# Choice and preference. Neuropsychological, autonomic and cognitive measures in response to supraliminal/subliminal stimulation and emotional masking effect

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**Abstract**

Neuromarketing and cognitive psychology perspectives underlined the present research which investigated the choice and preference of consumers, by using behavioural, psychophysiological and neuropsychological measures. In particular, research found that cognitive and affective advertising elicited activity in different cortical brain areas and it was shown that the deliberative and intuitive systems were both involved in decision-making. In the present research we analyzed if the consumer and luxury goods associated with emotional stimuli (neutral, negative or positive) showed in supraliminal or subliminal condition produced variations in response time, subjective preference, autonomic measures (electrodermal activity, puls, and blood volume pressure) and ERP indexes. Emotive stimuli (high arousal with positive/negative valence) were extracted from the IAPS database. Results revealed that the SCL (skin conductance) was significantly higher for the emotive (positive and negative) stimuli compared to the neutral stimuli and for female subjects in subliminal condition; the ERN effect (error-related negativity) was higher in subliminal condition within the left temporal area; the N200 (attentional index) was higher in subliminal condition and parietal area; the P300 index (alert response) is higher in right parietal area for supraliminal condition. So the research highlighted the hypothesis that consumers do not observe and process information in a neutral way. On the contrary, different conditions of stimulation and of emotional valence influence the choices of consumers, in the way they respond in both in an automatic and deliberative way.

**Keywords:** neuromarketing, decision making, ERPs, autonomic indexes, consumer behaviour.

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**Riassunto**

Le prospettive del neuromarketing e della psicologia cognitiva sono alla base della seguente ricerca che indaga le scelte e le preferenze dei consumatori usando misure comportamentali, psicofisiologiche e neuropsicologiche. Ricerche recenti hanno trovato che componenti cognitiva ed emotive di stimoli pubblicitari elicitano specifiche risposte in differenti aree corticali e hanno mostrato che entrambi i sistemi, deliberativo e intuitivo, sono coinvolti nella presa di decisione. Nella seguente ricerca abbiamo analizzato se i beni di consumo e di lusso, associati a stimoli emotivi (neutri, negativi o positivi) mostrati in condizione sovraliminale o subliminale, producano variazioni nei tempi di risposta, nelle preferenze soggettive, nelle misure autonomiche (attività elettrodermica, pulsazioni, pressione sanguigna) e negli indici ERP. Gli stimoli emotivi (ad alto arousal, con valenza positiva o negativa) derivano dal database IAPS. I risultati rivelano che SCL (conduttanza cutanea) è significativamente più alta per stimoli emotivi (positivi o negativi) rispetto a quelli neutri e per le femmine nella condizione subliminale; l'effetto ERN (negatività relata all'errore) è più alto in condizione subliminale all'interno dell'area temporale sinistra; l'N200 (indice di attenzione) è più marcato nella condizione subliminale e nell'area parietale; l'indice P300 (risposta di allerta) è più elevato nell'area parietale destra per la condizione sovraliminale. Quindi la ricerca ha confermato l'ipotesi che i consumatori non osservano e elaborano le informazioni in modo neutro. Al contrario, differenti condizioni di stimolazione e il tipo di stimolo emotivo influenzano le scelte dei consumatori, rispetto al modo in cui rispondono in modo automatico o deliberato.

**Parole chiave:** neuromarketing, presa di decisione, ERPs, indici autonomici, condotta del consumatore.

**Résumé**

Neuromarketing et les perspectives du psychologie cognitive sont à la base du présente étude qui a enquêté sur le choix et les préférences des consommateurs, en utilisant des comportement, des mesures psychophysiologiques et neuropsychologiques. En particulier, la recherche a révélé que les composantes cognitives et affectives de la publicité ont suscités activitées dans les différentes zones corticales du cerveau et il a été montré que les systèmes de délibération et intuitive étaient tous deux impliqués dans la prise de décision. Dans la présente étude, nous avons analysé si les biens de consommation et de luxe associées à des stimuli émotionnels (neutre, négatif ou positif) ont montré dans un état supraliminaires ou subliminale, produisent des variations dans le temps de réponse, la préférence subjective, des mesures autonomes (activité électrodermale, Puls, et la pression du volume sanguin ) et les indices ERP. Emotive stimuli (excitation élevée avec valences positifs et négatifs) ont été extraites de la base de données IAPS. Les résultats ont révélé que le SCL (conductance de la peau) était significativement plus élevé pour les stimuli émotives (positives et négatives) par rapport aux stimuli neutres et pour sujets de sexe féminin dans un état subliminal, l'effet ERN (négativité liée à l'erreur) était plus élevée en condition subliminale dans le région temporale gauche, la N200 (indice d'attention) était plus élevé dans un état subliminal et la région pariétale; l'indice P300 (réponse d'alerte) est plus élevé dans la région pariétale droite pour la condition supraliminaire. Ainsi, la recherche met en lumière l'hypothèse que les consommateurs ne sont pas capables d'observer et de traiter l'information de façon neutre. Au contraire, les différentes conditions de stimulation à valence émotionnelle influencent des choix des consommateurs, dans la façon dont ils réagissent à la fois de manière automatique et délibératives.

**Mots-clés:** neuromarketing, la prise de décision, ERP, les indices autonome, le comportement des consommateurs.

## • Introduction: decision-making, choice and preference

The advantages of physiological measurements for choice have been noted for at least two decades (Weinstein *et al.*, 1984; Lee, Broderick, & Chamberlain, 2007) and the contribution of neuroscientific methods to understanding the choice-relevant human behaviour is likely to be considerable for two main reasons. The first question we have to answer refers to which elements is based a choice, that is related to the concept of *preference*. Preference plays a substantial role in economic theory since it has a significant influence on economic decision making and marketing research (Smith *et al.*, 2002). Some recent studies have used neuropsychological measures to explore subjective responses to different decisional process: for example, memory and information processing were analyzed by Rossiter *et al.* (2001), showing that preferred visual scenes were better recognized and revealed fastest activation in left frontal cortices. Ioannides *et al.* (2000) and Ambler *et al.* (2000) found, by a MEG experiment, that cognitive and affective advertising elicited activity in different cortical centres. Moreover, differences betweean predictable and unpredictable choices, where predictability can be related to both the frequency of prior usage of product or the time gap between the choice and the exposure to stimulus, were analyzed (Braeutigam *et al.*, 2004). Unpredictable choices were found to generate activity in regions associated with judgement of rewards (Senior, 2003).

Previous researches have found that also *social significance* of a product may have a great effect on the decider, particularly the intrinsic feature of a good, the degree of social prestige, the novelty or the product monetary value are considered. Evaluating outcomes generally depended on the context, and, in particular on the most salient features of the good to be chosen. Nevertheless, in most cases it was unclear which option represented the best response in a decision-making.

The present paper intends to explore three main topics related to decision-making domains: the contribution of *conscious vs. unconscious processes* to make a choice, using a masking procedure; the analysis of the *emotional vs. cognitive nature* of a choice, monitoring the cortical (ERPs) and autonomic (psychophysiolgical, SCR and HR) correlates in response to different goods; the effect of *product features* (in terms categorical distinction as luxury vs. consumer goods) on choice-making.

### *1.1. Emotions, deliberation and consciousness*

It was stated that the concept of choice included the convergence of different decisional systems, such as a *deliberative* (generally conscious and cognitively mediated process) and an *intuitive* (mainly unconscious and emotionally mediated process) *system* (Deppe *et al.*, 2005; Kahneman & Tversky, 1982; Loewenstein *et al.*, 2001; Slovic *et al.*, 2004). Specifically, the mechanism of decision should be considered by an affective (emotional response) and a cognitive (mental effort) point of view. Thus, the intrinsic relationship between cognition and emotion needs to be considered (Elster, 1998; Glimcher & Rustichini, 2004; Loewenstein, 2000). More specifically, about the dichotomy *conscious vs. unconscious* contribution to decisional processes, it was demonstrated that the controlled processes are serial, deliberative and often associated to a subjective perception of effort. Generally they are localized in the frontal area of the brain. On the contrary, the automatic processes are multitasking, they are out of consciousness and they don't need a particular effort, so they are faster than the controlled processes. The posterior (occipital), superior (parietal) and lateral (temporal) areas of the brain are involved in automatic processes (Lieberman *and al.*, 2002). Moreover, LeDoux (1989) has argued that the emotional system gives an affective meaning to the stimuli and this brain mechanism operates unconsciously to generate the conscious experience of emotion. In different researches it was demonstrated that subjects are able to assign a semantic value to the emotional content of faces (Dimberg *and al.*, 2000; Wong & Root, 2003; Balconi & Lucchiari, 2009) or to other stimuli - visual or verbal, like words (Skrandies & Weber, 1996; Bernat *and al.*, 2001) or pictures (Johnston *and al.*, 1986; Yee & Miller, 1987; Cuthbert *and al.*, 2000) - in an unconscious condition.

Many studies have reported that emotions influence cognitive processes (Scott & Cervone, 2002) because affective conditions are used by people as salient information ready to formulate evaluations and judgements (*affect as information*). The affective processes (Zajonc, 1998) motivate approaching or avoidance behaviour, so they comprehend emotions, drives and motivational situation, while the cognitive processes are related more to true or false issues. Among the recent theories about emotion, the Russell's circumflex model proposes an *appraisal process* able to explain that each emotion represents a specific response to a particular kind of significant event, evaluated by the subject in line with its motivational significance. This appraisal process is governed by two criteria: the *arousing power* (high or low) and the *valence* (positive or negative) of the emotional stimulus (Russell, 2003). The affective dimension of valence, that is its hedonic quality, is related to the arousal dimension, because extremely pleasant or unpleasant stimuli are associated with increased arousal (Russell & Carroll, 1999).

### *1.2. ERPs and decision-making*

Recent studies have explored decision-making processes using event-related potentials (ERPs). Such studies have pointed out the significance of EEG measures for analyzing choice dynamic in case of gain/loss condition, error detection in decision, or outcomes prediction. Unrewarded or unfavourable choices, and more generally losses, were marked by a specific negative deflection, the ERN (*error-related negativity*), distributed on the medial-frontal scalp (Dehaene, Posner & Tucker, 1994; Falkenstein *et al.*, 1991; Gehring *et al.*, 1993; Johannes *et al.*, 2007). A second interesting deflection, the medial-frontal negativity (MFN) was found by Gehring and Willoughby (2002), it was related to the rapid assessment of the motivational impact of a stimulus and is larger for stimulus potentially negative (losses). The authors stated that the processing represented by the MFN could contribute to the experience that Kahneman names "instant utility", which is the momentary mental state resulting from the continuous evaluation of events along a good-bad dimension. Such a computation can contribute to decision making either by influencing the emotional state individuals anticipate they will feel while making a choice, or by affecting the emotional state that drives behaviour at the moment of the choice itself (Kahneman, 1999; Mellers, 2000; Loewenstein *et al.*, 2000).

Other studies focalized these ERP effects, such as the recent research on the predicted outcomes of decisions (Polezzi *et al.*, 2008). The authors found a significant negative deflection, the *feedback related negativity* (FRN), that could reflect the activity of coding the ongoing evaluation of events and prediction of future events in terms of favourable of unfavourable choices and outcomes (Holroyd & Coles, 2002).

The ERP morphological analysis reveals the similarity between supraliminal and subliminal conditions and in particular, the ERP measures, because of their very high temporal resolution, are useful to examine the time-course of the conscious vs. unconscious stimulus elaboration (Shevrin, 2001; Snodgrass, 2000). Liddell and al. (2004) have found that the supraliminal and subliminal conditions are modulated by two main ERP effects: N200 and P300. The negative deflection N200 is an attentive index. Thus, the selective attention at a particular stimulus category is expressed with a rise in the negativity recorded in the posterior area of the head between 150 and 300 msec. post-stimulus. This negativity is called selection negativity (Harter & Aine, 1984) or processing negativity (Näätänen, 1982). Balconi and coll. (Balconi & Mazza, 2009) have found that the N200 is a negative deflection more distributed on the frontal sites for both conscious and unconscious stimulation. Other researches evidence that the modulation of N200 is a function of attentive (conscious) vs. pre-attentive (unconscious) elaboration. In fact the former condition is marked by an ampler deflection underlying the attentive resources allocated by subjects (Balconi & Pozzoli, 2003; Eimer & Holmes, 2007).

Between the later or cognitive ERP components, the P300 effect is a positive deflection appearing 250 msec. after the stimulus. In particular the P300 index is a rating of complexity, of the central information processing. It consists of a cognitive elaboration of the stimulus and it was increased in amplitude when the situation requires a controlled information elaboration, whereas it decreases when the situation is automatically controlled by the system (Zani & Mado Proverbio, 2003). The response to emotional stimuli compared to neutral stimuli is characterized by an increased P300 magnitude and also by a sustained later positivity (Cuthbert *and al.*, 2000; Keil *and al.*, 2002). The P300 modulation was found in response to emotional faces and for other objects with an emotional content (Bernat *and al.*, 2001), and it is related to unconsciously processed stimuli that are relevant for the subject (Kotchoubey, 2005). Balconi and coll. (Balconi & Pozzoli, 2009) have found that the P300, in attentive and pre-attentive condition, is similar to the classical ERP index and it is mainly distributed on the parietal regions. In particular the subliminal stimuli are perceived and processed on a higher level, even if the people are not aware of this information. P300 has a decreased peak amplitude for neutral stimuli and for the low arousal negative stimuli in comparison with positive stimuli both in supraliminal and subliminal condition. In general the high arousal cues, with negative or positive valence, have a strong effect on the subject's response also in case of pre-attentive processing.

### *1.3. Autonomic measures and arousal modulation in decision-making*

In previous studies also psychophysiological measures (skin conductance, cardiac frequency and blood pressure) were used, taking into account the modulation in *arousal*. In fact arousal is considered a fundamental feature of behaviour and is defined as the neurophysiological basis underlying all the processes in the human organism. In particular, electrodermal activity (EDA) is considered a valid and sensitive indicator responding to the smallest variation in phasic arousal, that is the behavioural response to specific stimuli (Groeppel-Klein, 2005). Different studies focused on psychophysiological indexes of decision-making and preference for a good. The analysis of skin conductance and cardiac frequency, related to the choice of luxury or consumer goods, revealed significant differences related to the monetary value and, more generally, to the social value associated to goods. When the subjects choice luxury goods it was found an increasing in SCL (skin conductance level) and PULS (number of pulsations/minute) (Braeutigam, 2005; Watson & Gatchel, 1979).

Secondly, a great number of researches confirms that unconsciously processed emotional cues may elicit emotional responses by increasing the arousal level: a larger skin conductance response is observed when a more salient stimulus (for example a facial expression) is perceived without awareness (Dimberg & Öhman, 1996). It was found that, using IAPS stimuli, unpleasant pictures elicit greater muscle corrugators activity and heart rate deceleration. Moreover, all emotional conditions prompt larger increases in skin conductance than neutral conditions, since skin conductance change is a direct consequence of general activation of the autonomic nervous system (Cuthbert *and al.*, 2000).

Nevertheless, no previous study has explored the effect of consciousness, preference and emotional significance, by analyzing the *cognitive* (choice and response time – RT – and ERP profile) and the *emotive* (autonomic system modulation) correlates. In this research we considered the consumer reaction to luxury vs. consumer goods. Secondly we tested the subjective response to masking effect, since we associated each good to an emotional (positive, negative or neutral) stimuli presented in *supraliminal* (conscious perception) vs. *subliminal* (unconscious perception) condition. Thus, masking procedure is a useful measure to study conscious and unconscious effect: by low intensity and brief exposure, a target stimulus can be unrecognized when another stimulus is presented shortly before -forward masking- or shortly after – backward masking – (Rolls, 2006). Third, the effect produced by a supraliminal or subliminal presentation of the emotive stimulus associated with consumer or luxury goods is studied using ERP measure and psychophysiological indexes. Specifically, autonomic indexes (like skin conductance) are useful to study the subjective autonomic reaction to emotional stimuli shown in supraliminal or subliminal condition. Contrarily, ERPs modulation furnishes a valid measure of the cognitive response by the subject. Specifically, the effects explored in the present study are summarized in the present scheme

## • Experimental hypotheses

Three orders of data were considered in the current research. Firstly, behavioural indexes were analyzed by measuring the *number of choices* (*NC*) for some common products; and the time required to make the choice (*RT*). Secondly, the cognitive response to each option was monitored by *ERP modulations*. Third, the emotional contribution to the subjective choice was evaluated by analyzing the psychophysiological data (*skin conductance response*, *SCR,* and *skin conductance level*, *SCL*). These measures were used to test the subjective affective response to each experimental condition, taking into account especially the effect that the emotional information may produce in case of negative vs. positive emotional masking cues (Amrhein *et al.*, 2004).

A first comparison was made between products of high value (luxury goods) and products of low value (consumer goods), in order to verify differences in subjects' preferences. Secondly, we compared the decisional choice made in case of positive vs. negative emotional induction, when subjects may be conscious (supraliminal masking exposure) or unconscious (subliminal masking exposure) of the emotional information reproduced.

## • Methods

### *3.1. Subjects*

Sixteen healthy volunteers took part in the study (eight females, age range 20-26, mean = 22.75, SD = 2.05 and eight males, age range 20-23, mean = 21.625, SD = 1.87) after given informed consent. All the subjects are university students from different universities and courses.

### *3.2. Stimulus material*

Stimulus materials are taken from two distinct databases: the consumer and luxury goods come from a database of the Catholic University of Milan, while the emotional stimuli come from the IAPS database (*International Affective Picture System*) (Lang and al., 1999). Only high arousal stimuli with negative or positive valence were used[2]. In the Cartesian space defined by affective valence and arousal measure, pleasant and unpleasant IAPS pictures showed different distributions (Bradley and Lang, 2000). In addition, we create the neutral stimuli from the IAPS affective (positive and negative) picture, by using a morphing procedure in order to make them unrecognizable and with no emotional significance.

### *3.3. Backward masking procedure and experimental task*

We used a backward masking procedure: each consumer or luxury good (target stimulus) was presented for 200 msec. and it was followed by the emotional stimulus (positive, negative or neutral) presented for either 30 (*low exposure*, unconscious elaboration) or 100 (*high exposure, conscious elaboration*) msec. (masking stimulus). In total there were 126 target-mask pairs in each condition (supraliminal and subliminal). Stimuli were totally randomized across emotional type, good type and condition of presentation. The supraliminal and subliminal condition were ordered into two distinct sets of presen-

2 The IAPS pictures used were: 1019, 1300, 1932, 2811, 3170, 6350, 9910 (negative with high arousal); 2216, 5621, 8170, 8179, 8200, 8251, 8370 (positive with high arousal).

tation and each condition was divided into three batteries. The short stimulus presentation in subliminal condition prevents the people to have a clear cognition of the stimulus. The post-test questionnaire confirmed subjects were unable to detect the masking stimulus in the subliminal condition.

Subjects were seated comfortably in a moderately lighted room with the monitor screen situated approximately at 100 cm. in front of them. Pictures were presented in a randomized order in the centre of the pc monitor using the STIM 4.2 software. During the experiment participants were requested to minimize blinking. The instructions were presented in a written form prior to registration session, and the subjects were only told that they have to choose the product they prefer by pressing a stimpad. It was underlined that in three batteries the second stimulus would be difficult to see. The experimental session lasted about 1,30 hour. Prior to beginning the experimental phase subjects were familiarized with the overall procedure (training session). The duration of this phase was about 3 min., where every subject saw in a random order all the stimulus type presented in the successive experimental session (a block of 6 stimuli, each type repeated two times).

### *3.4. Data reduction*

a. Autonomic recording

Skin conductance (SCR and SCL), was measured continuously with a constant voltage by Biofeedback (Biofeedback 2000, version X-pert). This is a modular feedback system so the radio technology allowed to transfer the data to computer through radio signals (Bluetooth). The radio modules were positioned on the body: the radio module MULTI was put on the left wrist with a pulling action system. The sensors had plug-in connections and the connectors are signed with different colors. We used the combined sensor (for temperature, pulsations, skin conductance and pressure) attached to the finger through a stripe where is situated the electrode. The sample rate was of 400 Hz. SCRs elicited by each stimulus were scored manually and defined as the largest increase in conductance in a time window from 1500 to 4000 ms after stimulus presentation. Skin conductance level (SCL) corresponds to the conductance value computed at the onset of the stimulus. Trials with artefacts were excluded from analysis, whereas trials with no detectable response were scored as zero. The electrocardiogram was recorded using electrodes on the left and right forearms. Inter-beat intervals of the EKG were converted to heart rate in beats per minute (PULS, scoring peak acceleration during viewing the picture).

b. EEG recording

The EEG was recorded with a 32-channels DC amplifier (SYNAMPS system) and acquisition software (NEUROSCAN 4.2). An ElectroCap with Ag/AgCl electrodes was used to record EEG from active scalp sites referred to earlobe (10/20 system of electrode placement). Additionally two EOG electrodes were put on the outer sides of the eyes. The data were recorded using sampling rate of 501 (o 256) Hz, with a frequency band of 0.1-60 Hz. The impedance of recording electrodes was monitored for each subject prior to data collection and it was always below 5kW.

An averaged waveform (off-line) was obtained from about 17 artefact-free (trials exceeding 50 mV in amplitude were excluded from the averaging process) individual target stimuli for each type of emotion and condition. The EEG signals were visually scored on a high-resolution computer monitor and portions of the data containing eye movements, muscle movements or other source of artefacts were removed. Peak amplitude measurement was quantified relative to 100 msec. pre-stimulus. Only fifteen electrodes were used for the successive statistical analysis (five central: Fz, FCz, Cz, CPz, Pz; ten lateral: TP7, TP8, F7, F8, T5, T6, FC3, FC4, CP3, CP4) referred to the international system 10-20 (Jaspers, 1958).

# • Results

*4.1. Response time*

Repeated measure ANOVA was applied to response time (software SPSS 15.0 version). We found the main significant effect for Condition ($F(1,10)=11.482$, $p=.007$) (fig. 4.1.). The RT is higher in supraliminal condition compared to the subliminal one.

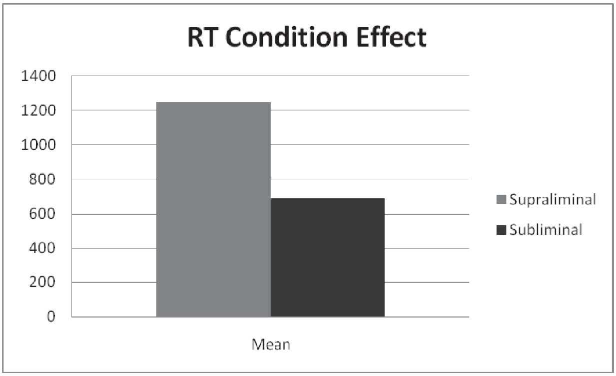



**Figure 4.1 RT mean values for supraliminal/subliminal condition**

*4.2 Psychophysiological indexes*

Repeated measure ANOVA was applied to SCL, SCR, BVP, PVA and PULS measures. The ANOVA did not reveal significant results for SCR, BVP, PVA and PULS. For SCL we have found the main effect of Emotion ($F(2,15)=10.607$, $p=.000$): the emotional (positive $p=.001$ and negative $p=.025$) stimuli elicited an increase in skin conductance compared to neutral stimuli.


**Figure 4.2 SCL mean values as function of Emotion**

We have also noticed an interaction effect (Condition x Gender): in subliminal condition female subjects showed increasing in the level of skin conductance (SCL) ($F(1,15)=4.640$, $p=.045$).

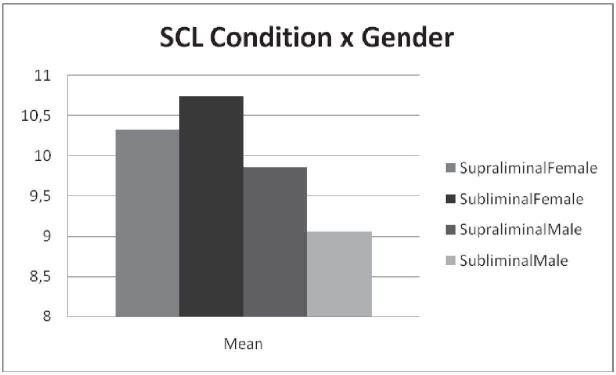



**Figure 4.3 SCL mean values for Supraliminal/Subliminal Condition and Gender**

### *4.3. ERP data*

*Morphological analysis*

The morphological analysis of wave profiles revealed three different ERP components for all the experimental conditions. The first was a negative deflection greater in the parietal and temporal sites, with a peak latency at about 100 msec. (ERN100); the second was a negative deflection greater in the frontal and central sites, with a peak latency at about 200 msec. (N200); the third was a positive deflection greater in parietal sites, measured about 300 msec. after stimulus-onset (P300). For both supraliminal and subliminal condition ERN100, N200 and P300 were apparent and morphologically similar. So to evaluate differences in ERP response we focused data analysis within the time window of 80-120 msec., 150-250 msec. and 250-350 msec. post-stimulus. We considered the dependent variable of peak amplitude (calculated from baseline to peak amplitude).

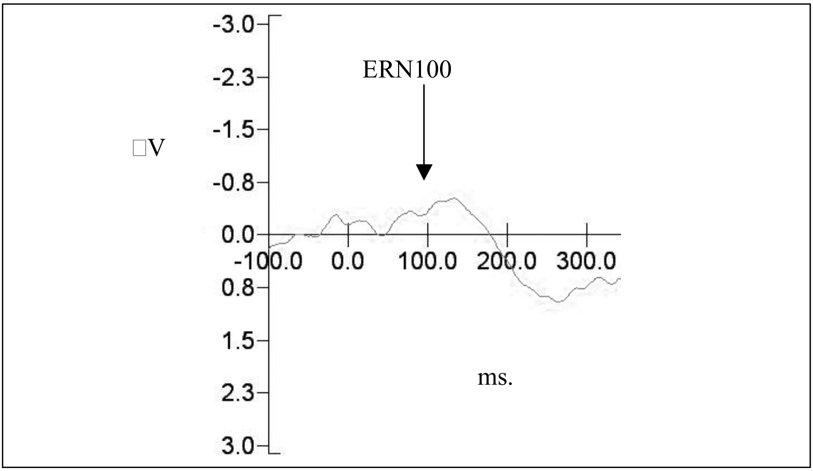



**Figure 4.4 ERN peak**

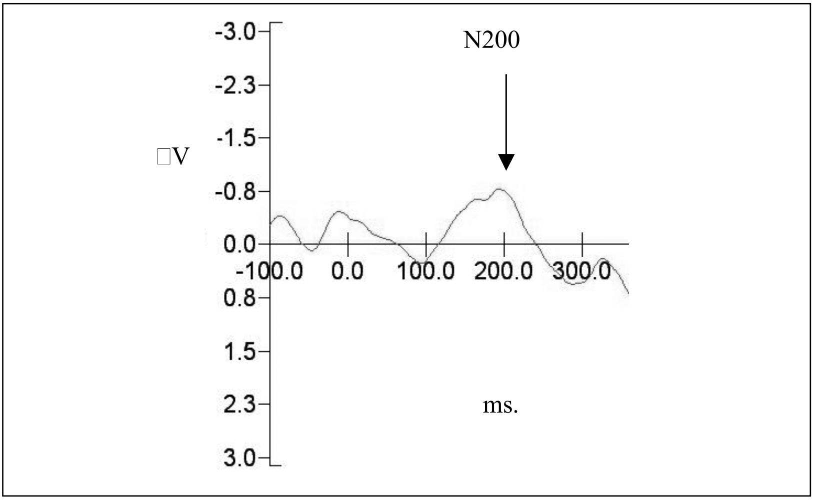



**Figure 4.5 N200 peak**

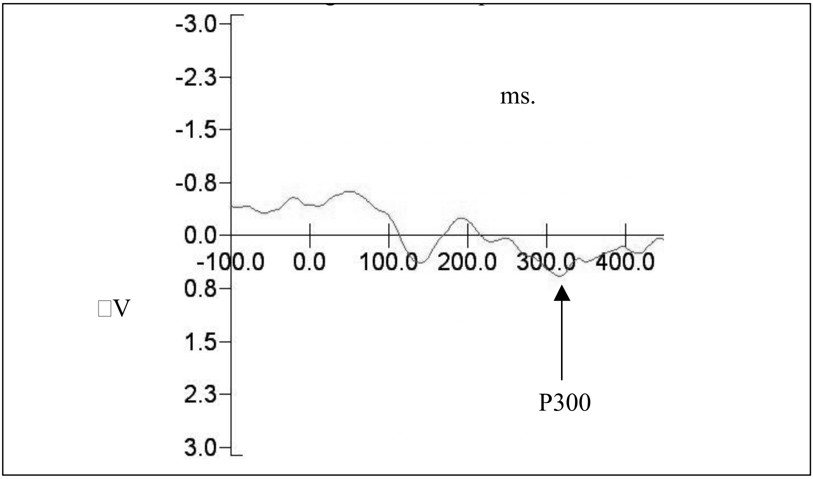



**Figure 4.6 P300 pe**

*Statistical analysis*

Repeated measure ANOVAs were applied to the three peaks amplitude of ERN100, N200 and P300. The dependent variable of peak amplitude was entered in four-way ANOVAs using the following repeated factors: condition (2: supraliminal/subliminal) x emotion (3: positive/negative/neutral) x lateralization (3: median/left/right) x site (3: frontal/centro-parietal/temporal). To assess Site, frontal (Fz, FCz, FC3, FC4, F7, F8), Parietal (CPz, Pz, CP3, CP4) and Temporal (Cz, TP7, TP8, T5, T6) sites were calculated as the mean of averaged peak amplitude.

*a. ERN effect*

The first main significant effect was Condition ($F(1,15)=11.384$, $p=.004$). The ERN100 is higher in subliminal condition compared to the supraliminal one.

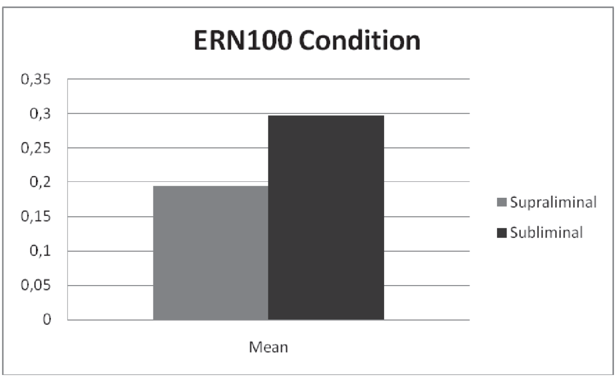



**Figure 4.7 ERN mean values as function of Supraliminal/Subliminal Condition**

The second main significant effect was Site (F(2,15)=6.594, p=.004): the ERN100 is higher in the parietal (p=.028) and temporal (p=.004) areas than in the frontal one.

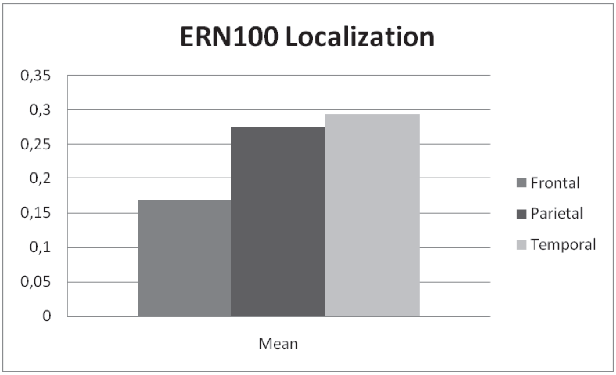
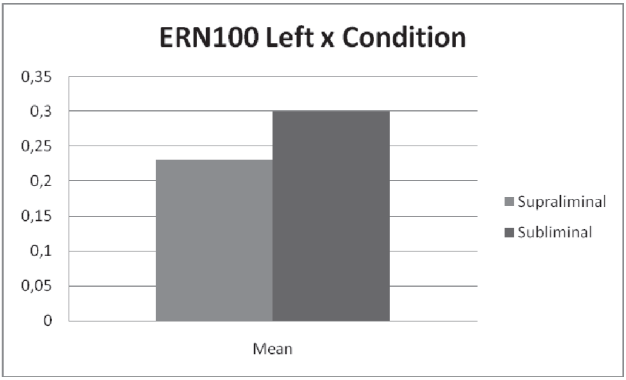
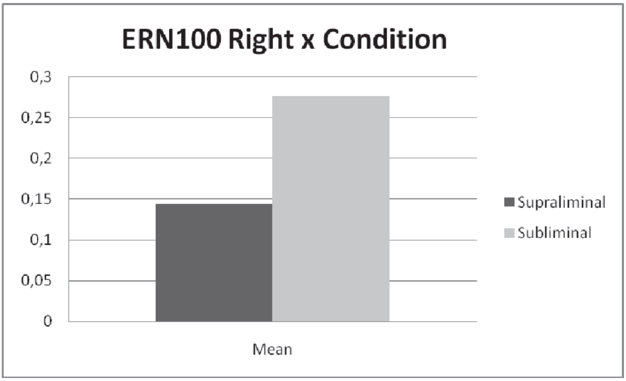



**Figure 4.8 ERN mean values for Frontal/Parietal/Temporal Localization**

Also the interaction effects were significant: Condition x Site (F(2,15)=4.390, p=.021). Contrast analysis revealed significant interactions (simple effects): in left lateralization, supraliminal vs. subliminal condition (F=6.799, s=.020); in right lateralization, supraliminal vs. subliminal condition (F=19.429, p=.001); in supraliminal condition, right vs. left lateralization (F=6.645, p=.021).




**Figures 4.9 - 4.10 ERN mean values as function of Supraliminal/Subliminal Condition and Left/Right Lateralization**

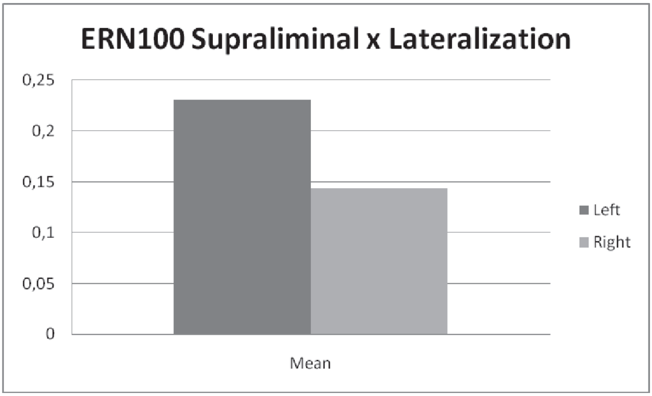



**Figure 4.11 ERN100 mean values**
**for Supraliminal condition and Left/Right Lateralization**

The second significant interaction effect is Emotion x Lateralization (F(4,15)=3.037, p=.024). In particular we found higher values of ERN100 in the median (F=4.392, s=.021), positive (p=.016) and negative (p=.021) emotion vs. the neutral one.

Contrast analysis revealed the significant Frontal x Lateralization simple effect (F=10.540, p=.000), right lateralization vs. median (p=.006) and left (p=.002) and median vs. left (p=.045).

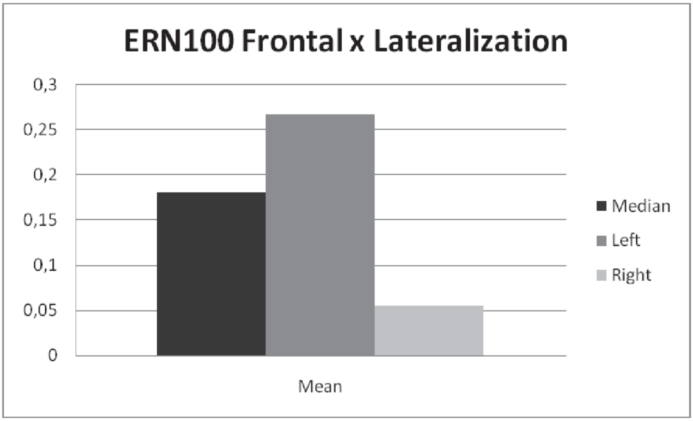



**Figure 4.13 ERN mean values as function of Frontal Site and Median/Left/Right Lateralization**

Finally, the interaction effect Condition x Lateralization x Site (F(4,15)=4.435, p=.003), as displayed in the next cortical maps.

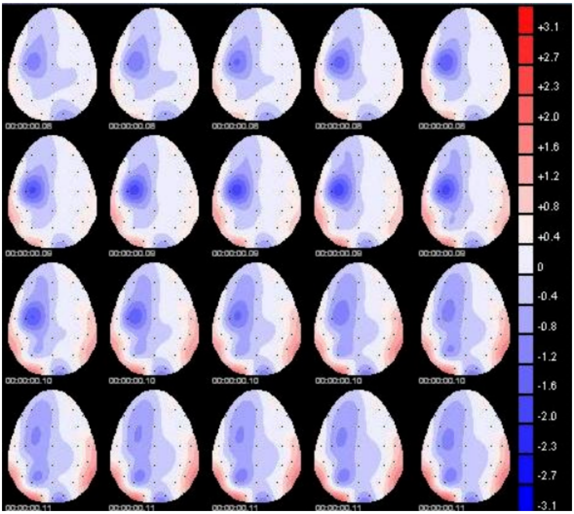



**Figure 4.14. Cortical map Subliminal Condition x Lateralization**

*b. N200 effect*

We noticed the main significant effect of Condition: a higher peak amplitude was measured in the subliminal condition compared to the supraliminal one (F(1,15)=30.555, p=.000).

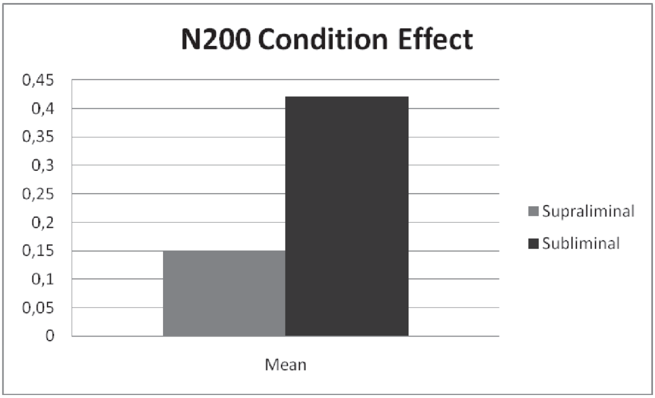
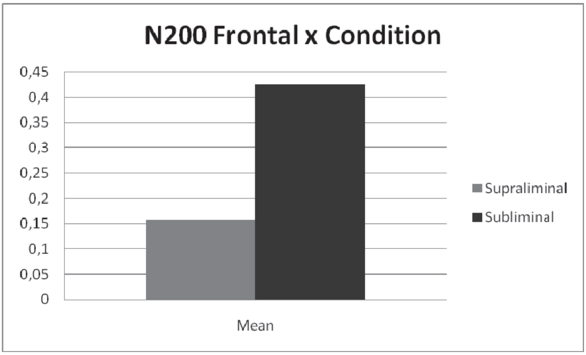
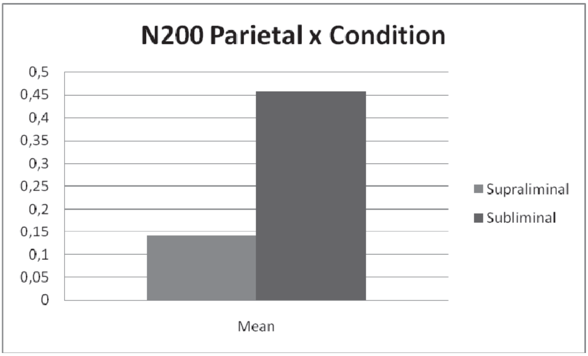
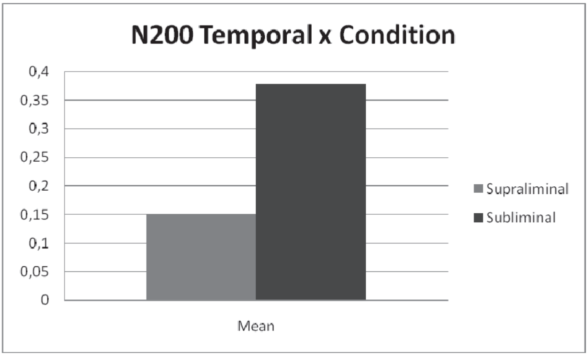



**Figure 4.15 N200 mean values for Supraliminal/Subliminal Condition**

We also found different interaction effects: the first was Condition x Site (F(2,15)=3.798, p=.034), in particular, after contrast analysis, we found the supraliminal vs. subliminal condition effect in the frontal site (F=29.740, p=.000), in the parietal site (F=25.084, p=.000) and in the temporal site (F=28.193, p=.000).




**Figures 4.16 – 4.17 – 4.18 N200 mean values as function of Supraliminal/Subliminal Condition and Frontal/Parietal/Temporal Site**

The second interaction effect was Condition x Emotion x Lateralization (F(4,15)=2.555, p=.048). After contrast analysis we found in Supraliminal condition associated to Median lateralization (F=7.005, p=.003), the positive vs. negative (p=.012) and neutral (p=.003) effect.

*P300 effect*

The same statistical analysis were applied to P300 (repeated measure ANOVAs). We found the main significant effect of Lateralization (F(2,15)=11.886, p=.000): the P300 is lower in the left lateralization vs. median (p=.004) and right (p=.001) lateralization.

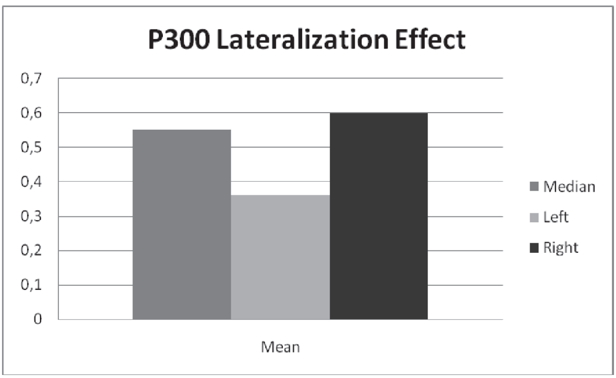
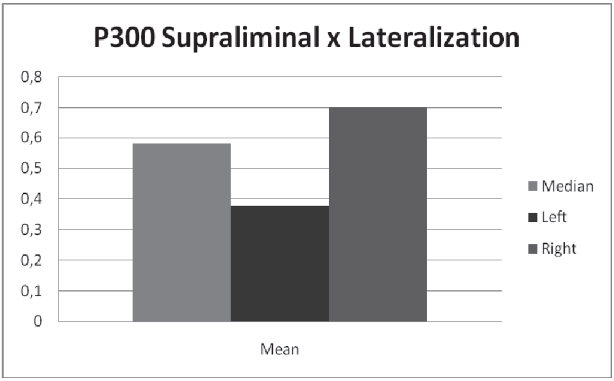
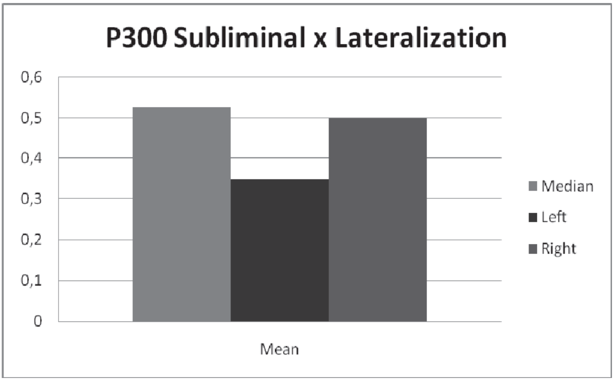



**Figure 4.19 P300 mean values as function of Median/Left/Right Lateralization**

There were also different interaction effects, the first is Condition x Lateralization (F(2,15)=8.005, p=.002): after contrast analysis we found the Supraliminal x Lateralization effect (F=13.076, p=.000), in particular median vs. left (p=.011) and right (p=.009) and left vs. right (p=.001); the Subliminal x Lateralization effect (F=7.864, p=.002), in particular median vs. left (p=.003), left vs. right (p=.006).




**Figures 4.20 – 4.21 P300 mean values for Supraliminal/Subliminal Condition and Median/Left/Right Lateralization**

After contrast analysis we found the Right x Condition effect (F=14.597, p=.002).


**Figure 4.22 P300 mean values for Supraliminal/Subliminal Condition and Right Lateralization**

The second interaction effect was Condition x Emotion x Site (F(4,15)=3.487, p=.013): after contrast analysis we found in the Supraliminal condition x Neutral stimuli the Site effect (F=7.764, p=.002), in particular the P300 is lower in the frontal site compared to parietal (p=.003) and temporal sites (p=.022).

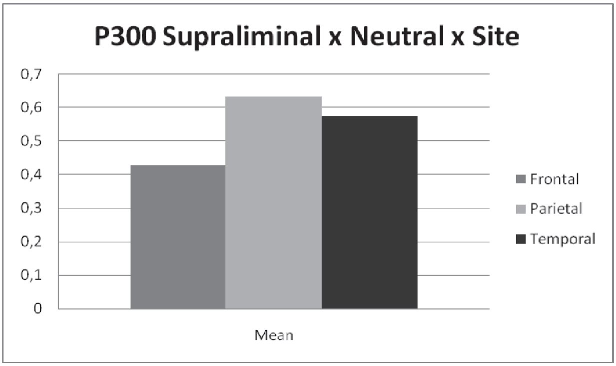



**Figure 4.23 P300 mean values for Supraliminal Condition, Neutral Emotion and Frontal/Parietal/Temporal Site**

In the Temporal site x Neutral stimuli we found the Condition effect (F=12.755, p=.003).

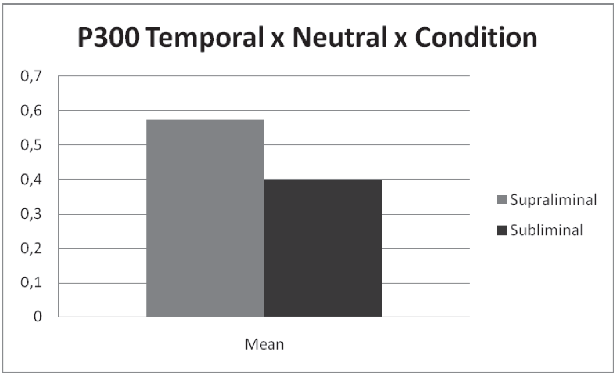



**Figure 4.24 P300 mean values for Supraliminal/Subliminal Condition, Temporal Site and Neutral Emotion**

The third interaction effect is Condition x Emotion x Lateralization x Site (F(8,15)=2.519, p=.014), reported in the next cortical maps.

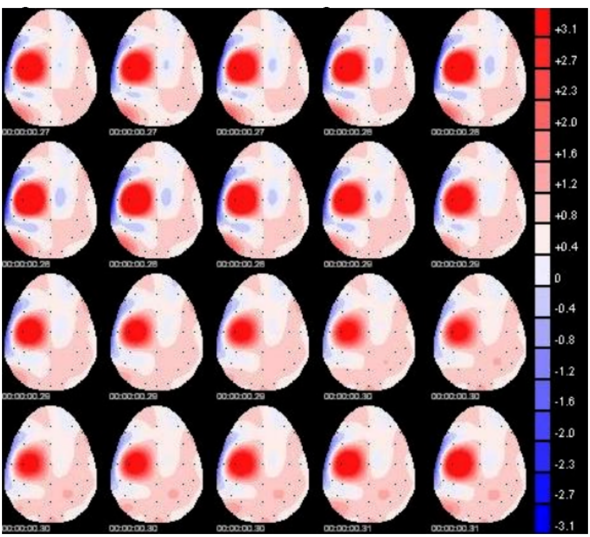



**Figure 4.25 Cortical map of activation in supraliminal condition, with an increased P300 within the left area**

## • Discussion

Neuromarketing has the capability to demonstrate that emotional and rational thinking co-exist and are co-dependent. In fact emotions attract people's attention and motives them to focus the rational brain on the issue (Coy, 2005). It is useful for market researchers and for advertisers to know how the stimuli and the advertising are understood and elaborated by the consumers, when the emotional stimuli or the different conditions of stimulation promote the purchase behaviour and when they inhibit it, when some emotional stimuli (positive or negative) associated to goods are useful and when they aren't. More generally, consumers do not observe and process information in a neutral way (Zaltman, 2003). Instead, prior knowledge serves as an organizing framework that is used to interpret new information.

In this research we found that different conditions of stimulation of emotional stimuli influence the choices of consumer and luxury goods. The RT revealed that subjects elaborate consciously in the supraliminal condition, while in the subliminal one they had to quickly respond to the stimuli. In this condition they unconsciously reacted and chose the consumer or luxury goods. So the deliberative and the intuitive systems both work during the subject's decision making and differentiate between the supraliminal and the subliminal condition. The psychophysiological index of skin conductance level is a significant value for the emotion discrimination of the stimuli and for condition of stimulation. At an autonomic level the subject responds automatically to the emotional content of the stimuli and this response is out of consciousness. According to the literature, the skin conductance level was higher when the goods were associated to emotional stimuli than to neutral stimuli, in particular the positive and negative stimuli elicited a greater SCL than neutral stimuli. So, the emotional stimuli activated arousal response in the subjects. Given the adaptive significance of emotional information, it is assumed that the processing of affectively salient stimuli can occur even when these stimuli are inaccessible to conscious awareness. We verified that hypothesis using the ERP indexes of ERN100 and N200 while we find the P300 index mainly in supraliminal condition (P300 reveals the conscious integration of an emotionally salient event into the current stimulus context).

The ERN, the error related negativity, underlined the perception of mistakes using the comparison between erroneous response and expected response also without consciousness (Zani & Mado Proverbio, 2003). The ERN index revealed that in subliminal condition the subjects perceive the situation and their choice as unfavourable and risky. This negative deflection is higher in subliminal condition and is located mainly in temporal area and it has a left lateralization. We noticed the ERN when the consumer and luxury goods are associated to the positive and negative stimuli so it's an index of a particular choice condition. This error related negativity is found when the subjects have to choice in an unconscious way due to the subliminal stimulation, so they perceive the situation as risky and their choice as probably erroneous and also when the emotive stimuli activate the subject brain because of their content.

The N200 is an index of selective attention toward a specific stimulus category, it's called selection negativity (Harter & Aine, 1984) or processing negativity (Näätänen, 1982). The N200 revealed a greater amplitude in subliminal condition compared to the supraliminal one, that is attention is greater when the subjects only perceive the stimulus and elaborate it automatically, without awareness than when they consciously do it. The N200 peak is situated in the frontal and central area of the scalp. We found also a left lateralization effect for subliminal condition associated to negative stimuli and a right lateralization effect for subliminal condition associated to positive stimuli. The N200 is a component used to recognize the emotive value of the faces, of the stimulus and also the specific emotional content has an impact on the ERP variation (Balconi & Lucchiari, 2006). In particular the N200 amplitude increases when there are emotional stimuli compared to neutral stimuli. This attention index is higher in subliminal condition because the subjects have to unconsciously elaborate and comprehend the stimuli before the purchase choice.

P300 might be a marker for consciousness itself and a P300 component was significantly greater for the less frequent than for the frequent stimuli (P300 oddball effect). The P300 amplitude is greater when the situation ask a controlled elaboration of the information while it isn't marked when the situation is automatically managed. The P300 peak is a parietal phenomenon, in particular the P300 is greater in supraliminal condition such as when the subjects consciously elaborate the target and the emotional stimuli too. Because of their motivational significance the emotional stimuli are selected by the brain for sustained attentive processing. We also noticed a right lateralization effect for supraliminal condition. The P300 index represents the cognitive complexity perceived by the subject during decision-making tasks, in fact is a marker of the central analysis of information so a decrease in this deflection is proportional to the task difficulty, to the confidence and autonomy degree of the subject. The P300 increases in complex, ambiguous, uncertain tasks or in undecided subjects.

To conclude, we found results useful for applied research in neuromarketing and in advertising research.

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