P300 and decision-making in neuromarketing

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Abstract: Neuromarketing provides insights into consumers' decision-making that traditional marketing test methods cannot offer. The foundation in the process of decision-making is P300. Thus, the P300 wave is a potential Event-Related Component (ERP) used to measure consumers' decision-making process. The P300 wave represents a positive transition in human event-related potential. Therefore, the P300 is determined by measuring the amplitude and latency of the consumers. A higher P300 amplitude indicates greater confidence in the decision-making process, while a longer P300 latency indicates lower attentiveness. Thus, P300 in neuroscience, which investigates customers' responses in-depth, cannot be accomplished by typical marketing methods. For many years, P300 components such as attitudes, preferences, and information-based decision-making have been examined extensively in marketing-related research. However, a review of an ERP in neuromarketing method is fewer reported. This mini-review describes some analysis on P300 and decision-making by several researchers.

Keywords: Neuromarketing; P300 amplitude; marketing; decision-making;

1.0 INTRODUCTION

Neuromarketing is a study area that combines neuroscience principles and conventional marketing research ideas to assess how customers' decisions process responds to marketing stimuli. Neuromarketing employs cognitive behavioural activities to understand consumers' subconscious mind, explain consumers' preferences, motivations, and expectations, and predict consumers' behaviour (Bercea, 2011; Colaferro & Crescitelli, 2014; Dapkevičius & Melnikas, 2009; Fugate, 2007). To achieve these objectives, neuromarketers use a wide range of neuromarketing techniques and technology to measure neurological brain activity. For example, neuromarketing tools such as, Functional Magnetic Resonance Imaging (fMRI),

Electroencephalography (EEG), and eye-tracking are capable of analysing consumers' decision-making process in detail (Roth, 2014; Zurawicki, 2010). This is because neuromarketing is very significant for quantifying and recording consumer decision-making, cognitive and emotional processes towards marketing campaigns (Alsharif et al., 2021). These neuromarketing tools can help researchers and marketers develop effective approaches and provide innovative and efficient services to consumers. Thus, the results gathered from neuromarketing tools should generously provide insights into consumers' decision-making that traditional marketing test methods cannot offer. Neuromarketing can reveal what is happening in the brain in response to some advertising stimuli and the

application of neuromarketing can reveal which strategy leads to the buying decision (Zito et al., 2021). This innovative idea offers new perspectives and effective tools in marketing research, particularly in consumer analysis (Mansor & Isa, 2020).

Detailed research of a neuromarketing method is fewer reported, such as Event Related Potential (ERP). As a result, this paper provides a review format for one of the neuromarketing components, ERP. ERP is a specific technique that uses time-locked activity, i.e. brainwave responses triggered by stimuli to help capture sensory and cognitive-related neural activity, which is strongly associated with the decision-making process. These attributes of the ERP can be used as dependent variables in consumers' decision-making processes, according to Johnson and Donchin (1982). The P300, also called the "P3" wave, is an ERP component foundation in the process of decision making. P300 correlated to the decision-making process when subjects are required to decide stimuli (Pirtošek et al., 2009; Wang et al., 2015).

2.0 P300 AND DECISION MAKING

The event-related potential (ERP) is used to record a brain signal as it is a non-invasive and risk-free method during auditory and visual stimulus (Key et al., 2005). According to Begum & Reza (2021), ERP responses are divided into 2; early wave (first 100 ms after stimulation) and late wave (after 100 ms after stimulus) can be recorded during ERP study. To measure consumers' decision-making, P300 is the main component of brainwaves, a basis in decision-making (Luck, 2005), and the catalyst for the brain to process incoming information. For many years, P300 components such as attitudes, preferences, and information-based decision-making have been studied in marketing-related fields (Lin et al., 2018).

The P300 component is characterised by its amplitude (size) and latency (timing). Amplitude (μV) is defined as the voltage difference between the component peak, and the pre-stimulus baseline, whereas latency (ms) is defined as the time from stimulus onset (Mayaud et al., 2013). In the present study, P300 components were collected from participants who responded to stimuli on a computer screen. Respondents' brainwaves were subsequently recorded with EEG (Berry, 2011). P300 occurred around 300 milliseconds and 600 milliseconds after respondents had produced a simple task (Bledowski, 2004; Harris et al., 2018; Horlings et al., 2008; Jongsma et al., 2013; Pirtošek et al., 2009; Powers et al., 2015). The component P300 was calculated by

assessing amplitude and latency (Sowndhararajan et al., 2018).

The higher P300 amplitude was positively linked with confidence in the decision-making process (Pirtošek et al., 2009). In fact, Luck (2005) argued in favour of this position because when respondents put more effort into a task, the amplitude of P300 was higher. Consequently, higher amplitudes of P300 components reflected higher awareness. Using EEG methods, researchers can distinguish between cause and effect, marketing stimuli, and the associated cognitive response (Lin et al., 2018). In the latest ten years, numerous empirical studies about decision-making using P300. **Table 1** summarises studies on amplitude and latency components of P300 and decision-making.

3.0 DISCUSSION

Table 1 shows that during the decision-making process, the outcomes of the study focused around P300 amplitude and latency. P300 is referred to as a valuable tool for cognitive function measurement. This is because knowledge about P300 will be essential to understand its cognition better. Each of the P300 components discussed in this review has distinguishable and important roles in cognitive processes. The researchers also proposed P300 study should include larger groups of participants.

The focus or target of the experiment served as standard and target stimuli. Rosenfeld et al (2005) found that the P300 amplitude was greater than non-targets. Another study also found a significant increase in the latency and P300 amplitude for the target condition of all analysed electrodes compared to the non-target condition. Similarly, Pileliene and Grigaliunaite (2017) found a larger P300 amplitude for the target (celebrity spokesperson) compared to the non-target (non-celebrity spokesperson). This difference suggests that the amplitude of P300 reflects the attention given to updating memory content (Saliasi et al., 2013).

Luck (2005) opined that the P300 amplitude is larger when subjects make a significant effort in a task; however, the P300 amplitude is smaller if the subject is unsure whether a given stimulus was a target or a non-target. Confidence in the decision was positively correlated with the P300 amplitude, which indicates that greater confidence in the decision-making process results in a higher P300 amplitude (Pirtošek et al., 2009). Conversely, Samsuri et al. (2018) found higher P300 component amplitudes at most brain sites in the target

Table 1: Studies on amplitude and latency of P300

Author	Objective	Results
Ma et al. (2008)	To decide the suitability of extending the brand in stimulus 1 to the product category in stimulus 2 during a S1–S2 paradigm.	The higher the perceived similarity of their attributes, the larger the amplitude of the P300.
Porbadnigk et al. (2010)	To investigate the use of Event Related Potentials (ERPs) as a quantitative measure for quality assessment of disturbed audio signals.	The harder it is to detect noise in a stimulus, the higher the latency and the lower the amplitude of the P300 component.
Machado et al. (2014)	To investigate possible correlations among the source(s) involved in the generation of the P300 and their possible neurocognitive function.	Greater amplitude was easily detected in this region for the target condition.
Wang et al. (2015)	To contrast the neural temporal features of the early stage of decision-making in the context of risk and ambiguity.	The P300 amplitude elicited in risky conditions was significantly larger than the amplitude in ambiguous condition.
Teixeira et al. (2015)	To evaluate the electrophysiological and behavioural changes occurring in the P300 after consuming modafinil (200mg) and bromazepam (6mg) in healthy subjects.	A significant increase in the P300 latency and amplitude for the target condition compared to the non-target condition for all analysed electrodes. No significant difference was found for group or moment.
Fabre et al. (2015)	How participants playing the ultimatum game as responders modulate their decisions according to the proposers' stereotypical identity.	Greater P300 amplitudes were found in response to both fair and unfair offers.
He et al. (2018)	Examined the influence of social distance on outcome feedback by requiring participants to make decisions for themselves, their friends, or strangers	Increased social distance reduced the feedback-related negativity amplitude in the early stage of outcome evaluation and reduced the P300 amplitude in the late stage of outcome evaluation.
Sehrig et al. (2019).	Focused on decision-related versus feedback-related processes as potential contributors to decision-making in AUD by examining the relationship between decision choices and decision- and feedback-related ERP phenomena in the balloon analogue risk task (BART).	The decision P3 200–400 ms after decision prompt (balloon) was larger in AUD than in HC, and decision P3 enhancement on high-risk trials predicted choices to pump.
Sun et al. (2020)	The investigate the outcome of decisions influences behavioural changes	P300, and late positive potential (LPP) served as the neural substrates for behavioural decision
Li et al. (2020).	Examining how social distance modulates costly prosocial behaviours in the gain (i.e., helping another win a good outcome) and loss contexts (i.e., helping another avoid a bad outcome).	A larger P3 was observed in response to prosocial decision-making for friends than for strangers, while the effect of social distance did not emerge in P3 under the loss context

view than in the non-target view. According to Luck (2005), higher P300 component amplitudes occurs because subjects put more effort into a task. Dehaene et al. (1998) and Dehaene et al. (2003) agreed that higher P300 component amplitudes reflect higher awareness. If a task is made more difficult, it could increase the P300 amplitude by encouraging subjects to devote more effort to the task. However, it could also reduce the P300 amplitude by making subjects unsure of the stimulus category (Luck, 2005).

Longer P300 latency showed less attention (Brookhuis et al., 1983). Reimann and Bechara (2010) argued that a longer latency choice response is associated with the new brands compared to well-known brands. Latency also increases when targets are more difficult to distinguish from non-targets (Linden, 2005). The increase in P300 latency is linked to difficulty processing cognitive information (Cheng & Hsu, 2011). Moreover, (Emmerson et al., 1989; Johnson et al., 1985; Pelosi et al., 1992; Polich et al., 1983), as cited in Polich (2007),

found that individual differences in P300 latency are correlated with the speed of mental function so that shorter latencies are linked to superior cognitive performance. Regarding complex decisions, longer latency responses are observed (Lepping et al., 2015). Lin et al. (2018) posited that a bigger amplitude in marketing associated with unfamiliar brands and longer P300 latency indicated less attention. The P300 latency was prolonged when the stimulus was cognitively difficult to process (Cheng & Hsu, 2011). Thus, the amplitude and latency of the P300 primarily reflected the depth or degree of cognitive stimulus processing (Sowndhararajan et al., 2018). In other words, it was closely linked to the level of attention.

In layman terms, a higher P300 amplitude indicates greater confidence in decision-making, higher awareness, and more effort being put into a task. Meanwhile, longer P300 latency was associated with lower attention and difficulty processing cognitive information. Both variables are associated with how consumers make decisions.

4.0 CONCLUSIONS

Due to failure in understanding the consumers' decision-making process, 80% of all new products are unsuccessful in their first year. This challenge is addressed through neuroscience tools that help uncover hidden information oblivious to traditional marketing methods. With the help of neuroscience, the consumers' decision-making process is made known. Therefore, marketers can use the available information such as P300 from ERP to adjust and improve their marketing strategies appropriately. Researchers have shown interest in using neuroscience technology in marketing research to study consumers' response in detail and close the existing gap. New researchers may help investigate more of the role of P300 in consumer decisions in the presence of multiple writers. Nonetheless, despite its advancement in academia, its implementation in the professional sector remains a big challenge. As a result, more researchers and marketers can be trained in neuromarketing to develop more capable and effective marketing strategies to beat the challenges.

Conflicts of Interest: The authors declare no conflict of interest.

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