NEURAL CORRELATES OF EMOTIONAL AROUSAL PROCESSING IN N200 AND P300 EVENT-RELATED POTENTIAL (ERP) COMPONENTS: A STUDY IN YOUNG ADULT MALAYSIAN

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by

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LIST OF SYMBOLS

nA	Nanoampere
%	Percentage
μv	Microvolt
1-β	Statistical Power
CI	Confidence Interval
df	Degree of Freedom
F	F-Statistic
Hz	Hertz
ms	Milisecond
N	Number
nA	Nanoampere
NS	Non Significant
P	P-Value
S	Significant
α	Alpha value; Significance level
X^2	Chi square
T	Test statistic
r	Effect size

LIST OF ABBREVIATIONS

Ag/AgCl	Silver/Silver Chloride
BA	Broadmann Area
Cz	Central Midline
EEG	Electroencephalography
ERP	Event-related potential
Fz	Frontal Midline
HCGSN	HydroCel Geodesic Sensor Net
IAPS	International Affective Picture System
LPP	Late Positive Potential
MEG	Magnetoencephologography
Oz	Occipital Midline
Pz	Parietal Midline
SPSS	Statistical Package for the Social Sciences
USM	Universiti Sains Malaysia

KORELASI NEURAL DALAM PROSES EMOSI KETERUJAAN KOMPONEN N200 DAN P300 *EVENT RELATED POTENTIAL*: SATU KAJIAN DI KALANGAN BELIA MUDA MALAYSIA

ABSTRAK

PENGENALAN: *Event-related potential (ERP)* adalah sangat sesuai bagi kajian proses kognitif yang merangkumi resolusi temporal tinggi sama seperti kajian pemprosesan regulasi emosi dalam keseluruhan bidang neurosains dan psikologi.

OBJEKTIF: Kajian ini bertujuan untuk menentukan perbezaan amplitud dan kependaman komponen N200 dan P300 ERP yang dicetuskan oleh kepelbagaian tahap rangsangan visual dan untuk mengenal pasti bahagian otak yang terlibat dalam pemprosesan emosi.

METODOLOGI: Seramai 30 peserta berumur antara 18-24 tahun dari Universiti Sains Malaysia, Kampus Kesihatan, Kubang Kerian, Kelantan telah mengambil bahagian dalam sesi *Event Related Potential* yang menggunakan 128 *HydroCel Geodesic Sensor Net* yang dijalankan di Makmal Neurosains, Universiti Sains Malaysia. Gambar-gambar dari *International Affective Picture System (IAPS)* telah digunakan sebagai rangsangan. Gambar-gambar telah dikelompokkan kepada tiga tahap keterujaan iaitu rendah, sederhana, dan tinggi berdasarkan nilai normative *IAPS*.

DAPATAN: Ujian bukan parametrik (ujian *Friedman*) menunjukkan perbezaan yang tidak signifikan bagi kesemua rangsangan keterujaan (rendah, tinggi dan sederhana) pada hampir semua amplitud dan kependaman di elektrod tengah (Fz, Cz, Pz, dan Oz) bagi N200 dan P300. Ini berbeza dengan kependaman pada Cz N200 yang menunjukkan perbezaan yang signifikan (x2 = 12. 940, df = 2, p = 0. 002). Analisis *Post Hoc* dengan menggunakan ujian *Wilcoxon* menunjukkan bahawa tiada perbezaan yang signifikan di antara kependaman rangsangan keterujaan rendah dan tinggi pada N200 Cz (z = -1. 78, p = 0. 075) atau di antara kependaman ransangan keterujaan sederhana dan tinggi pada N200 cz (z = -1. 190, p = 0. 234). Walau bagaimanapun, didapati bahawa rangsangan keterujaan rendah (peringkat min = 1. 53) ditanggapi lebih ketara terangsang (masa yang lebih pendek diambil) daripada rangsangan sederhana yang mempunyai kependaman yang lebih lama bagi elektrod Cz (peringkat min = 2. 45, t = 79, z = -2. 83, p = 0. 005). Tiada perbezaan bagi lokalisasi di antara kedua-dua komponen ERP N200 dan P300 yang didapati berada di lobus temporal tetapi dengan kawasan *Broadmann (BA)* yang terpisah. Selain itu, rangsangan rendah dan sederhana ditemui di BA 20 sementara rangsangan tinggi ditemui di BA 38.

KESIMPULAN: Rangsangan keterujaan rendah menunjukkan tindakbalas yang lebih tinggi berbanding dengan keterujaan sederhana dan keterujaan tinggi. Ini kerana ia merangkumi memori yang dikenali sebagai *Priming* bawah memori tersirat (aktiviti pengecaman). Sesetengah orang memerlukan rangsangan yang lebih tinggi, iaitu rangsangan yang akan memberikan inspirasi kepada mereka untuk mencari pengalaman-pengalaman yang santai dan menggembirakan. Individu lain mungkin melakukan yang terbaik pada tahap rangsangan rendah, dan mungkin bermotivasi untuk mencari tugasan yang menenangkan dan merangsang.

Kata Kunci: Rangsangan, ERP, IAPS, Malaysia, Golongan Belia Muda.

NEURAL CORRELATES OF EMOTIONAL AROUSAL PROCESSING IN N200 AND P300 EVENT-RELATED POTENTIAL (ERP) COMPONENTS: A STUDY IN MALAYSIAN YOUNG ADULTS

ABSTRACT

INTRODUCTION: The event-related potentials were ideally suited for the study of cognitive processes comprising high temporal resolution as it was for the study of the processing of emotional regulation in the whole of neuroscience and psychological field.

OBJECTIVE: This study aims to determine the difference of amplitude and latency of N200 and P300 ERP component as evoked by different levels of visual arousal stimulus and to identify which part of the brain was involved in emotion processing.

METHODOLOGY: A total of 30 participants between age of 18-24 years old participated for this cross-sectional study which were recruited from Universiti Sains Malaysia, Health Campus, Kubang Kerian, Kelantan. Affective visual stimuli were chosen randomly from the international affective picture system (IAPS) based on the normative value given and the pictures were grouped into 3 levels of arousal (low, moderate, and high). An event-related potential (ERP) recording using 128 HydroCel Geodesic Sensor Net was done on participants during the passive viewing of the affective visual stimuli.

RESULTS: A non-parametric test (Friedman test) indicated that all the midline electrodes (Fz, Cz, Pz, and Oz) were statistically not significant ($p>0.\ 05$) with regards to different arousal levels of affective visual stimuli (low, moderate, and high), except for electrode Cz N200 latency a statistically significant result was shown ($x2 = 12.\ 940$, $df = 2$, $p = 0.\ 002$). Hence, follow up post hoc analysis using the Wilcoxon signed-rank test (adjusted bonferroni α of 0. 017) results indicated that there was no statistically significant difference between N200 latency Cz low and Cz high (z = -1. 78, p = 0. 075) or between the Cz moderate and Cz high (z = -1. 190, p = 0. 234). However, Wilcoxon post hoc test indicated that the low arousal (mean rank = 1. 53) was perceived as significantly more aroused (shorter time were taken) than the moderate arousal, in which the latency was longer for Cz electrode (mean rank = 2. 45, t = 79, z = -2. 83, p = 0. 005). There were no differences for source localization between both N200 and P300 ERP components which was found to be located in the temporal lobe but with a separate Broadmann area (BA). In addition, low and moderate arousal was found in the BA 20 while high arousal was found in the BA 38.

CONCLUSION: Low arousal images display a higher stimulation compared to moderate and high images. This is because it includes memory that we call as priming under implicit memory (recognition task). Besides, we can say that different individuals respond differently to each situation, since the brain is still controlled. Some people will need a greater degree of stimulation, which would inspire them to look for relaxing and enjoyable experiences. Others may do best at low levels of arousal, and may feel motivated to look for calming and stimulating tasks.

Keywords: Arousal, ERP, IAPS, Malaysian, Young Adults.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this section, the paper will outline several key elements such as research background in a detailed way, followed by problem statement and study rationale, research questions, study purpose, hypothesis, and variable definitions before the conclusions of this chapter.

1.2 Research Background

Research on emotions are vital because emotions are important to human beings and play a significant role in human cognition which generally associated with rational decision making, perception, human interaction, and, to a certain degree, human intelligence itself (Suhaimi, Mountstephens & Teo, 2020). According to World Health Organization (2006) some believe that emotions, particularly among adolescence, often play a major role in young adults because it is a crucial and delicate brain formative phase, structural reorganization, cognitive maturation, and it may be a period in which a person undergoes colossal physical and psychological changes. In addition to that, the brain will experience growth and major brain development will occur, particularly in frontal lobes, especially in subcortical structures including basal ganglia, amygdala, hippocampus, and the main brain structure, which play an important role in mediating higher executive functions and emotion regulations, which is pre-frontal cortex, refer Figure 1-1 (Nyaradi, Li, Hickling, Foster, & Oddy, 2013).

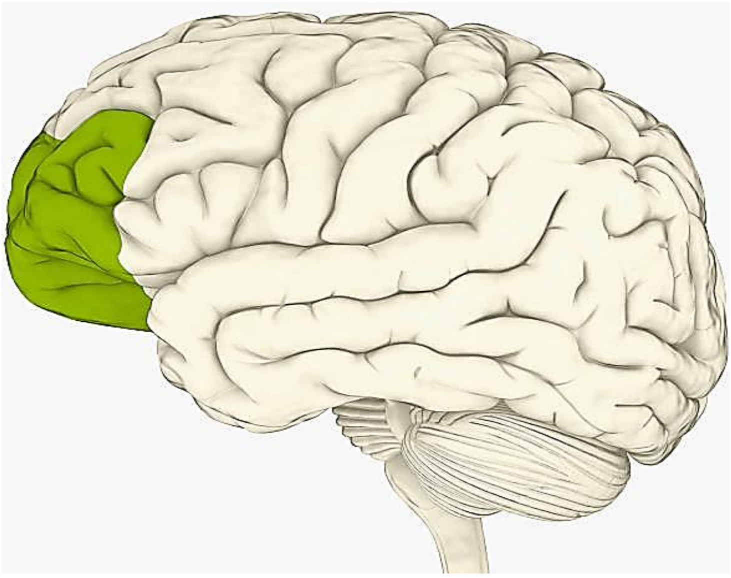

Figure 1-1 Colored part indicates the pre-frontal cortex of the brain

There's an expanding body of literature review (Russell, Lewicka, & Niit, 1989; Russell, 1980; Remington, Fabrigar & Visser, 2000; Jaeger et al. 2020) indicated that research on emotion has been influenced heavily by a theoretical model of basic emotions, named as “Circumplex Model of Affect” or also known as “Circumplex Model of Emotion” which was introduced by James Russell in 1980. Circumplex model of affect is a model that illustrates how different emotions are related, which is divided into four quadrants and a continuum that shows a visual relationship between different emotions (Russell, 1980). In the context of emotion research, usually most research has been reinforced by utilized visual stimuli from the International Affective Picture System (IAPS). IAPS is database of pictures for studying attention, emotion, neurological measurements and physiological (Bradley & Lang, 2007).

Also can supported with Yusoff, Reza, Anuar, & Ahmad (2020) where they defined IAPS as a database of pictures that has been widely used for studying attention and emotion as well as the pictures are able to evoke emotions. All the pictures are rated according to their valence category (unpleasant-to-pleasant) and arousal level (low-to-high) on a nine point scale, which this standardized stimulus set, are considered as the goal standard for the most Event-Related Potential (ERP) studies using an Electroencephalography (EEG) tool (Olofsson et al., 2008; Stange, 2017; Santaniello et al. 2018; Schindler & Bublatzky, 2020).

Researcher believes that both two orthogonal dimensions in circumplex model of affect which is valence and arousal can interpret emotions because according to (Kensinger & Corkin, 2004). Memory enhancement for valence develops to rely on controlled encoding process moderated by the prefrontal cortex-hippocampal while for arousal develop automatically and moderated by amygdala-hippocampal. This processing of affective data could be received by analyzing amplitude and the latency of ERP components (Rugg & Coles, 1995; Schindler & Bublatzky, 2020).

On the top of that, Posner (2005) also stated that many EEG studies suggested greater activation of the right frontal lobe are related to the experience of negatively valence emotions, meanwhile greater left frontal activation is linked to the experience of more positively valence emotions. Generally, individual with no major medical disorder like nerves disorder, cardiac or psychiatric disorder has a potential to remember incident with a high emotional impact better than incident without such an impact (Kensinger, 2004; Huntjens, 2015).

Posner et al. (2005) also did explained that the arousal dimension of the circumplex model of affect were applicable in understanding the patterns of other common psychiatric comorbidities such as attention-deficit/hyperactivity disorder (ADHD), bipolar disorder, and anxiety disorders. Studies found that ADHD, bipolar disorder, and anxiety disorder are all characterized by hyper-arousal which is consistent with the model. This claimed is also supported by Hepach et al. (2011) where he emphasized that emotion recognition is important in order to successfully engage in social interaction and many psychiatric disorders conditions share severe impairments in recognizing emotion.

Hence, this study aimed to explore on how our brain response to affective emotional stimuli because the cognitive functions like emotional processing can influence the visual attention span. Using an EEG device and administration of passive viewing visual stimuli were performed to record an ERP component in a Malaysian sample. Narrowing down, this study only emphasized on arousal domain from the circumplex model of affect which to see the effect of different levels of arousing visual stimulus on the process of Neuro-emotions in a Malaysian sample and also finding if there are any different in the localization with regards to different level of arousal pictures (low, moderate, high).

1.3 Problem Statement and Study Rationale (Justification)

As mentioned in the previous section, emotion studies are very crucial because it play an important role in how we behave and think (Domitrovich, 2017). The emotion that we feel everyday could influence the decision making in our life and it allows other people to understand us as emotion is not just our own feelings, but it give valuable info to others, as well as emotion play an important element of our daily lives interactions. This can be supported by Mayer, Salovey, & Caruso (2004) over the past years from 1990 to 2013, emotion regulation / mental control has been seen as an underlying focus in the whole of psychology and neuroscience (solid line) as per shown in Figure 1-2.

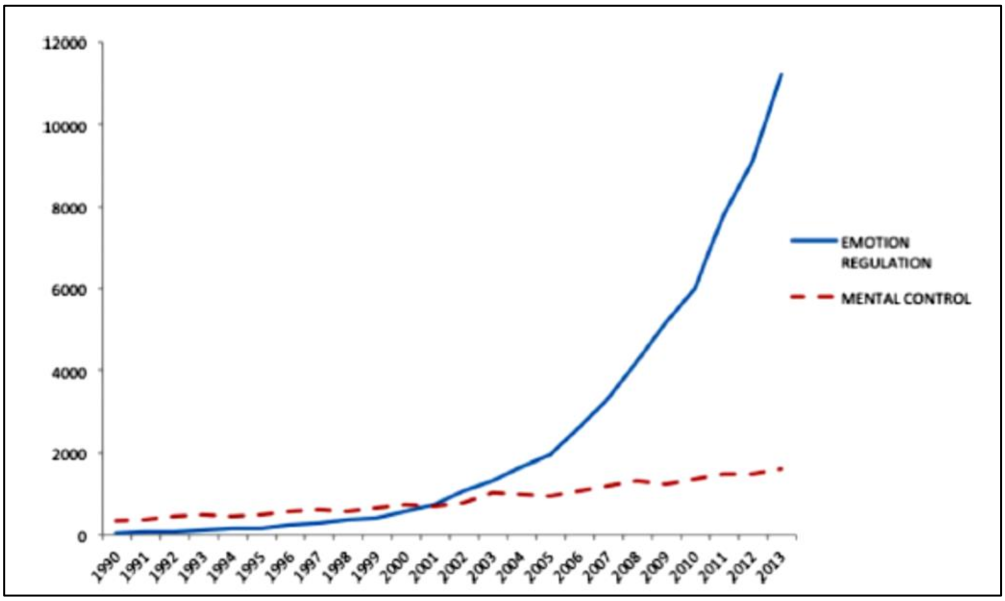

Figure 1-2 Emotion regulation citations (total of publications featuring the exact term "Emotion Regulation" in Google Scholar every year from 1990 to 2013).

Above finding paper support this present study because since biological and physiological of human body greatly connected with our patterns of thoughts, feelings and behaviors (personality mostly), it is timely to assess this factor and its influence on people's well-being and therefore, it is advantageous in studying the spatiotemporal features of the emotional effect as well as detecting abnormalities in the process of cognition.

Besides that, while there are many technologies that can be used to research affective reactions, the ERP approach still has a significant advantage over other modalities (Cona, 2015), and the transmission of emotions can be studied by measuring the amplitudes and latencies of the ERP components (Olofsson et al., 2008). In addition, this research focuses on the components of the N200 and P300 ERP, which tend to be closely related to cognitive processes of visual attention and perception.

Posner et al. (2005) stated that the circumplex effect model are consistent with many recent results from behavioral, cognitive neuroscience, neuroimaging, and developmental affect research, as well as providing new theoretical and empiric approaches to study the development of affective disorders along with the genetic and cognitive factors of central nervous system affective processing.

Researcher has also revealed that individuals have brain damage that impacts their tendency to recognize feelings, and that they also suppress the ability to make the right judgment (Rupp, 2017). This paper related to the present study as we can detect the changes in the amplitude and latency of ERP component especially at the occipital electrode if there are any damages to the brain structure as well as the recognition tendency of the participants.

This research is therefore important for the reasons set out above. The findings can be useful to understand the cognitive growth of the person as well as to ensure the well-being of the individual.

1.4 Research Questions

1. Is there a difference in amplitudes and latency of N200 ERP component on different levels of arousing visual stimulus?
2. Is there a difference in amplitudes and latency of P300 ERP component on different levels of arousing visual stimulus?
3. Which part of the brain involves in emotion processing and is there any different in the localization with regards to different levels of arousing visual stimulus?

1.5 Objectives of Study

1.5.1 General Objective

To study the effect of different levels of arousing visual stimulus on the process of Neuro-emotions in a Malaysian sample

1.5.2 Specific Objectives

1. To examine the difference of amplitude and latency of N200 ERP component as evoked by different levels of visual arousal stimulus
2. To examine the difference of amplitude and latency of P300 ERP component as evoked by different levels of visual arousal stimulus

3. To identify the source localization of N200 ERP component with regards to the different levels of visual arousal stimulus (low, moderate, and high)
4. To identify the source localization of P300 ERP component with regards to the different levels of visual arousal stimulus (low, moderate, and high)

1.6 Hypothesis

1. There is no significant difference in amplitudes and latency of N200 ERP component on different levels of arousing visual stimulus.
2. There is no significant difference in amplitudes and latency of P300 ERP component on different levels of arousing visual stimulus.
3. There is no difference in the source of localization of N200 and P300 ERP component with regards to the different levels of visual arousal stimulus (low, moderate, and high).

Justification, this study raises a questions whether the element of arousal (and its intensity) indicating a significant effect across the different type of arousal images as manifested by the ERP component. It is because there's need of high arousal pictures with more unpleasant valence to test the emotion evoked as previous studies is less influenced (not strong enough). Thus, to understand better understanding of ERP component, amplitude and latency of N200 and P300 is fundamental to study the effect of arousal level (low, moderate, high) by using the IAPS.

1.7 Operational Definition

This section describes several operational definition related to the important factor or that will be mentioned repeatedly throughout the paper which are circumplex model of affect, arousal, and ERP component.

1.7.1 Circumplex Model of Affect

Gurtman (2015) has declared circumplex model of affect as a theoretical model that intended to capture the postulated circular structure of specific domains of interest that illustrates how different emotions are related, which is divided into four quadrants and a continuum that shows a visual relationship between different emotions.

1.7.2 Arousal

Arousal indicates the degrees of feelings, where the emotions are higher include aggression and enthusiasm, and vulnerability includes exhaustion and tranquilly (Chang et al., 2019). In this study, arousal levels were defined based on the IAPS normative value as follow: 1-3 (low), 4-6 (moderate), and 7-9 (high) (Lang, Bradley, & Cuthbert, 2008).

1.7.3 ERP Component

ERP refers to particular events or stimuli, and the specific actions measured by the EEG may be extracted. Which it means the signal average over several trials leaves just the element of the response that is time-locked to the stimulus onset (Ding et al., 2017). In this study, the waveform that will be focus more is N200 and P300. N200 is a negative wave that peaks at about (200-400ms) post-stimulus and is typically detected at the anterior scalp site signaling the visual focus phase while

P300 is a positive on-going wave that peaks between (300-700ms) and implies the decision-making phase as well as visual attention (Wang, 2018; Okamoto, & Nakagawa, 2015).

1.8 Summary

In conclusion, this paper aimed to study on the differences in neuronal activity of different types of arousal level in the process of emotion by using ERP components and to identify which part of the brain involves in emotion processing and is there any different in the localization with regards to different level of arousal. Aspects of the study, such as research background, problem statement and study justification, research questions, study purpose, hypothesis, operational definition, have been clarified in depth in this chapter and will be covered in the following chapter on the literature review of previous research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

As mentioned earlier, emotions play an important role in how we act and think. The emotion that we feel every day could affect decision-making in our lives. Therefore, this chapter will include a concise overview of the following areas / elements of current study on emotions and cover a variety of studies of previous related research.

2.2 Circumplex Model of Affect

As discussed in previous section, the Circumplex Model is a model that illustrates how different emotions react to each other. The paradigm consists of four quadrants and a spectrum. The model offers a visual relationship between various forms of emotions. In 1980, James Russell developed the Circumplex Model of Affect or also known as the Circumplex Model of Feeling. On the horizontal axis (x-axis) of the model, there is a continuum between pleasant and unpleasant or valence, while the vertical axis (y-axis) is a continuum of high and low arousal, some referred to as activation and deactivation (Russell, 1980). The middle of the circle, on the other side, reflects a neutral valence and a medium excitement (Zhong, Qiao, & Zhang, 2019).

This model is common to test stimuli of emotion words, emotional facial expressions, and affective states (refer figure 2-1).

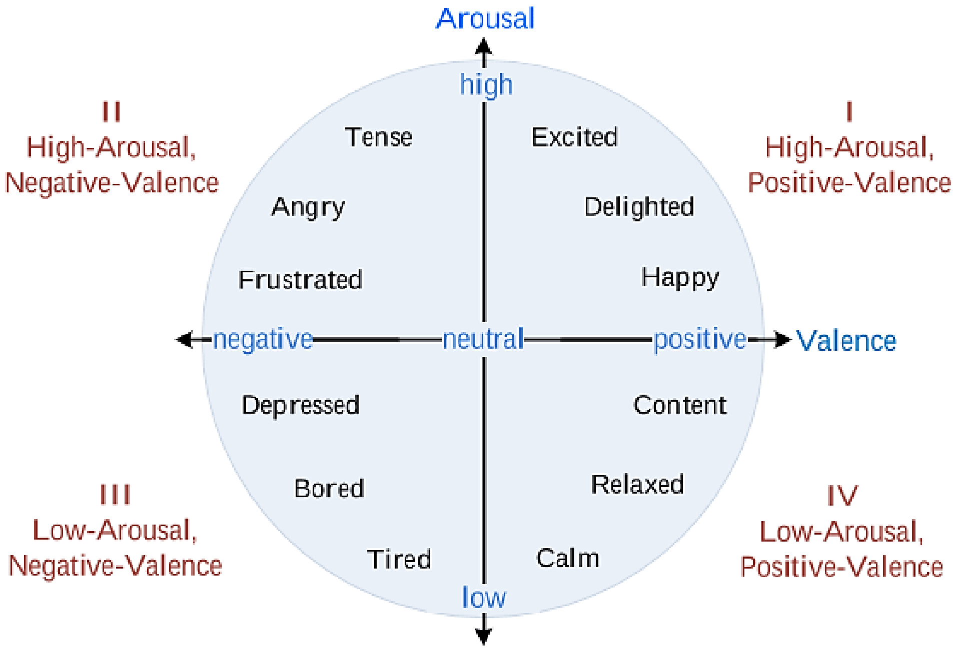

Figure 2-1 Schematic representation of circumplex model of affect (Liu et al., 2018)

The theory indicates that the affective indices are interconnected rather than independent and that they alter from one group to another due to their dynamic existence Ekman & Cordaro, 2011). It also explains people's emotional state by studying cognitive emotional interpretations based on what's going on around the person (Posner et al., 2005; Samuel et al., 2019). Circumplex model of affect has been commonly used in many areas such as electronics, marketing, communication (Teo et al., 2019; Van Der Spek, 2019; Loizou & Karageorghis, 2015) and not only in medical and psychological fields.

This paradigm serves as a critical platform for a study to perform a number of experiments and train themselves in the area of arousal and valence. For instance, Samuel et al. (2019) has performed a study using this model to investigate whether motorcycle rider emotions depend on the atmosphere and behavior. This was to describe potential emotional state riders who might find themselves in the way they dealt with the road environment. Finding reveals that feelings are evolving in organized and repetitive ways, based on the setting and what the rider is doing. The number of transitions takes place around inside a dominant state of relaxation.

Also in the field of marketing, there has been growing expectation that more favorable intense emotions to customer problems can contribute to good corporate results, such as improved market share by a result of increased loyalty, re-purchase and enhanced credibility. But much of the psychology studies on emotion did not apply specifically to the effects of consumption, but rather to greater life routines. Therefore, Darbyshire, Bell, & McDonald (2006) have undertaken a research to establish if one of the main hypotheses on emotional function, the circumplex model, is valid and coherent when applicable directly to the experience of consumption. The findings are significant, with the paradigm fully endorsed, and offer insight into the development and interaction of various emotional responses (e.g. happiness, great pleasure) that consumers will have to undergo with consumption.

Besides, according to (Posner et al, 2005) the circumplex affect model proposes that negative feelings originate from strongly interrelated behavior within the nervous system valence system. They are all located in the left part of the circumplex indicating unpleasant valence interactions. Different phases of arousal and different cognitive tests, considering previous experience and existing history, further distinguish these sensations of negative valence (Jacobs, 2020).

Adding to above statement, this model is consistent with many recent results from neurological, cognitive neuroscience, neuroimaging, and developmental impact research (Gu, 2019). In particular, the model also provides specific theoretical and scientific approaches for researching the emergence of affective disorders in combination with the genetic and cognitive influences of the central nervous system. The data collected from the models draw conclusions for preferred methods in the analysis and applications of the model in science continue to develop and to be improved (Posner et al, 2005).

Circumplex model of emotion is a multifunctional framework that can be broadly applicable, and many studies concentrate on the valence and arousal aspect. Therefore the present paper would only focus on the arousal context in order to connect with affective visual stimulation.

2.3 Affective Visual Stimuli and Emotion

In the context of emotion research, IAPS has been widely used to study the emotions. IAPS is a category of picture illustrated a wide range of subject matters. According to (Bradley & Lang (2007) IAPS is database of pictures for studying attention, emotion, neurological measurements and physiological. Arousal and valence are both a main way to decide the dimensional emotion model and are effective in understanding how people label their affective states (Barrett, 1998).Individuals with high arousal and low valence showed decreased co-occurrences between like-valence affective states. On the other hand, individuals with low arousal and high valance recorded significant co-occurrences between like-valence affective states (Barrett, 1998; Gallant, 2020).

Emotional study typically uses emotional facial expression as stimulus (Coll et al., 2019). Previous study suggested that visual pictures, such as facial expression, are essential to understanding the strength of emotion expression compared to still image (Biele & Grabowska, 2006). The study showed that males had better impact rates for vibrant images displaying frustration compared to static, but no variations were observed for vibrant and still images reflecting pleasure. But in the meantime, the female subject expressed large differences for both frustration and pleasure (Plass et al., 2020).

In yet another study it was observed that the greatest affective reaction was seen in both men and women, when viewing high arousal images, where women displayed a large aggressive sensitivity to aversive images, regardless of content, while increased enjoyable stimulation was observable to men only when viewing seductive images (Bradley et al, 2001; Wisman & Shrira, 2020).

Most emotional research has been done using by an ERP technique and has been utilized affective stimulus (IAPS) as a structured stimulus for attention and emotion analysis. For example, Rozenkrants (2008) did an oddball paradigm ERP analysis using high-low arousal and valence IAPS images, and this study has been performed for both male and female participants. Comparing high to low arousal stimuli, high arousal stimuli generated greater amplitude for ERP N200 and P300 ERP components.

As a result, they stated that the arousal intensity was the key determinant of oddball processing, although the valence did not really affect the ERP amplitude. Fenske & Raymond (2006) has stated that visual attention and emotion systems work together to evaluate thoughts and behaviors, and those emotional states will decide how visual attention is administered. This brings up an interesting question as to whether attention often influences emotional responses. Therefore, Fenske & Raymond (2006) believed that focus had a negative affective effect upon other pleasant visual features (abstract designs and unknown faces) that had to be avoided or otherwise disrupted during the execution of the task. The observation that selective attention has distinguished affective effects for visual information is a recent, structural insight of the relationship between the two major interest mechanisms of the human brain.

Psychologically speaking, emotions are the mental language of a person closely linked to the physical reaction rather than the sensibility of internal and external emotions (social interaction). It is a change of the subconscious that has been released by external forces (Fiske, 2020). The subconscious is passive and still accepts everything that comes in to affect it. When the mind rises to demonstrate what it looks like, that's what emotion means. Yusoff, Reza, Anuar, & Ahmad (2020) claimed that, most fundamental emotion is that emotion can be applied in a destructive or positive category, unconstrained emotion purpose, distinctive subjective perception, distinctive feelings, memories and images, unbidden occurrence, can be short-lived, capable of rapid onset, appearance in other primates, and distinctive occurrence.

Therefore, we can justify that emotion has a major impact on decision-making and generates important knowledge to help us understand how we feel and how to react to all circumstances (Weurlander, 2019). Visual stimuli will reflect our spontaneous reactions to what we typically feel or to remember some specific incident. We will perceive our own assumption of what our personality is like from visual stimuli. Consequently, this is one of the explanations for this research

2.4 ERP Component of N200 and P300

ERP are time-locked and averaged fluctuations which represent a neural process in EEG include visual / attention processes and emotional arousal indices (Usler et al., 2020). The ERP consists of a sequence of peaks and referred as ERP components. The names of these components also indicate their voltage amplitude (P for positive, N for negative voltage), refer Figure 2-2. Each ERP component is often defined as a specific information processing task. Commonly, the latency at each ERP component peak is assumed to measure the time at which these operations have been performed, whereas the amplitude of the ERP component shows the frequency to which such processes are engaged in the stimulus event (Fabiani et al., 2007; Ghani et al., 2020).

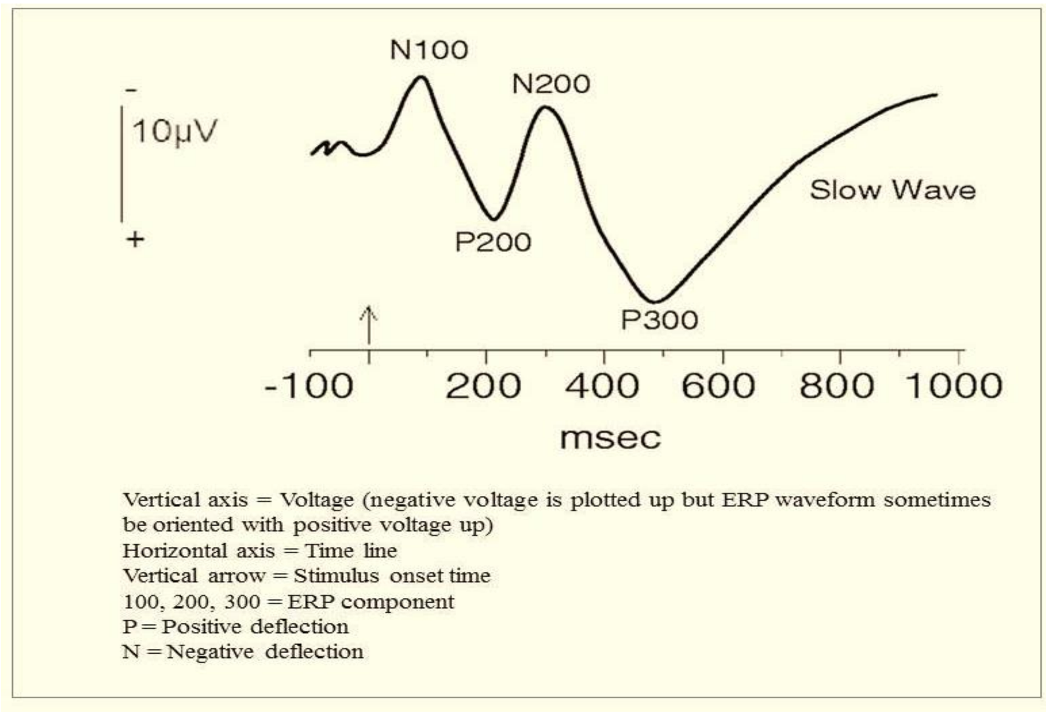

Figure 2-2 Schematic of ERP waveform

In most emotional research, ERP has been used mostly since it focuses on cognitive functions like attention, vocabulary, and perception. Narrowing down, the N200 and P300 components have been extensively studied as they deflect both visual and auditory focus. This can be supported by Patel & Azzam (2005) and Ghani et al. (2020) two components of the ERP that are of particular significance for stimulus analysis, visual processing and cognitive perception in humans are P300 positivity and N200 negativity, occurring at 300ms and 200ms post-stimulus.

Patel & Azzam (2005) claimed that, the N200 sub-area is divided into three parts in repeated stimulus presentation. First, the N2a is an anterior cortical distribution evoked either by conscious exposure to or by avoiding a deviating stimulus. Second, the N2b is a central cortical distribution negativity shown only during conscious stimulus attention and the last part is N2c appears posteriorly and internally during categorizing.

P300 latency is also used to calculate the rate of stimulus detection as it is (Siripornpanich, 2020). Encoding the process time it takes before the extraction of the response. P300 Latency is also a critical period variable in neural activity that provides the key to attention allocation processes and immediate memory (Hassan et al., 2016). Similarly, Conroy & Polich (2007) reported that the affective processing affects the P300 ERP even though the stimulus arousal level is regulated. These results were found mainly at frontal recording sites and tended to be peculiar to the valence hemisphere.

P300 also tends to be involved not only in working memory functions, but can also associate with (N200b) N2b in the regulation of motor response to external stimuli cues. Using the "GO/NOGO" method, requiring participants to recognize targets with either a motor task or a stimulation of activity, is therefore possible to explore the processes underlying with voluntary movement (Patel & Azzam, 2005). Adding with those, Balconi, & Lucchiari (2007) conducted a study where they decided to assess if facial expression recognition is distinguished by specific ERP associations and if the consciously and unconsciously processing of emotional facial stimuli is qualitatively different from the processes where N200 and P300 ERP component has been focused in terms of peak amplitude and latency differences. Results indicate that unconscious stimulation induced more delayed peak difference than conscious stimulation does.

A more posterior distribution of the ERP was also observed for N200 as a feature of the emotional content of the stimulus. Also on contrast, prefrontal lateralization (right/left) was not associated with conscious/unconscious stimulus (Vernet, 2019). Many agree that ERP has several benefits and it is strongly recommended to use this method when studying emotion and visual attention as ERP direct measure of neural activity with a very high spatial and temporal resolution. Similarly, Sanger & Dorjee (2015) discovered the advantages of the ERP technique in neurodevelopmental scientific research. It is suggested that research using validated experimental tasks targeting ERP components such as N200 and P300 can elucidate the developmental changes in adolescence brain neural plasticity caused by mindfulness practices, as well as the recognition of early mechanisms for human brain.

2.5 Studies on ERP and Arousal

Emotional processing can be explored using visual stimuli and as described in the previous section, ERP has been commonly used to investigate both relationships and each ERP component may represent different cognitive processing (Zhang, 2019). An ERP analysis was initiated during the visual discrimination experiment, which again was studied on N300 and P300. The emotional intensity is defined by two indicators, arousal (relaxing / activating) and valence (attractive / repulsive). Findings showed that P300 did not exhibit greater amplitudes in response to emotional stimuli than to neutral (building) images, while N300 showed greater amplitudes in response to naked images at parietal areas (Carretie, 1997; Ziogas, 2020).

But the dissimilar result showed by Zhao et al. (2019) where larger P300 amplitudes was found when the faces were linked to positive and negative images compared to neutral images during the experiment using the Go/Nogo task that indicated inhibition of the response, which was influenced by the arousal elicited by emotional stimuli. In addition, larger P300 amplitudes were also found in negative images compared to neutral and positive images (Bai et al., 2019).

According to Lithari et al. (2010) females reacted with increased negative components (N100 and N200) compared to males, particularly for unpleasant visual stimuli, while both males and females reacted more quickly to high arousal or unpleasant stimuli. Narrowing, high arousing stimuli are cognitively implemented during visual perception for all genders and high arousing stimuli elicit larger ERP amplitudes in women compared to males. Similarly, female displayed a high defensive response to aversive images, despite of particular content, while increased enticing activation was observable to male only when viewing lusty images (Bradley et al, 2001).

Affective stimulus factors generally modulate the amplitude of the ERP component with no alteration found in peak latency, which is reliably encountered and occurs at longer latencies (Shukla et al., 2020). Predominantly, unpleasant images occur at earlier components (<300ms), whereas images with presumed intrinsic motivational concern occur at later components (>300ms) with task-induced differences that result in emotional reactivity (Olofsson et al., 2008).

In specific psychiatric diagnoses, a number of different in early to mid neuroelectric traits tend to be pathological which frequently revealing findings of P300 defects. For the more timed event, the average P300 amplitude was lower and latency was shorter (Jung, 2011). This supported by Campanella et al. (2002) which in some pathological conditions, altered P300 measures are plausible findings, such as temporal dysregulation, short-term memory and cognitive triggered by frontal lobe impairment.

In addition, a study was undertaken to investigate the association between ERP interference and posttraumatic stress disorder (PTSD) clusters using an auditory oddball task. The result reveals that the N200 and P300 components in PTSD have been impaired, indicating impairments in stimulus discrimination and attention. The result that numbing has been associated with decreased attention processing (P300) is compatible with models that have an interaction between impaired arousal and attention in PTSD clusters (Felmingham et al. 2002).

Besides, P300 amplitude is believed to responsive to the affective image where in the presence of stimulus arousal alterations, it showed greater amplitude at frontal areas and that stimulus color leads to the effects of ERP valence. However the research had been using a different method where instead of emotional visual stimulation, they used the IAPS visual images (Cano, Class, & Polich, 2009). Meanwhile, occipital region found to be recorded the largest N200 amplitudes during visual stimuli task such as written words task, images of objects (abstract) or human emotion faces, which regulates the variance of the N200 (Hassan et al., 2016).

Also in order to identify which part of the brain involves in emotion processing with regards to different level of arousal, summarization on literature review has been shown in Table 2-1. Basically, for all components of ERP especially for N200 and P300, source localization can be found in the same lobe either occipital or temporal. So, all the summarize studies above shows finding at different brain structure during affective visual stimuli while valence and arousal on neural activation during visual processing of images found that anterior temporal areas and extrastriate visual cortical were independently activated by emotional attention. All those brain structure finding usually activated by the vision stimulus or visual fixation and plays an important role/part in emotion studies.

Table 2-1 Findings on source of localization of affective visual stimuli

Author	Study Focuses	Finding	Brain Regions Involved
Balconi & Vanutelli (2016)	Audio and visual stimulus, congruence and lateralization influence brain oscillations in the intercultural between positive and negative emotional experiences.	Lateral right dorsolateral prefrontal cortex (DLPFC) activation in response to disruptive and incongruous intercultural experiences.	Right Dorsolateral Prefrontal Cortex (DLPFC)
Bradley et al. (2003)	Activation of the visual cortex in motivated attention.	Occipital cortex was more extensive when participants view pictures strongly related to primary motive states (i.e., victims of violent death, viewer-directed threat, and erotica).	Occipital Cortex
Carretie et al. (2001)	Cues showing the stimulus type comparing the stimulus to the schematic cues	Largest valence effect found at temporal lobe	Temporal Lobe
Carretie et al. (2003)	Habituation to cued affective stimuli	Interaction affect found at frontal sites.	Frontal Lobe
Carretie et al. (2006)	Non-emotional categorization viewing and analyzing	High arousing in visual association cortex and prefrontal-cortex	Visual Association Cortex Prefrontal-Cortex
Davidson & Fox (1982)	Ten-month-old infants viewed videotape segments of an actress spontaneously generating a happy or sad facial expression.	Showed greater activation of the left frontal than of the right frontal area in response to the happy segments	Left Frontal Area
Gao, weber, & shinkareva (2019)	The brain structure for audio-visual affective processing: results from a co-ordinated activation risk prediction meta-analysis	Identified audio-visual emotional processing network, comprising the right posterior superior temporal gyrus, left anterior superior temporal gyrus, right amygdala, and thalamus.	Right posterior superior temporal gyrus, left anterior superior temporal gyrus, right amygdala, and thalamus

Inman et al. (2018)	Human amygdala activation influence over mental physiology and emotion	The activation of amygdala triggered subjective feelings of fear and anxiety, followed by irregular heartbeat.	Amygdala
Sabatinelli et al. (2007)	ERP passive viewing (IAPS)	High arousing (hemodynamic activity) occipital, parietal & temporal lobes	Occipital, Parietal & Temporal Lobes
Schupp et al. (2003)	Task- viewing unrelated affective images	High arousing at occipital-temporal	Occipital-Temporal
Simola et al. (2015)	Sensitive detection in natural visualization: Valence and arousal experiences in eye-fixing-related potentials	Over through the central site, stronger responses were seen for high versus low arousing images in uncomfortable situations, while the parietal LPP responses at 400–500 ms post-fixation were improved for stimuli representing congruent stimulus proportions, which are stronger responses for high versus low arousing images.	Central brain and parietal lobe
Vuilleumier (2015)	Identifying and analyzing emotional bias in perception and attention in people with psychiatric disorders which including phobias, depression, and addiction	Recognition and attention to emotionally arousing information with either negative (threatening) or positive (rewarding) links in visual attention and saccade regulation through subcortical following specific visual areas with basal ganglia and superior colliculus.	Basal ganglia and superior colliculus