08	.918	.01
Word Valence x Face Valence x Hemisphere x Region	0.22	1, 33	.642	.01
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.81	2.24, 73.95	.168	.05
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.08	3, 99	.361	.03
Emotion x Word Valence x Hemisphere x Region x Neuroticism	2.66	3, 99	.053	.07
Emotion x Face Valence x Hemisphere x Region x Neuroticism	0.51	1.91, 63.08	.592	.02
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.08	1, 33	.786	.00
Emotion x Word Valence x Face Valence x Hemisphere x Region	1.40	2.28, 75.10	.253	.04
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	1.07	2.28, 75.10	.355	.03

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

Although the main effect of Neuroticism was only marginal, it is important to our study to report it. Thus, participants with low neuroticism showed a tendency for a more negative N170 (M = -10.77 µV, SE = 0.98) than participants with high neuroticism (M = -8.06 µV, SE = 0.97).

The interaction between Emotion and Neuroticism was also only marginal, but pairwise comparisons showed more negative N170 amplitudes for low (M = -11.48 µV, SE = 1.03) compared to high (M = -7.64 µV, SE = 1.00, p = .012) neuroticism participants, only in the fear condition. The results were similar in the anger condition but did not reach statistical significance (p = .054).

The interaction between Emotion, Word Valence and Neuroticism was significant. Thus, two 4 (Emotion) x 2 (Neuroticism) split-plot ANOVAs were conducted: one for positive and another for negative words. Negative word valence assessment had no significant effects. On the contrary, the interaction between Emotion and Neuroticism, for positive valence assessment was significant, $F(3, 105) = 3.73$, $p = .014$, $\eta_p^2 = .10$. Pairwise comparisons showed a higher N170 elicited in the fear condition (M = -11.62 µV, SE = 1.03) compared to the disgust condition (M = -9.42 µV, SE = 0.97, p = .024), only in participants with low neuroticism. Higher N170 amplitudes were also found in the fear condition in participants with low compared to high (M = -7.43 µV, SE = 1.05, p = .007) neuroticism scores. The same pattern of results was found in the sadness block but it did not reach statistical significance.

In order to explore the significant interaction between Emotion, Face Valence and Hemisphere, four 2 (Face Valence) x 2 (Hemisphere) repeated measures ANOVAs were conducted, one for each emotional block. The fear block was the only one with significant results: an interaction between Face Valence and Hemisphere, $F(1, 37) = 4.29$, $p = .045$, $\eta_p^2 = .10$. No significant effect was found in pairwise comparisons.

Aiming to investigate the significant interaction between Emotion, Face Valence and Region, four 2 (Face Valence) x 2 (Region) repeated measures ANOVAs were conducted, one for each emotional condition. Only one significant effect was found: the interaction between Face Valence and Region in the disgust block, $F(1, 37) = 5.31$, $p = .027$, $\eta_p^2 = .13$. Again, no significant effects were found.

2.2.2. Peak Latency

2.2.2.1. Face Valence Assessment

Similar to previous analysis, the results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted for N170 peak latency elicited by the Face Valence Assessment task in parietal (electrode sites P_7, P_5, P_6 and P_8) and parieto-occipital (PO_7 and PO_8) regions are presented in Table 22.

Table 22: ANOVA results from the analysis of N170 peak latency elicited by Face Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.74	1, 29	.398	.03
Emotion	0.87	3, 87	.459	.03
Word Valence	0.25	1, 29	.620	.01
Face Valence	0.40	1, 29	.533	.01
Hemisphere	**7.78**	**1, 29**	**.009**	**.21**
Region	1.85	1, 29	.185	.06
Emotion x Neuroticism	2.03	3, 87	.116	.07
Word Valence x Neuroticism	0.85	1, 29	.364	.03
Face Valence x Neuroticism	1.09	1, 29	.306	.04
Hemisphere x Neuroticism	3.07	1, 29	.090	.10

Region x Neuroticism	0.29	1, 29	.592	.01
Emotion x Word Valence	1.23	3, 87	.304	.04
Emotion x Face Valence	1.05	3, 87	.373	.04
Word Valence x Face Valence	0.21	1, 29	.648	.01
Emotion x Hemisphere	0.56	2.04, 59.03	.577	.02
Word Valence x Hemisphere	0.82	1, 29	.374	.03
Face Valence x Hemisphere	1.56	1, 29	.222	.05
Emotion x Region	1.02	3, 87	.386	.03
Word Valence x Region	0.61	1, 29	.443	.02
Face Valence x Region	1.53	1, 29	.226	.05
Hemisphere x Region	0.70	1, 29	.411	.02
Emotion x Word Valence x Neuroticism	0.74	3, 87	.532	.03
Emotion x Face Valence x Neuroticism	0.98	3, 87	.407	.03
Word Valence x Face Valence x Neuroticism	0.10	1, 29	.760	.00
Emotion x Word Valence x Face Valence	0.88	3, 87	.454	.03
Emotion x Hemisphere x Neuroticism	0.81	2.04, 59.03	.450	.03
Word Valence x Hemisphere x Neuroticism	0.84	1, 29	.368	.03
Emotion x Word Valence x Hemisphere	1.78	2.29, 66.46	.172	.06
Face Valence x Hemisphere x Neuroticism	0.30	1, 29	.591	.01
Emotion x Face Valence x Hemisphere	**3.76**	**3, 87**	**.014**	**.12**
Word Valence x Face Valence x Hemisphere	3.20	1, 29	.084	.10
Emotion x Region x Neuroticism	1.07	3, 87	.365	.04
Word Valence x Region x Neuroticism	3.03	1, 29	.093	.09
Emotion x Word Valence x Region	0.70	3, 87	.552	.02
Face Valence x Region x Neuroticism	0.02	1, 29	.885	.00
Emotion x Face Valence x Region	2.11	3, 87	.105	.07
Word Valence x Face Valence x Region	0.75	1, 29	.393	.03
Hemisphere x Region x Neuroticism	2.43	1, 29	.130	.08
Emotion x Hemisphere x Region	1.22	2.30, 66.67	.306	.04
Word Valence x Hemisphere x Region	**5.28**	**1, 29**	**.029**	**.15**
Face Valence x Hemisphere x Region	3.37	1, 29	.077	.10
Emotion x Word Valence x Face Valence x Neuroticism	1.54	3, 87	.210	.05
Emotion x Word Valence x Hemisphere x Neuroticism	0.30	2.29, 66.46	.769	.01
Emotion x Face Valence x Hemisphere x Neuroticism	0.10	3, 87	.958	.00
Word Valence x Face Valence x Hemisphere x Neuroticism	0.28	1, 29	.598	.10
Emotion x Word Valence x Face Valence x Hemisphere	0.38	3, 87	.766	.01
Emotion x Word Valence x Region x Neuroticism	0.25	3, 87	.862	.01
Emotion x Face Valence x Region x Neuroticism	0.59	3, 87	.621	.02
Word Valence x Face Valence x Region x Neuroticism	0.94	1, 29	.342	.03

Emotion x Word Valence x Face Valence x Region	0.78	3, 87	.508	.03
Emotion x Hemisphere x Region x Neuroticism	1.61	2.30, 66.67	.204	.05
Word Valence x Hemisphere x Region x Neuroticism	0.66	1, 29	.424	.02
Emotion x Word Valence x Hemisphere x Region	0.94	3, 87	.424	.03
Face Valence x Hemisphere x Region x Neuroticism	2.72	1, 29	.110	.09
Emotion x Face Valence x Hemisphere x Region	1.01	3, 87	.394	.03
Word Valence x Face Valence x Hemisphere x Region	3.43	1, 29	.074	.11
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.76	3, 87	.161	.06
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.53	3, 87	.213	.05
Emotion x Word Valence x Hemisphere x Region x Neuroticism	0.39	3, 87	.763	.01
Emotion x Face Valence x Hemisphere x Region x Neuroticism	2.19	3, 87	.094	.07
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.41	1, 29	.526	.01
Emotion x Word Valence x Face Valence x Hemisphere x Region	0.50	3, 87	.684	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.81	3, 87	.494	.03

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The only significant main effect found was the Hemisphere: an earlier N170 elicited by face valence assessment was found in the right (M = 177.47 ms, SE = 2.02) compared to the left (M = 180.09 ms, SE = 2.08) hemisphere.

To explore the significant interaction between Emotion, Face Valence and Hemisphere four new 2 (Face Valence) x 2 (Hemisphere) repeated measures ANOVAs were conducted, one for each Emotion. Regarding the fear block, a significant interaction was found between Face Valence and Hemisphere, $F(1, 34) = 6.45$, $p = .016$, $\eta_p^2 = .16$ (see Figure 23). Multiple comparisons showed an earlier N170 elicited by positive compared to negative face valence assessment in the left hemisphere ($p = .044$). Regarding valence judgments of fearful faces, N170 component peaked earlier in the right than in the left hemisphere ($p = .012$). In relation to the disgust condition, a main effect of Face Valence was found, $F(1, 34) = 4.88$, $p = .034$, $\eta_p^2 = .13$: the N170 elicited by the evaluation of happy faces peaked early (M = 176.79 ms, SE = 2.10) than valence judgments of disgusted faces (M = 178.32 ms, SE = 2.04). The main effect of Hemisphere was also significant, $F(1, 34) = 5.86$, $p = .021$, $\eta_p^2 = .15$ and showed an early N170 in the right (M = 176.18 ms, SE = 2.07) compared to the left (M = 178.93 ms, SE = 2.16) hemisphere. No significant results were found in the anger or sadness conditions.

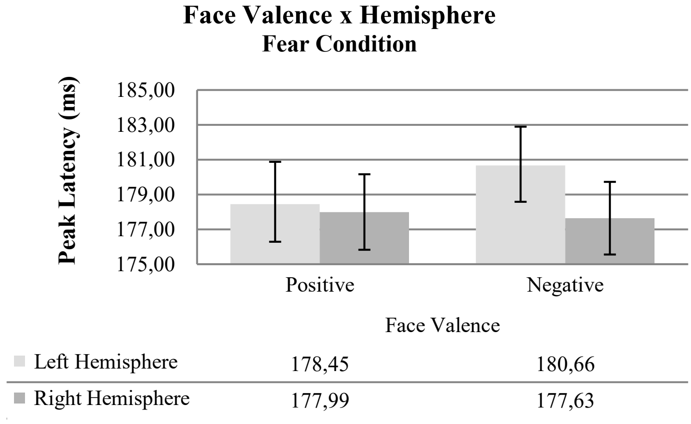


Figure 23: N170 peak latency, in the Face Valence Assessment task, plotted by Face Valence and Hemisphere conditions for the fear condition. Error bars represent standard errors.

The interaction between Word Valence, Region and Hemisphere was significant but as it is not relevant to the main objectives of the thesis, it was not reported.

2.2.2.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse the N170 peak latency in parietal and parieto-occipital regions are presented in Table 23.

Table 23: ANOVA results from the analysis of N170 peak latency elicited by Word Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	1.78	1, 33	.192	.05
Emotion	0.70	2.47, 81.48	.530	.02
Word Valence	0.03	1, 33	.860	.00
Face Valence	0.00	1, 33	.993	.00
Hemisphere	1.85	1, 33	.183	.05
Region	0.77	1, 33	.388	.02
Emotion x Neuroticism	0.18	2.47, 81.48	.879	.01
Word Valence x Neuroticism	0.58	1, 33	.452	.02
Face Valence x Neuroticism	2.64	1, 33	.114	.07
Hemisphere x Neuroticism	0.21	1, 33	.649	.01
Region x Neuroticism	0.48	1, 33	.492	.01
Emotion x Word Valence	2.59	2.49, 82.16	.057	.07
Emotion x Face Valence	1.70	3, 99	.171	.05

Word Valence x Face Valence	**5.18**	**1, 33**	**.029**	**.14**
Emotion x Hemisphere	0.45	2.39, 78.80	.677	.01
Word Valence x Hemisphere	0.13	1, 33	.726	.00
Face Valence x Hemisphere	0.53	1, 33	.472	.02
Emotion x Region	1.06	3, 99	.371	.03
Word Valence x Region	**5.78**	**1, 33**	**.022**	**.15**
Face Valence x Region	3.62	1, 33	.066	.10
Hemisphere x Region	0.39	1, 33	.535	.01
Emotion x Word Valence x Neuroticism	0.78	2.49, 82.16	.490	.02
Emotion x Face Valence x Neuroticism	2.03	3, 99	.115	.06
Word Valence x Face Valence x Neuroticism	0.81	1, 33	.374	.02
Emotion x Word Valence x Face Valence	0.42	2.20, 72.47	.677	.01
Emotion x Hemisphere x Neuroticism	1.13	2.39, 78.80	.334	.03
Word Valence x Hemisphere x Neuroticism	3.77	1, 33	.061	.10
Emotion x Word Valence x Hemisphere	0.23	3, 99	.875	.01
Face Valence x Hemisphere x Neuroticism	0.14	1, 33	.712	.00
Emotion x Face Valence x Hemisphere	1.66	2.33, 76.85	.193	.05
Word Valence x Face Valence x Hemisphere	0.23	1, 33	.637	.01
Emotion x Region x Neuroticism	0.70	3, 99	.552	.02
Word Valence x Region x Neuroticism	1.11	1, 33	.299	.03
Emotion x Word Valence x Region	**3.30**	**3, 99**	**.024**	**.09**
Face Valence x Region x Neuroticism	2.05	1, 33	.162	.06
Emotion x Face Valence x Region	1.62	2.46, 81.10	.199	.05
Word Valence x Face Valence x Region	0.12	1, 33	.732	.00
Hemisphere x Region x Neuroticism	0.35	1, 33	.560	.01
Emotion x Hemisphere x Region	1.35	3, 99	.262	.04
Word Valence x Hemisphere x Region	3.09	1, 33	.088	.09
Face Valence x Hemisphere x Region	0.35	1, 33	.561	.01
Emotion x Word Valence x Face Valence x Neuroticism	0.97	2.20, 72.47	.393	.03
Emotion x Word Valence x Hemisphere x Neuroticism	0.63	3, 99	.600	.02
Emotion x Face Valence x Hemisphere x Neuroticism	1.16	2.33, 76.85	.325	.03
Word Valence x Face Valence x Hemisphere x Neuroticism	0.31	1, 33	.585	.01
Emotion x Word Valence x Face Valence x Hemisphere	0.30	3, 99	.823	.01
Emotion x Word Valence x Region x Neuroticism	1.48	3, 99	.226	.04
Emotion x Face Valence x Region x Neuroticism	0.15	2.46, 81.10	.900	.00
Word Valence x Face Valence x Region x Neuroticism	0.02	1, 33	.877	.00
Emotion x Word Valence x Face Valence x Region	1.25	3, 99	.296	.04
Emotion x Hemisphere x Region x Neuroticism	1.27	3, 99	.289	.04
Word Valence x Hemisphere x Region x Neuroticism	0.05	1, 33	.828	.00

Emotion x Word Valence x Hemisphere x Region	**6.62**	**3, 99**	**< .001**	**.17**
Face Valence x Hemisphere x Region x Neuroticism	0.37	1, 33	.548	.01
Emotion x Face Valence x Hemisphere x Region	2.32	3, 99	.080	.07
Word Valence x Face Valence x Hemisphere x Region	2.62	1, 33	.115	.07
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	2.60	3, 99	.057	.07
Emotion x Word Valence x Face Valence x Region x Neuroticism	0.58	3, 99	.631	.02
Emotion x Word Valence x Hemisphere x Region x Neuroticism	2.38	3, 99	.075	.07
Emotion x Face Valence x Hemisphere x Region x Neuroticism	0.63	3, 99	.600	.02
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.73	1, 33	.399	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region	2.62	3, 99	.055	.07
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.28	3, 99	.839	.01

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The interaction between Word and Face Valence was significant. As can be seen in Figure 24, when participants assessed positive and negative words in congruent trials, the N170 seemed to peak later than in incongruent trials. However, these results did not reach statistical significance in pairwise comparisons.

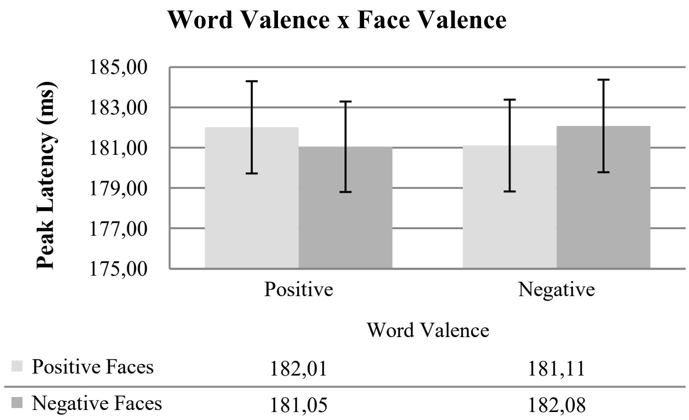


Figure 24: N170 peak latency, in Word Valence Assessment task, plotted by Word Valence and Face Valence conditions. Error bars represent standard errors.

The multiple comparisons performed for the interactions between Emotion and Word Valence and Word Valence and Region did not show any significant effects, neither did the several analysis conducted to clarify the significant interaction between Emotion, Word Valence and Region and Emotion, Word Valence, Hemisphere and Region.

2.3. EPN

Four 2 (Neuroticism) x 4 (Emotion) x 2 (Word Valence) x 2 (Face Valence) x 2 (Hemisphere) x 2 (Region) split-plot ANOVAs were conducted to analyse EPN peak amplitude and peak latency in parietal (average of the electrode sites P_5, P_6, P_7, and P_8) and parieto-occipital (average of the electrode sites PO_3, PO_4, PO_7 and PO_8) regions for Word and Face Valence Assessment tasks separately.

2.3.1. Peak Amplitude

2.3.1.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse EPN peak amplitude elicited by Face Valence Assessment are presented in Table 24.

Table 24: ANOVA results from the analysis of EPN peak amplitude elicited by Face Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.27	1, 31	.606	.01
Emotion	**3.15**	**3, 93**	**.029**	**.09**
Word Valence	0.04	1, 31	.836	.00
Face Valence	1.61	1, 31	.214	.05
Hemisphere	**6.31**	**1, 31**	**.017**	**.17**
Region	**18.48**	**1, 31**	**< .001**	**.37**
Emotion x Neuroticism	**3.48**	**3, 93**	**.019**	**.10**
Word Valence x Neuroticism	2.57	1, 31	.119	.08
Face Valence x Neuroticism	0.44	1, 31	.510	.01
Hemisphere x Neuroticism	0.41	1, 31	.529	.01
Region x Neuroticism	0.47	1, 31	.496	.02
Emotion x Word Valence	0.49	3, 93	.691	.02
Emotion x Face Valence	1.10	3, 93	.351	.03
Word Valence x Face Valence	0.14	1, 31	.713	.00
Emotion x Hemisphere	1.49	3, 93	.222	.05

Word Valence x Hemisphere	0.30	1, 31	.590	.01
Face Valence x Hemisphere	2.84	1, 31	.102	.08
Emotion x Region	0.73	3, 93	.537	.02
Word Valence x Region	0.40	1, 31	.531	.01
Face Valence x Region	0.86	1, 31	.362	.03
Hemisphere x Region	0.01	1, 31	.944	.00
Emotion x Word Valence x Neuroticism	1.72	3, 93	.160	.05
Emotion x Face Valence x Neuroticism	0.40	3, 93	.755	.01
Word Valence x Face Valence x Neuroticism	0.35	1, 31	.560	.01
Emotion x Word Valence x Face Valence	0.07	3, 93	.974	.00
Emotion x Hemisphere x Neuroticism	0.69	3, 93	.562	.02
Word Valence x Hemisphere x Neuroticism	0.85	1, 31	.364	.03
Emotion x Word Valence x Hemisphere	1.04	3, 93	.380	.03
Face Valence x Hemisphere x Neuroticism	0.02	1, 31	.903	.00
Emotion x Face Valence x Hemisphere	0.73	3, 93	.536	.02
Word Valence x Face Valence x Hemisphere	0.00	1, 31	.990	.00
Emotion x Region x Neuroticism	1.23	3, 93	.302	.04
Word Valence x Region x Neuroticism	0.15	1, 31	.701	.01
Emotion x Word Valence x Region	2.99	2.09, 64.77	.055	.09
Face Valence x Region x Neuroticism	1.20	1, 31	.281	.04
Emotion x Face Valence x Region	0.66	3, 93	.577	.02
Word Valence x Face Valence x Region	2.05	1, 31	.162	.06
Hemisphere x Region x Neuroticism	1.99	1, 31	.168	.06
Emotion x Hemisphere x Region	1.06	2.29, 71.12	.358	.03
Word Valence x Hemisphere x Region	1.88	1, 31	.180	.06
Face Valence x Hemisphere x Region	2.07	1, 31	.160	.06
Emotion x Word Valence x Face Valence x Neuroticism	2.05	3, 93	.112	.06
Emotion x Word Valence x Hemisphere x Neuroticism	0.67	3, 93	.571	.02
Emotion x Face Valence x Hemisphere x Neuroticism	**3.10**	**3, 93**	**.030**	**.09**
Word Valence x Face Valence x Hemisphere x Neuroticism	0.61	1, 31	.442	.02
Emotion x Word Valence x Face Valence x Hemisphere	2.27	3, 93	.086	.07
Emotion x Word Valence x Region x Neuroticism	1.98	2.09, 64.77	.144	.06
Emotion x Face Valence x Region x Neuroticism	**5.53**	**3, 93**	**.002**	**.15**
Word Valence x Face Valence x Region x Neuroticism	0.10	1, 31	.750	.00
Emotion x Word Valence x Face Valence x Region	0.49	2.09, 64.78	.622	.02
Emotion x Hemisphere x Region x Neuroticism	0.82	2.29, 71.12	.459	.03
Word Valence x Hemisphere x Region x Neuroticism	0.06	1, 31	.814	.00
Emotion x Word Valence x Hemisphere x Region	0.65	3, 93	.587	.02
Face Valence x Hemisphere x Region x Neuroticism	2.07	1, 31	.160	.06

Emotion x Face Valence x Hemisphere x Region	0.17	2.15, 66.52	.857	.01
Word Valence x Face Valence x Hemisphere x Region	2.51	1, 31	.123	.08
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.32	3, 93	.811	.01
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.06	2.09, 64.78	.355	.03
Emotion x Word Valence x Hemisphere x Region x Neuroticism	1.48	3, 93	.224	.05
Emotion x Face Valence x Hemisphere x Region x Neuroticism	0.91	2.15, 66.52	.413	.03
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	1.77	1, 31	.193	.05
Emotion x Word Valence x Face Valence x Hemisphere x Region	0.56	1.96, 60.63	.571	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.54	1.96, 60.63	.582	.02

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The main effect of Emotion was significant. Post-hoc tests suggested that EPN amplitude was more negative in sadness (M = -5.21 µV, SE = 0.83) compared to fear (M = -4.10 µV, SE = 0.85, p = .016) blocks.

Concerning the main effect of Hemisphere, a more negative EPN was found in the left (M = -4.97 µV, SE = 0.81) compared to the right (M = -4.14 µV, SE = 0.83) hemisphere.

The main effect of Region was also significant: a more negative EPN was found in parietal (M = -4.88 µV, SE = 0.82) than in parieto-occipital (M = -4.23 µV, SE = 0.79) sites.

The interaction between Emotion and Neuroticism was significant and multiple comparisons showed a more negative EPN elicited in sadness (M = -5.76 µV, SE = 1.24) than in fear (M = -4.27 µV, SE = 1.25, p = .034) conditions, only in low neuroticism participants.

In order to explore the significant interaction between Emotion, Face Valence, Hemisphere and Neuroticism, two new 4 (Emotion) x 2 (Face Valence) x 2 (Neuroticism) split-plot ANOVAs were conducted, one for each Hemisphere. There were no significant effects in the left hemisphere. On the contrary, in the right hemisphere a main effect of Emotion was found, $F(3, 93) = 3.34$, $p = .023$, $\eta_p^2 = .10$. The sadness condition evoked a more negative EPN amplitude (M = -4.81 µV, SE = 0.87) than the fear condition (M = -3.67 µV, SE = 0.84, p = .026). The interaction between Emotion and Neuroticism was also significant, $F(3, 93) = 3.51$, $p = .018$, $\eta_p^2 = .10$. Multiple comparisons showed a more negative EPN elicited by sadness (M = -5.32 µV, SE = 1.29) compared to fear

(M = -3.76 µV, SE = 1.23, p = .046) and anger (M = -3.62 µV, SE = 1.25, p = .022) conditions, only in participants with low neuroticism.

Aiming to further explore the interaction between Emotion, Face Valence, Region and Neuroticism, four new 4 (Emotion) x 2 (Face Valence) split-plot ANOVAs were conducted, one for each combination of Neuroticism and Region – high neuroticism in parietal sites, high neuroticism in parieto-occipital sites, low neuroticism in parietal sites and low neuroticism in parieto-occipital sites. Results only showed significant effects for the low group in both Regions. Multiple comparisons showed a significant main effect of Emotion for low neuroticism participants in parietal sites, $F(3, 42) = 5.66$, $p = .005$, $\eta_p^2 = .29$. Post-hoc tests showed less negative EPN amplitudes in the fear (M = -4.57 µV, SE = 1.38) than in disgust (M = -5.83 µV, SE = 1.25, p = .004) and sadness (M = -5.97 µV, SE = 1.20, p = .040) conditions. A similar effect was found for low neuroticism participants in parieto-occipital sites – main effect of Emotion, $F(3, 42) = 5.51$, $p = .007$, $\eta_p^2 = .28$. Post-hoc tests showed again less negative EPN amplitudes in the fear (M = -3.97 µV, SE = 1.33) than in disgust (M = -5.31 µV, SE = 1.23, p = .003) and sadness (M = -5.54 µV, SE = 1.23, p = .028) conditions.

2.3.1.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse EPN peak amplitude in parietal and parieto-occipital regions elicited by Word Valence Assessment are presented in Table 25.

Table 25: ANOVA results from the analysis of EPN peak amplitude elicited by Word Valence Assessment task.

Effect	F	d. f. [a]	p	η_p^2
Neuroticism	0.58	1, 35	.450	.02
Emotion	2.16	2.38, 83.12	.113	.06
Word Valence	0.10	1, 35	.756	.00
Face Valence	2.63	1, 35	.114	.07
Hemisphere	**6.30**	**1, 35**	**.017**	**.15**
Region	**26.48**	**1, 35**	**< .001**	**.43**
Emotion x Neuroticism	2.08	2.38, 83.12	.122	.06
Word Valence x Neuroticism	1.31	1, 35	.261	.04
Face Valence x Neuroticism	0.00	1, 35	.957	.00

Hemisphere x Neuroticism	1.53	1, 35	.224	.04
Region x Neuroticism	0.24	1, 35	.628	.01
Emotion x Word Valence	0.80	3, 105	.495	.02
Emotion x Face Valence	1.45	3, 105	.232	.04
Word Valence x Face Valence	0.00	1, 35	.999	.00
Emotion x Hemisphere	0.08	3, 105	.971	.00
Word Valence x Hemisphere	3.60	3, 105	.066	.09
Face Valence x Hemisphere	1.59	1, 35	.216	.04
Emotion x Region	0.39	3, 105	.759	.01
Word Valence x Region	0.84	1, 35	.365	.02
Face Valence x Region	0.69	1, 35	.413	.02
Hemisphere x Region	**7.06**	**1, 35**	**.012**	**.17**
Emotion x Word Valence x Neuroticism	1.09	3, 105	.357	.03
Emotion x Face Valence x Neuroticism	0.51	3, 105	.673	.01
Word Valence x Face Valence x Neuroticism	2.63	1, 35	.114	.07
Emotion x Word Valence x Face Valence	**2.77**	**3, 105**	**.046**	**.07**
Emotion x Hemisphere x Neuroticism	2.46	3, 105	.067	.07
Word Valence x Hemisphere x Neuroticism	0.93	3, 105	.342	.03
Emotion x Word Valence x Hemisphere	0.99	3, 105	.399	.03
Face Valence x Hemisphere x Neuroticism	0.55	1, 35	.462	.02
Emotion x Face Valence x Hemisphere	**2.84**	**3, 105**	**.042**	**.08**
Word Valence x Face Valence x Hemisphere	0.56	1, 35	.460	.02
Emotion x Region x Neuroticism	0.60	3, 105	.618	.02
Word Valence x Region x Neuroticism	1.63	1, 35	.210	.04
Emotion x Word Valence x Region	0.31	3, 105	.819	.01
Face Valence x Region x Neuroticism	0.04	1, 35	.835	.00
Emotion x Face Valence x Region	0.42	3, 105	.736	.01
Word Valence x Face Valence x Region	0.70	1, 35	.409	.02
Hemisphere x Region x Neuroticism	3.86	1, 35	.058	.10
Emotion x Hemisphere x Region	0.84	2.32, 81.23	.452	.02
Word Valence x Hemisphere x Region	2.29	1, 35	.140	.06
Face Valence x Hemisphere x Region	0.76	1, 35	.391	.02
Emotion x Word Valence x Face Valence x Neuroticism	0.47	3, 105	.706	.01
Emotion x Word Valence x Hemisphere x Neuroticism	1.61	3, 105	.191	.04
Emotion x Face Valence x Hemisphere x Neuroticism	1.68	3, 105	.177	.05
Word Valence x Face Valence x Hemisphere x Neuroticism	0.80	1, 35	.376	.02
Emotion x Word Valence x Face Valence x Hemisphere	0.17	1, 35	.919	.01
Emotion x Word Valence x Region x Neuroticism	0.66	3, 105	.580	.02
Emotion x Face Valence x Region x Neuroticism	1.13	3, 105	.340	.03

Word Valence x Face Valence x Region x Neuroticism	1.92	1, 35	.174	.05
Emotion x Word Valence x Face Valence x Region	0.92	3, 105	.437	.03
Emotion x Hemisphere x Region x Neuroticism	0.21	2.32, 81.23	.840	.01
Word Valence x Hemisphere x Region x Neuroticism	0.55	1, 35	.463	.02
Emotion x Word Valence x Hemisphere x Region	0.97	2.53, 88.71	.401	.03
Face Valence x Hemisphere x Region x Neuroticism	1.83	1, 35	.185	.05
Emotion x Face Valence x Hemisphere x Region	1.66	3, 105	.180	.05
Word Valence x Face Valence x Hemisphere x Region	**4.80**	**1, 35**	**.035**	**.12**
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.94	1, 35	.129	.05
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.15	3, 105	.335	.03
Emotion x Word Valence x Hemisphere x Region x Neuroticism	2.20	2.53, 88.71	.104	.06
Emotion x Face Valence x Hemisphere x Region x Neuroticism	0.34	3, 105	.795	.01
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	1.21	1, 35	.278	.03
Emotion x Word Valence x Face Valence x Hemisphere x Region	1.71	2.21, 77.49	.184	.05
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	1.00	2.21, 77.49	.380	.03

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The main effect of Hemisphere was significant: the EPN component was more negative on the left (M = -3.69 μV, SE = 0.67) compared to the right (M = -2.70 μV, SE = 0.63) hemisphere.

A more negative EPN was found in parietal (M = -3.63 μV, SE = 0.61) than in parieto-occipital (M = -2.77 μV, SE = 0.64) sites, as indicated by the significant main effect of Region.

The interaction between Hemisphere and Region was significant and multiple comparisons showed a more negative EPN, in both hemispheres, in parietal (LH M = -4.27 μV, SE = 0.68; RH: M = -2.98 μV, SE = 0.62) than in parieto-occipital (LH: M = -3.11 μV, SE = 0.68, p < .001; RH: M = -2.42 μV, SE = 0.66, p = .003) regions. Additionally, the EPN component was more negative on the left than on the right hemisphere only in parietal sites (p = .006).

With the objective of exploring the significant interaction between Emotion, Face Valence and Word Valence, four new 2 (Face Valence) x 2 (Word Valence) repeated measures ANOVAs were conducted, one for each Emotion. In the disgust condition, the interaction between Word and Face Valence was significant, $F(1, 37) = 4.29$, p = .045,

$\eta_p^2 = .10$. As can be seen in Figure 25 and proved by the multiple comparisons, negative word valence assessment evoked a more negative EPN in congruent than in incongruent trials ($p = .005$). The same pattern of results was found in the sadness condition, but it did not reach statistical significance.

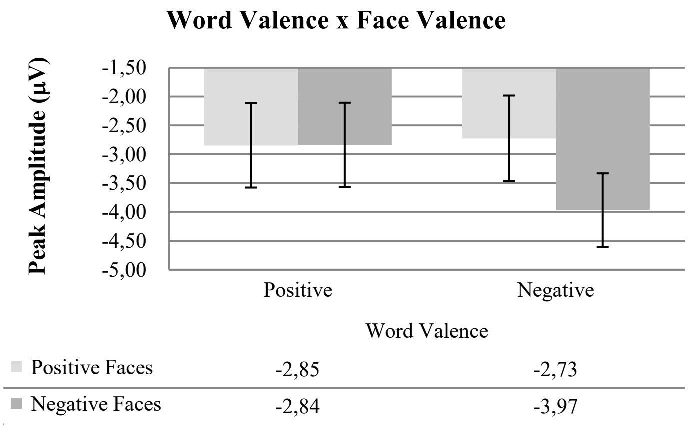


Figure 25: EPN peak amplitude, in Word Valence Assessment task, plotted by Word Valence and Face Valence conditions. Error bars represent standard errors.

Four new 2 (Hemisphere) x 2 (Face Valence) repeated measures ANOVAs (one for each Emotion) were conducted to explore the significant interaction between Emotion, Face Valence and Hemisphere. The main effect of Hemisphere was found in all emotional conditions except in sadness: fear – $F(1, 37) = 5.06$, $p = .030$, $\eta_p^2 = .12$; disgust – $F(1, 37) = 4.79$, $p = .035$, $\eta_p^2 = .12$; and anger – $F(1, 36) = 7.00$, $p = .016$, $\eta_p^2 = .16$. For all emotions, the EPN elicited on the left (fear: M = -3.85 µV, SE = 0.73; disgust: M = -3.58 µV, SE = 0.70 and anger: M = -3.23 µV, SE = 0.68) was more negative than on the right (fear: M = -2.86 µV, SE = 0.69; disgust: M = -2.63 µV, SE = 0.68 and anger: M = -2.27 µV, SE = 0.68) hemisphere. The interaction between Face Valence and Hemisphere was also significant, $F(1, 37) = 9.29$, $p = .004$, $\eta_p^2 = .20$, in the fear condition. Multiple comparisons showed a more negative EPN evoked by word valence assessment of stimuli with negative faces on the left (M = -4.24 µV, SE = 0.73) compared to the right (M = -2.98 µV, SE = 0.68, $p = .012$) hemisphere.

In order to explore the interaction between Word Valence, Face Valence, Hemisphere and Region, four new 2 (Word Valence) x 2 (Face Valence) repeated measures ANOVAs were conducted, one for each combination of Hemisphere and Region – left parietal, right parietal, left parieto-occipital and right parieto-occipital sites. A main effect of Face

Valence was found in left parietal sites, $F(1, 37) = 6.32$, $p = .016$, $\eta_p^2 = .15$: stimuli with negative faces elicited a more negative EPN (M = -4.55 µV, SE = 0.66) than stimuli with positive faces (M = -4.10 µV, SE = 0.66).

2.3.2. Peak Latency

2.3.2.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyze EPN peak latency evoked by Face Valence Assessment in parietal (P_5, P_6, P_7 and P_8) and parieto-occipital (PO_3, PO_4, PO_7 and PO_8) electrode sites are presented in Table 26.

Table 26: ANOVA results from the analysis of EPN peak latency elicited by Face Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	1.88	1, 31	.180	.06
Emotion	1.77	2.15, 66.69	.176	.05
Word Valence	1.85	1, 31	.183	.06
Face Valence	0.01	1, 31	.908	.00
Hemisphere	1.39	1, 31	.248	.04
Region	0.21	1, 31	.651	.01
Emotion x Neuroticism	0.58	2.15, 66.69	.578	.02
Word Valence x Neuroticism	1.10	1, 31	.302	.03
Face Valence x Neuroticism	0.57	1, 31	.458	.02
Hemisphere x Neuroticism	0.15	1, 31	.698	.01
Region x Neuroticism	0.70	1, 31	.408	.02
Emotion x Word Valence	1.45	3, 93	.232	.05
Emotion x Face Valence	0.20	3, 93	.896	.01
Word Valence x Face Valence	1.78	1, 31	.192	.05
Emotion x Hemisphere	1.59	3, 93	.198	.05
Word Valence x Hemisphere	1.61	1, 31	.214	.05
Face Valence x Hemisphere	0.23	1, 31	.634	.01
Emotion x Region	1.11	3, 93	.351	.03
Word Valence x Region	1.85	1, 31	.183	.06
Face Valence x Region	1.28	1, 31	.267	.04
Hemisphere x Region	0.01	1, 31	.944	.00
Emotion x Word Valence x Neuroticism	1.10	3, 93	.355	.03
Emotion x Face Valence x Neuroticism	0.73	3, 93	.534	.02

Word Valence x Face Valence x Neuroticism	0.04	1, 31	.854	.00
Emotion x Word Valence x Face Valence	0.89	3, 93	.450	.03
Emotion x Hemisphere x Neuroticism	0.97	3, 93	.412	.03
Word Valence x Hemisphere x Neuroticism	0.17	1, 31	.681	.01
Emotion x Word Valence x Hemisphere	1.73	3, 93	.166	.05
Face Valence x Hemisphere x Neuroticism	0.39	1, 31	.537	.01
Emotion x Face Valence x Hemisphere	1.46	3, 93	.230	.05
Word Valence x Face Valence x Hemisphere	1.08	1, 31	.306	.03
Emotion x Region x Neuroticism	1.56	3, 93	.203	.05
Word Valence x Region x Neuroticism	1.74	1, 31	.197	.05
Emotion x Word Valence x Region	0.22	3, 93	.885	.01
Face Valence x Region x Neuroticism	0.02	1, 31	.885	.00
Emotion x Face Valence x Region	0.53	2.30, 71.37	.614	.02
Word Valence x Face Valence x Region	0.67	1, 31	.421	.02
Hemisphere x Region x Neuroticism	1.74	1, 31	.197	.05
Emotion x Hemisphere x Region	0.16	3, 93	.920	.01
Word Valence x Hemisphere x Region	0.51	1, 31	.479	.02
Face Valence x Hemisphere x Region	0.59	1, 31	.447	.02
Emotion x Word Valence x Face Valence x Neuroticism	0.94	3, 93	.424	.03
Emotion x Word Valence x Hemisphere x Neuroticism	0.19	3, 93	.900	.01
Emotion x Face Valence x Hemisphere x Neuroticism	1.84	3, 93	.145	.06
Word Valence x Face Valence x Hemisphere x Neuroticism	0.00	1, 31	.954	.00
Emotion x Word Valence x Face Valence x Hemisphere	1.28	3, 93	.285	.04
Emotion x Word Valence x Region x Neuroticism	0.67	3, 93	.573	.02
Emotion x Face Valence x Region x Neuroticism	0.48	2.30, 71.37	.647	.02
Word Valence x Face Valence x Region x Neuroticism	0.73	1, 31	.399	.02
Emotion x Word Valence x Face Valence x Region	0.45	3, 93	.715	.01
Emotion x Hemisphere x Region x Neuroticism	0.35	3, 93	.788	.01
Word Valence x Hemisphere x Region x Neuroticism	0.47	1, 31	.497	.02
Emotion x Word Valence x Hemisphere x Region	2.63	3, 93	.055	.08
Face Valence x Hemisphere x Region x Neuroticism	0.00	1, 31	.960	.00
Emotion x Face Valence x Hemisphere x Region	1.23	3, 93	.304	.04
Word Valence x Face Valence x Hemisphere x Region	1.26	1, 31	.270	.04
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.44	3, 93	.236	.04
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.04	3, 93	.377	.03
Emotion x Word Valence x Hemisphere x Region x Neuroticism	1.51	3, 93	.217	.05
Emotion x Face Valence x Hemisphere x Region x Neuroticism	1.83	3, 93	.146	.06
Word Valence x Face Valence x Hemisphere x Region x	0.89	1, 31	.354	.03

Neuroticism				
Emotion x Word Valence x Face Valence x Hemisphere x Region	**2.99**	**3, 93**	**.035**	**.09**
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.72	3, 93	.543	.02

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The only significant effect found was the interaction between Emotion, Word Valence, Face Valence, Hemisphere and Region. In order to explore this interaction, four new 4 (Emotion) x 2 (Word Valence) x 2 (Face Valence) were conducted, one for each combination of Hemisphere and Region – left parietal, right parietal, left parieto-occipital and right parieto-occipital sites. No significant effects were found in left parietal electrode sites. On the other hand, in right parietal sites, the interaction between Face and Word Valence was significant, $F(1, 32) = 4.60$, $p = .040$, $\eta_p^2 = .13$ (see Figure 26). Happy face valence assessment in congruent trials elicited an earlier EPN than in incongruent trials ($p = .027$). Regarding the left parieto-occipital sites, the interaction between Emotion and Word Valence was significant, $F(3, 96) = 3.11$, $p = .030$, $\eta_p^2 = .09$. Multiple comparisons showed an earlier EPN elicited by face valence assessment of stimuli with positive words ($M = 276.11$ ms, $SE = 2.70$) compared to stimuli with negative words ($M = 282.40$ ms, $SE = 3.20$, $p = .020$), only in the sadness condition. In addition, stimuli with negative words belonging to the fear condition elicited an earlier EPN ($M = 272.33$ ms, $SE = 4.40$) than the same stimuli in the sadness condition ($p = .032$). At last, in right parieto-occipital sites, a main effect of Emotion was found, $F(1.93, 61.69) = 3.93$, $p = .042$, $\eta_p^2 = .10$, but no significant differences were found in post-hoc tests.

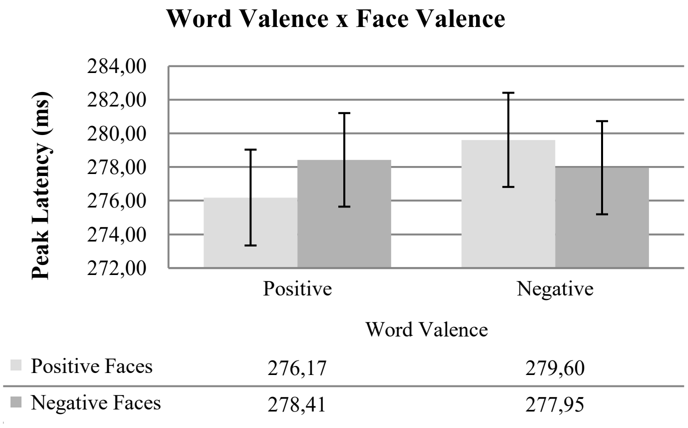


Figure 26: EPN peak latency, in Face Valence Assessment task, plotted by Word Valence and Face Valence conditions in right parietal sites. Error bars represent standard errors.

2.3.2.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse EPN peak latency in parietal and parieto-occipital sites elicited by Word Valence Assessment are presented in Table 27.

Table 27: ANOVA results from the analysis of EPN peak latency elicited by Word Valence Assessment task.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.24	1, 35	.628	.01
Emotion	2.53	2.02, 70.65	.086	.07
Word Valence	2.63	1, 35	.114	.07
Face Valence	2.27	1, 35	.141	.06
Hemisphere	**12.06**	**1, 35**	**.001**	**.26**
Region	0.96	1, 35	.334	.03
Emotion x Neuroticism	1.08	2.02, 70.65	.344	.03
Word Valence x Neuroticism	0.54	1, 35	.466	.02
Face Valence x Neuroticism	1.06	1, 35	.310	.03
Hemisphere x Neuroticism	0.54	1, 35	.466	.02
Region x Neuroticism	1.87	1, 35	.180	.05
Emotion x Word Valence	0.21	3, 105	.892	.01
Emotion x Face Valence	2.22	3, 105	.090	.06
Word Valence x Face Valence	3.30	1, 35	.078	.09
Emotion x Hemisphere	0.89	2.08, 72.72	.420	.03
Word Valence x Hemisphere	0.11	1, 35	.744	.00
Face Valence x Hemisphere	0.95	1, 35	.338	.03
Emotion x Region	0.45	2.28, 79.74	.666	.01
Word Valence x Region	1.26	1, 35	.269	.04
Face Valence x Region	0.26	1, 35	.613	.01
Hemisphere x Region	**10.97**	**1, 35**	**.002**	**.24**
Emotion x Word Valence x Neuroticism	2.13	3, 105	.101	.06
Emotion x Face Valence x Neuroticism	0.31	3, 105	.820	.01
Word Valence x Face Valence x Neuroticism	0.96	1, 35	.334	.03
Emotion x Word Valence x Face Valence	0.62	3, 105	.605	.02
Emotion x Hemisphere x Neuroticism	1.13	2.08, 72.72	.329	.03
Word Valence x Hemisphere x Neuroticism	0.02	1, 35	.884	.00
Emotion x Word Valence x Hemisphere	1.19	3, 105	.316	.03
Face Valence x Hemisphere x Neuroticism	0.02	1, 35	.881	.00
Emotion x Face Valence x Hemisphere	0.89	3, 105	.449	.03

Word Valence x Face Valence x Hemisphere	0.04	1, 35	.844	.00
Emotion x Region x Neuroticism	0.63	2.28, 79.74	.557	.02
Word Valence x Region x Neuroticism	0.08	1, 35	.778	.00
Emotion x Word Valence x Region	0.08	3, 105	.971	.00
Face Valence x Region x Neuroticism	0.08	1, 35	.780	.00
Emotion x Face Valence x Region	1.27	3, 105	.290	.04
Word Valence x Face Valence x Region	0.01	1, 35	.934	.00
Hemisphere x Region x Neuroticism	0.22	1, 35	.640	.01
Emotion x Hemisphere x Region	0.41	2.51, 87.83	.750	.01
Word Valence x Hemisphere x Region	0.08	1, 35	.781	.00
Face Valence x Hemisphere x Region	0.31	1, 35	.584	.01
Emotion x Word Valence x Face Valence x Neuroticism	1.75	3, 105	.162	.05
Emotion x Word Valence x Hemisphere x Neuroticism	0.38	3, 105	.766	.01
Emotion x Face Valence x Hemisphere x Neuroticism	2.25	3, 105	.087	.06
Word Valence x Face Valence x Hemisphere x Neuroticism	1.84	1, 35	.183	.05
Emotion x Word Valence x Face Valence x Hemisphere	0.05	3, 105	.986	.00
Emotion x Word Valence x Region x Neuroticism	0.25	3, 105	.861	.01
Emotion x Face Valence x Region x Neuroticism	1.93	3, 105	.129	.05
Word Valence x Face Valence x Region x Neuroticism	1.74	1, 35	.196	.05
Emotion x Word Valence x Face Valence x Region	1.19	2.41, 84.37	.313	.03
Emotion x Hemisphere x Region x Neuroticism	1.41	2.51, 87.83	.249	.04
Word Valence x Hemisphere x Region x Neuroticism	3.51	1, 35	.069	.09
Emotion x Word Valence x Hemisphere x Region	1.13	3, 105	.340	.03
Face Valence x Hemisphere x Region x Neuroticism	0.11	1, 35	.744	.00
Emotion x Face Valence x Hemisphere x Region	0.38	3, 105	.769	.01
Word Valence x Face Valence x Hemisphere x Region	0.14	1, 35	.716	.00
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.99	3, 105	.402	.03
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.18	2.41, 84.37	.317	.03
Emotion x Word Valence x Hemisphere x Region x Neuroticism	2.01	3, 105	.117	.05
Emotion x Face Valence x Hemisphere x Region x Neuroticism	1.33	3, 105	.270	.04
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.82	1, 35	.372	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region	0.75	3, 105	.527	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.73	3, 105	.539	.02

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The main effect of Hemisphere was significant: overall, an earlier EPN was found in the left (*M* = 271.71 ms, *SE* = 2.59) compared to the right (*M* = 276.35 ms, *SE* = 2.88) hemisphere.

The interaction between Hemisphere and Region was significant and pairwise comparisons revealed an earlier EPN in the left hemisphere for both site locations (Ps: *M* = 270.63 ms, *SE* = 2.42; POs: *M* = 272.79 ms, *SE* = 2.82) compared to the right hemisphere (Ps: *M* = 276.56 ms, *SE* = 2.84, p <.001; POs: *M* = 276.14 ms, *SE* = 3.01). Moreover, in the left hemisphere the EPN peaked earlier in parietal than in parieto-occipital sites (p = .033).

2.4. MEAN AMPLITUDES

This section is divided into two time windows: 367 – 567 ms and 771 – 867 ms that were chosen through the visual analysis of the grand averages (see Appendix). For both time windows, 2 (Neuroticism) x 4 (Emotion) x 2 (Word Valence) x 2 (Faces Valence) x 2 (Hemisphere) x 2 or 3 (Region) split-plot ANOVAs were conducted separately for Face and Word Valence Assessment.

2.4.1. 367 – 567 ms

In this time window, three brain locations were analysed: centro-parietal (the average of CP_1, CP_2, CP_3 and CP_4 electrode sites), parietal (the average of P_3, P_4, P_5 and P_6 electrode sites) and parieto-occipital (the average of PO_3, PO_4, PO_7 and PO_8 electrode sites).

2.4.1.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 3 split-plot ANOVA conducted to analyse mean amplitude in 367 – 567 ms time window evoked by Face Valence Assessment task are presented in Table 28.

Mean amplitudes in the left hemisphere were lower (*M* = 3.39 μV, *SE* = 0.52) than in the right hemisphere (*M* = 3.90 μV, *SE* = 0.55), as evidenced by the main effect of Hemisphere.

Table 28: ANOVA results from the analysis of mean amplitudes evoked by Face Valence Assessment task in the 367 – 567 ms time window.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	1.31	1, 31	.261	.04
Emotion	0.43	3, 93	.729	.01
Word Valence	1.19	1, 31	.283	.04
Face Valence	1.69	1, 31	.203	.05
Hemisphere	**14.33**	**1, 31**	**.001**	**.32**
Region	3.66	1.19, 36.81	.057	.11
Emotion x Neuroticism	0.15	3, 93	.931	.01
Word Valence x Neuroticism	0.29	1, 31	.596	.01
Face Valence x Neuroticism	2.23	1, 31	.145	.07
Hemisphere x Neuroticism	0.98	1, 31	.331	.03
Region x Neuroticism	0.38	1.19, 36.81	.577	.01
Emotion x Word Valence	0.89	3, 93	.449	.03
Emotion x Face Valence	2.68	3, 93	.052	.08
Word Valence x Face Valence	1.38	1, 31	.248	.04
Emotion x Hemisphere	0.98	3, 93	.406	.03
Word Valence x Hemisphere	0.07	1, 31	.800	.00
Face Valence x Hemisphere	2.49	1, 31	.125	.07
Emotion x Region	1.80	3.09, 95.90	.101	.06
Word Valence x Region	0.21	1.34, 41.57	.723	.01
Face Valence x Region	3.82	1.19, 36.87	.052	.11
Hemisphere x Region	**26.02**	**2, 62**	**< .001**	**.46**
Emotion x Word Valence x Neuroticism	**3.63**	**3, 93**	**.022**	**.10**
Emotion x Face Valence x Neuroticism	0.14	3, 93	.936	.01
Word Valence x Face Valence x Neuroticism	0.12	1, 31	.728	.00
Emotion x Word Valence x Face Valence	0.39	3, 93	.760	.01
Emotion x Hemisphere x Neuroticism	1.80	3, 93	.154	.06
Word Valence x Hemisphere x Neuroticism	0.14	1, 31	.708	.01
Emotion x Word Valence x Hemisphere	0.43	2.23, 69.02	.672	.01
Face Valence x Hemisphere x Neuroticism	0.08	1, 31	.776	.00
Emotion x Face Valence x Hemisphere	0.74	3, 93	.529	.02
Word Valence x Face Valence x Hemisphere	0.33	1, 31	.571	.01
Emotion x Region x Neuroticism	1.26	3.09, 95.90	.292	.04
Word Valence x Region x Neuroticism	0.40	1.34, 41.57	.592	.01
Emotion x Word Valence x Region	0.86	3.56, 110.42	.480	.03
Face Valence x Region x Neuroticism	1.58	1.19, 36.87	.219	.05
Emotion x Face Valence x Region	1.42	3.50, 108.55	.235	.04

Word Valence x Face Valence x Region	0.42	1.41, 43.67	.587	.01
Hemisphere x Region x Neuroticism	1.64	2, 62	.203	.05
Emotion x Hemisphere x Region	1.19	3.60, 111.57	.321	.04
Word Valence x Hemisphere x Region	0.42	1.64, 50.96	.617	.01
Face Valence x Hemisphere x Region	0.27	2, 62	.767	.01
Emotion x Word Valence x Face Valence x Neuroticism	0.52	3, 93	.668	.02
Emotion x Word Valence x Hemisphere x Neuroticism	0.93	2.23, 69.02	.410	.03
Emotion x Face Valence x Hemisphere x Neuroticism	**5.08**	**3, 93**	**.003**	**.14**
Word Valence x Face Valence x Hemisphere x Neuroticism	0.44	1, 31	.510	.01
Emotion x Word Valence x Face Valence x Hemisphere	1.06	2.26, 69.91	.359	.03
Emotion x Word Valence x Region x Neuroticism	0.22	3.56, 110.42	.908	.01
Emotion x Face Valence x Region x Neuroticism	0.46	3.50, 108.55	.740	.02
Word Valence x Face Valence x Region x Neuroticism	**4.32**	**1.41, 43.67**	**.031**	**.12**
Emotion x Word Valence x Face Valence x Region	0.44	3.77, 116.93	.767	.01
Emotion x Hemisphere x Region x Neuroticism	0.63	3.60, 111.57	.623	.02
Word Valence x Hemisphere x Region x Neuroticism	1.53	1.64, 50.96	.227	.05
Emotion x Word Valence x Hemisphere x Region	**2.59**	**3.46, 107.16**	**.049**	**.08**
Face Valence x Hemisphere x Region x Neuroticism	0.96	2, 62	.389	.03
Emotion x Face Valence x Hemisphere x Region	1.79	3.51, 108.94	.145	.05
Word Valence x Face Valence x Hemisphere x Region	0.20	2, 62	.820	.01
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.17	2.26, 69.91	.866	.01
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.16	3.77, 116.93	.334	.04
Emotion x Word Valence x Hemisphere x Region x Neuroticism	1.16	3.46, 107.16	.332	.04
Emotion x Face Valence x Hemisphere x Region x Neuroticism	1.24	3.51, 108.94	.297	.04
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.52	2, 62	.597	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region	1.51	3.36, 104.04	.214	.05
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.44	3.36, 104.04	.746	.01

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The interaction between Emotion and Face Valence was marginally significant. The only emotional condition with significant results was disgust: multiple comparisons showed lower mean amplitudes elicited by disgusted (M = 3.20 µV, SE = 0.62) compared to happy (M = 4.13 µV, SE = 0.57, p = .003) faces.

The interaction between Hemisphere and Region was significant (see Figure 27). Multiple comparisons revealed higher amplitudes in the right compared to the left hemisphere in centro-parietal sites ($p < .001$). Regarding the left hemisphere, mean amplitudes in parietal sites were higher than in centro-parietal sites ($p = .002$). In the right hemisphere, mean amplitudes elicited by face valence assessment were lower in parieto-occipital sites compared to centro-parietal ($p = .040$) and parietal sites ($p = .001$).

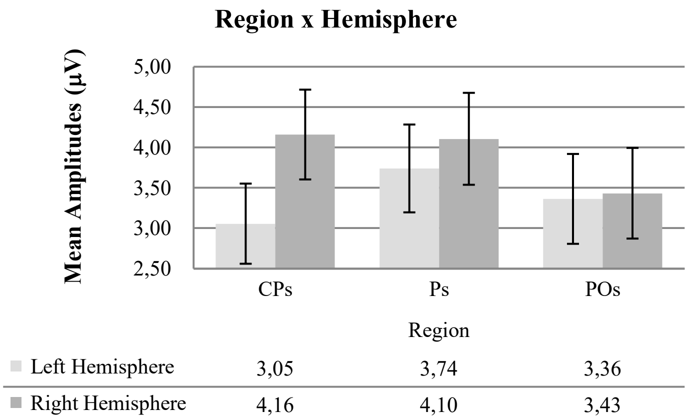


Figure 27: Mean amplitudes (367 – 567 ms time window), in Face Valence Assessment task, plotted by Region and Hemisphere conditions.Error bars represent standard errors.

To explore the significant interaction between Emotion, Word Valence and Neuroticism, two more 4 (Emotion) x 2 (Word Valence) repeated measures ANOVAs were conducted separately for high and low neuroticism groups. The interaction between Emotion and Word Valence was significant, $F(3, 42) = 3.28$, $p = .030$, $\eta_p^2 = .19$, only for high neuroticism participants. Stimuli with negative words elicited higher mean amplitudes ($M = 4.83$ μV, $SE = 0.80$) than stimuli with positive words ($M = 4.00$ μV, $SE = 0.80$, $p = .008$), only in the sadness condition.

Several analyses were conducted in order to explore the significant interaction between Word Valence, Face Valence, Region and Neuroticism. However, no significant effects were found.

The interaction between Emotion, Face Valence, Hemisphere and Neuroticism was significant. To explore this interaction, four new 2 (Face Valence) x 2 (Hemisphere) x 2 (Neuroticism) were conducted, one for each Emotion. All emotional conditions showed the main effect of Hemisphere – fear: $F(1.33) = 8.73$, $p = .006$, $\eta_p^2 = .21$; disgust: $F(1, 33) = 12.75$, $p = .001$, $\eta_p^2 = .28$; anger: $F(1, 31) = 9.71$, $p = .004$, $\eta_p^2 = .24$ and sadness: $F(1, 33) = 14.22$, $p = .001$, $\eta_p^2 = .30$. For all emotional conditions mean amplitudes on the left hemisphere were lower (fear: $M = 3.11$ µV, $SE = 0.43$; disgust: $M = 3.39$ µV, $SE = 0.54$; anger: $M = 3.61$ µV, $SE = 0.69$; and sadness: $M = 3.37$ µV, $SE = 0.50$) than on the right hemisphere (fear: $M = 3.61$ µV, $SE = 0.49$; disgust: $M = 3.86$ µV, $SE = 0.56$; anger: $M = 4.05$ µV, $SE = 0.72$; and sadness: $M = 3.91$ µV, $SE = 0.55$). In fear and anger conditions no significant effects were found. In the disgust condition, a main effect of Face Valence was found, $F(1, 33) = 8.25$, $p = .007$, $\eta_p^2 = .20$: the evaluation of happy faces elicited lower mean amplitudes ($M = 3.21$ µV, $SE = 0.59$) than the evaluation of disgusted faces ($M = 4.04$ µV, $SE = 0.54$). On the other hand, in the sadness condition, the interaction between Hemisphere and Neuroticism was significant, $F(1, 33) = 4.20$, $p = .048$, $\eta_p^2 = .11$. Participants with high neuroticism ratings revealed lower mean amplitudes on the left ($M = 3.92$ µV, $SE = 0.67$) compared to the right ($M = 4.75$ µV, $SE = 0.74$) hemisphere ($p < .001$). Still in the sadness condition, the interaction between Face Valence, Hemisphere and Neuroticism was significant, $F(1, 33) = 6.21$, $p = .018$, $\eta_p^2 = .16$. In order to explore this interaction, several analyses were conducted but none of them showed significant results.

Aiming to explore the significant interaction between Emotion, Word Valence, Hemisphere and Region, six new 4 (Emotion) x 2 (Word Valence) repeated measures ANOVAs were conducted, one for each combination of Hemisphere and Region (left centro-parietal, right centro-parietal, left parietal, right parietal, left parieto-occipital and right parieto-occipital sites). The interaction between Emotion and Word Valence was significant only in right centro-parietal sites, $F(3, 96) = 5.62$, $p = .001$, $\eta_p^2 = .15$. Higher mean amplitudes were found in the disgust condition elicited by stimuli with positive ($M = 4.28$ µV, $SE = 0.62$) compared to stimuli with negative ($M = 3.18$ µV, $SE = 0.60$, $p = .003$) words.

2.4.1.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 3 split-plot ANOVA conducted to analyse mean amplitude in the 367 – 467 ms time window in centro-parietal, parietal and parieto-occipital regions evoked by Word Valence Assessment task are presented in Table 29.

Table 29: ANOVA results from the analysis of mean amplitudes evoked by the Word Valence Assessment task in the 367 – 567 ms time window.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.68	1, 35	.416	.02
Emotion	0.42	3, 105	.742	.01
Word Valence	**8.68**	**1, 35**	**.006**	**.20**
Face Valence	**8.88**	**1, 35**	**.005**	**.20**
Hemisphere	**4.25**	**1, 35**	**.047**	**.11**
Region	**14.82**	**1.11, 38.90**	**< .001**	**.30**
Emotion x Neuroticism	0.76	3, 105	.518	.02
Word Valence x Neuroticism	**10.18**	**1, 35**	**.003**	**.23**
Face Valence x Neuroticism	0.05	1, 35	.833	.00
Hemisphere x Neuroticism	0.99	1, 35	.327	.03
Region x Neuroticism	0.09	1.11, 38.90	.787	.00
Emotion x Word Valence	1.11	3, 105	.348	.03
Emotion x Face Valence	0.18	3, 105	.908	.01
Word Valence x Face Valence	**5.03**	**1, 35**	**.031**	**.13**
Emotion x Hemisphere	1.47	3, 105	.226	.04
Word Valence x Hemisphere	1.29	1, 35	.264	.04
Face Valence x Hemisphere	0.45	1, 35	.508	.01
Emotion x Region	0.76	3.64, 127.54	.544	.02
Word Valence x Region	**5.00**	**1.42, 49.79**	**.019**	**.13**
Face Valence x Region	**8.97**	**1.39, 48.56**	**.002**	**.20**
Hemisphere x Region	0.53	1.52, 53.26	.542	.02
Emotion x Word Valence x Neuroticism	1.25	3, 105	.297	.03
Emotion x Face Valence x Neuroticism	0.63	3, 105	.596	.02
Word Valence x Face Valence x Neuroticism	0.00	1, 35	.967	.00
Emotion x Word Valence x Face Valence	0.30	3, 105	.829	.01
Emotion x Hemisphere x Neuroticism	1.50	3, 105	.220	.04
Word Valence x Hemisphere x Neuroticism	1.44	1, 35	.238	.04
Emotion x Word Valence x Hemisphere	0.34	1.95, 68.22	.708	.01
Face Valence x Hemisphere x Neuroticism	0.04	1, 35	.840	.00
Emotion x Face Valence x Hemisphere	0.74	3, 105	.528	.02
Word Valence x Face Valence x Hemisphere	0.55	1, 35	.463	.02
Emotion x Region x Neuroticism	0.82	3.64, 127.54	.503	.02
Word Valence x Region x Neuroticism	**3.89**	**1.42, 49.79**	**.040**	**.10**
Emotion x Word Valence x Region	1.56	3.08, 107.79	.202	.04
Face Valence x Region x Neuroticism	1.25	1.39, 48.56	.283	.04
Emotion x Face Valence x Region	**3.91**	**3.87, 135.42**	**.005**	**.10**

Word Valence x Face Valence x Region	2.51	2, 70	.088	.07
Hemisphere x Region x Neuroticism	0.71	1.52, 53.26	.459	.02
Emotion x Hemisphere x Region	1.56	6, 210	.160	.04
Word Valence x Hemisphere x Region	2.45	1.65, 57.60	.105	.07
Face Valence x Hemisphere x Region	0.86	1.68, 58.66	.412	.02
Emotion x Word Valence x Face Valence x Neuroticism	1.18	3, 105	.323	.03
Emotion x Word Valence x Hemisphere x Neuroticism	1.18	1.95, 68.22	.312	.03
Emotion x Face Valence x Hemisphere x Neuroticism	1.02	3, 105	.386	.03
Word Valence x Face Valence x Hemisphere x Neuroticism	0.00	1, 35	.989	.00
Emotion x Word Valence x Face Valence x Hemisphere	0.99	3, 105	.402	.03
Emotion x Word Valence x Region x Neuroticism	0.30	3.08, 107.79	.834	.01
Emotion x Face Valence x Region x Neuroticism	0.07	3.87, 135.42	.990	.00
Word Valence x Face Valence x Region x Neuroticism	0.74	2, 70	.483	.02
Emotion x Word Valence x Face Valence x Region	0.71	3.50, 122.39	.569	.02
Emotion x Hemisphere x Region x Neuroticism	0.72	6, 210	.637	.02
Word Valence x Hemisphere x Region x Neuroticism	0.81	1.65, 57.60	.428	.02
Emotion x Word Valence x Hemisphere x Region	1.06	1.86, 65.17	.348	.03
Face Valence x Hemisphere x Region x Neuroticism	1.64	1.68, 58.66	.206	.05
Emotion x Face Valence x Hemisphere x Region	1.23	3.92, 137.14	.301	.03
Word Valence x Face Valence x Hemisphere x Region	2.50	1.71, 59.91	.099	.06
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	1.32	3, 105	.273	.04
Emotion x Word Valence x Face Valence x Region x Neuroticism	0.47	3.50, 122.39	.734	.01
Emotion x Word Valence x Hemisphere x Region x Neuroticism	0.91	1.86, 65.17	.400	.03
Emotion x Face Valence x Hemisphere x Region x Neuroticism	2.42	3.92, 137.14	.052	.06
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	2.57	1.71, 59.91	.093	.07
Emotion x Word Valence x Face Valence x Hemisphere x Region	1.74	3.03, 106.07	.164	.05
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.67	3.03, 106.07	.575	.02

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The main effect of word Valence was significant: the evaluation of positive words elicited higher mean amplitudes (M = 0.05 μV, SE = 0.32) than the evaluation of negative words (M = -0.31 μV, SE = 0.31).

Stimuli with positive faces elicited lower mean amplitudes (M = -0.32 μV, SE = 0.30) than stimuli with negative faces (M = 0.05 μV, SE = 0.32) as evidenced by the main effect of Face Valence.

Higher mean amplitudes were found in the right (*M* = -0.01 µV, *SE* = 0.29) compared to the left (*M* = -0.25 µV, *SE* = 0.33) hemisphere as evidenced by the main effect of Hemisphere.

The main effect of Region was also significant and post-hoc tests proved higher amplitudes in centro-parietal (*M* = 0.30 µV, *SE* = 0.34) than in parietal (*M* = -0.11 µV, *SE* = 0.32, *p* = .023) and parieto-occipital (*M* = -0.58 µV, *SE* = 0.31, *p* = .001) sites. The difference between the last two was also significant (*p* < .001).

A significant interaction between Word Valence and Neuroticism was found and multiple comparisons showed higher mean amplitudes in response to positive (*M* = -0.01 µV, *SE* = 0.45) than negative (*M* = -0.76 µV, *SE* = 0.43, *p* < .001) words, only in low neuroticism participants.

The interaction between Word Valence and Face Valence was significant (see Figure 28) and parwise comparisons showed that negative word valence assessment elicited lower mean amplitudes in incongruent than in congruent stimuli (*p* = .001). Additionally, when participants were presented with stimuli with happy faces, positive word valence assessment evoked higher amplitudes than negative word valence assessment (*p* = .001).

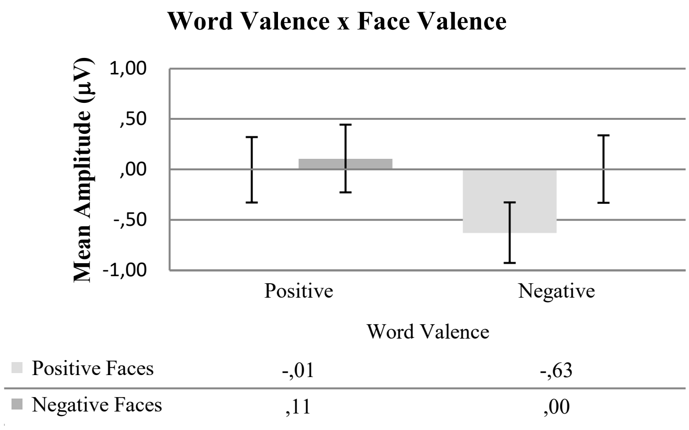


Figure 28: Mean amplitudes (367 – 567 ms time window), in Word Valence Assessment task, plotted by Word Valence and Face Valence conditions. Error bars represent standard errors.

The interaction between Face Valence and Region was significant (see Figure 29) and multiple comparisons showed that stimuli with negative faces elicited higher mean amplitudes than stimuli with positive faces in all regions (CPs: *p* = .026; Ps: *p* = .005; and POs: *p* = .002). Stimuli with positive faces evoked higher mean amplitudes in centro-parietal than in parietal (*p* = .010) and parieto-occipital (*p* < .001) sites. The difference between Ps and POs was also significant ($p < .001$). The same pattern of results was found for stimuli with negative faces: lower amplitudes in parieto-occipital than in parietal ($p < .001$) and centro-parietal ($p = .003$) sites.

The interaction between Word Valence and Region was also significant. Multiple comparisons revealed the main effect of Region both in positive and in negative word valence assessment (see Figure 30): positive and negative words elicited higher mean amplitudes in centro-parietal than in parietal ($p = .019$ and $p = .032$, respectively) and parieto-occipital ($p = .001$ and $p = .002$, respectively) sites and the difference between the last two regions was also significant (all $p_s < .001$). For all regions, higher amplitudes were found for positive than for negative word valence assessment (CPs: $p = .002$; Ps: $p = .005$; and POs: $p = .022$).

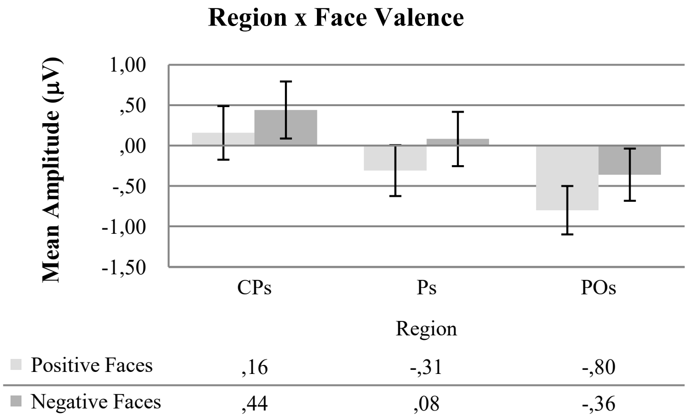


Figure 29: Mean amplitudes (367 – 567 ms time window), in Word Valence Assessment task, plotted by Region and Face Valence conditions. Error bars represent standard errors.

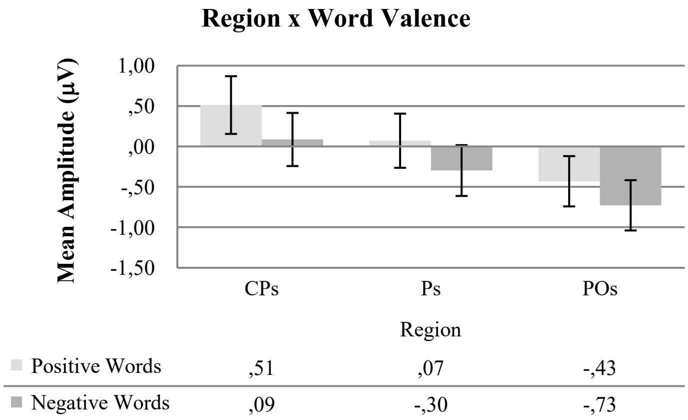
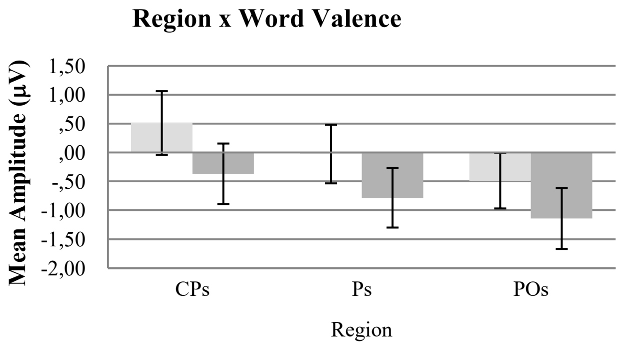


Figure 30: Mean amplitudes (367 – 567 ms time window), in Word Valence Assessment task, plotted by Region and Word Valence conditions. Error bars represent standard errors.

In order to explore the significant interaction between Word Valence, Region and Neuroticism, two 2 (Word Valence) x 3 (Region) repeated measures ANOVAs were conducted for high and low neuroticism separately. High and low neuroticism participants revealed a main effect of Region, $F(1.18, 21.15) = 11.12$, $p = .002$, $\eta_p^2 = .38$ and $F(1.08, 19.42) = 6.36$, $p = .019$, $\eta_p^2 = .26$, respectively. Multiple comparisons showed lower mean amplitudes in parieto-occipital ($M =$ -0.38 µV, $SE = 0.32$) than in centro-parietal ($M = 0.15$ µV, $SE = 0.36$, $p = .008$) and parietal ($M = 0.54$ µV, $SE = 0.38$, $p = .001$) sites, in high neuroticism participants. Regarding low neuroticism participants, mean amplitudes were lower in parieto-occipital ($M = -0.82$ µV, $SE = 0.50$) than in parietal ($M =$ -0.41 µV, $SE = 0.51$, $p = .022$) sites. Still in the group of low neuroticism participants, a main effect of Word Valence was also found, $F(1, 18) = 25.78$, $p < .001$, $\eta_p^2 = .59$: the evaluation of positive words elicited higher mean amplitudes ($M = -0.00$ µV, $SE = 0.49$) than the evaluation of negative words ($M =$ -0.77 µV, $SE = 0.50$). Moreover, the interaction between Word Valence and Region was significant too, $F(1.50, 26.99) = 9.62$, $p = .002$, $\eta_p^2 = .35$ (see Figure 31). The results were similar to those found in the interaction described above: for all regions, positive words elicited higher mean amplitudes than negative words (CPs: $p < .001$; Ps: $p < .001$; and POs: $p = .001$). In positive word valence assessment, lower amplitudes were found in parieto-occipital compared to centro-parietal ($p = .014$) and parietal ($p = .032$) sites. In negative word valence judgments, lower amplitudes were found in parieto-occipital than in parietal sites ($p = .043$).



	CPs	Ps	POs
Positive Words	,51	-,03	-,49
Negative Words	-,37	-,79	-1,14

Figure 31: Mean amplitudes (367 – 567 ms time window), in Word Valence Assessment task, for low neuroticism participants, plotted by Region and Word Valence conditions. Error bars represent standard errors.

With the objective of exploring the interaction between Emotion, Face Valence and Region, four new 2 (Face Valence) x 3 (Region) repeated measures ANOVAs were conducted, one for each Emotion. For all emotional conditions, a main effect of Region was found – fear: $F(1.11, 41.21) = 18.75$, $p < .001$, $\eta_p^2 = .34$; disgust: $F(1.15, 42.62) = 15.58$, $p < .001$, $\eta_p^2 = .30$; anger: $F(1.12, 40.44) = 14.97$, $p < .001$, $\eta_p^2 = .29$; and sadness: $F(1.18, 43.66) = 16.78$, $p < .001$, $\eta_p^2 = 0.31$. These effects were not reported because they follow the same pattern as in previous analysis. The interaction between Face Valence and Region was also significant in all emotional conditions except in disgust: fear – $F(1.45, 54.18) = 7.77$, $p = .003$, $\eta_p^2 = .17$; anger – $F(1.38, 49.67) = 8.79$, $p = .002$, $\eta_p^2 = .11$; and sadness – $F(1.12, 41.25) = 4.38$, $p = .039$, $\eta_p^2 = .11$). The results found in the interaction were similar to the ones found in the separate main effects of Face Valence and Region, therefore they were not reported. In the fear condition, the main effect of Face Valence was significant, $F(1, 37) = 5.94$, $p = .020$, $\eta_p^2 = .14$. Stimuli with positive faces elicited lower mean amplitudes (M = -0.41 μV, SE = 0.33) than stimuli with negative faces (M = 0.07 μV, SE = 0.37).

2.4.2. 717 – 867 ms

In this time window, two brain regions were analysed: parietal (the average of P_3, P_4, P_5 and P_6 electrode sites) and parieto-occipital (the average of PO_3, PO_4, PO_7 and PO_8 electrode sites).

2.4.2.1. Face Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse mean amplitude in the 717 – 867 ms time window evoked by the Face Valence Assessment task are presented in Table 30.

Table 30: ANOVA results from the analysis of mean amplitude evoked by Face Valence Assessment task in the 717 – 867 ms time window.

Effect	F	d. f. [a]	p	η_p^2
Neuroticism	1.91	1, 31	.177	.06
Emotion	0.43	3, 93	.730	.01
Word Valence	0.00	1, 31	.984	.00

Face Valence	3.64	1, 31	.066	.11
Hemisphere	1.79	1, 31	.191	.06
Region	**10.23**	**1, 31**	**.003**	**.25**
Emotion x Neuroticism	0.23	3, 93	.877	.01
Word Valence x Neuroticism	0.33	1, 31	.572	.01
Face Valence x Neuroticism	0.56	1, 31	.458	.02
Hemisphere x Neuroticism	1.95	1, 31	.173	.06
Region x Neuroticism	0.05	1, 31	.821	.00
Emotion x Word Valence	1.84	3, 93	.145	.06
Emotion x Face Valence	2.09	2.15, 66.50	.128	.06
Word Valence x Face Valence	0.88	1, 31	.355	.03
Emotion x Hemisphere	0.15	3, 93	.929	.01
Word Valence x Hemisphere	3.67	1, 31	.065	.11
Face Valence x Hemisphere	3.59	1, 31	.067	.10
Emotion x Region	1.76	1.99, 61.57	.181	.05
Word Valence x Region	0.00	1, 31	.963	.00
Face Valence x Region	3.25	1, 31	.081	.10
Hemisphere x Region	1.45	1, 31	.238	.05
Emotion x Word Valence x Neuroticism	**5.04**	**3, 93**	**.003**	**.14**
Emotion x Face Valence x Neuroticism	0.83	2.15, 66.50	.448	.03
Word Valence x Face Valence x Neuroticism	0.02	1, 31	.891	.00
Emotion x Word Valence x Face Valence	0.33	3, 93	.802	.01
Emotion x Hemisphere x Neuroticism	0.95	3, 93	.423	.03
Word Valence x Hemisphere x Neuroticism	0.62	1, 31	.437	.02
Emotion x Word Valence x Hemisphere	1.69	3, 93	.174	.05
Face Valence x Hemisphere x Neuroticism	0.97	1, 31	.333	.03
Emotion x Face Valence x Hemisphere	1.80	3, 93	.153	.06
Word Valence x Face Valence x Hemisphere	0.04	1, 31	.846	.00
Emotion x Region x Neuroticism	1.35	1.99, 61.57	.268	.04
Word Valence x Region x Neuroticism	0.13	1, 31	.720	.00
Emotion x Word Valence x Region	0.33	2.13, 65.88	.732	.01
Face Valence x Region x Neuroticism	0.27	1, 31	.607	.01
Emotion x Face Valence x Region	**4.71**	**3, 93**	**.004**	**.13**
Word Valence x Face Valence x Region	0.00	1, 31	.948	.00
Hemisphere x Region x Neuroticism	0.40	1, 31	.534	.01
Emotion x Hemisphere x Region	0.87	1.72, 53.41	.412	.03
Word Valence x Hemisphere x Region	2.17	1, 31	.151	.07
Face Valence x Hemisphere x Region	0.23	1, 31	.632	.01
Emotion x Word Valence x Face Valence x Neuroticism	0.61	3, 93	.613	.02

Emotion x Word Valence x Hemisphere x Neuroticism	0.65	3, 93	.588	.02
Emotion x Face Valence x Hemisphere x Neuroticism	2.64	3, 93	.054	.08
Word Valence x Face Valence x Hemisphere x Neuroticism	2.14	1, 31	.154	.06
Emotion x Word Valence x Face Valence x Hemisphere	0.18	3, 93	.909	.01
Emotion x Word Valence x Region x Neuroticism	0.05	2.13, 65.88	.957	.00
Emotion x Face Valence x Region x Neuroticism	2.26	3, 93	.087	.07
Word Valence x Face Valence x Region x Neuroticism	1.75	1, 31	.196	.05
Emotion x Word Valence x Face Valence x Region	0.45	3, 93	.719	.01
Emotion x Hemisphere x Region x Neuroticism	0.35	1.72, 53.41	.674	.01
Word Valence x Hemisphere x Region x Neuroticism	0.69	1, 31	.413	.02
Emotion x Word Valence x Hemisphere x Region	1.53	3, 93	.212	.05
Face Valence x Hemisphere x Region x Neuroticism	0.47	1, 31	.498	.02
Emotion x Face Valence x Hemisphere x Region	0.36	3, 93	.784	.01
Word Valence x Face Valence x Hemisphere x Region	0.48	1, 31	.495	.02
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	0.68	3, 93	.568	.02
Emotion x Word Valence x Face Valence x Region x Neuroticism	1.50	3, 93	.219	.05
Emotion x Word Valence x Hemisphere x Region x Neuroticism	0.56	3, 93	.642	.02
Emotion x Face Valence x Hemisphere x Region x Neuroticism	0.69	3, 93	.562	.02
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.72	1, 31	.403	.02
Emotion x Word Valence x Face Valence x Hemisphere x Region	1.07	2.11, 65.30	.351	.03
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	1.54	2.11, 65.30	.221	.05

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

The main effect of Face Valence was marginally significant and showed a tendency for lower mean amplitudes in negative (M = -3.60 μV, SE = 0.58) compared to positive (M = -3.23 μV, SE = 0.63) face valence assessment.

The main effect of Region was significant: mean amplitudes in parietal (*M* = -3.66 μV, *SE* = 0.58) were lower than in parieto-occipital (*M* = -3.17 μV, *SE* = 0.62) sites.

Aiming to explore the significant interaction between Emotion, Word Valence and Neuroticism, four new 2 (Word Valence) x 2 (Neuroticism) split-plot ANOVAs were conducted, one for each Emotion. Fear and disgust conditions did not reveal any significant effects. In the anger condition, the interaction between Word Valence and Neuroticism was significant, $F(1, 31) = 4.33$, $p = .046$, $\eta_p^2 = .12$. Multiple comparisons showed lower amplitudes evoked by stimuli with negative words (*M* = -3.40 μV, *SE* = 1.17) compared to stimuli with positive words (*M* = -2.68 μV, *SE* = 1.04, *p* = .033), only for high neuroticism participants. Similarly, in sadness block, the same interaction was also significant, $F(1, 33) = 8.82$, $p = .006$, $\eta_p^2 = .21$. Pairwise comparisons showed lower mean amplitudes evoked by stimuli with negative (*M* = -4.59 μV, *SE* = 0.79) compared to positive (*M* = -3.77 μV, *SE* = 0.79, *p* = .004) words, only in participants with high neuroticism ratings.

In order to explore the significant interaction between Emotion, Face Valence and Region, four new 2 (Face Valence) x 3 (Region) repeated measures ANOVAs were conducted, one for each Emotion. The main effect of Region was significant for all emotional conditions – fear: $F(1, 34) = 8.73$, $p = .006$, $\eta_p^2 = .20$; disgust: $F(1, 34) = 16.50$, $p < .001$, $\eta_p^2 = .33$; anger: $F(1, 32) = 9.16$, $p = .005$, $\eta_p^2 = .22$; and sadness: $F(1, 34) = 7.94$, $p = .008$, $\eta_p^2 = .19$. For all emotional blocks, mean amplitudes in parietal (fear: *M* = -3.64 μV, *SE* = 0.52; disgust: *M* = -3.68 μV, *SE* = 0.60; anger: *M* = -3.99 μV, *SE* = 0.71; sadness: *M* = -3.59 μV, *SE* = 0.57) were lower than in parieto-occipital (*M* = -3.23 μV, *SE* = 0.55; disgust: *M* = -3.11 μV, *SE* = 0.62; anger: *M* = -3.48 μV, *SE* = 0.77; sadness: *M* = -3.14 μV, *SE* = 0.61) sites. In the fear condition, the interaction between Face Valence and Region was significant, $F(1, 34) = 10.18$, $p = .003$, $\eta_p^2 = .23$. Multiple comparisons showed lower mean amplitudes in parietal than in parieto-occipital sites for stimuli with positive (Ps: *M* = -3.56 μV, *SE* = 0.61; POs: *M* = -3.05 μV, *SE* = 0.63) and negative (Ps: *M* = -3.73 μV, *SE* = 0.51, *p* = .001; POs: *M* = -3.40 μV, *SE* = 0.55, *p* = .041) faces. In the disgust condition, a main effect of Face Valence was observed, $F(1, 34) = 16.89$, $p < .001$, $\eta_p^2 = .33$. The valence judgment of disgusted faces elicited lower mean amplitudes (*M* = -3.84 μV, *SE* = 0.59) than the valence judgment of happy faces (*M* = -2.95 μV, *SE* = 0.64).

2.4.2.2. Word Valence Assessment

The results from the 2 x 4 x 2 x 2 x 2 x 2 split-plot ANOVA conducted to analyse mean amplitude in the 717 – 867 ms time window evoked by the Word Valence Assessment task are presented in Table 31.

The main effect of Word Valence was significant: more negative mean amplitudes were evoked by positive (*M* = -0.76 μV, *SE* = 0.32) compared to negative (*M* = -0.38 μV, *SE* = 0.32) word valence assessment.

Table 31: ANOVA results from the analysis of mean amplitude evoked by Word Valence Assessment task in the 717 – 867 ms time window.

Effect	F	d. f. [a]	*p*	η_p^2
Neuroticism	0.10	1, 35	.760	.00
Emotion	0.66	3, 105	.577	.02
Word Valence	**7.02**	**1, 35**	**.012**	**.17**
Face Valence	0.35	1, 35	.559	.01
Hemisphere	1.53	1, 35	.224	.04
Region	**42.59**	**1, 35**	**< .001**	**.55**
Emotion x Neuroticism	0.47	3, 105	.704	.01
Word Valence x Neuroticism	0.22	1, 35	.646	.01
Face Valence x Neuroticism	0.32	1, 35	.577	.01
Hemisphere x Neuroticism	2.80	1, 35	.103	.07
Region x Neuroticism	0.49	1, 35	.490	.01
Emotion x Word Valence	1.08	3, 105	.360	.03
Emotion x Face Valence	1.06	3, 105	.368	.03
Word Valence x Face Valence	**9.49**	**1, 35**	**.004**	**.21**
Emotion x Hemisphere	1.94	3, 105	.128	.05
Word Valence x Hemisphere	0.04	1, 35	.845	.00
Face Valence x Hemisphere	1.39	1, 35	.246	.04
Emotion x Region	0.60	3, 105	.618	.02
Word Valence x Region	0.83	1, 35	.368	.02
Face Valence x Region	**4.37**	**1, 35**	**.044**	**.11**
Hemisphere x Region	0.36	1, 35	.551	.01
Emotion x Word Valence x Neuroticism	0.88	3, 105	.454	.03
Emotion x Face Valence x Neuroticism	0.84	3, 105	.478	.02
Word Valence x Face Valence x Neuroticism	0.59	1, 35	.446	.02
Emotion x Word Valence x Face Valence	0.38	3, 105	.768	.01
Emotion x Hemisphere x Neuroticism	1.15	3, 105	.331	.03
Word Valence x Hemisphere x Neuroticism	0.95	1, 35	.335	.03
Emotion x Word Valence x Hemisphere	1.31	1.63, 57.16	.275	.04
Face Valence x Hemisphere x Neuroticism	0.15	1, 35	.700	.00
Emotion x Face Valence x Hemisphere	1.84	2.46, 86.25	.156	.05
Word Valence x Face Valence x Hemisphere	0.31	1, 35	.583	.01
Emotion x Region x Neuroticism	0.54	3, 105	.659	.02
Word Valence x Region x Neuroticism	**4.87**	**1, 35**	**.034**	**.12**
Emotion x Word Valence x Region	0.95	1.97, 68.87	.392	.03
Face Valence x Region x Neuroticism	0.08	1, 35	.781	.00
Emotion x Face Valence x Region	**5.15**	**3, 105**	**.002**	**.13**

Word Valence x Face Valence x Region	**6.16**	**1, 35**	**.018**	**.15**
Hemisphere x Region x Neuroticism	3.22	1, 35	.082	.08
Emotion x Hemisphere x Region	0.45	2.21, 77.31	.662	.01
Word Valence x Hemisphere x Region	1.49	1, 35	.231	.04
Face Valence x Hemisphere x Region	0.02	1, 35	.886	.00
Emotion x Word Valence x Face Valence x Neuroticism	1.03	3, 105	.381	.03
Emotion x Word Valence x Hemisphere x Neuroticism	0.87	1.63, 57.16	.404	.02
Emotion x Face Valence x Hemisphere x Neuroticism	0.80	2.46, 86.25	.474	.02
Word Valence x Face Valence x Hemisphere x Neuroticism	0.08	1, 35	.777	.00
Emotion x Word Valence x Face Valence x Hemisphere	0.71	2.34, 81.96	.515	.02
Emotion x Word Valence x Region x Neuroticism	0.13	1.97, 68.87	.879	.00
Emotion x Face Valence x Region x Neuroticism	0.65	3, 105	.588	.02
Word Valence x Face Valence x Region x Neuroticism	2.29	1, 35	.139	.06
Emotion x Word Valence x Face Valence x Region	1.33	2.46, 86.22	.270	.04
Emotion x Hemisphere x Region x Neuroticism	1.92	2.21, 77.31	.149	.05
Word Valence x Hemisphere x Region x Neuroticism	1.81	1, 35	.187	.05
Emotion x Word Valence x Hemisphere x Region	1.22	1.18, 41.33	.284	.03
Face Valence x Hemisphere x Region x Neuroticism	0.10	1, 35	.757	.00
Emotion x Face Valence x Hemisphere x Region	1.02	1, 35	.385	.03
Word Valence x Face Valence x Hemisphere x Region	0.23	1, 35	.632	.01
Emotion x Word Valence x Face Valence x Hemisphere x Neuroticism	2.12	2.34, 81.96	.118	.06
Emotion x Word Valence x Face Valence x Region x Neuroticism	0.30	2.46, 86.22	.789	.01
Emotion x Word Valence x Hemisphere x Region x Neuroticism	1.20	1.18, 41.33	.289	.03
Emotion x Face Valence x Hemisphere x Region x Neuroticism	0.77	1, 35	.511	.02
Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.00	1, 35	.950	.00
Emotion x Word Valence x Face Valence x Hemisphere x Region	0.88	1.41, 49.32	.388	.03
Emotion x Word Valence x Face Valence x Hemisphere x Region x Neuroticism	0.75	1.41, 49.32	.436	.02

[a] Degrees of freedom were corrected with the *Greenhouse-Geisser* coefficient for violations of sphericity

Concerning the main effect of Region, higher mean amplitudes were observed in parieto-occipital (M = -0.27 μV, SE = 0.31) than in parietal (M = -0.87 μV, SE = 0.33) sites.

Regarding the significant interaction between Word Valence and Face Valence (see Figure 32), multiple comparisons revealed more negative mean amplitudes evoked by negative word valence assessment of congruent compared to incongruent stimuli

(p = .013). Furthermore, in relation to stimuli with positive faces, more negative mean amplitudes were elicited by positive (congruent) compared to negative (incongruent) word valence judgments ($p < .001$).

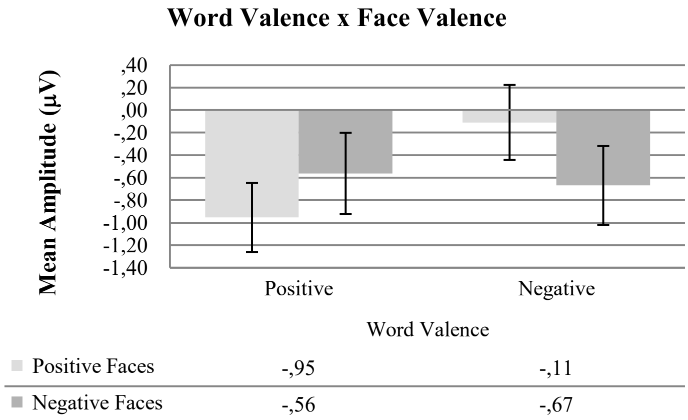


Figure 32: Mean amplitude in the 717 – 867 ms time window, in Word Valence Assessment, plotted by Word Valence and Face Valence conditions. Error bars represent standard errors.

Concerning the interaction between Face Valence and Region, pairwise comparisons showed lower mean amplitudes in parietal than in parieto-occipital sites elicited by stimuli with positive (Ps: M = -0.85 µV, SE = 0.32; POs: M = -0.21 µV, SE = 0.29) and negative (Ps: M = -0.90 µV, SE = 0.34, $p < .001$; POs: M = -0.34 µV, SE = 0.33, $p < .001$) faces.

In order to explore the significant interaction between Word Valence, Region and Neuroticism, two new 2 (Word Valence) x 2 (Region) repeated measures ANOVAs were conducted in separate for high and low neuroticism. A main effect of Region was found only in high neuroticism participants, $F(1, 18) = 7.84$, $p = .012$, $\eta_p^2 = .30$. Again, lower mean amplitudes were observed in parietal (M = -4.42 µV, SE = 0.83) than in parieto-occipital (M = -3.95 µV, SE = 0.86) sites.

The interaction between Emotion, Face Valence and Region was significant. Thus, four new 2 (Face Valence) x 2 (Region) repeated measures ANOVAs were conducted, one for each Emotion. The main effect of Region was significant for all emotional conditions – fear: $F(1, 37) = 47.85$, $p < .001$, $\eta_p^2 = .56$; disgust: $F(1, 37) = 36.63$, $p < .001$, $\eta_p^2 = .50$; anger: $F(1, 36) = 35.75$, $p < .001$, $\eta_p^2 = .50$; and sadness: $F(1, 37) = 41.71$, $p < .001$, $\eta_p^2 = .16$. The results were similar to the ones already presented, therefore they were not described. The main effect of Face Valence was significant in the fear condition, $F(1, 37) = 4.77$, $p = .035$, $\eta_p^2 = .11$: higher amplitudes were found in response to stimuli with happy ($M = -0.09$ µV, $SE = 0.32$) compared to stimuli with fearful ($M = -0.55$ µV, $SE = 0.40$) faces. The interaction between Face Valence and Region was significant in the fear and sadness conditions, $F(1, 37) = 5.10$, $p = .030$, $\eta_p^2 = .12$ and $F(1, 37) = 6.96$, $p = .012$, $\eta_p^2 = .16$, respectively. In the fear condition, the main effect of Region was observed in stimuli with happy and fearful faces. Only parieto-occipital sites showed differences in mean amplitudes that were more positive in response to stimuli with happy ($M = 0.27$ µV, $SE = 0.31$) than with fearful ($M = -0.25$ µV, $SE = 0.40$, $p = .018$) faces. In the sadness condition, only the main effect of Region was found in stimuli with happy and sad faces. However, as it was similar to previous results, it was not described.

In order to explore the significant interaction between Word Valence, Face Valence and Region, two more 2 (Face Valence) x 2 (Region) split-plot ANOVAs were conducted, one for each Word Valence. Both positive and negative words had a significant effect of Region, $F(1, 37) = 43.83$, $p < .001$, $\eta_p^2 = .54$ and $F(1, 37) = 45.56$, $p < .001$, $\eta_p^2 = .55$, respectively. The differences were not reported since they had already been described in previous analysis. In positive word valence assessment, the interaction between Face Valence and Region was significant, $F(1, 37) = 10.57$, $p = .002$, $\eta_p^2 = .22$, but not surprising, since it was similar to the results described above, therefore it was not reported. The main effect of Face Valence was only found in negative word valence assessment, $F(1, 37) = 7.22$, $p = .011$, $\eta_p^2 = .55$: higher mean amplitudes were found in incongruent ($M = -0.04$ µV, $SE = 0.33$) than in congruent ($M = -0.59$ µV, $SE = 0.34$) stimuli.

DISCUSSION

1. BEHAVIOURAL RESULTS

Congruency effects were found in face and in word valence assessment task, both in accuracy and reaction times – fast and accurate valence assessment of congruent compared to incongruent stimuli – confirming the results found in other studies using the WFS task and our own previous results (Avram et al., 2010; Baggott et al., 2010; Basgöze & Gökçay, 2008; Başgöze et al., 2015; Beall & Herbert, 2008; Chechko et al., 2013; Cothran et al., 2012; Egner et al., 2008; Favre et al., 2015; Haas et al., 2006, 2007; Hu et al., 2012; Keedwell et al., 2016; Krebs et al., 2013; Osinsky et al., 2012; Ovaysikia et al., 2010; Shen et al., 2013; Soutschek & Schubert, 2013; Stenberg et al., 1998; Strand et al., 2012; Vivekananth et al., 2013; Worsham et al., 2015; Xue et al., 2016; Yang et al., 2016; Zhu & Luo, 2012; Zhu et al., 2010).

The only main effect of Neuroticism was found in the FVA task, but only approached significance. High neuroticism participants showed a tendency for lower accuracy compared to low neuroticism participants. In the WVA task, on the other hand, we did not find differences between high and low neuroticism participants as Haas et al. (2007) did. We were also expecting to find differences in congruency effects between low and high neuroticism participants since studies with major depressive disorder patients showed more difficulties in solving emotional conflict – less accurate and longer response times in incongruent compared to congruent trials (Başgöze et al., 2015; Chechko et al., 2013; Strand et al., 2012). Nonetheless, our results point to more difficulties in categorizing face valence as positive or negative and perhaps more difficulties in recognizing facial expressions; these results may also mean that high neuroticism participants can suffer more influence from words which could lead to more difficulties in solving emotional conflict at least when face valence assessment is required.

Still in the FVA task, the interaction between Emotion and Neuroticism revealed that high neuroticism participants evaluated face valence in the disgust block slower than low neuroticism participants. Additionally, participants with low neuroticism assessed face valence slower in fear compared to disgust experimental blocks. In turn, high neuroticism participants judged face valence of stimuli in disgust blocks slower than in sadness blocks. Since the only difference between blocks is the negative emotion displayed by the face, we can conclude that participants with high neuroticism seem to have more difficulties assessing disgust faces and/or that these stimuli attract more attention than sad faces since they are rarer in everyday life, they have a unique face configuration and its concept it is not well defined (it can be related to people, objects, smells, food, among other categories and can even overlap the concept of other emotions, like anger) (Adolphs, 2002; Stenberg et al., 1998). So, disgusted faces can attract more attention, occupy more cognitive resources and high neuroticism participants may have even more difficulties in withdrawing attention from them, resulting in slower reaction times. Additionally, distracting words can generate more interference effects in disgust faces in high compared to low neuroticism participants. Regarding the results found in the low neuroticism group – slower reaction times in the fear than in the disgust condition – low neuroticism participants can recognize disgusted faces as negative more easily compared to fearful faces. Participants did not know which emotional expression they were about to see as it could alternate between happy, neutral and fearful; so, in the specific case of fearful expression, participants could mistake fearful with surprise faces – that can be positive or negative – leading to higher reaction times deciding if the face was positive or negative (Adolphs, 2002).

The happy superiority effect was observed in facial valence assessment – higher accuracy and faster reaction times for happy faces – in general and in all emotional conditions except disgust, where no differences between positive and negative face valence assessment were found (Başgöze et al., 2015; Fox & Zougkou, 2011; Hu et al., 2012; Stenberg et al., 1998).

Most of the effects found both in accuracy and reaction times, in the FVA task, involved the disgust condition. The main effect of Emotion concerning negative face valence assessment revealed more accurate valence judgments in disgusted faces compared to all other emotions. This result can point to an easy recognition of disgusted faces as negative emotions. That is probably why higher accuracy was found for happy compared to negative face valence assessments in general and in all conditions, except disgust. No stronger evidence was found regarding the attention captured by disgusted faces that could lead to slower valence categorizations. In fact, the interaction between Emotion and Face Valence showed slower valence judgments for fearful and angry compared to disgusted faces. Moreover, participants tended to assess face valence in the sadness condition faster than in the fear condition (main effect of Emotion). Altogether these results point to higher accuracy and faster face valence judgments of disgusted and sad faces compared to fearful and angry faces. These effects can be due to more interference effects from positive words in fearful and angry faces or to the fact that these faces can capture more attention compared to disgusted and sad faces, leading to slower reaction times.

In the word valence assessment task, besides the congruency effects that were discussed earlier, we also found a positive valence advantage: positive words were evaluated faster than negative words confirming the results from Stenberg et al., 1998.

2. PSYCHOPHYSIOLOGICAL RESULTS

2.1. P1

Regarding psychophysiological results, the literature confirms that the P1 ERP component is affected by stimuli's emotional valence and salience (Batty & Taylor, 2003; Luck, 2005; Luck et al., 2000; Olofsson et al., 2008; Pourtois et al., 2004; Van Strien et al., 2009; Vuilleumier, 2005). P1 analysis, in this study, showed a strong influence of negative material, in particular negative words. In the FVA task, a higher and earlier P1 was found in the evaluation of stimuli with negative words compared with stimuli with positive words, thus confirming the results found by Bar-Haim et al. (2005), Bernat et al. (2001), Taake et al. (2009), Thomas et al. (2007), Van Hooff, Dietz, Sharma, and Bowman (2008), and Citron (2012).

As for the word valence assessment task, effects involving the neuroticism trait were found only in the fear condition. In this condition, the interaction between Neuroticism and Word Valence showed a higher P1 elicited by negative as opposed to positive word valence assessment for low neuroticism participants. A similar result was found in the interaction between Neuroticism and Face Valence, but here when happy faces were presented. These results point to a lower P1 for low neuroticism participants elicited by positive congruent stimuli. High neuroticism participants showed a higher P1 for congruent stimuli, that is, in the evaluation of negative words superimposed on fearful faces. It seems that the implicit processing of fearful faces had more influence on high than on low neuroticism participants. The congruency effect in P1 was found only in interactions with neuroticism. Since high neuroticism scores were only related to higher P1 amplitudes elicited by negative congruent stimuli in fear blocks, this enhanced amplitude can be associated not only with negative words, but also with the implicit processing of fearful faces. This hypothesis is in accordance with the findings of Eimer and Holmes (2007) that discovered higher P1 positivity for fearful compared to neutral faces, Holmes et al. (2008) that revealed higher P1 amplitudes elicited by fearful faces in anxious compared to non-anxious individuals, and Li et al. (2007) that found a more pronounced P1 in response to threat words as trait anxiety increased. Therefore, if high neurotic participants have a mechanism of attentional vigilance to negative material (Holmes et al., 2008; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Yiend, 2010), the congruent negative stimuli would activate that threat evaluation system more than any other stimuli presented in this experiment, and thus capture the attention of high neuroticism participants.

There are studies that confirm differences in response or detection of emotional expressions in the P1 time window (Eimer & Holmes, 2007; Holmes et al., 2008; Pourtois et al., 2004; Rellecke et al., 2011) and even earlier (Pourtois et al., 2004; Zhu & Luo, 2012). Most of these studies reported differences relative to fearful expressions, which can point to better recognition and identification, and greater interference (when implicitly presented) from this facial expression. We did not find any effects elicited by faces when they were the target, but we did find them in the implicit task, when they were the distractor. As P1 reflects stimuli emotional salience (Bayer et al., 2012; Taake et al., 2009), congruent negative stimuli with fearful faces can be highly salient and emotionally relevant for individuals with high neuroticism, eliciting enhanced P1 amplitudes. We believe that this effect is only generated when the distracting stimuli have already been evaluated at the level of its emotional category and not just its valence. This seems to be the case with fearful faces (Méndez-Bértolo et al., 2016) and to some degree also with happy faces in the same experimental block.

In the word assessment task, a main effect of hemisphere was found, which showed higher P1 amplitude in the left compared to the right hemisphere. These results confirmed the left hemisphere's dominance in the early and more automatic processing of emotional word salience (Abbassi et al., 2011; Mazza & Pagano, 2017; Van Hooff et al., 2008).

2.2. N170

As hypothesized and according to the literature, a significant effect of hemisphere was found in N170 amplitude and latency that showed a lateralized and earlier N170 in the right hemisphere when faces were the target, that is, when they were explicitly assessed (Baggott et al., 2010; Bentin et al., 1996; Blau et al., 2007; Rossion & Jacques, 2012;

Rossion, Joyce, Cottrell, & Tarr, 2003). This effect did not occur in the word assessment task.

In this study, the effects on N170 amplitude and latency appeared especially in the fear and disgust conditions. In the face valence assessment task, the interaction between Face Valence and Hemisphere was significant in fear and disgust conditions and showed an earlier N170 elicited by face valence assessment of happy compared to fearful faces in the left hemisphere, and an earlier N170 in the right compared to the left hemisphere when subjects evaluated fearful faces. Regarding the disgust condition, the N170 peaked earlier when participants were asked to evaluate happy compared to disgusted faces, and also peaked earlier in the right compared to the left hemisphere. The earlier N170 elicited by the evaluation of happy compared to fearful and disgusted faces could be explained by the "Valence Hypothesis" that states that the left hemisphere is specialized in processing positive emotions and the right hemisphere in negative emotions (Adolphs, 2002; Demaree, Everhart, Youngstrom, & Harrison, 2005; Oatley & Jenkins, 1996a, 1996b).

As for the word assessment task, we found a marginally significant main effect of neuroticism that indicated a tendency for a more negative N170 in low compared to high neuroticism participants. Zhu et al. (2010) found less negative N170 amplitudes in incongruent compared to congruent trials in a WVA task, showing that the N170 can be modulated by conflict – processing of relevant stimuli and the suppression of the task-irrelevant information (Baggott et al., 2010; Zhu et al., 2010). Since high neuroticism participants are more prone to experience conflict because they are more influenced by distracting stimuli, we can suggest that high neuroticism participants had a tendency to experience more conflict than low neuroticism participants in the WVA task. This is a relevant finding in our study, which could have reached statistical significance if more data had been collected or if our participants had more extreme neuroticism scores.

The interaction between Emotion and Neuroticism did not reach significant levels, but still showed a more negative N170 in low compared to high neuroticism participants in the fear condition and a similar, but smaller effect in the anger condition (which did not reach statistical significance). This effect was found in the fear condition in general, and specifically for positive word valence assessment. Participants assessed positive words paired with positive and negative (in this case fearful) faces and assessed negative words paired with positive and negative (fearful) faces. The literature on the effects of the different facial expressions on the N170 points to a strong influence of fearful expressions (Batty & Taylor, 2003; Blau et al., 2007; Frühholz et al., 2011; Rossignol et al., 2005); since participants with high neuroticism scores are faster in detecting and processing negative material (especially threatening) and have more difficulties in withdrawing attention from it (Berggren & Derakshan, 2013; Bradley et al., 1998; Bradley & Lang, 1999; Campanella et al., 2002; Cremers et al., 2010; Fox & Zougkou, 2011; Frühholz et al., 2010; Haas et al., 2008; Haas et al., 2007; Mogg et al., 2007; Rafienia et al., 2008; Rossignol et al., 2005; Surcinelli et al., 2006), the differences found can point to greater interference effects from the implicit processing of threatening (fearful and angry) faces in high neuroticism participants (Zhu et al., 2010).

The interaction between Emotion and Neuroticism for positive word valence assessment also showed a more negative N170 in fear compared to disgust blocks in the low neuroticism group, suggesting less interference effects from fearful compared to disgusted faces when positive word valence assessment was required.

2.3. EPN

The EPN ERP component reflects attentional processes towards emotional stimuli, implicit and automatic emotional processing, being sensitive to stimuli's emotional content and arousal (Bayer et al., 2012; Calvo & Beltrán, 2013; Citron, 2012; Hajcak et al., 2012; Junghöfer et al., 2001; Kissler et al., 2009; Schacht & Sommer, 2009; Schupp et al., 2004). In both tasks, the EPN was more negative at parietal compared to parieto-occipital sites and in the left compared to the right hemisphere (demonstrated by the main effects of Region and Hemisphere and the interaction between them). Research about word processing has confirmed the hemispheric asymmetry of the EPN – more enhanced amplitudes in the left compared to the right hemisphere (Frühholz et al., 2011; Kissler et al., 2007; Zhang et al., 2014a), but we could not find strong evidence that this asymmetry also exists for faces.

Regarding the face valence assessment task, only the interaction between Face Valence and Word Valence in right parietal sites suggested an influence of conflict trials in EPN peak latency: an earlier EPN was elicited in congruent compared to incongruent trials, but only when participants were evaluating happy faces. In behavioural data, we found higher accuracy and faster reaction times for positive compared to negative face valence assessment, and congruency effects involving positive congruent stimuli (in accuracy and in reaction times). Since ERP latency is related to processing speed (Luck, 2005; Luck & Kappenman, 2012; Luck et al., 2000), EPN results can point to the straightforwardness of recognizing happy faces as positive and to the facilitation effect of positive words on happy faces in congruent compared to incongruent trials – positive valence advantage (Adolphs, 2002; Stenberg et al., 1998).

In the left parieto-occipital sites, results from the interaction between Word Valence and Emotion showed an earlier EPN elicited by the evaluation of stimuli with positive compared to negative words in the sadness condition. Moreover, an earlier EPN was also found in the fear compared to the sadness condition elicited only by negative words. These results could reflect the implicit processing of word valence and its influence in face valence assessment. Again, since ERP latency indexes processing speed and given the fact that, in behavioural results, we found congruency effects in reaction time analysis for all emotional conditions except sadness, these results can indicate that regardless of the facial expression participants were evaluating – sad or happy – the evaluation process started earlier in stimuli with positive compared to negative words. This can be evidence of a facilitation effect of the implicit processing of positive over negative words. The second result points to a facilitation effect (at least in the initial stages of the valence judgment processing) of negative words in the fear over the sadness condition. Given that the only difference between both conditions was the negative facial expression each one contains, we suggest that fearful faces might be more influenced by the implicit processing of negative words, thus generating an earlier EPN that could reflect an initial facilitation (processing speed) of fearful compared to sad faces' valence judgment.

Moreover, all peak amplitude results in the face valence judgment task involved sadness and fear conditions. The main effect of Emotion showed a more pronounced EPN in the sad compared to the fear condition in general and in the right hemisphere (RH). In behavioural results we found congruency effects in accuracy and in reaction time for all conditions. Additionally, we found one marginal difference between sadness and fear conditions in reaction times: participants tended to be slower in face valence assessment in the fear compared to the sadness condition. We did not expect this result, since EPN is modulated by arousal. Thus, since both blocks have positive faces with high arousal levels (Calvo & Beltrán, 2013; Gerber et al., 2008; Posner et al., 2005; Russell, 1980) and all stimuli are the same except the negative facial expression portrayed by the face, we would expect a more pronounced EPN in the fear compared to the sadness condition. However, we can relate these results to conflict or interference effects. We know that fearful faces are more arousing, more important to survival, and can capture more attention (Campanella et al., 2002; Fox & Zougkou, 2011; Gerber et al., 2008; Öhman, 2005; Pourtois et al., 2004; Schupp et al., 2004) than sad faces. Therefore, fearful faces can influence participants' response not only in the current trial but also in the following, acting as a prime and reinforcing the conflict. If that is the case, we can rely on the literature that points towards a more pronounced EPN in congruent compared to incongruent trials (Frühholz et al., 2009; Rampone et al., 2014), and suggest that the differences found are a consequence of less conflict in the sadness compared to the fear condition.

In the low neuroticism group of participants, various interactions suggest more negative EPN amplitudes in sadness compared to fear and anger conditions in the RH and in sadness and disgust compared to fear conditions in parietal and parieto-occipital sites. Low neuroticism participants are less affected by distractors (Wallace & Newman, 1998) and, therefore might be less influenced by the emotional conflict than high neuroticism participants (Haas et al., 2008; Haas et al., 2007; Huang et al., 2009). As fearful and angry faces are more threatening than sad and disgusted faces (Bradley et al., 1998; Oatley & Jenkins, 1996a, 1996b; Schupp et al., 2004), have more evolutionary significance (Lin, Schulz, & Straube, 2015), and higher arousal levels (Beall & Herbert, 2008; Gerber et al., 2008), we suggest that they act as a prime to negative words, making them more influential in the processing of faces. In fact, participants with low neuroticism took less time to evaluate happy faces in the disgust compared to the fear condition.

Regarding the WVA task, a congruency effect resulted from the interaction between Word and Face Valence for negative words and was found only in disgust blocks: more pronounced EPN amplitudes were elicited by congruent compared to incongruent trials, thus strengthening the results found in the FVA task and in Rampone et al. (2014) and Frühholz et al. (2009). So, disgusted faces appear to have a facilitation effect on negative word valence assessment compared to happy faces.

The interaction between Face Valence and Hemisphere revealed a more negative EPN in the left hemisphere elicited by word evaluation of stimuli with fearful faces. In the FVA task we found more pronounced results in the RH, whereas in the WVA task, where explicit judgments of words were requested, we found more salient results in the LH. The contribution of both hemispheres to emotional word processing occurs in different processing stages: an early, more automatic stage that seems to be associated with left brain activation and a later, more controlled stage more linked with right brain activation (Abbassi et al., 2011; Mazza & Pagano, 2017). Thus, this left EPN can be explained by the automatic processing of words, since it only reached significance in the WVA task. The fact that this result was only observed in WVA in stimuli with fearful faces can be related to the implicit processing of these faces. Together with behavioural results – more correct evaluations of negative words in congruent negative compared to incongruent stimuli and a positive advantage in word valence assessment – the pronounced left EPN can be evidence of a facilitation effect of fearful faces in congruent stimuli that leads to a more automatic processing of negative word valence in the left hemisphere, in this emotional condition. Similar results were found by Frühholz et al. (2011) during the "emotional judgment task" only for negative words paired with fearful faces.

Finally, in left parietal sites, a more pronounced EPN was elicited by stimuli with negative compared to positive faces. This result can reflect the rapid detection and processing of negative faces (Frühholz et al., 2011; Holmes et al., 2008; Rellecke et al., 2011; Schupp et al., 2004) which may indicate a more automatic implicit processing of negative compared to positive faces in word valence assessment.

2.4. 367 – 567 MS

We analyzed mean amplitudes in the time window between 367 and 567 ms based on visual inspection of the grand-average waveforms and on the literature review. Thus, we focused our analysis on the N450, evident in this time window, which reflects conflict detection, monitoring, and resolution (Larson et al., 2014; Liotti et al., 2000; Ma et al., 2014; Osinsky et al., 2012; Shen et al., 2013; West et al., 2005; Xue et al., 2016; Xue et al., 2015).

A significant effect of Hemisphere was found in both tasks and showed lower mean amplitudes in the left compared to the right hemisphere, which is not consistent with the N450 literature (Tang, Hu, Li, Zhang, & Chen, 2013), that points to a right lateralization of this ERP potential. At this time, we are unable to provide a solid explanation for this incongruence with the literature, although it is possible that methodological dissimilarities and/or differences in data analysis could have contributed to this result. Nevertheless, the main effect of Region, also common in both tasks, is in the line with N450 studies, which observed higher amplitudes in centro-parietal sites (Citron, 2012; Hajcak et al., 2012; Luck, 2005; Osinsky et al., 2012).

The interaction between Word and Face Valence in the word assessment task is consistent with our hypothesis that incongruence effects would be found in the N450 time window. Our data showed lower mean amplitudes in negative word valence assessment in incongruent compared to congruent trials, which indicates that when participants were assessing negative words they suffered more interference effects from happy faces (conflict trials) compared to when they were assessing the valence of negative words superimposed on a negative face – congruent trials – regardless of the negative expression presented). These results, together with the fact that congruency effects in behavioural results were also found both in accuracy and reaction times, confirmed that in this time window (consistent with the N450), more negative amplitudes can be found that reflect conflict interference effects (Larson et al., 2014; Liotti et al., 2000; Ma et al., 2014; Osinsky et al., 2012; Shen et al., 2013; West et al., 2005; Xue et al., 2016; Xue et al., 2015) and the superiority effect of happy faces (Fox & Zougkou, 2011; Stenberg et al., 1998).

In the word evaluation task a main effect of Word Valence was also found that points to lower mean amplitudes elicited by the assessment of negative compared to positive words. Moreover, a main effect of Face Valence was found as well, and showed lower mean amplitudes elicited by stimuli with positive compared to negative faces. Since N450 amplitudes are related to conflict, and conflict is observed in incongruent trials, it seems that the implicit processing of happy faces generates more conflict in negative word valence assessment than the interference from the implicit processing of negative faces in the positive word valence assessment. The main effect of Word Valence was found in general for all participants and in particular in low neuroticism participants, which suggests that they can suffer more interference effects from happy faces in negative word valence assessment (Haas et al., 2007).

The main effect of Face Valence was found in the fear condition as well, that is, when participants were asked to assess word valence in the fear block they suffered more interference effects from happy faces in negative word valence assessment than from fearful faces in positive word valence assessment. These results were also found by Yang et al. (2016) with fearful faces and by Beall and Herbert (2008) with sad faces. Combined with the congruency effects found in behavioural results, fearful faces seem to have a facilitation effect on negative word valence judgments and a lack of interference in positive WVA. The explanation for these effects may rely on the rapid processing of fearful expressions (Batty & Taylor, 2003; Eimer & Holmes, 2007; Méndez-Bértolo et al., 2016; Mogg et al., 2007; Öhman, 2005; Pourtois et al., 2004; Zhu & Luo, 2012). Accordingly, fearful faces could be recognized so fast that by the time conflict detection occurs, they have already been processed. Therefore, fearful faces can facilitate the processing of negative WVA and cease to interfere in positive WVA (Zhu & Luo, 2012).

On the other hand, in the face valence assessment task, more negative mean amplitudes were found in the disgust condition, elicited by happy compared to disgusted face valence assessment (the main effect of Face Valence in the disgust condition and the marginal interaction between Emotion and Face Valence). Moreover, the significant interaction between Emotion and Word Valence found at centro-parietal sites in the disgust condition showed lower mean amplitudes in face valence assessment of stimuli with negative compared to positive words. Since the N450 is an index of emotional conflict, we can suggest that negative words caused more interference effects, and therefore, more conflict in happy face valence assessment than the conflict produced by positive faces in disgusted face valence judgments in the disgust condition. These effects confirmed the higher accuracy found in disgusted face recognition.

In this time window, a significant effect of Word Valence was found in the sadness condition that showed more negative mean amplitudes in face valence assessment of stimuli with positive compared to negative words. This result points to more conflict and more interference effects from positive words in sad faces valence assessment than from negative words in happy faces valence assessment. This result is in line with behavioural measures – less accurate responses in sad compared to disgusted faces and a strong superiority effect of happy faces. This effect was also significant for high neuroticism participants in particular, showing that, unlike low neuroticism participants, they suffer more conflict in the sadness condition.

Finally, the interaction between Neuroticism and Hemisphere in the sad condition showed more negative amplitudes in the left compared to the right hemisphere in high neuroticism participants. Similar to the main effect of Hemisphere described above, we were not able to provide an explanation for these effects.

2.5. 717 – 867 MS

Regarding mean amplitudes in the 717 – 867 ms time window, we found a congruency effect only in the word valence assessment task, evidenced by the main effect of Face Valence observed for negative words and by the interaction between Word and Face Valence: higher mean amplitudes were found in incongruent compared to congruent trials. Because this time window is consistent with the Conflict SP, our results confirmed those found by Shen et al. (2013), West et al. (2005), Xue et al. (2016), Xue et al. (2015), and Osinsky et al. (2012).

The main effect of Word Valence showed higher mean amplitudes in negative than positive word valence assessment. Together with the fact that the congruency effect was found specifically for negative word valence assessment, this could mean that happy faces caused more interference in negative word processing than negative faces in positive valence assessment (Beall & Herbert, 2008; Yang et al., 2016). This effect was more pronounced in fear blocks, as suggested by the main effect of Face Valence in the fear condition: higher mean amplitudes were elicited by word valence assessment of stimuli with happy compared to fearful faces. This result was also found by Yang et al. (2016), and proved the superiority effect of happy faces and its large interference effects in the task at-hand (Başgöze et al., 2015; Fox & Zougkou, 2011; Hu et al., 2012; Stenberg et al., 1998). Since no differences between negative facial expressions were found in behavioural results, in this task, the reason why this difference only appeared in the fear condition could be related with the fact that fearful faces are processed earlier (Batty & Taylor, 2003; Eimer & Holmes, 2002, 2007; Holmes et al., 2003; Palermo & Rhodes, 2007; Pourtois et al., 2004; Williams et al., 2004; Zhu & Luo, 2012; Zhu et al., 2010) and in this stage of processing might not interfere with positive word valence assessment, and thus produce a facilitation effect on negative word valence assessment.

In the face valence assessment task, a tendency for higher mean amplitudes was found in face valence assessment of positive compared to negative faces. This result was also observed with statistical significance specifically in the disgust condition. Accuracy analysis revealed that disgusted faces were, among all negative facial expressions, the ones with fewer errors in the face valence assessment task. Thus, we can assume that participants did not suffer a great amount of interference from words in this block. Therefore, it is logical that the Conflict SP had higher amplitudes for positive compared to negative face valence in the disgust condition.

The interaction between Word Valence and Neuroticism was significant in the sadness and anger conditions in the FVA task: higher mean amplitudes were found in face valence assessment of stimuli with positive compared to negative words only in high neuroticism participants. Given that Conflict SP is an index of interference, we can argue that positive words interfered more with negative face evaluation than negative words with positive face evaluation (Cacioppo & Gardner, 1999; Hinojosa et al., 2009; Hinojosa et al., 2010; Schacht & Sommer, 2009; Stenberg et al., 1998). These results were exclusive for high neuroticism participants, which indicate that these subjects suffered more interference effects when they had to evaluate negative facial expressions, in particular sad and angry faces, with a superimposed positive distracting word than when they had to evaluate happy faces with a negative distracting word superimposed. Because these results were only observed in the angry and sadness conditions, on top of a greater interference from positive words, this can also mean that, for high neuroticism, these two facial expressions were somehow more difficult to assess than fearful and disgusted faces. In a colour-naming facial Stroop task, Isaac et al. (2012) induced participants with sad mood and found that they took longer to identify the colour of angry than happy and neutral faces; the same result was found by Mauer and Borkenau (2007). Given the fact that high neuroticism ratings are related to mood disorders that are often associated with higher negative attentional emotional bias (Keedwell et al., 2016), our results can point to more difficulties in withdrawing attention from angry faces (Mauer & Borkenau, 2007; Stenberg et al., 1998). Although angry and sad faces represent negative emotions in different ways and for different purposes (anger represents revolt and insurgence, whereas sadness represents conformity with the cause of negative feelings), they are both related to neuroticism. Associations between sad faces and neuroticism were found by Haas et al. (2008), Jimura et al. (2009), Cremers et al. (2010), and Stewart et al. (2005), and can help explain why high neuroticism participants showed higher mean amplitudes in response to sad faces paired with positive words.

The main effect of Region – higher mean amplitudes in parieto-occipital than in parietal sites – was found in both tasks and confirmed the posterior parietal location of the Conflict SP (Larson et al., 2014; Larson et al., 2009; Liotti et al., 2000; Osinsky et al., 2012; Shen et al., 2013; West et al., 2005; Xue et al., 2016; Xue et al., 2015). In the word valence evaluation task, this effect was observed in high neuroticism participants in particular, which can be evidence of more interference effects in high neuroticism participants, since we know from other studies that subjects with higher neuroticism ratings suffer more interference effects than low neuroticism participants (Bienvenu et al., 2001; Bienvenu et al., 2004; Canli, 2004; Cremers et al., 2010; Haas et al., 2008; Haas et al., 2006, 2007; Huang et al., 2009; Malouff et al., 2005; Mauer & Borkenau, 2007; McAdams, 2009a; Ormel et al., 2004; Reynaud et al., 2012; Samuel & Widiger, 2008; Wallace & Newman, 1998).

CHAPTER V: GENERAL DISCUSSION AND CONCLUSIONS

This work was conducted to deepen our knowledge on the effects of the neuroticism personality trait in emotional conflicts between emotional faces and words, and the interference effects that they have on each other. For that purpose we used a modified Stroop task – the word-face Stroop – in which emotional words are superimposed on emotional expressions, and asked participants to evaluate word and/or face valence. We used a combination of happy, sad, disgusted, fearful, angry and neutral faces and positive, neutral and negative words as stimuli. Surprised faces were not used because they could be either positive or negative. Thus, three experiments were conducted where we tested the automaticity effects of implicit and explicit processing of words and faces. Additionally, we looked into the role of neuroticism in those processes in all experiments.

Given that behavioural measures do not allow for the analysis of the cognitive processes that underlie the emotional conflicts, we used electroencephalography in order to do so. ERPs are an excellent technique that enables us to measure the neural time course of cognitive and emotional processes, thus allowing for a deeper understanding of the neurological pathways behind these processes. According to the literature reviewed and the visual inspection of the grand averages of ERPs, we decided to analyse the peak amplitude and latency of three ERP waves – P1, N170, and EPN – and the mean amplitude of two post-stimulus time windows (367 – 567 ms and 717 – 867 ms, where the N450 and the Conflict SP, respectively, were more conspicuous).

In order to look at the data in a more holistic manner, so as to allow us to draw meaningful conclusions, results from all experiments will be discussed together in this final chapter.

FACE VALENCE ASSESSMENT TASK

In this task, participants had to evaluate face valence – positive, negative, or neutral – while ignoring and inhibiting the distracting information from the word presented, which could also be positive, negative, or neutral. A happy superiority effect was found in the experiments presented on Chapters II and IV, thus confirming results from other studies using the WFS task and proving that happy faces are easily recognizable as positive stimuli (Adolphs, 2002; Başgöze et al., 2015; Beall & Herbert, 2008; Calvo & Lundqvist, 2008; Calvo & Beltrán, 2013; Cothran et al., 2012; Fox & Zougkou, 2011; Hu et al., 2012; Montagne et al., 2007; Oatley & Jenkins, 1996a, 1996b; Stenberg et al., 1998).

In both experiments in which face valence was assessed explicitly, we found congruency effects, that is, higher accuracy ratings and faster reaction times for congruent – positive or negative – than for incongruent stimuli. Incongruent trials generate these response patterns because they are a source of emotional conflict and require more extensive/complex processing (Avram et al., 2010; Baggott et al., 2010; Basgöze & Gökçay, 2008; Başgöze et al., 2015; Beall & Herbert, 2008; Botvinick et al., 2004; Botvinick et al., 2001; Cothran et al., 2012; Egner et al., 2008; Haas et al., 2006, 2007; Hu et al., 2012; Krebs et al., 2013; Osinsky et al., 2012; Ovaysikia et al., 2010; Shen et al., 2013; Stenberg et al., 1998; Strand et al., 2012; Vivekananth et al., 2013; Worsham et al., 2015; Zhu et al., 2010). Another important finding that confirms these congruency effects and the superiority of happy facial recognition is an earlier EPN elicited by happy face valence assessment in congruent compared to incongruent trials. Since the EPN is sensitive to automatic emotional processing and to stimuli arousal (Bayer et al., 2012; Citron, 2012; Hajcak et al., 2012; Junghöfer et al., 2001; Kissler et al., 2009; Schacht & Sommer, 2009; Schupp et al., 2004), we believe that this earlier EPN can indicate the facilitated processing of happy face recognition in congruent positive stimuli.

In this task we also found enhanced amplitudes and earlier latencies for the P1 component elicited by face valence assessment of stimuli with negative compared to positive words, regardless of the targets' facial expression. Since P1 is modulated by stimuli's emotional valence and salience (Batty & Taylor, 2003; Luck, 2005; Luck et al., 2000; Olofsson et al., 2008; Pourtois et al., 2004; Van Strien et al., 2009; Vuilleumier, 2005) these results can point to a higher salience of negative compared to positive words and, consequently, more influence of the implicit processing of negative words in participants' performance.

Furthermore, we found emotional differences that deepened our understanding about the interference and facilitation effects of words on face valence assessment that could also have repercussions on the literature about facial recognition. Specifically, we found that in face valence assessment participants made more errors in sad than in disgusted (in both studies) and fearful (only in the first experiment) faces. Moreover, face valence assessment of stimuli with neutral words was also impaired – more errors – in sad compared to disgusted conditions. However, in reaction time analysis, we observed faster responses in face valence assessment in the sadness compared to the fear condition and also faster positive face valence assessment in the sad compared to the disgust block. These results point towards faster but more incorrect responses in FVA in the sadness condition, which can mean that participants suffered more interference effects from words in this particular emotional condition and that they could have had more difficulties in discriminating sad from neutral faces. Evidence for the first hypothesis came from EPN analysis, where we found an earlier EPN elicited by the evaluation of stimuli with positive compared to negative words in the sadness condition, and a later EPN in face valence assessment of stimuli with negative words in sadness compared to fear conditions. Since no congruency effects were found in reaction time in the sadness condition, these results can indicate that, regardless the facial expression participants were evaluating – sad or happy, the evaluation process started earlier in stimuli with positive compared to negative words. Additionally, results found in the N450 time window point to higher interference effects and, therefore, higher conflict caused by positive words in sad faces evaluation than the conflict caused by negative words in happy faces. Taken together, these results point to stronger and earlier implicit processing of positive compared to negative words on face valence assessment in sad conditions. However, no evidence was found in the literature that suggested more interference effects from words on sad face (valence) categorization (WFS studies with similar tasks: Başgöze et al. (2015); Beall and Herbert (2008); Chechko et al. (2013); Hu et al. (2012); Osinsky et al. (2012); Ovaysikia et al. (2010); Strand et al. (2012); Xue et al. (2016)). Evidence for the second hypothesis - more difficulties in discriminating sad from neutral faces – was found by Palermo and Coltheart (2004) in a facial categorization/discrimination task in which neutral faces were only mistaken with sad faces (4.2 %), and where 17.3 % of all sad faces presented were mistaken with neutral faces.

Taking both experiments together, fearful faces were assessed more accurately than sad faces but more incorrectly than disgusted faces. As has been mentioned before, sad faces could have been confused with neutral, thus causing more errors in their valence identification. For fearful faces, a misidentification can occur because of their similarities with surprised faces that can be either positive or negative (Adolphs, 2002; Palermo & Coltheart, 2004). Since participants did not know which faces would be presented, they could have mistaken fearful with surprised faces. However, we suggest that this difference found in accuracy between fearful and disgusted faces came from the higher identification ratings of disgusted faces that will be discussed later. We also found congruency effects on fearful faces valence assessment – stimuli with negative words were evaluated more accurately when superimposed on fearful compared to happy faces. This result points to a facilitation effect of negative words on fearful valence assessment and an interference effect from the same words in happy face valence assessment.

Furthermore, participants' categorization of happy and fearful faces was slower (in the fear condition) compared to the valence assessment of happy and sad faces (in the sadness condition). We noted and discussed above that faces in the sadness condition were overall assessed more incorrectly but faster compared to other emotional blocks. Therefore, we suggest that fearful faces could have captured more attention, as several studies have stated (Beall & Herbert, 2008; Öhman, 2005; Rellecke et al., 2011; Schupp et al., 2004; Stenberg et al., 1998), and participants could thus have more difficulties in withdrawing attention from both of them in congruent and incongruent stimuli, consequently delaying their response. As for the slower responses for happy faces, the delay in participants' answers only occurred in incongruent trials, since studies point to a facilitation effect of face and word identification in congruent positive stimuli. If the only difference between emotional blocks is the negative facial expression presented, we believe that somehow fearful faces influenced the interference effects of negative words on happy face valence assessment. The Conflict Monitoring Theory states that the processing of incongruent trials preceded by other incongruent trial is faster than when they are preceded by congruent trials (Botvinick et al., 2004; Botvinick et al., 2001; Clayson & Larson, 2011; Cohen et al., 2004). If a stimulus can affect the processing of another stimulus presented immediately after, the explicit processing of fearful faces may very likely affect the implicit processing of the negative word presented in the following trial – resembling a prime effect. Therefore, negative words would interfere more with happy valence assessment and consequently delay participants' responses, thus explaining our results. Further evidence for these effects could also include a more pronounced EPN in the sadness compared to the fear condition that points to less conflict (Frühholz et al., 2009; Rampone et al., 2014) in the sadness than in the fear condition.

Results regarding disgusted faces were quite interesting and innovative since, as far as we know, only two studies have used this negative facial expression in the WFS paradigm (Hu et al., 2012; Stenberg et al., 1998), and only Hu et al. (2012) have explicitly evaluated disgusted faces. However, it is not possible to compare results from our experiment to theirs because they analyzed all the negative expressions together – angry, disgusted, sad, and fearful faces – in order to explore the interference of positive, negative, and depression-related words on positive and negative face valence assessment. In our study, on the other hand, we looked into the effects of each negative expression individually. Nevertheless, our results showed that disgusted faces were, in both experiments, the negative facial expression more easily identified and participants were faster than in the identification of fearful faces. In the disgust condition, participants were also faster in face valence assessment (regardless of its valence) than in the anger condition and, compared to the sadness condition, participants' evaluation of stimuli with neutral words was more accurate. Furthermore, it was the only condition in which positive face judgment was not faster than the judgement of negative and neutral faces. Moreover, mean amplitude analysis of the time windows consistent with the N450 and Conflict SP components showed that negative words caused more interference effects in happy faces, and therefore more conflict, than positive words in disgusted face valence judgments in the disgust condition. All these results point towards an easier (faster and more accurate) recognition of disgusted faces compared to other facial emotions, which is in contrast with some authors' findings (Adolphs, 2002). Since, in this study, only the identification of valence was required, that is, participants were not asked to categorize the emotion presented by the face, rather they were asked to identify their valence – positive or negative – participants may have more easily discriminated disgusted faces from neutral and happy. In Palermo and Coltheart (2004) study, disgusted faces (mean of correct responses: 68.2 %) were only mistaken with other negative expressions such as anger (M = 11.8 %) and sadness (M = 9.9 %). Furthermore, we know that happy expressions are the easiest to recognize (Adolphs, 2002; Palermo & Coltheart, 2004) and, although neutral faces are ambiguous (Cooney et al., 2006; Isaac et al., 2012; Somerville et al., 2004), it seems more plausible that neutral faces could be assessed as positive or negative than disgusted faces as neutral.

Finally, in the anger condition, participants made more errors than in the disgust condition, not only in negative face valence assessment but also in FVA in general (which comes to no surprise after the disgust condition analysis). Moreover, participants were slower in FVA of stimuli with positive than neutral words and were also slower in neutral and happy face valence assessments in this condition compared to all other conditions. These results, especially those described in Chapter II, are not straightforward, and likely require further tests in order to explain them. The stimuli that elicited more correct responses were the ones with positive words (regardless of face valence), that is, participants were more accurate in judging face valence in stimuli with positive words. At this time, we are unable to find an explanation for these results, and additional tests may be required in order to reach a satisfactory conclusion.

WORD VALENCE ASSESSMENT TASK

In this task, participants were asked to evaluate word valence, regardless of the facial expression presented, that is, in order to complete this task successfully, participants had to inhibit the distracting information displayed by the face.

Congruency effects were found in the experiment described in Chapter IV in reaction time and accuracy analysis. Related to these effects, we found lower mean amplitudes in the 367-567 ms time window – consistent with the N450 component – in negative word valence assessment in incongruent compared to congruent trials. This indicates that when participants were assessing negative words they suffered more interference effects from happy faces (conflict trials) compared to when they were assessing the valence of negative words superimposed on a negative face – congruent trials – regardless of the negative expression presented. We have also found higher mean amplitudes in incongruent compared to congruent trials in the time window consistent with the Conflict SP. These results are consistent with the majority of the studies that used the WFS task (Avram et al., 2010; Baggott et al., 2010; Basgöze & Gökçay, 2008; Başgöze et al., 2015; Beall &

Herbert, 2008; Cothran et al., 2012; Egner et al., 2008; Haas et al., 2006, 2007; Hu et al., 2012; Krebs et al., 2013; Larson et al., 2014; Liotti et al., 2000; Ma et al., 2014; Osinsky et al., 2012; Ovaysikia et al., 2010; Shen et al., 2013; Stenberg et al., 1998; Strand et al., 2012; Vivekananth et al., 2013; West et al., 2005; Worsham et al., 2015; Xue et al., 2016; Xue et al., 2015; Zhu et al., 2010).

We found major differences in the main effect of Word Valence in the three experiments. In the experiment described in Chapter II, participants were more accurate in negative, followed by positive and neutral word valence assessment, and were slower in neutral than in emotional word valence assessment. An explanation for these data can be related with emotional words' arousal ratings. Because we selected words on the basis of their valence ratings and did not control their arousal, we believe that the effects found could be due to the fact that negative words could have been more arousing than positive, which led to higher accuracy in negative word valence assessment. In the experiment described in Chapter III, participants were faster and more accurate in emotional compared to neutral word valence assessment. Given that all facial expressions were negative in this experiment, they could have had a facilitation effect in negative word valence assessment. However, there were no differences in accuracy between positive and negative word valence assessment. Since, in this experiment, we selected words based on their arousal and valence ratings, it is possible that the results found in the first experiment have in fact been influenced by negative arousal ratings. Nevertheless, these results are in line with studies of emotional word processing, which state that emotional words are more easily processed than neutral (Bayer et al., 2012; Citron, 2012; Herbert et al., 2006; Kissler et al., 2007; Kissler et al., 2009; Schacht & Sommer, 2009). Finally, in the experiment described in Chapter IV we did not find differences in accuracy, but rather in reaction times: participants were faster in positive compared to negative word valence evaluation, which confirmed results found by Stenberg et al. (1998), but seems to indicate less interference effects from negative facial expressions. Therefore, we need to look more closely into the differences found in each emotional block in order to draw meaningful conclusions.

Few significant effects were found in the sadness condition in all experiments. We found more accurate negative valence assessments in congruent stimuli – negative words superimposed on sad faces – compared to incongruent stimuli – negative words superimposed on happy and neutral faces, which can indicate a facilitation effect of sad faces in negative word valence assessment. Also in Chapter II, we found more accurate assessment of emotional compared to neutral words when happy faces were presented. This can point to higher interference effects from happy faces in neutral word valence, probably leading to a positive bias in neutral valence assessment. Overall, sad faces did not appear to interfere much with positive word valence assessment.

Congruency effects were found in the fear condition that indicate more accurate negative word valence evaluations when fearful faces were presented – congruent stimuli – compared to incongruent stimuli. Evidence from the Conflict SP are in line with these behavioural findings – higher mean amplitudes were found in the fear condition, elicited by negative word valence assessment of stimuli with happy faces – suggesting more conflict in incongruent trials. Moreover, positive word valence judgments were also more accurate in fear compared to other emotional conditions and WVA in general was more accurate in the fear than in the disgust condition. Reaction time analysis also revealed slower valence assessments for neutral than for emotional words. All these data seem to point to a facilitation effect of fearful faces in congruent negative WVA and to a lack of interference in positive WVA. The explanation for these effects may rely on the rapid processing of fearful expressions (Batty & Taylor, 2003; Eimer & Holmes, 2007; Méndez-Bértolo et al., 2016; Mogg et al., 2007; Öhman, 2005; Pourtois et al., 2004; Zhu & Luo, 2012). Accordingly, fearful faces could be recognized so fast that by the time conflict detection occurs, they have already been processed. Therefore, fearful faces may facilitate the processing of negative WVA and cease to interfere in positive WVA (Zhu & Luo, 2012). These effects were confirmed by ERP results: more negative mean amplitudes were found in the N450 time window for stimuli with happy compared to fearful expression, which suggests that when participants were asked to assess word valence in the fear block they suffered more interference effects from happy faces in negative word valence assessment – more emotional conflict – than from fearful faces in positive word valence assessment.

Behavioural results found for the explicit processing of disgusted faces were far more interesting than those found for the implicit processing of disgusted faces. We only found one significant result, described in Chapter III – a faster evaluation of positive compared to negative and neutral word valence assessment, similar to the main effect of Word Valence. However, EPN analysis showed more pronounced EPN amplitudes elicited by negative word valence assessment in congruent compared to incongruent trials in the disgust condition, which could point to a facilitation effect from disgusted faces on negative word valence assessment compared to happy faces.

Regarding the anger condition, and similar to what had been found in the sadness and disgust conditions, participants were faster and more accurate in emotional than in neutral word valence assessment. Additionally, the congruency effect found points to a facilitation effect of angry faces in negative compared to positive word valence assessment. Moreover, we did not find the positive valence advantage for word valence assessment described in Chapter IV for the anger condition, that is, in this condition, positive words were not assessed faster than negative words. Combined, these results suggest a facilitation effect of angry faces in negative WVA and an interference effect of those faces in positive WVA, since angry faces seemed to cancel the positive word valence advantage, slowing down participants' response.

NEUROTICISM

The differences between high and low neuroticism participants were only tested directly in Chapter IV, and significant effects were exclusive to the face valence assessment task in behavioural results. We found a tendency for more errors in face valence assessment in general for high compared to low neuroticism participants. This is an interesting result that points to more difficulties in categorizing face valence as positive or negative and perhaps suggests a general impairment in facial emotion recognition in the high neuroticism group. It might have reached statistical significance if more subjects were tested and/or the sample included participants with more extreme neuroticism scores.

High neuroticism participants also evaluated face valence in the disgust block slower than low neuroticism participants. Moreover, participants with low neuroticism assessed face valence slower in fear compared to disgust experimental blocks. In turn, high neuroticism participants judged face valence of stimuli in disgust blocks slower than in sadness blocks. Disgusted faces were the negative facial expression with better accuracy performance. Therefore, the differences found between high and low neuroticism participants may be related to more allocation of attentional resources in high versus low neuroticism participants. Disgusted faces are rarer in everyday life, have a unique facial configuration, and are arousing negative faces (Adolphs, 2002; Gerber et al., 2008; Stenberg et al., 1998). Therefore, they can capture more attention and high neuroticism participants may have even more difficulties in withdrawing attention from them than low neuroticism participants, leading to slower reaction times. This could also be the reason why high neuroticism participants took longer to evaluate face valence in disgust compared to sadness blocks. Additionally, the differences between high and low neuroticism participants can also be related with the interference of distracting words. That is, positive and negative words could generate more conflicting effects in disgusted and happy faces, respectively, in high compared to low neuroticism participants.

In the low neuroticism group, results showed slower reaction times in the fear than in the disgust condition. Since the only difference between both conditions was the negative facial expression presented and disgusted faces were more accurately assessed than fearful faces, we can argue that in the specific case of fearful expressions and in the low neuroticism group, participants could have had more difficulties in classifying fearful expressions as negative. That is, they could be more prone than high neuroticism participants (who did not show this effect) to mistake fearful with surprised faces – that can be either positive or negative (Adolphs, 2002). Even if they, at the end, correctly identified fearful faces as negative, the time this decision process requires could lead to higher reaction times.

Evidence from ERPs point to higher conflict in high neuroticism participants in the FVA task in anger and fear compared to sadness and disgust conditions. We found more negative EPN amplitudes in the sadness compared to the fear and anger conditions in the RH, and in the sadness and disgust compared to fear conditions. Low neuroticism participants are less affected by distractors (Wallace & Newman, 1998) and high neuroticism participants are more reactive to threatening stimuli – angry and fearful – because of the inherent threat they represent (Bradley et al., 1998; Oatley & Jenkins, 1996a, 1996b; Schupp et al., 2004), the fact that they have more evolutionary significance (Lin et al., 2015), and more arousal levels (Beall & Herbert, 2008; Gerber et al., 2008). Therefore, we suggest that angry and fearful faces can act as a prime on negative words, making them more influential in the processing of happy faces, thereby creating more conflict in high versus low neuroticism participants.

We also found evidence from the N450 analysis for more conflict and interference effects from positive words in sad faces valence assessment than from negative words in happy faces valence assessment in the sadness condition, but only in high neuroticism participants. This shows that, unlike low neuroticism participants, high neuroticism participants suffer more conflict in the sadness condition. Also related to the sadness condition, the Conflict SP analysis showed more interference effects from positive words in sad and angry facial assessment and less interference from negative words in happy face valence assessment, but only for high neuroticism participants. Because these results were only observed in the angry and sadness conditions, in addition to a greater interference from positive words, this can also indicate that, for high neuroticism participants, these two facial expressions were somehow more difficult to assess than fearful and disgusted faces.

All correlations described in Chapters II and III were observed in the WVA task and showed that, as neuroticism scores increased, participants were more accurate and faster in negative word valence assessment in congruent stimuli. This result could point to a facilitation effect of negative facial emotions in negative word valence assessment for high neuroticism participants, since neuroticism and related personality traits have been linked to a processing bias towards negative information and more sensitivity to negative cues in the environment, which tend to be considered as threatening (Berggren & Derakshan, 2013; Bradley et al., 1998; Bradley & Lang, 1999; Campanella et al., 2002; Canli, 2004; Cremers et al., 2010; De Pascalis et al., 2004; Fox, 2002; Fox & Zougkou, 2011; Gotlib et al., 1988; Mogg & Bradley, 1999; Mogg et al., 2007; Perlman et al., 2009; Rafienia et al., 2008; Richards et al., 2002; Richards et al., 1992; Rossignol et al., 2005; Stewart et al., 2005; Surcinelli et al., 2006). In Chapter IV we found evidence for this correlation in P1 analysis exclusively in the fear condition – more pronounced P1 amplitudes were elicited by congruent negative stimuli with fearful faces in high versus low neuroticism participants. Since P1 is linked to stimuli’s emotional salience, we believe that congruent negative stimuli coupled with fearful faces are arousing enough to elicit a stronger and faster response from high compared to low neuroticism participants. However, this effect is only possible because in the P1 time window fearful faces had already been discriminated from happy faces (Eimer & Holmes, 2007). That is probably why more positive P1 amplitudes were also found for stimuli with happy faces in low neuroticism participants.

Regarding ERPs, we found a tendency for less negative amplitudes in N170 for high compared to low neuroticism participants. The N170 had already been found to be an index of conflict, being more negative when faces are the target and less negative when words are the target (Baggott et al., 2010; Frühholz et al., 2011; Zhu et al., 2010). Together with this, our results could indicate that high neuroticism participants could be more prone to suffer conflict. These effects were also found particularly in fear and marginally in anger conditions – blocks with threatening faces. Since high neuroticism individuals are faster in detecting and processing negative faces (especially those that are threatening) and have more difficulties in withdrawing attention from them, they could suffer even more interference effects from threatening faces. Moreover, low neuroticism participants showed more negative N170 amplitudes in positive word valence assessment in fear compared to disgust conditions. Since the only difference between both conditions is the negative facial expression presented, we can infer that low neuroticism participants suffer less interference effects from fearful compared to disgusted faces when positive word valence assessment was required.

Two more correlations were found, which suggested that increased neuroticism ratings were associated with faster responses to neutral word valence assessment in stimuli with disgusted faces and with higher accuracy in positive word valence assessment of incongruent stimuli – positive words presented with negative and neutral faces. We were unable to reach a satisfactory explanation for the first correlation given all the available data. Individuals high in neuroticism often perceive ambiguous stimuli as more negative, since they have a negative processing bias; therefore, they could have perceived neutral words as more negative, leading to a faster neutral word valence assessment. However, only correct responses were used in reaction time analysis, that is, only neutral words evaluated as neutral were considered. As such, it would be vital to expand this analysis in the future in order to test for this hypothesis. Regarding the second correlation, we could not find any suitable explanation for the results found.

CONCLUSIONS

This work has contributed to a broader understanding of the influence of neuroticism on the emotional conflict between emotional faces and words. In the FVA task, participants had to explicitly evaluate faces while ignoring the words presented. We found a well documented superiority of happy face processing proving that happy faces are easily recognizable and identified as positive. With no surprise, congruency effects were also found in this task, proving the influence of implicit word processing.

Regarding the more interesting and innovative effects of emotional faces and words in the FVA task, in the sadness condition, sad faces were assessed more incorrectly compared to fearful and disgusted faces possibly due to the implicit processing of positive faces evidenced by EPN latency and N450 mean amplitude. Furthermore, neutral faces, in this condition, were also evaluated less accurately suggesting that they could have been mistaken by sad faces and, therefore classified as negative.

Fearful faces, on the other hand, were assessed more accurately than sad faces but less accurately than disgusted faces. The interesting result in this condition is the facilitation effect of the implicit processing of negative words that improved – higher accuracy – fearful facial recognition. However, as threatening and arousing, fearful faces captured more attention which led to slower valence assessment.

One of the most interesting findings of our study was the easier recognition of disgusted faces evidenced by higher accuracy ratings than other negative facial emotions and lower reaction times compared to fearful faces. Not only were they faster and more accurately assessed, as they seemed to resist the influence of distracting words, as suggested by the analysis of the N450 and the Conflict SP components that indicated more interference effects of negative words on happy faces in this emotional condition.

On the other hand, in the WVA task, participants were asked to judge word valence of stimuli presented with an emotional face. In order to perform this task successfully, they had to ignore information from the face. Similar to the FVA task, congruency effects were found and confirmed by Conflict SP and N450 mean amplitudes. Moreover, combining the results from the three experiments, we found slower but more accurate results for negative word valence assessment, regardless of the facial expression concomitantly presented. Regarding the implicit face processing, EPN results showed evidence for a more automatic processing of negative faces, and the results from the N450 and the Conflict SP for a facilitation effect of negative faces on negative word valence assessment and an interference effect of happy faces on negative word valence assessment, hence creating conflict.

Congruency effects were found in the fear condition, which point to a facilitation effect of fearful faces on negative WVA and a lack of interference effects on positive WVA, that is, the implicit processing of fearful faces is very fast, therefore it helps to indentify the valence of the presented word. However, because fearful faces are easily and more quickly recognized, they failed to create interference effects on positive WVA. These results were confirmed by N450 and Conflict SP mean amplitudes.

Very distinctive results were found regarding the effects from negative facial expressions in the WVA task. Although we found a congruency effect created by sad and disgusted expressions, it did not reach statistical significance, and as such these facial expressions did not seem to interfere with word valence evaluation. The congruency effect was only significant in the anger condition and pointed to more conflict interference effects in positive word valence assessment and also to a facilitation effect on negative word valence assessment.

Regarding the main goal of this work – study the role of the neuroticism trait on the processing of emotional conflict – we found evidence for interference effects in high neuroticism participants from the EPN, Conflict SP and N450 analysis. The EPN showed more conflict only in high neuroticism participants in sadness and disgust conditions than in fear and anger conditions, which have been related with the threatening and arousing nature of fear and angry faces compared to sad and disgusted faces. Moreover, the analysis of N450 and Conflict SP mean amplitudes also revealed conflict effects specifically in high neuroticism, related to anger and sadness conditions.

High neuroticism participants showed a tendency for more inaccurate responses to face valence assessment than low neuroticism participants which can indicate a tendency for facial emotion recognition impairments in the high versus low neuroticism group. Moreover, low neuroticism participants were faster than high neuroticism participants in face valence assessment of stimuli from the disgust condition; this can point to higher ability for recognizing disgusted, happy and neutral faces by low neuroticism participants.

Results from amplitude analysis of the N170 component were only found in the WVA task and showed a tendency for higher conflict experienced by high compared to low neuroticism participants in general, and specifically in fear, and marginally in anger conditions in the WVA task.

Neuroticism was also associated with more accurate and faster responses in negative word valence assessment in congruent stimuli pointing to a higher facilitation effect from negative faces' implicit processing on negative word valence assessment as neuroticism scores increased. Evidence for this effect was found in P1 amplitude but was limited to the fear condition. Nonetheless it suggests that negative congruent stimuli with fearful faces are more salient for high versus low neuroticism participants.

In relation to ERP components, P1 was the earliest ERP component analysed in this work and was modulated by stimuli's emotional valence and salience. In the FVA task, P1 was modulated essentially by the implicit processing of negative words, and in the WVA task P1 appears to be modulated explicitly by negative words and implicitly by fearful faces. In turn, the N170 was more negative and appeared earlier in the right compared to the left hemisphere, and was modulated by emotional conflict and neuroticism only in the word valence assessment task. We also found evidence for the "Valence Hypothesis" that states that the LH is specialized in processing positive emotions and the RH is specialized in processing negative emotions, since disgusted and fearful faces seemed to elicit an earlier N170 in the RH and happy faces in the LH. The EPN was modulated by neuroticism, explicit processing of face and word valence, and stimuli arousal. The N450 and the Conflict SP were modulated by emotional conflict and interference effects from emotional words and faces.

In science there is no complete or perfect work. Therefore, in our study we identified some limitations that need to be taken into consideration for future studies. The use of neutral faces and words can be interesting to analyse, especially if we want to study the negative bias in emotional processing, although we now believe that the introduction of neutral words in this study was not beneficial, particularly considering the fact that we were assessing reaction times, and if we only had two response options, participants might have been faster. Moreover, neutral words may have caused differential interference effects, which we were not able to explore or control. Additionally, emotional faces have different meanings, as do emotional words, that is, a negative word can be more congruent with a specific emotion than with another. For instance: the word “dead” can be perceived in different ways if presented along with a sad or with an angry face. Therefore, for future studies, we suggest that words should be selected on the basis of their valence, arousal and meaning. In the future, we should also try to control or analyse the sequence of the trials presented, as one trial might influence the way we perceive the next trial, as previously argued.

In short, our work highlighted some interesting and important effects regarding the influence of neuroticism on the processing of emotional conflict, its temporal dynamics and the influence of implicit processing of different facial expressions on word valence assessment as well as the implicit processing of emotional words in the valence assessment of different facial expressions.

CHAPTER VI: REFERENCES

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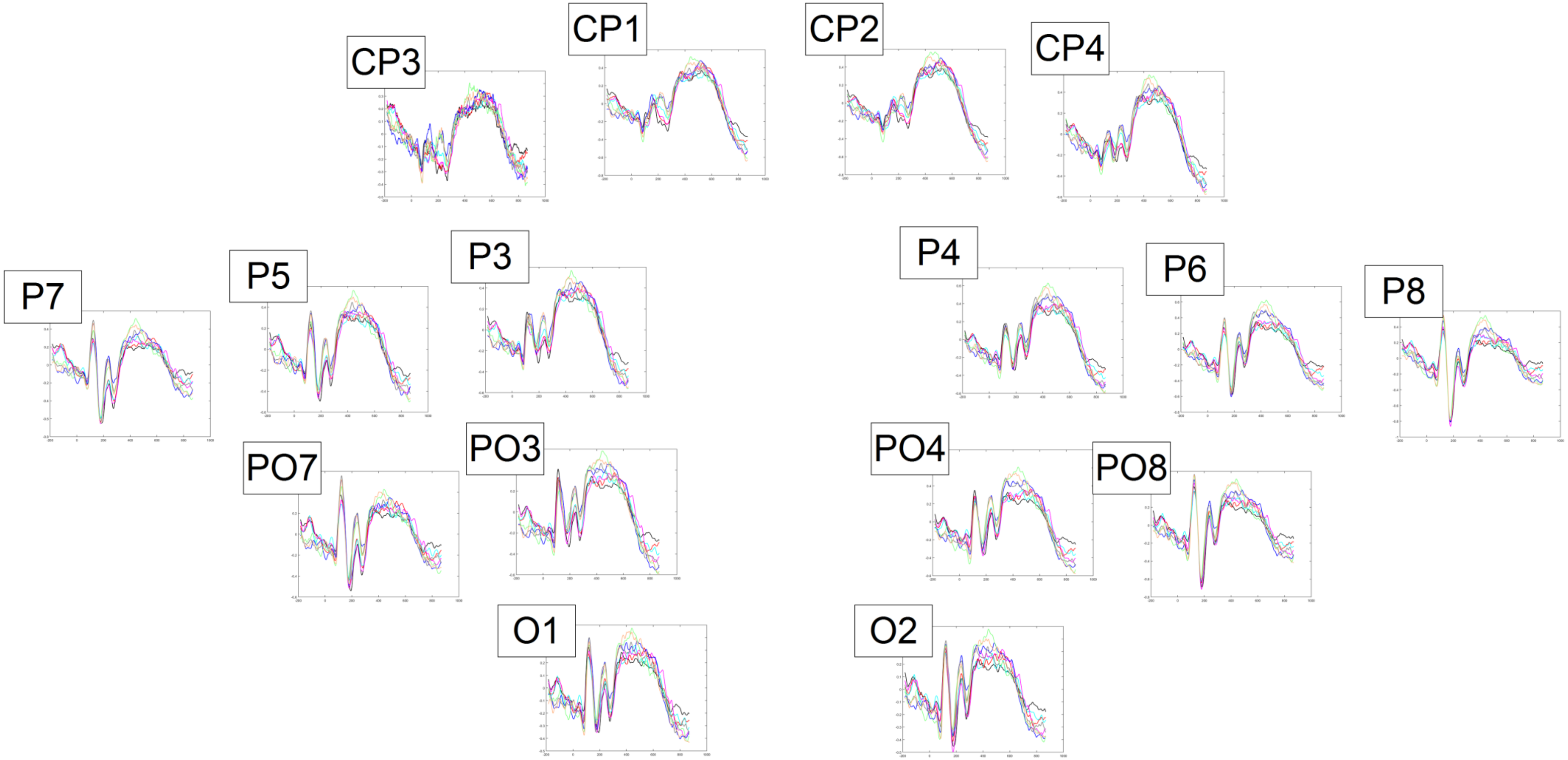
APPENDIX

Face Valence Assessement in the Anger Condition



Black lines: Low neuroticism group & Stimuli with positive words and positive faces;

Red lines: Low neuroticism group & Stimuli with positive words and negative faces;

Dark blue: Low neuroticism group & Stimuli with negative words and positive faces;

Pink lines: Low neuroticism group & Stimuli with negative words and negative faces.

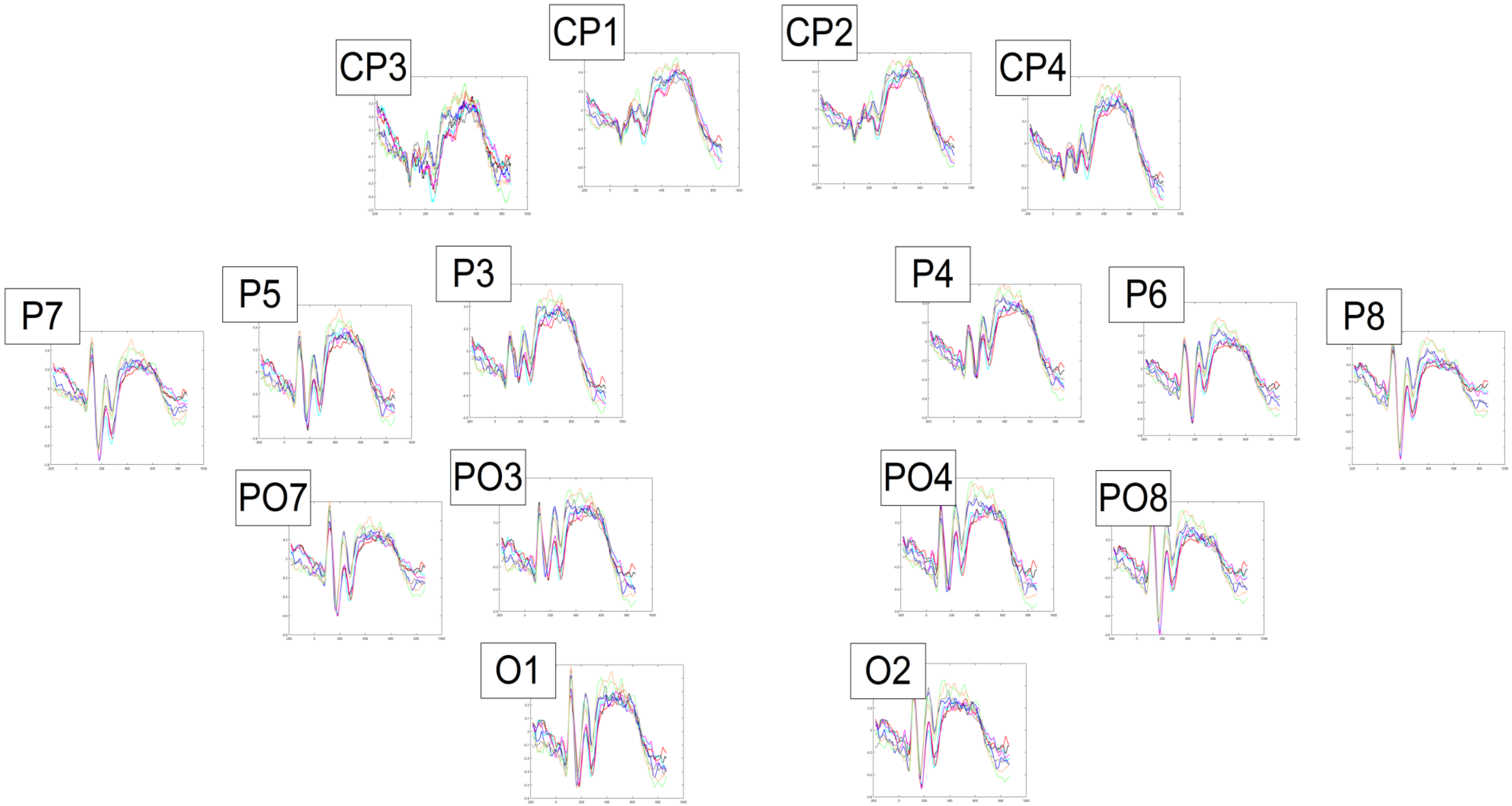
Light blue lines: High neuroticism group & Stimuli with positive words and positive faces;

Grey lines: High neuroticism group & Stimuli with positive words and negative faces;

Green lines: High neuroticism group & Stimuli with negative words and positive faces;

Orange lines: High neuroticism group & Stimuli with negative words and negative faces.

Face Valence Assessement in the Disgust Condition



Black lines: Low neuroticism group & Stimuli with positive words and positive faces;

Red lines: Low neuroticism group & Stimuli with positive words and negative faces;

Dark blue: Low neuroticism group & Stimuli with negative words and positive faces;

Pink lines: Low neuroticism group & Stimuli with negative words and negative faces.

Light blue lines: High neuroticism group & Stimuli with positive words and positive faces;

Grey lines: High neuroticism group & Stimuli with positive words and negative faces;

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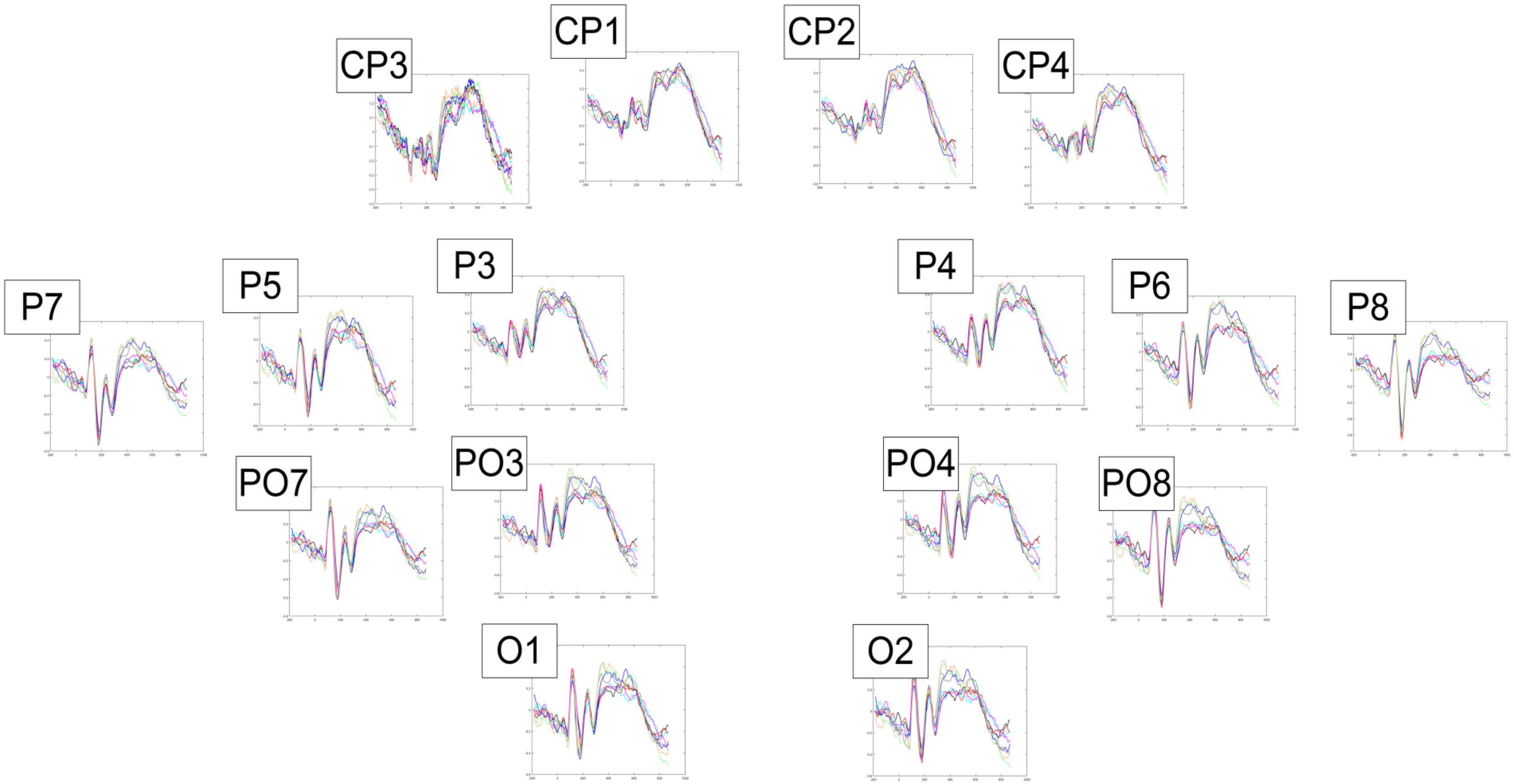
Orange lines: High neuroticism group & Stimuli with negative words and negative faces.

Face Valence Assessement in the Fear Condition



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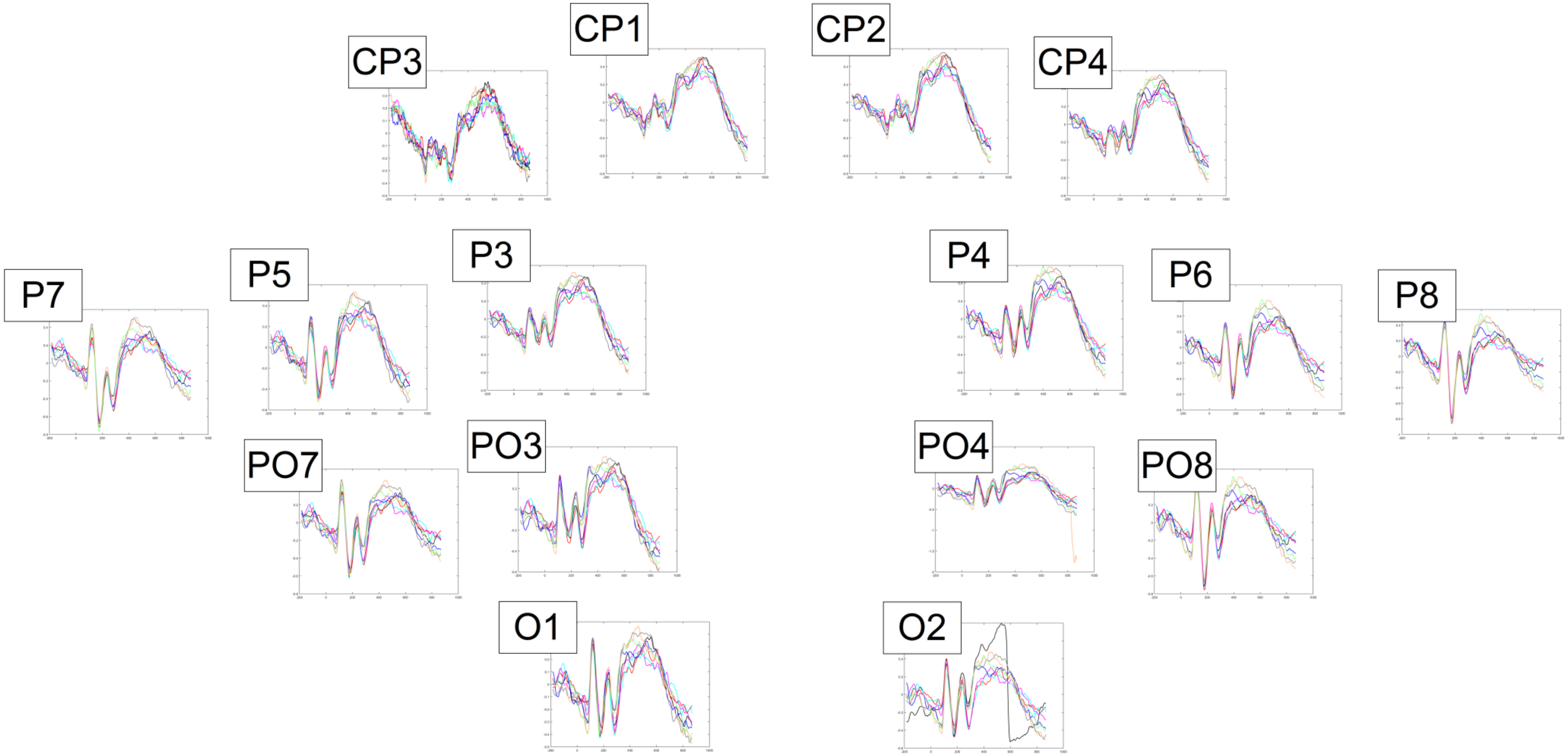
Grey lines: High neuroticism group & Stimuli with positive words and negative faces;

Green lines: High neuroticism group & Stimuli with negative words and positive faces;

Orange lines: High neuroticism group & Stimuli with negative words and negative faces.

Face Valence Assessement in the Sadness Condition



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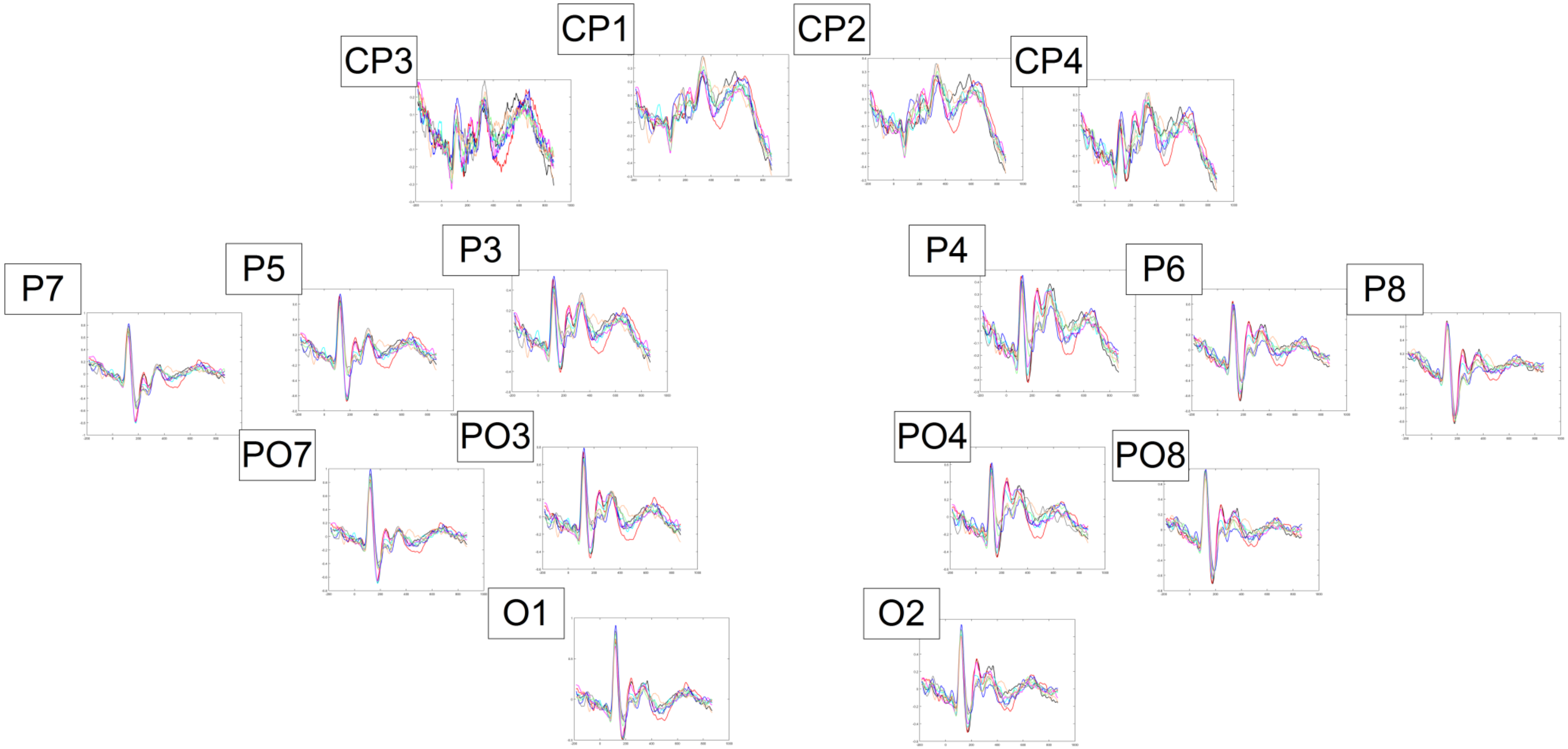
Orange lines: High neuroticism group & Stimuli with negative words and negative faces.

Word Valence Assessement in the Anger Condition



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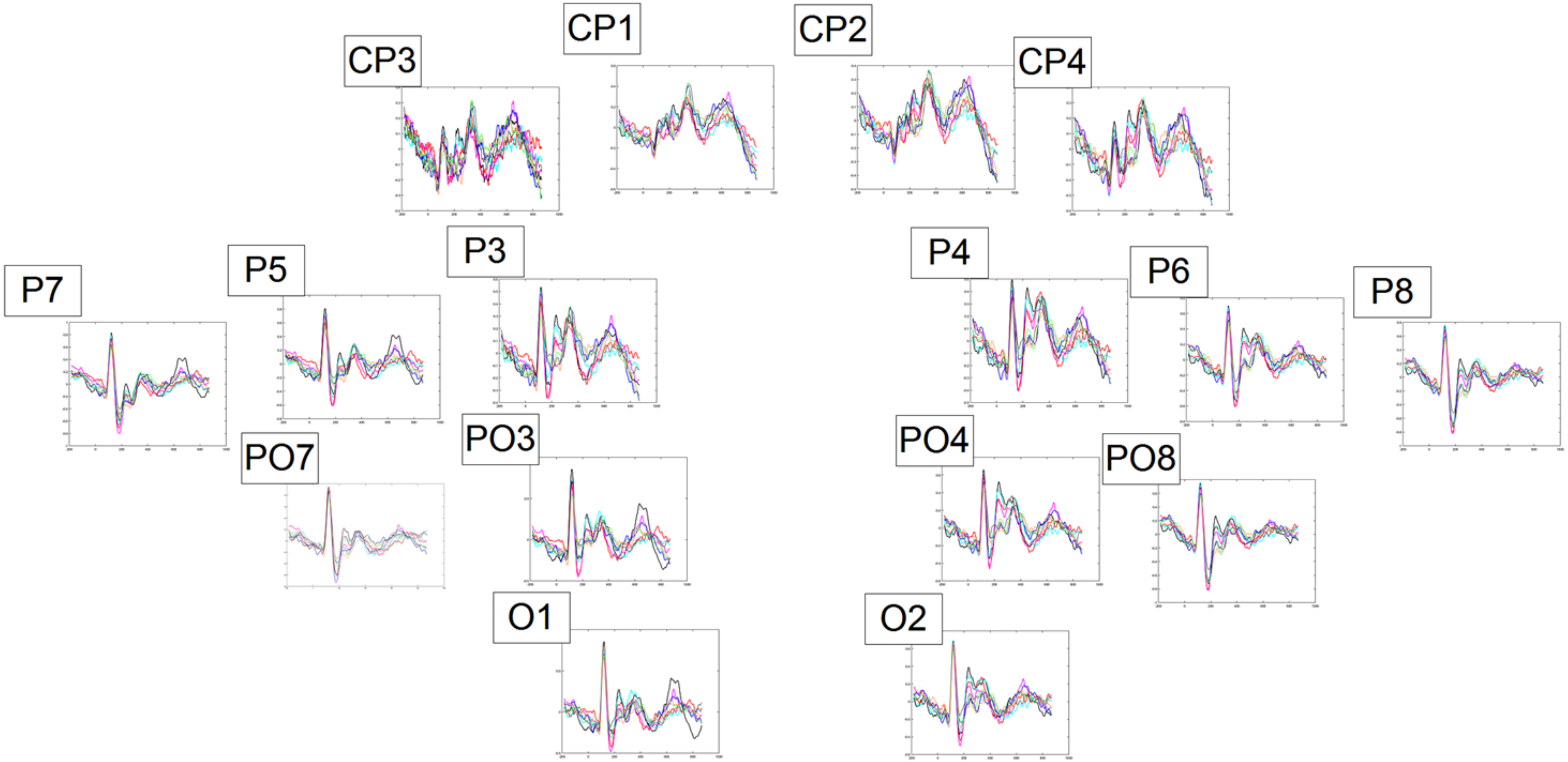
Word Valence Assessement in the Disgust Condition



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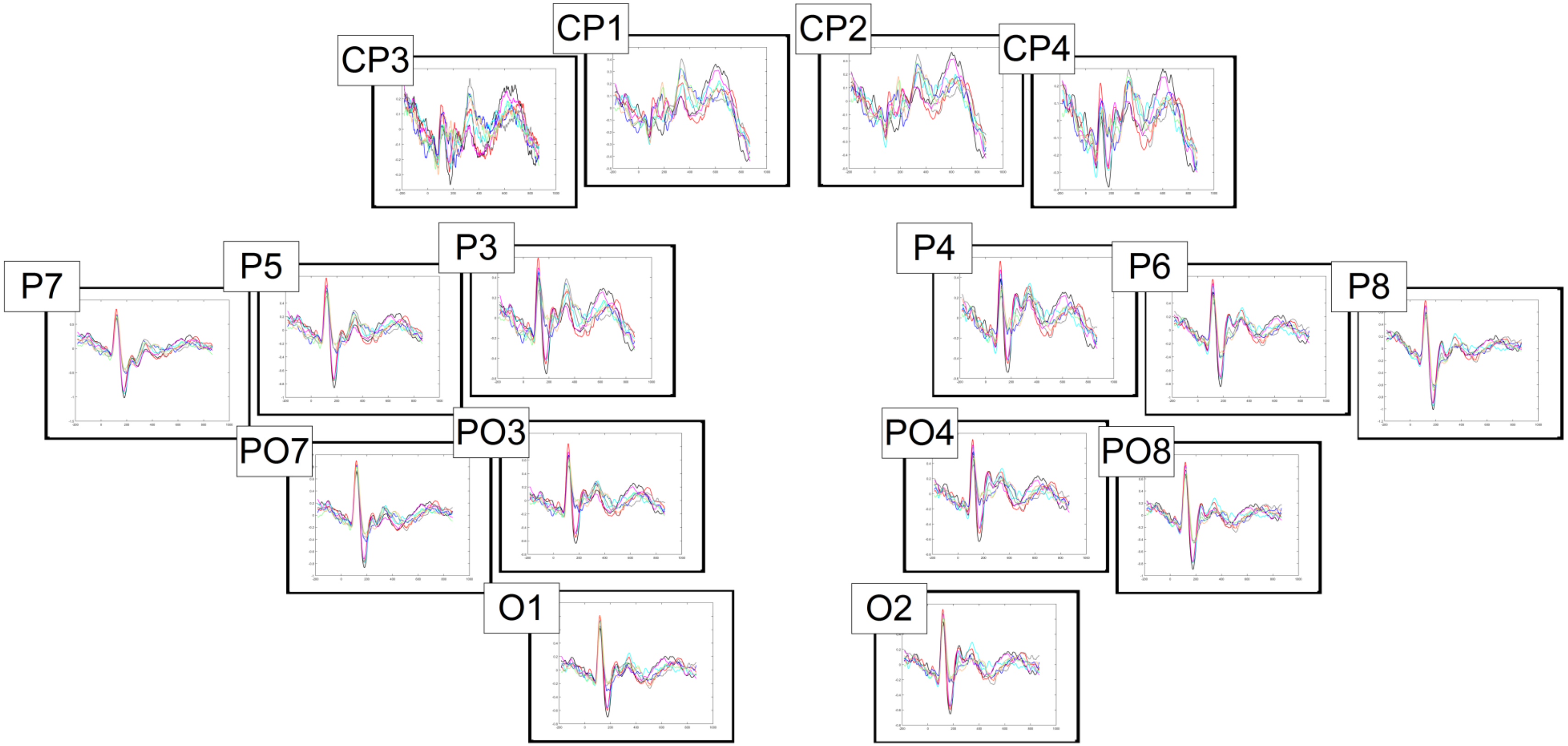
Green lines: High neuroticism group & Stimuli with negative words and positive faces;

Orange lines: High neuroticism group & Stimuli with negative words and negative faces

Word Valence Assessement in the Fear Condition



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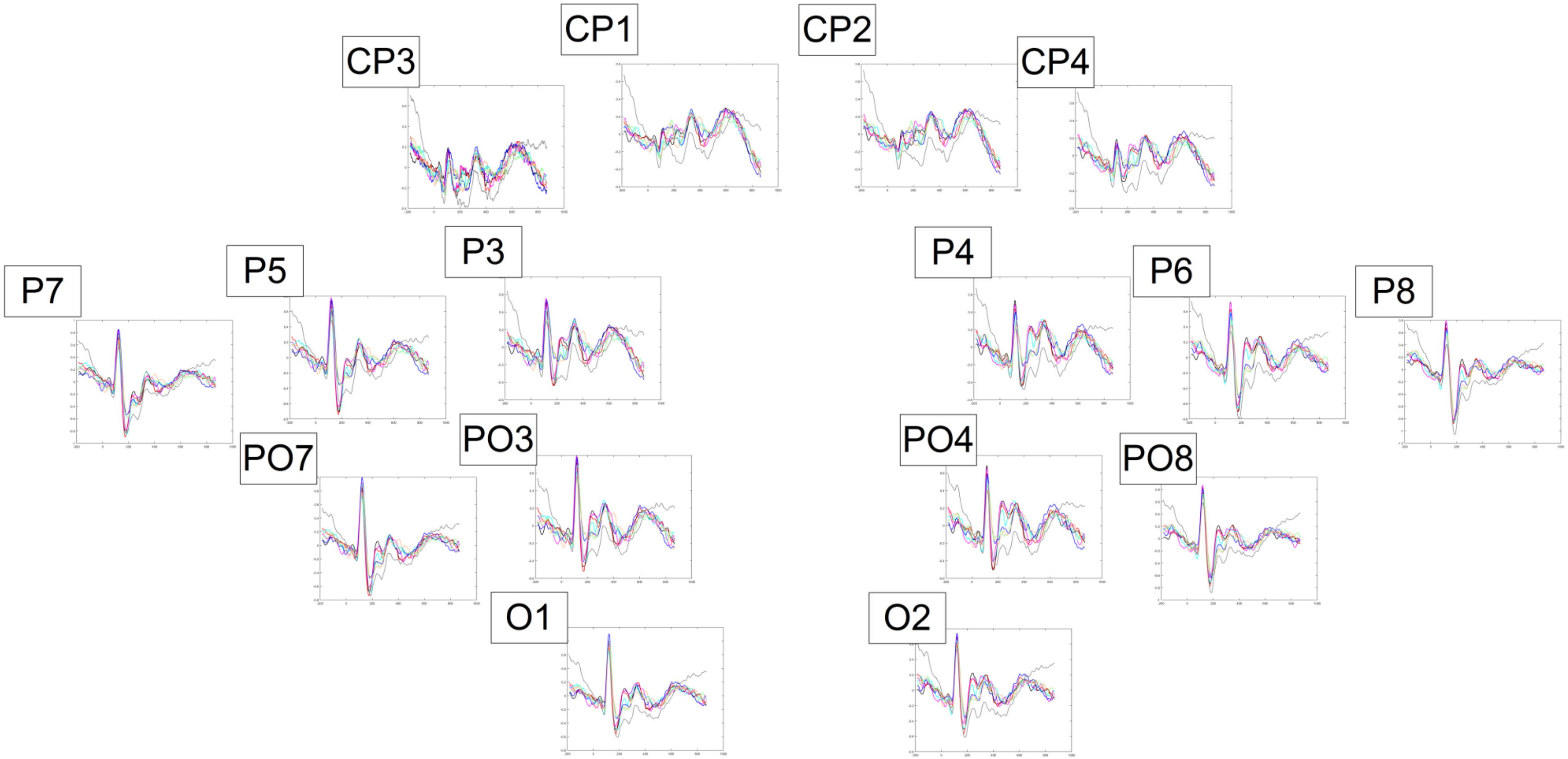
Orange lines: High neuroticism group & Stimuli with negative words and negative faces.

Word Valence Assessement in the Sadness Condition



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