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HOW MOMENT-TO-MOMENT EEG MEASURES ENHANCE AD EFFECTIVENESS EVALUATION

Peak Emotions during Branding Moments As Key Indicators

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ABSTRACT

Existing literature compares neuromarketing and traditional methods which make the questionable assumption that these are monolithic measurement alternatives all serving the same, predictive purpose. This study challenges and empirically verifies this notion by relying on a neuroscientific perspective and a robust empirical study to examine the correspondence of expanded sets of diverse EEG and survey ad indicators. The key findings are that EEG and survey indicators measure different kinds of emotions (and attention) and that the newly developed, momentary EEG indicators are superior to the conventional, aggregated ones. The findings suggest that moment-to-moment EEG ad indicators like peak emotions during branding moments distinctively enhance ad effectiveness evaluation and enhancement.

MANAGEMENT SLANT

- EEG is a time-sensitive, portable, and cost-efficient methodology that enables the construction of additional ad indicators beyond those currently used for advertising testing.
- EEG provides specific measures of unconscious appraisal emotions and visual attention, which survey-measured constructs are unable to capture.
- The aggregate approach, which provides averaged advertising indicators across whole advertising duration, misses decisive 'branding moments', and cannot utilize the true potential of EEG.

- Established associations among EEG indicators provide new insights into unconscious emotional responses to advertisements, which counter straightforward attention-interest-desire-action AIDA logic.
- EEG exhibits great potential for advertising pretesting in terms of additional communication goals and distinct effectiveness criteria – beyond the constraints inherent to survey indicators.

INTRODUCTION

Neuromarketing research promises insights beyond those revealed by traditional techniques (Kennedy and Northover, 2016; Plassmann et al., 2015; Yoon et al., 2012; Ariely and Berns, 2010), presumably by improving the accuracy of predictions of consumer preferences and behaviors (Boksem and Smidts 2015; Smidts et al., 2014; Venkatraman et al., 2015). Despite its acclaimed merits and expected advantages over traditional methods (e.g. surveys), the advertising profession has been quite slow to adopt it. Serious challenges remain ahead (see Plassmann et al. 2015) along with doubts as to whether neuro-methods can in fact provide useful findings and replace existing research techniques (Solnais et al., 2013). As a result, as the field has grown, so too have doubts about neuromarketing (Stanton et al., 2016).

These doubts seem to partly stem from superficial understanding of neuromarketing methods and their managerial relevance, which hinders its application in commercial research (Marci, 2008). Even some of the most comprehensive industry-level research projects to date further question the claims made about the superior reliability and validity of neuromarketing by providing worrying conclusion that there is “no commonality” among these methods and vendors (see Varan et al., 2015). Hence, what neuroscience can actually offer to marketing should be a matter of critical discussion (Lee et al., 2018). Advanced use of neuro-measures for better decision-making depends on asking the right questions, more refined systematic testing of measures and the provision of robust answers supported by empirical validations (Kennedy and Northover, 2016). This imperative is more far-reaching and challenging than may appear due to certain persistent and uncritically examined assumptions about the validity and relevance of neuromarketing measures.

Current research relies on several, largely unverified assumptions, such as that neuromarketing and traditional methods are competitors and propose “either-or” alternatives (Marci, 2008). Having made this assumption, the same things are measured and are, as such, suitable for the same purposes, in particular for predicting in-market success (Varan et al., 2015; Venkatraman et al., 2015). Yet, as emphasized by Haley and Baldinger (2000) and Micu and Plummer (2010), certain measures are only appropriate for particular objectives and no single measure is the ‘gold standard’ measure for the effectiveness of ads. Hence, neuromarketing measures can only be relevant and suitable for the right purpose, which might not be the same as with traditional methods (Shen and Morris, 2016; Deitz et al., 2016).

Another implicit and problematic assumption is that neuromarketing is a single method. Even with comprehensive overviews and industry outlooks (e.g. Kennedy and Northover, 2016), neuro-methods are largely treated as a methodological monolith that subsumes diverse brain-methods like fMRI, EEG, and other neuro/physiological measures. Neuromarketing is, however, a broad term that covers a wide range of specific methodologies and techniques, thereby making a more nuanced, specialized, and comprehensive empirical examination of each research method crucial. A suitable question here concerns the relevant details and managerial implications of each particular neuro-scientific method. From a managerial standpoint, a major consideration is the choice of a certain and adequate neuro-based method and the resulting indicators where the popular fMRI method is, for instance, found to be extremely expensive and unpractical. In contrast, EEG is cost-efficient, accessible, and portable (Varan et al., 2015). Still, fMRI appears to be a more fully explored method in the past.

Comprehensive neuromarketing overviews like that of Plassman et al. (2012) were for instance almost exclusively focused on fMRI studies. Several studies also pointed out that fMRI dominated in neuromarketing due to its greater precision (Venkatraman et al., 2015; Varan et al., 2015). However, EEG has recently enjoyed considerable growth to become the commercial method of choice due to its distinct advantages (see Lee et al. 2018).

EEG methodology provides detailed and relevant insights into consumers' responses to being exposed to an ad, yet still seems underexplored and inadequately deployed (Solnais et al., 2013; Ohme et al., 2010; Reeves et al. 1985; Vecchiato et al., 2011). In particular, the existing EEG insights are not fully exploited to provide the foundation for the development of distinctive ad indicators. The specifics of EEG (i.e. patterned, moment-to-moment signals) hold the promise of the construction of additional ad indicators beyond those currently in use. Namely, in many studies the EEG signal is averaged across the whole ad, resulting in a survey-like approach to analysis of the EEG signal, then reduced to a single (average) value for the constructs being measured. This suggests that the operationalization and use of neuro methods (including EEG) are still dominated by the traditional psychometric and statistical paradigm (see Rossiter and Percy, 1987; Bergkvist and Rossiter, 2007, Bergkvist and Langner, 2017). Still, EEG's greatest potential is that its signal capture momentary (patterned) brain responses, like frequency of peaks, or maximum height value for a particular ad section (scene), and corresponding ad indicators can be constructed and analyzed.

Accordingly, the purpose of this paper is to advance the development and use of EEG ad indicators by adopting a neuro-scientific perspective and verifying an expanded set of EEG-based ad indicators. The paper first discusses how EEG and neuroscience facilitate a rethinking of traditional, survey-based ad indicators with regard to their nature, purpose, equivalence, and limitations. In particular, two key constructs (emotions and attention) are discussed as they inform the construction of new EEG ad indicators and the examination of their level of correspondence with survey counterparts. In the empirical study, the authors investigate inter/intra correspondences among a wide set of EEG and survey ad indicators developed by a European vendor. In order to provide a robust validation and reliable conclusions, a sample of diverse TV ads was utilized where a single ad was used as a unit of analysis (N=40), each being evaluated by 30 respondents according to both EEG and the survey-based methodology.

LITERATURE REVIEW, RESEARCH QUESTIONS AND HYPOTHESES

Decades of survey use suggest that surveys are inherently inaccurate as participants are unable to articulate their unconscious impressions (Singer, 2010). This has fueled expectations that new methods based on technological advances and neuroscience would emerge that are better at uncovering emotional reactions (Varan et al., 2015). One of these methods is Electroencephalography (EEG), whereby electrodes placed on the surface of the scalp record the electric activity of the brain by means of detecting and amplifying very faint electrical signals. These are recorded at a very high sampling rate since the signal can be captured as fast as 3/10ths of a second (Hakim and Levy, 2019; Polich and Criado, 2006).

Analysis of complex EEG brainwave patterns gives inferences about mental responses to stimuli and for the construction of ad indicators. The three most relevant types of such analyses are frequency (or spectral) analysis (i.e. analysis of different frequency bands – in terms of power and coherence), hemispheric asymmetry analysis (itself an application of frequency analysis to different regions of the brain), and ERP (event-related potential analysis; analysis of responses to rapid exposures to stimuli – in terms of polarity and latency). Each of these analyses has quickly developed and led to different emotional, motivational, and cognitive measures that serve as indicators of product preferences and/or in the prediction of behavioral responses (Genco, 2020). While decades ago electrical signal was

captured for the “whole brain” (resulting in highly diffuse constructs like ‘brain engagement’), today’s advanced EEG measures chiefly focus on examining changes in the activation of the occipital region and frontal lobe asymmetry, yielding indicators of attention and emotions (Venkatraman et al., 2015).

Unlike survey methods, EEG samples data hundreds of times per second, being more adequate for identification of interesting variations within the ad and in the examination of moment-to-moment reactions (Libet, 2009; Venkatraman et al., 2015). Another major limit of survey methods is they are incapable of adequately capturing affective responses. The cognitive process may encumber the ability to report affective experiences while one may question whether respondents can truly delineate between these two dimensions (Wiles and Cornwell, 1991). Moreover, self-reported measures are subjective and incomplete because they only capture conscious, declared (i.e. “offered”) responses (Micu and Plummer, 2010). EEG, on the other hand, provides highly sensitive, time-precise, and “spontaneous” brain responses to ad exposure. In comparison to a survey where the unit of analysis is typically a 30-second ad, the potential unit of EEG signal available for analysis is each millisecond. While survey methods provide conscious, retrospective, memorized, recalled, verbalized, and cognitively-interpreted information, EEG provides unconscious, real-time, affective, and autonomous responses. As such, EEG captures *total* brain responses that also encompass non-verbal modalities of stimuli (e.g. music, imagery), and is itself an outcome of non-verbal information processing (see Young, 2002; Rothschild et al., 1988). Consequently, EEG provides relevant and reliable insights into momentary emotional appraisals that cannot be adequately captured by self-reported verbal indicators.

Emotions are a complex and multilevel construct where the lack of consensus on its conceptualization and measurement is evident between and within different disciplines. In the behavioral paradigm, emotion refers to any brief conscious experience that characterizes intense mental activity and an elevated level of pleasure or displeasure (Cabanac, 2002). Such a conception is very broad and yet different to those developed by *neuroscience*, which emphasizes that emotions are immediate and “objective” *unconscious* bio-regulatory responses that encompass different regions of the *body and brain* and are aimed at promoting beneficial behaviors and physiological states. Feelings, on the other hand, are “subjective” and are conscious mental representations of emotions associated with valences – from pleasure to pain (Damasio, 2000; Damasio, 2003).

Emotions thus consist of different classes and exist on different levels; the lower level being *background* emotions (e.g. excitement, energy, approach/withdrawal), followed by *discrete* emotions comprising *primary* (happiness, fear, surprise) and *secondary* emotions (pride, jealousy). While marketing acknowledges emotions as unconscious ‘dispositional tendencies’ (see O’Shaughnessy, 2003), advertising still seems to be focused solely on the conscious and discrete aspects of emotions (see Poels and Dewitte, 2019). Emotions, however, operate and should be studied on both levels (unconscious/physiological and conscious/mental), which calls for different measurement approaches and methods. It is apparent that traditional survey methods can only access feelings and discrete emotions, while neuro-methods can actually register and measure basic emotions on an unconscious level (see Figure 1).

EEG methodology can validly and reliably detect diffuse “background” emotions (i.e. approach-avoidance emotions), which play the functions of appraisal, activation, and ‘dispositional’ motivation and ‘prepare the body for action’ (Parrott, 2004). Yet, background emotions lack specifics and a distinct influence since they differ from discrete emotions. From a neuroscientific perspective, it is also not completely clear how emotion interacts with attention and how to separate them (see Vimal, 2008). The latest advances, for instance, suggest that unconscious emotional appraisals in fact ‘activate and guide’ attention (Garces and Finkel, 2019). It is hence logical that neurophysiological ad indicators of emotion and attention were found to correlate (also see Venkatraman et al., 2015).

Figure 1: Different levels and measures of emotional response

Source: Adapted from Damasio (2003, Figure 2.1, p. 32).

While the diffuse nature of EEG metrics can make the interpretation of the obtained ad measures challenging, it should still be pointed out that its relevance and growing popularity arise from its key advantage: time-sensitivity. The fast development of technology and analytical methodology in recent years has vastly increased its portability, topological precision, and reliability (see Dimpfel, 2015). These are strong arguments in favor of EEG as one of the most suitable methods for the direct assessment of brain reactions at the “speed of thought” and the reliable measurement of relevant marketing constructs (Genco, 2020). Ultimately, the advertising profession cannot completely avoid the challenge of the “level and diffuse” nature of the basic constructs accessible with EEG and their correspondence with discrete, survey-measured counterparts, which calls for the further validation of EEG measures. In line with the identified imperatives and findings, three main research goals were established in order to structure and direct our empirical study and examination of the research hypotheses:

1. To examine how respective EEG indicators correspond with survey counterparts that measure the same constructs of emotions and attention.
2. To examine how different EEG indicators of emotions and attention predict advertising effectiveness (as measured by survey indicators).
3. To examine whether EEG indicators correspond with the conventional logic of ad effectiveness evaluation (positive links in the AIDA chain), which is typically found among survey ad indicators.

The first research goal was aimed at the validation of EEG measures against their survey counterparts which measure emotions and attention. The resulting research hypotheses therefore intend to examine the common assumption that EEG indicators measure (i.e. correspond with) the “same” constructs as

survey indicators. Several studies in the advertising domain provide support for expectations of a correspondence between EEG and survey indicators (e.g. Vecchiato et al. 2011; Deitz et al., 2016; Daugherty et al., 2018; Rothschild and Hyun, 1990). On the other hand, some comprehensive studies found no correlation or a weak one among EEG and self-reported measures for the same constructs (e.g. Venkatraman et al., 2015). While literature partially supports it, such an important assumption necessitates its empirical verification. Accordingly, the following research hypotheses are proposed:

H1: The aggregate EEG indicator of approach/avoidance emotions (measured as frontal lobe asymmetry) will be positively associated with the survey indicator of positive emotions.

H2: The aggregate EEG indicator of visual attention (measured as alpha wave desynchronization) will be positively associated with the survey indicator of attention.

The second research goal was aimed at examining how EEG indicators of basic emotions and visual attention correspond with survey ad effectiveness indicators. For basic approach/avoidance emotions, frontal lobe asymmetry is an established EEG measure. The relationship between the metrics of EEG asymmetry and emotions seem to be well-replicated and beyond question (Allen et al., 2004). Greater relative activity in the left frontal region in turn was found to correlate with approach motivations, including liking, wanting, motivation to act, purchase intent, and willingness to pay (Ravaja et al., 2013; Ohme, et al., 2009). More specifically, greater responses in the alpha band frequencies were found for positive stimuli in the left hemisphere (i.e. Harmon-Jones et al., 2010) and for negative stimuli in the right hemisphere (Davidson et al. 1990; Wheeler et al., 1993). In advertising, the respective EEG ad indicators are typically aggregated (indexed) across the whole ad duration (see Deitz et al., 2016), which is acknowledged to be a comparable time unit (Varan et al., 2015). Hence, it is proposed that:

H3: The aggregate EEG indicator of approach/avoidance emotions (measured as frontal lobe asymmetry) will be positively associated with the survey indicator of behavioral intentions.

In ad effectiveness frameworks and studies other relevant indicators were found to be positively related, such as attention and favorable/positive emotions (Yelkur et al., 2013). For *visual attention*, which is relevant while watching ads, desynchronization of the alpha waves in the occipital cortex is an acknowledged neuroscientific measure. A high degree of desynchronization of the alpha band (a drop in relative alpha power) in the occipital region was found to correlate with attention activation (Rothschild et al., 1988; Klimesch et al., 2006). Other studies report that attention correlates with liking, informativeness, excitability, and ad relevancy (Biel and Bridgwater, 1990; Brown and Stayman, 1992; Smit et al., 2006). Finally, emotions and attention are neurologically-dependent phenomena (Simons et al., 2003; Vimal, 2008). Their expected relationship was also confirmed in the advertising domain where emotions were found to be related with engagement, motivation, and long-term memory (Ravaja, 2004). Accordingly, it is proposed that:

H4: The aggregate EEG indicator of visual attention (measured as alpha wave desynchronization in the occipital lobe) will be positively associated with the survey indicator of positive emotions.

Another key task of ad evaluation is to verify the transfer of positive reactions from the ad to the *brand*. Traditional methods were thus deployed to test different types of transfer, such as that of ad feelings to ad attitudes (Pieters and Warlop, 1999; Cho and Stout, 1993), but also the transfer from ad to brand.

The transfer of emotions experienced during ad exposure to a brand was supported by some early studies like that of Machleit and Wilson (1988). More recently, the positive influence of emotions on brand evaluations was supported by Derbaix (1995) and Pham et al. (2013). This leads to the following proposition:

H5: The aggregate EEG indicator of approach/avoidance emotions (measured as frontal lobe asymmetry) will be positively associated with the survey indicator of (cognitive) brand evaluation.

The time-precise pattern of the EEG signal that enables the development of new, non-aggregated (patterned) ad indicators of relevance currently seems to be an underutilized opportunity. Several studies confirm that the timing of ad scenes corresponds with neurophysiological reactions (Smith and Gevins 2004; Bolls et al., 2001). Frequency or the *number of peaks* of EEG signal changes, which indicate ad dynamics, is thus a potentially relevant ad indicator. Another relevant patterned indicator is *highest emotional peak*. As found by Young (2002), peak branding moments in an ad ‘do much of the work’. Ohme et al. (2009) established that even a single scene (that distinguishes two adds) affects the EEG emotional response pattern. In addition, Baumgartner et al. (1997) found that overall ad judgments were mostly affected by the peak emotional moments. This phenomenon is known as the peak–end rule (see Fredrickson and Kahneman, 1993; Do et al., 2008). While some studies confirm that physiological measures can identify emotional peaks in ads (see Micu and Plummer, 2010), no attempts are known to verify this peak-end effect by means of respective EEG ad indicators. It is therefore proposed that:

H6: Peak EEG indicators of approach/avoidance emotions will be *more strongly* positively associated with behavioral intentions than respective *aggregate* EEG indicators (of approach/avoidance emotions).

The third research goal was focused on examining the conventional (i.e. positive) AIDA logic deployed in survey research. This logic implies that respondents evaluate ads in a conscious and rational manner and is rooted in a tripartite model made up of cognitive, affective, and behavioral components (Rosenberg and Hovland, 1960). In more recent literature, additional components of ad effectiveness have been recognized like attention, affect, memory and desirability (Venkatraman et al., 2015). Still, survey research of advertising effectiveness follows the same “linear and positive” hierarchy of communication goals assumed by the traditional AIDA model. Since this model enjoyed considerable empirical support (see e.g. Haley and Baldinger, 2000), this leads to the following proposition:

H7: All survey ad indicators (attention, positive emotions, cognitive brand evaluation, behavioral intentions) will be positively associated with each other.

Neuroscience challenges the assumption of ‘cognitive primacy’, and conscious ad processing. The latest neuroscientific theories namely build on the assumption of *emotional primacy* (Garces and Finkel, 2019; Achar et al., 2016). These theories are grounded on adaptive (evolutionary) logic and suggest that emotions belong to the distinctive, largely unconscious nervous system that operates in a different manner, being prone to *negativity bias* (Cacioppo et al., 1999; Smith et al., 2003). Negativity bias is the tendency of negative information to have a stronger impact on attention, motivation, and behavior, than positive information, and is empirically well supported in neuroscience (see Norris, 2019). In particular, negative bias is evident in the emotions-attention relationship (Smith et al., 2003; Carretié et al., 2001; Pérez-Edgar et al., 2013; Schutter et al., 2001). The effects of negativity bias were also explored in advertising, where Brown et al. (1998) concluded that positive and negative ad-evoked emotions have

contingently asymmetrical effects. Negativity bias was namely found to be contingent upon (low) cognitive elaboration. The contingent asymmetry principle resolves and explains the contrast between the positive AIDA correlations proposed in H7 and negative correlations, which is expected between emotions and attention among neuroscientific (EEG) ad indicators. Hence, the final research hypothesis is proposed:

H8: The aggregate EEG ad indicator of approach/avoidance emotions (measured as frontal lobe asymmetry) will be *negatively* related with the aggregate EEG ad indicator of visual attention (measured as alpha wave desynchronization in the occipital lobe).

METHODOLOGY

The research team, study approach, and sample

To enable the systematic and robust examination of the proposed research questions, this study deployed proprietary sets of ad indicators developed for commercial use. The empirical study was conducted in partnership with a market research and consultancy agency that operates in a European (CEE) region where it was a pioneer and a leading company in the development of EEG-based neuro ad indicators. Over the past 5 years, it has developed an expanded set of EEG ad indicators, some of which were newly developed and innovative on the global scale. The company has also deployed a wide set of traditional survey ad indicators that may be classified in four basic construct categories of relevance as they capture emotional response, attention, cognitive brand evaluation, and behavioral intentions.

To test the proposed hypotheses, two corresponding studies on the same sample of 40 ads were conducted. The analyzed ads varied in length (with an average of 36 seconds), had different communication goals (focused on promoting products as well as corporate image), and covered different industries (FMCG, telecom, financial) in four different (EU/non-EU) countries. In Study 1, EEG measures were employed with 30 respondents aged from 15 to 65 years, and representative of the target population by age, gender, and geographic region. Those 30 subjects were the same for different ads and were exposed to blocks of ads. Each participant was exposed to a random selection (i.e. block) of 20 to 25 commercials, where each ad was presented only once within a block and the sequence of ads was randomized in order to control for the effect of ad sequence. All potential participants for the EEG measurement were required to complete a recruitment questionnaire to ensure the relevance and validity of the results obtained. Participants who reported they were relying on glasses with a lens with a diopter greater than 5 or had a particular type of neurodegenerative disease were excluded from the research process. Others who met the required research conditions and signed a voluntary and informed consent to participate in the electroencephalographs were included in the study. Once the subjects had provided the mentioned consent, special instructions were given to them, such as: to have enough hours of sleep the night before the research; to not drink alcohol, coffee or energy drinks 1 hour before the research, and to not use products for hairstyling (as this affects skin conductance).

The EEG study was conducted in a laboratory setting for greater experimental control and ecological validity. Each participant was individually introduced into the study room and the necessary equipment was connected to their body. For this research, the actiCAP Xpress EEG model was used. This is a novel, dry-electrode system with sensitive gold-plated electrodes. Dry electrodes (without conductive gel) are becoming more popular because they enhance the ability to move traditional lab-based research into the real world. The dry actiCAP Xpress is convenient for respondents as it speeds up the preparation and is more comfortable. Comfortability and flexibility add to the ecological validity, which is an important issue in neuromarketing studies. The electrode system deployed can reliably measure EEG spectra, although the system records greater noise, which is better controlled in a lab setting and mitigated with active amplification (Mathewson et al., 2017). After the necessary

experimenter checks, each participant viewed a randomized block of commercials for a total maximum length of 20 minutes. After completing the experiment, the lab assistant thanked the participants and gave them a suitable gift for having participated in the study.

For Study 2, a standardized survey questionnaire was used with a sample of respondents aged from 15 to 65 years, representative of the target population by age, gender, and geographic region, and comprised 30 respondents for each commercial. A computer-assisted online interviewing (CAWI) method was used to collect the answers. It took around 15 minutes to complete the questionnaire. The exposure procedure and randomization were the same as described above for Study 1.

Measures used

Study 1 – EEG-based ad indicators

This study examined a wider set of EEG ad indicators for two key constructs (i.e. emotions and attention). Discrete indicators were also aggregated to form a summary EEG-measure called the NEMFA INDEX™. Emotions were measured on the basis of frontal lobe asymmetry, while attentional indicators were based on alpha waves' desynchronization (i.e. an inverse drop in alpha power) in the occipital cortex. Based on these two basic neuro-methods and proprietary processing algorithms, several discrete ad indicators were used for each key construct (see Table 1 for the complete list and descriptions). For example, the 'ERi – Emotional Reaction index' was constructed as the average emotion score across the entire ad and revealed the overall emotional approach/avoidance response. A higher ERi index indicated more intensive "approach" emotions such as liking, pleasure, happiness and wanting. Other indicators, such as the 'ERph – Emotional Reaction peak', showed the highest single peak score during the whole ad, while 'ERpn' provided the number of significant positive peaks during the whole ad (*those whose magnitude exceeded the average score (i.e. > 50% ERi) were considered to be 'significant peaks'*).

The same logic and derived indicators also applied to the attention construct. Emotion and attention peaks were additionally separately captured and processed for the ad segment where the brand is displayed, resulting in corresponding indicators (i.e. BERph – Branded Emotional Reaction Peak height and BAph – Branded Attention Peak height).

Table 1: Description of the EEG ad indicators

EEG indicator (label)	Measured Construct	Description – construction	Referential studies
ERi	Emotions (approach-avoidance tendency)	ERi – Emotional Reaction index; the average score of frontal lobe asymmetry for the whole ad length	Venkatraman et al. (2015) Ravaja et al. (2013) Davidson et al. (1990) Ohme et al. (2009, 2010) Vecchiato et al. (2011)
ERph	Emotions (approach-avoidance tendency)	ERph – Emotional Reaction peak; the highest positive score of frontal lobe asymmetry during the whole ad	
ERpn	Emotions (approach-avoidance tendency)	ERpn – Number of significant positive peaks of frontal lobe asymmetry during the whole ad	Ohme et al. (2009)
BERph	Emotions (approach-avoidance tendency)	BERph – Branded Emotional Reaction Peak; the highest positive score of frontal lobe asymmetry for the scene where the brand is displayed	

ATi	Attention (visual)	ATi – Attention index; average alpha waves' desynchronization (inversed drop) score in the occipital cortex for the whole ad	Venkatraman et al. (2015) Rotschild et al. (1988) Reeves et al. (1985)
ATph	Attention (visual)	ATph – Attention peak; a highest score of alpha waves' desynchronization in the occipital cortex during the whole ad	Ravaja (2004)
ATpn	Attention (visual)	ATpn – Number of significant attention peaks of alpha waves' desynchronization in the occipital cortex during the whole ad	
BATph	Attention (visual)	BATph – Branded Attention Peak; the highest peak/score of alpha waves' desynchronization in the occipital cortex for the branding scene	Ravaja et al. (2013)
NEMFA index	Emotions and Attention	NEMFA index; Neuro-engagement index; a summary (averaged) measure which combines ERi, ERph, BERph, Ai, Aph and BAph	Deitz et al. (2016) Smith and Gevins (2004) Young (2002)

Study 2 – Survey measures

Survey-based indicators were elaborated in the extensive questionnaire developed by the Agency, with a wide set of ad indicators that altogether encompassed 105 different, discrete variables and composite measures of various types (i.e. interval scales, multiple response choices, and top-of-mind open-ended questions). Based on 80 scaled questionnaire items, five different summary ad indicators (indexes) were constructed including the overall Advertising Effectiveness Index (ADI Index™).

For the purpose of this study, data were aggregated at the level of an ad (for a similar procedure, see Venkatraman et al., 2015). In order to use those items to form a meaningful index (see Diamantopoulos and Winklhofer, 2001), first the content specification of the indexes was examined in detail and five indexes were defined, namely the Emotional index of positive emotions (EI), Attention index (AI), Cognition Index (CI), Behavioral intentions (BI), and overall Advertising Effectiveness Index (ADI) (see Appendix 1 for a detailed list of included items). All indicators were examined as to whether they represent the scope of the latent variable, thus following the indicator specification. The items were examined by industry professionals, marketing academics and independent experts in the field. As the outcome, only items that belong to the same construct across all evaluators were kept for further index formation. In the next step, the issue of multicollinearity was examined by means of collinearity indicators, ensuring that there are no correlations higher than 0.8 and that the VIF factor is not above 10. Finally, in order to ensure external validity in the index development process, the indexes were correlated among themselves. In addition, to further assure the validity of the measures, Cronbach's alpha coefficients were calculated for the indexes created (see Table 3).

ANALYSIS AND RESULTS

The research methodology deployed a large number of indexes for EEG and survey ad indicators, but also of discrete, item-level variables (where all 720 bivariate correlations were inspected). Due to space limits and the fact that only a few correlations among item-level variables were statistically significant, only the results for validated indexes that served in the testing of the hypotheses are reported. Given the small sample employed, correspondence among the ad indexes was analyzed by means of simple pair-wise correlational analysis (presented in Table 2 and Table 3). The results in the upper half of Table

2 provide an insight into first two research goals and examination of hypotheses H1 – H6, while Table 3 is relevant for the third research goal and the test of hypotheses H7 and H8.

Results shown in the upper half of Table 2 reveal that, with a single exception, the examined relationships among EEG and survey ad indicators exhibit statistically non-significant correlations, including the composite EEG (NEMFA™) and survey (ADI™) measures. The bottom part of Table 2 which depicts bivariate correlations among EEG ad indexes reveals a different picture since it contains more significant correlations. Most correlations between different EEG indicators (i.e. 21 out of 36) are namely significant, where correlations among the attentional EEG indicators also tend to be of a higher magnitude than among the emotional EEG indicators. Given that the emotional indicators exhibit higher intra-correlations among themselves than with attentional indicators, this affirms that the EEG indicators reflect the common underlying constructs, which are distinctive. The overall, composite EEG index (NEMFAi) that summarizes all of the EEG indicators deployed significantly correlates with seven (out of eight) neuro-measures, where the highest is the correlation with both highest peaks for branded sections (BERph and BATph). This reveals that the peaks of the EEG indicators better explain general “brain-engagement” than the aggregate EEG indicators.

Table 2: Correlations among the summary EEG and survey-based ad indicators

	NEMFA	ERi	ERph	ERpn	BERph	ATi	ATph	ATpn	BATph
		Emotional Reaction Index ERI	ERI highest peak	ERI number of peaks	Brand section peak ERI	Attention Index AI	AI highest peak	AI number of peaks	Brand section peak AI
ADI	0.11	-0.19	-0.07	-0.04	0.09	0.13	0.01	0.09	0.25
EI	0.16	-0.24	-0.01	-0.05	0.11	0.15	0.03	0.10	0.31
AI	0.22	0.01	0.04	0.03	0.23	0.16	0.02	0.01	0.16
CI	0.08	0.09	0.02	0.11	0.11	0.12	0.01	-0.02	-0.06
BI	0.26	-0.11	-0.01	-0.08	0.34*	0.11	0.05	-0.01	0.27
NEMFA	1	0.23	0.56**	0.47**	0.63**	0.56**	.55**	.45**	.65**
ERi		1	0.33*	0.48**	0.35*	-0.33*	-0.30	-0.31*	-0.16
ERph			1	0.41**	0.06	0.07	0.36*	0.26	0.11
ERpn				1	0.31*	-0.03	0.04	0.16	0.32*
BERph					1	0.03	-0.08	-0.16	0.27
ATi						1	0.67**	0.67**	0.51**
ATph							1	0.74**	0.26
ATpn								1	0.43**
BATph									1

N = 40 ads

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

First research goal was aimed at examining whether the EEG indicators correspond with their survey counterparts. H1 proposed a positive association between the aggregate EEG index of approach emotions (ERi) and the survey index of positive emotions (EI) and was not supported. H2, which proposed a positive association between the aggregate EEG index of visual attention (ATi) and the survey index of attention (AI), was not supported either.

In line with the second research goal, hypotheses H3–H6 proposed an association between EEG ad indicators and survey indicators of ad effectiveness. H3 that proposed a positive association between the aggregate EEG index of approach emotions (ERi) and the survey index of behavioral intentions (BI) was not supported. H4 proposed a positive association between the aggregate EEG index of visual attention (ATi) and the survey index of positive emotions (EI) and was also not supported. H5, which

proposed a positive association between the aggregate EEG index of approach emotions (ERi) and the survey index of cognitive brand evaluation (CI) was not supported too. H6 was aimed at a comparison of the aggregate and peaked EEG indicators and proposed a more positive association among the peak EEG indexes of approach emotions (ERph and BERph) and the survey index of behavioral intentions (BI). While the ERi-BI and BERph-BI correlations are not significant, the correlation between BERph and BI is significant ($r=0.34$), thereby partially supporting H6.

Table 3: Correlations among the survey ad indexes

Index	Cronbach's alpha	EI	AI	CI	BI	ADI
Emotional Index (EI)	0.82	1.000				
Attention Index (AI)	0.86	0.71**	1.00			
Cognitive Index (CI)	0.81	0.53**	0.57**	1.00		
Behavioral intention (BI)	0.86	0.74**	0.63**	0.45**	1.00	
Aggregated ADI Index	0.93	0.79**	0.87**	0.77**	0.77**	1.00

N = 40 ads

** Correlation is significant at the 0.01 level (2-tailed) * Correlation is significant at the 0.05 level (2-tailed)

The third research goal sought to examine whether the associations among the survey ad indexes support a different underlying logic (i.e. positive AIDA links) than the EEG ad indicators of emotion and attention. To this end, H7 proposed that all survey ad indicators (positive emotions (EI), attention (AI), cognitive brand evaluation (CI) and behavioral intentions (BI), would be positively associated with each other. The results in Table 3 reveal that all respective survey ad indicators are indeed significantly and positively correlated, thereby providing full support for H7. Following an alternative, neuroscientific logic, H8 proposed a negative association between the aggregate EEG indicators of approach emotions (ERi) and the EEG indicator of visual attention (ATi). Given that their correlation is significant and negative ($r=-0.33$), H8 was also supported.

DISCUSSION AND IMPLICATIONS

The obtained results and verification of the proposed hypotheses (summarized in Table 4) affirm the distinct relevance of EEG indicators and provide important implications for the evaluation and improvement of ad effectiveness.

First key finding of the present study that warrants discussion is the lack of correspondence between the EEG and survey indicators for attention and emotions. This finding is in line with those of Venkatraman et al. (2015) and Young (2002) which are, to date, rare studies that deployed comparable EEG and survey measures to the current study. Given that a robust research design (i.e. ad as a unit of analysis, with 30 respondents per ad) and an expanded set of indicators for each method were deployed, this provides support for the conclusion that 'different methods measure different things', as suggested by Young (2002). This conclusion is also consistent with neuro-scientific paradigm (illustrated with Figure 1), which proposes that emotional reactions captured by EEG and surveys exist on different levels of (sub)consciousness. Notably, even different neuro-measures of emotions such as EEG and fMRI were found to correspond weakly (see e.g. Varan et al., 2015; Venkatraman et al., 2015). Relevant meta-reviews of emotional measures also reveal that the correlations among multiple measures of emotion are 'moderate at best' (see Maus and Robinson, 2009), suggesting that autonomic and self-report measures of emotion 'fundamentally differ in the aspect of emotions they register' (Poels and Dewitte, 2006).

It thus makes no sense to approach ad evaluation from standpoint that there is a single gold standard for the measurement of emotional responses to ads, and is even more problematic to treat survey measures as such a validation criterion. Instead, the lack of correspondence among EEG and survey measures suggests they are alternative measures of broader evaluative constructs of use for complementary purposes. Since advertising works on a number of levels, multiple measurements are needed for a full evaluation of ad effectiveness. The repeated calls for improved understanding of the differences, dis/advantages, differential use and complementarity of both approaches (see Shen and Morris, 2016; Deitz et al., 2016; Ohme et al., 2010; Haley and Baldinger, 2000) thus seem well justified.

EEG is particularly useful for a more detailed examination of responses to *branding scenes* since it reveals unconscious and spontaneous emotional reactions, which are considered to be more authentic and impactful (Micu and Plummer, 2010). Researchers may also deploy EEG in contemporary, digital contexts in order to detect and assess real-time responses to particular scenes in online videos. This is, for instance, especially valuable for movie trailers since their optimization is vital for viewers' intention to watch the movie (see Liu et al., 2018). Another aspect where EEG is practically relevant is an examination of the *narrative dynamics* of ads. Some studies have namely confirmed that scene changes and timing were reflected in EEG patterns (Reeves et al., 1985; Rossiter et al., 2001; Ohme et al., 2009). In addition, Gordon et al. (2018) found that narrative video segments in ads affected attention, memory, emotions, and imagination. This suggests that in the future additional 'dynamic' EEG indicators could be constructed, such as the 'slope of affective trend' (see Baumgartner et al., 1997). Eventually, EEG indicators are potentially also relevant for the examination of storytelling aspects and improvement of the creative briefing process (see Young, 2002; Ravaja, 2004; Micu and Plummer, 2010).

Regarding the predictive capacity of EEG indicators, the findings show that aggregate EEG indicators are poor predictors of ad effectiveness against survey-based criteria. The composite EEG NEMFA™ index that represents "general neuro-engagement", and the aggregate indexes of emotion (ERi) and attention (ATi), did not prove to be significant predictors of either cognitive brand evaluation (CI) or behavioral intentions (BI). Among the tested EEG indicators, there is however a notable exception that provides support for the peak-end effect hypothesis and identifies a potentially more predictable type of EEG ad indicators; namely, the indicator of emotional peak during branded moments (BERph) significantly correlates with behavioral intentions (BI). It seems that the tested EEG indicators only predict behavioral intentions when emotional reaction to a branded section is strong enough to "breakthrough" from the unconscious to conscious level, and cause respondents to be aware of their behavioral intentions reported in a survey. Also important is that, in comparison to the aggregate indexes of emotion (ERi) and attention (ATi), the patterned, 'branded peak' ones (BERph, BATph) exhibit the highest correlations with the composite neuro-engagement measure (NEMFA™ index).

These findings suggest that composite EEG indexes which are averaged for the whole ad are probably too insensitive and "leave out" decisive (peak) moments. This may explain why some comparable studies, such as that of Venkatraman et al. (2015), found no correlation among (averaged) EEG indicators and purchase intentions. In line with peak-end theory, overall evaluation of the ad is based on the most intense sensation felt during the entire experience (the peak) and the sensation felt in the last moment (the end) of the experience (Fredrickson and Kahneman, 1993; Baumgartner et al., 1997). The study of Woltman Elpers et al. (2003) also suggests that higher initial levels of informative value irritate viewers and negatively affect the likelihood that viewers will continue to watch an ad. These insights were supported by experimental and survey-based advertising research, yet are still waiting to be widely deployed by means of EEG, which captures the "dynamic pattern" of brain response and is highly useful for identifying such *decisive moments* in advertisements. Accordingly, the aggregate treatment of EEG indicators as alternative predictors of in-market behavior seems misleading as it fails

to exploit the true potential of the EEG methodology. Instead, “patterning” appears as a better alternative (also see Davidson et al., 1990; Ravaja, 2004).

Table 4: Summary of hypotheses testing:

H1	The aggregate EEG indicator of approach/avoidance emotions will be positively associated with the aggregate survey indicator of positive emotions.	Not supported
H2	The aggregate EEG indicator of visual attention will be positively associated with the aggregate survey indicator of attention.	Not supported
H3	The aggregate EEG indicator of approach emotions will be positively associated with the aggregate survey indicator of behavioral intentions.	Not supported
H4	The aggregate EEG indicator of visual attention will be positively associated with the aggregate survey indicator of positive emotions.	Not supported
H5	The aggregate EEG indicator of approach emotions will be positively associated with the survey indicator of (cognitive) brand evaluation.	Not supported
H6	<i>Peak</i> EEG indicators of approach emotions will be more strongly positively associated with behavioral intentions than respective <i>aggregate</i> EEG indicators (of approach emotions).	Partially supported
H7	Survey ad indicators (attention, positive emotions, cognitive brand evaluation, behavioral intentions) will all be positively associated with each other.	Supported
H8	EEG ad indicators of approach/avoidance emotions will be negatively related with EEG ad indicators of visual attention.	Supported

The final key issue is the different (i.e. AIDA-negative) logics that relate to EEG ad indicators and warrants further discussion. The findings obtained concur with neuroscientific theories, which posit that appraisal emotions activate attention (Garcés and Finkel, 2019) and exhibit negativity bias (Smith et al., 2003; Carretie et al., 2001). Due to the dominance of rational and cognitive (AIDA-positive) logic, the advertising profession on the other hand seems to exhibit *positivity bias*. In order to account for the universal and disproportionately significant effects of negative emotions (see Norris, 2019), advertising research should in the future instead devote more attention to examining the negative emotional responses to ads.

In advertising, negativity bias was found to be contingent upon low cognitive elaboration (Brown et al., 1998). Here, it is important to note that ad processing depends on task load (see Wang and Duff, 2016) and, while survey methodology (due to the conscious and verbal processing) itself requires substantive cognitive elaboration, EEG indicators capture spontaneous (non-declared) brain responses and do not require *any* conscious or elaborated cognitive processing. This implies that AIDA-negative findings are *method-contingent* and suggest caution with their interpretation, yet also further illuminates why they are often inconsistent (see Thorson et al., 1992; Goodrich, 2011). Notably, Thorson et al. (1992) deployed survey (self-reported) measures of emotions and attention, while Goodrich (2011) deployed a combination of survey and *behavioral* (mouse-clicks) methodology. Further and more rigorous exploration of the biases and contingencies that affect AIDA links is thus needed, due to the idiosyncratic and immanent cognitive loads of different methods. This necessitates the use of neuroscientific methods like EEG because only they can capture cognitively non-elaborated emotional and attentional responses.

While emotions proverbially ‘wreak havoc’ on rationality, their distinctive and constructive role in judgement is increasingly recognized (Cacioppo et al., 1999; Damasio, 2000; Wang, 2006). Among

others, emotions protect costly cognitive resources and lead consumers to act like ‘cognitive misers’. Accordingly, choices that require more cognitive effort prompt negative “process-induced” emotions and result in brand avoidance (Garbarino and Edell, 1997). In a similar manner, information overload was found to trigger negative emotions (Woltman Elpers et al., 2003; Moon et al., 2017). Given that EEG ad indicators register the ‘total’ brain response, they are relevant for identifying and exploring such process- and overload-related ad inefficiencies that induce negative emotions or unwanted attention. Such ad inefficiencies are, for instance, the poor synchronization or timing of different modalities (e.g. audio/video), an illogical flow/sequence of scenes etc. These aspects of ads increase attention because they are unclear and cannot be processed automatically and effortlessly, thereby demanding more cognitive work. In this way, EEG indicators can signal cognitive workload (see Antonenko et al., 2010) and illuminate important drivers of decreased ad and brand preferences.

EEG thereby enables differential examination of ad effectiveness in terms of concepts, effects, and implications – beyond the constraints immanent to survey indicators. Accordingly, researchers and practitioners are advised to use EEG indicators in the pursuit of additional communication goals and beyond baseline in-market effectiveness criteria. In this manner, they could more comprehensively verify if an ad is actually doing what the creative team designed it to do and to better understand why successful ads were successful. This is how the time-sensitive EEG methodology can fruitfully facilitate the replication and improvement of ad effectiveness in the future.

LIMITATIONS AND FUTURE RESEARCH

The main limitations of the current study stem from the small sample, but also from the proprietary data source. While the former suggests caution with interpretation and conclusions, the latter suggests a need for greater transparency and point to some important research challenges that need to be addressed in the future. While comparable EEG studies often examine only a handful of ads, this sample of 40 ads was still small given that the ad was the unit of analysis. The sample namely consists of different industries and was not controlled for potentially relevant factors, such as product type (e.g. high/low involvement / impulse vs. deliberate) and communication goals (e.g. corporate image and product promotion). In the case of a different sample of ads, findings regarding emotional responses, attention, and behavioral intentions might thus have been different.

Another limitation is that this study did not include any measure of *actual* purchase behavior, which is an important recommendation for the future. In addition, data were aggregated at the level of an ad, thus preventing any more elaborate statistical analysis, such as examination of the factorial structure of basic constructs (i.e. positive emotions, attention and cognition) that were measured with an extensive proprietary survey. Had discrete variables been examined (e.g. discrete positive/negative emotions), the results might have also differed. Anger as a negative emotion was, for instance, found to be a ‘coactive’ emotion with both ‘aversive and appetitive’ effects (Lee and Lang, 2009). This research avenue is thus warranted in the future.

For EEG indicators, details of the construction (e.g. calculation algorithms) were not accessible to the researchers due to the proprietary methodology and non-disclosure agreement with the Agency. In neuromarketing/EEG, a lack of correspondence among ad indicators is a common problem and may be a consequence of the different technologies and neurophysiological procedures employed by different vendors (Varan et al., 2015). The methodology that transforms raw signals into theoretically sensible ad-indicators is a potentially important source of variance, and this could have affected the results obtained in the present study, yet of unknown scope and magnitude. This is, to some extent, a general characteristic of neuromarketing methods that, unlike surveys, do not operate with universally standardized and comparable values. Further, in the present study the raw EEG signal for

approach/avoidance emotions was normalized on the individual-respondent level. Yet, for visual attention the signal was calibrated (i.e. normalized) within the sample of ads and not normalized within participants. As a result, the EEG ad indicators provided by different vendors are hardly fully comparable. The obtained findings are thus mainly comparable with EEG studies that deployed the same EEG measures (i.e. frontal lobe asymmetry and alpha waves' desynchronization in the occipital cortex).

This makes it important that further EEG studies be founded on a single source of data, deploy transparently developed EEG indicators, and acknowledge and discuss the *comparability* of the findings, especially as the rapid development of EEG methodology enables the measurement of additional constructs and is opening up new research possibilities (Genco, 2020). Besides emotions and attention, future studies should include additional constructs, such as motivation, memory, and cognition that are also measurable by EEG (see Dimpfel, 2015). Neuromarketing could thereby further complement the existing methods, and distinctively contribute to the advertising profession.

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REFERENCES

- Achar C., So J., Agrawal N., Duhachek A. "What we feel and why we buy: the influence of emotions on consumer decision-making." *Current Opinion in Psychology* 10 (2016): 166-170.
- Allen J.J., Coan J.A., Nazarian M. "Issues and assumptions on the road from raw signals to metrics of frontal EEG asymmetry in emotion." *Biological psychology*, 67,1-2 (2004): 183-218.
- Antonenko P., Paas F., Grabner R., Van Gog T. "Using electroencephalography to measure cognitive load." *Educational Psychology Review* 22, 4 (2010): 425-438.
- Ariely D., Berns G.S. "Neuromarketing: the hope and hype of neuroimaging in business." *Nature reviews neuroscience* 11, 4 (2010): 284.
- Baumgartner H., Sujan M., Padgett D. "Patterns of affective reactions to advertisements: The integration of moment-to-moment responses into overall judgments." *Journal of Marketing Research* 34, 2 (1997): 219-232.
- Bergkvist L., Rossiter J.R. "The Predictive Validity of Multiple-Item Versus Single-Item Measures of the Same Constructs." *Journal of Marketing Research* 44, 2 (2007): 175-84.
- Bergkvist L., Langner T. "Construct measurement in advertising research." *Journal of Advertising* 46, 1 (2017): 129-140.
- Biel A.L., Bridgwater C.A. "Attributes of likable television commercials." *Journal of Advertising Research* 30, 3 (1990): 38-44.
- Boksem M. A. S., Smidts A. "Brain responses to movietrailers predict individual preferences for movies and their population-wide commercial success." *Journal of Marketing Research* 52, 4 (2015): 482-492.
- Bolls P.D., Lang A., Potter, R.F. „The effects of message valence and listener arousal on attention, memory, and facial muscular responses to radio advertisements." *Communication Research* 28 (2001): 627-651.
- Brown S.P., Homer P.M., Inman J.J. "A meta-analysis of relationships between ad-evoked feelings and advertising responses." *Journal of Marketing Research* 35, 1 (1998): 114-126.

- Brown S.P., Stayman D.M. "Antecedents and consequences of attitude toward the ad: A meta-analysis." *Journal of Consumer Research* 19, 1 (1992): 34-51.
- Cabanac M. "What is emotion?" *Behavioural Processes* 60, 2 (2002): 69-83.
- Cacioppo J.T., Gardner W.L., Berntson G.G. „The affect system has parallel and integrative processing components: Form follows function." *Journal of personality and Social Psychology*, 76, 5 (1999): 839-855.
- Carretié L., Mercado F., Tapia M., Hinojosa, J.A. "Emotion, attention, and the 'negativity bias', studied through event-related potentials." *International journal of psychophysiology* 41, 1 (2001): 75-85.
- Cho H., Stout, P. A. "An extended perspective on the role of emotion in advertising processing." *ACR North American Advances*. (1993)
- Damasio A. *The feeling of what happens*. Heinemann, London, 2000.
- Damasio A. *Looking for spinoza: Joy, sorrow, and the feeling brain*. London, 2003.
- Daugherty T., Hoffman E., Kennedy K., Nolan M. "Measuring consumer neural activation to differentiate cognitive processing of advertising: Revisiting Krugman." *European Journal of Marketing* 52, 1-2 (2018): 182-198.
- Davidson R.J., Chapman J.P., Chapman L.J., Henriques J.B., "Asymmetrical brain electrical activity discriminates between psychometrically-matched verbal and spatial cognitive tasks." *Psychophysiology* 27 (1990): 528–543.
- Deitz G. D., Royne M.B., Peasley M.C., Coleman J. T. "EEG-based measures versus panel ratings: Predicting social media-based behavioral response to super bowl ads." *Journal of Advertising Research*, 56, 2 (2016): 217-227.
- Derbaix C.M. "The impact of affective reactions on attitudes toward the advertisement and the brand. A step toward ecological validity." *Journal of Marketing Research* 32. 4 (1995): 470–479.
- Diamantopoulos A., Winklhofer H.M. "Index construction with formative indicators: An alternative to scale development." *Journal of marketing research* 38, 2 (2001): 269-77.
- Dimpfel W. "Neuromarketing: neurocode-tracking in combination with eye-tracking for quantitative objective assessment of TV commercials." *Journal of Behavioral and Brain Science* 5, 4 (2015): 137.
- Fredrickson B.L., Kahneman D. "Duration neglect in retrospective evaluations of affective episodes." *Journal of Personality and Social Psychology* 65, 1 (1993): 45-55.
- Garbarino E.C., and Edell, J.A. "Cognitive effort, affect, and choice." *Journal of consumer research*, 24, 2, (1997): 147-158.
- Garcés M., Finkel L. "Emotional theory of rationality." *Frontiers in integrative neuroscience* 13, 11 (2019): 1-24.
- Genco S. "Why and How do Neuromarketers Measure Brainwaves using EEG?" (found on 17.2. 2020 - available at): <https://www.nmsba.com/buying-neuromarketing/neuromarketing-techniques/why-and-how-do-neuromarketers-measure-brainwaves-using-eeg>
- Goodrich K. "Anarchy of effects? Exploring attention to online advertising and multiple outcomes." *Psychology and marketing* 28, 4 (2011): 417-440.
- Gordon R., Ciorciari J., van Laer T. "Using EEG to examine the role of attention, working memory, emotion, and imagination in narrative transportation." *European Journal of Marketing* 52, 1-2 (2018): 92-117.
- Haley R.I., Baldinger A.L. "The ARF copy research validity project." *Journal of Advertising Research* 40, 6 (2000): 114-135.

- Hakim A., Levy D.J. "A gateway to consumers' minds: Achievements, caveats, and prospects of electroencephalography-based prediction in neuromarketing." *Wiley Interdisciplinary Reviews: Cognitive Science*, 10, 2 (2019): 1-21.
- Harmon-Jones E., Gable P.A., Peterson C.K. "The role of asymmetric frontal cortical activity in emotion-related phenomena: a review and update." *Biological Psychology* 84, 3 (2010): 451-462.
- Heath R., Brandt D., Nairn A. "Brand relationships: Strengthened by emotion, weakened by attention." *Journal of Advertising Research* 46, 4 (2006), 410-419.
- Herr P.M., Page C.M. "Asymmetric association of liking and disliking judgments: So what's not to like?" *Journal of Consumer Research* 30, 4 (2004) 588-601.
- Kennedy R., Northover H. "How to use neuromasures to make better advertising decisions: Questions practitioners should ask vendors and research priorities for scholars." *Journal of Advertising Research* 56, 2 (2016): 183-192.
- Klimesch W., Doppelmayr M., Hanslmayr, S. "Upper Alpha ERD and Absolute Power: Their Meaning for Memory Performance." *Progress in Brain Research* 159 (2006): 151-165
- Lee N., Chamberlain L., Brandes, L. "Welcome to the jungle! The neuromarketing literature through the eyes of a newcomer." *European Journal of Marketing* 52, 1-2 (2018): 4-38.
- Lee S., and Lang, A. "Discrete emotion and motivation: Relative activation in the appetitive and aversive motivational systems as a function of anger, sadness, fear, and joy during televised information campaigns." *Media Psychology*, 12, 2 (2009): 148-170.
- Libet B. *Mind time: The temporal factor in consciousness*. Harvard University Press. (2009).
- Liu X., Shi, S.W., Teixeira, T., and Wedel, M. "Video content marketing: The making of clips." *Journal of Marketing* 82 (2018): 86–101.
- Machleit K.A., and Wilson, R.D. "Emotional feelings and attitude toward the advertisement: The roles of brand familiarity and repetition." *Journal of Advertising* 17, 3 (1988): 27-35.
- Marci C.D. "Minding the gap: The evolving relationships between affective neuroscience and advertising research." *International Journal of Advertising* 27, 3 (2008): 473-475.
- Mathewson K.E., Harrison T.J., Kizuk S.A. "High and dry? Comparing active dry EEG electrodes to active and passive wet electrodes." *Psychophysiology* 54, 1 (2017): 74-82.
- Micu A.C., Plummer J.T. "Measurable Emotions: How Television Ads Really Work", *Journal of Advertising Research* 50, 2 (2010): 137-53.
- Moon S.J., Costello J.P., Koo D.M. "The impact of consumer confusion from eco-labels on negative WOM, distrust, and dissatisfaction." *International Journal of Advertising* 36, 2 (2017): 246-271.
- Norris C.J. "The negativity bias, revisited: Evidence from neuroscience measures and an individual differences approach." *Social neuroscience* (Published online 12 Dec 2019): 1-15. (<https://doi.org/10.1080/17470919.2019.1696225>)
- Ohme R., Reykowska D., Wiener D., Choromanska A. „Analysis of neurophysiological reactions to advertising stimuli via EEG and GSR measures." *Journal of Neuroscience, Psychology and Economics* 2, 1 (2009): 21–31.
- Ohme R., Reykowska D., Wiener D., Choromanska A. "Application of frontal EEG asymmetry to advertising research." *Journal of Economic Psychology* 31, 5 (2010): 785-793.
- O'Shaughnessy B. *Consciousness and the World*. Oxford University Press (2003)
- Parrott W.G. "Appraisal, emotion words, and the social nature of self-conscious emotions." *Psychological Inquiry* 15, 2 (2004): 136-138.
- Pérez-Edgar K., Kujawa, A., Nelson, S.K., Cole, C., and Zapp, D. J. "The relation between electroencephalogram asymmetry and attention biases to threat at baseline and under stress." *Brain and cognition* 82, 3 (2013): 337-343.

- Pham M.T., Geuens M., De Pelsmacker P. "The influence of ad-evoked feelings on brand evaluations: Empirical generalizations from consumer responses to more than 1000 TV commercials." *International Journal of Research in Marketing* 30, 4 (2013): 383-394.
- Pieters R., Warlop L. "Visual attention during brand choice: The impact of time pressure and task motivation." *International Journal of Research in Marketing* 16, 1 (1999): 1-16.
- Plassmann H., Venkatraman V., Huettel S.A., Yoon C. "Consumer neuroscience: applications, challenges, and possible solutions." *Journal of Marketing Research* 52, 4 (2015): 427-435.
- Poels K., Dewitte, S. "How to Capture the Heart? Reviewing 20 Years of Emotion Measurement in Advertising." *Journal of Advertising Research* 46, 1 (2006): 18-37.
- Polich J., and J. R. Criado. "Neuropsychology and Neuropharmacology of P3a and P3b." *International Journal of Psychophysiology* 60, 2 (2006): 172-185.
- Ravaja N. "Contributions of psychophysiology to media research: Review and recommendations." *Media Psychology* 6, 2 (2004): 193-235.
- Ravaja N., Somervuori O., Salminen M. "Predicting purchase decision: The role of hemispheric asymmetry over the frontal cortex." *Journal of Neuroscience, Psychology, and Economics* 6, 1 (2013): 1
- Reeves B., Thorson E., Rothschild M.L., McDonald D., Hirsch J., Goldstein R. "Attention to television: Intrastimulus effects of movement and scene changes on alpha variation over time." *International Journal of Neuroscience* 27 (1985): 241-255.
- Rosenberg M.J., Hovland C.I. "Cognitive, Affective, and Behavioral Components of Attitudes," In *Attitude Organization and Change*, Hovland C. I., Rosenberg M. J. Eds. New Haven: Yale University Press, (1960).
- Rossiter J.R., Percy L. *Advertising and promotion management*. McGraw-Hill Book Company, 1987.
- Rossiter J.R., Silberstein R.B., Harris P.G., Nield G. "Brain-imaging detection of visual scene encoding in long-term memory for TV commercials." *Journal of Advertising Research* 41, 2 (2001): 13-21.
- Rothschild M.L., Hyun Y.J., Reeves B., Thorson E., Goldstein R. "Hemispherically lateralized EEG as a response to television commercials." *Journal of Consumer Research* 15, 2 (1988): 185-198.
- Rothschild M.L., Hyun Y.J. "Predicting memory for components of TV commercials from EEG." *Journal of consumer research* 16, 4 (1990): 472-478.
- Schupp H.T., Flaisch T., Stockburger J., Junghöfer M. "Emotion and attention: event-related brain potential studies." *Progress in brain research* 156, 1 (2006): 31-51.
- Schutter D.J., Putman P., Hermans E., van Honk J. "Parietal electroencephalogram beta asymmetry and selective attention to angry facial expressions in healthy human subjects." *Neuroscience letters* 314, 1-2 (2001): 13-16.
- Shen F., Morris J.D. "Decoding Neural Responses To Emotion in Television Commercials: An Integrative Study Of Self-Reporting and fMRI Measures." *Journal of Advertising Research* 56, 2 (2016): 193-204.
- Simons J.S., Peers P.V., Hwang D.Y., Ally B.A., Fletcher P.C., Budson, A.E. "Is the parietal lobe necessary for recollection in humans?." *Neuropsychologia* 46, 4 (2008): 1185-1191.
- Singer N. *Making Ads That Whisper to the Brain*. The New York Times, November 14, 2010.
- Smidts A., Hsu M., Sanfey A.G., Boksem M.A., Ebstein R. B., Huettel S. A., Kable J. W., Karmarkar U. R., Kitayama S., Knutson B., Liberzon I. "Advancing consumer neuroscience." *Marketing Letters* 25, 3 (2014): 257-267.
- Smit E. G., Van Meurs L., Neijens P.C. "Effects of advertising likeability: A 10-year perspective." *Journal of Advertising Research* 46, 1 (2006): 73-83.
- Smith M. E., Gevins A. "Attention and brain activity while watching television: Components of viewer engagement." *Media Psychology* 6, 3 (2004): 285-305.

- Smith N.K., Cacioppo J.T., Larsen, J.T., Chartrand, T.L. "May I have your attention, please: Electro cortical responses to positive and negative stimuli." *Neuropsychologia* 41, 2 (2003): 171-183.
- Solnais C., Andréa-Perez J., Sánchez-Fernández J., Andréu-Abela J. "The contribution of neuroscience to consumer research: A conceptual framework and empirical review." *Journal of Economic Psychology* 36 (2013): 68-81.
- Stanton S. J., Sinnott-Armstrong W., Huettel S. A. "Neuromarketing: Ethical Implications of its Use and Potential Misuse." *Journal of Business Ethics* 144, 4 (2016): 1-13.
- Thorson E., Chi, A., Leavitt, C. "Attention, memory, attitude, and conation: A test of the advertising hierarchy." *ACR North American Advances* 19 (1992): 366-379.
- Van Reijmersdal E. "Brand placement prominence: Good for memory! Bad for attitudes?" *Journal of Advertising Research* 49, 2 (2009) 151-153.
- Varan D., Lang A., Barwise P., Weber R., Bellman S. „How Reliable Are Neuromarketers' Measures of Advertising Effectiveness?" *Journal of Advertising Research* 55, 2 (2015): 176-191.
- Vecchiato G., Astolfi L., Fallani F.D.V., Toppi J., Bez F., Wei D., Kong W., Dai J., Cincotti F., Mattia D. and Babiloni F. "On the use of EEG or MEG brain imaging tools in neuromarketing research." *Computational Intelligence and Neuroscience* 2011 (2011): 1-12.
- Venkatraman V., Dimoka A., Pavlou P.A., Vo K., Hampton W., Bollinger B., Hershfield H.E., Ishihara M., Winer R.S., "Predicting advertising success beyond traditional measures: New insights from neurophysiological methods and market response modeling." *Journal of Marketing Research* 52, 4 (2015): 436-452.
- Vimal R.L. "Attention and emotion." *The Annual Review of Biomedical Sciences (ARBS)* 10 (2008): 84-104.
- Wang X.T. "Emotions within reason: Resolving conflicts in risk preference". *Cognition and Emotion* 20, 8 (2006): 1132-1152.
- Wang Z., Duff B.R. "All Loads Are Not Equal: Distinct Influences of Perceptual Load and Cognitive Load on Peripheral Ad Processing." *Media Psychology* 19, 4 (2016): 589-613.
- Wheeler R.E., Davidson R.J., Tomarken A.J. "Frontal brain asymmetry and emotional reactivity: A biological substrate of affective style." *Psychophysiology* 30, 1 (1993): 82-89.
- Wiles J.A., Cornwell T.B. "A review of methods utilized in measuring affect, feelings, and emotion in advertising." *Current Issues and Research in Advertising* 13, 1-2 (1991): 241-275.
- Woltman Elpers J.L., Wedel M., and Pieters R.G. "Why Do Consumers Stop Viewing Television Commercials? Two Experiments on the Influence of Moment-to-Moment Entertainment and Information Value." *Journal of Marketing Research* 40, 4 (2003): 437-453.
- Yelkur R., Tomkovick C., Hofer A., Rozumalski D. "Super Bowl ad likeability: Enduring and emerging predictors." *Journal of Marketing Communications* 19, 1 (2013): 58-80.
- Yoon C., Gonzalez R., Bechara A., Berns G.S., Dagher A. A., Dube L., et al. „Decision neuroscience and consumer decision making." *Marketing Letters* 23 (2012): 473–485.
- Young C., "Brain waves, picture sorts and branding moments." *Journal of Advertising Research* 42, 4 (2002): 42-53.

Appendix 1: Description of survey-based indicators

Measured construct	Indicators (items)
<p>POSITIVE EMOTIONS Emotional Index – EI</p>	<ol style="list-style-type: none"> 1. Satisfaction 2. Confusion (R) 3. Get on nerves (R) 4. Excitement 5. Disgust (R) 6. Disappointment (R) 7. Shame (R) 8. Joy 9. Warmth 10. Fun 11. Vibrant 12. Unobtrusive 13. Funny 14. Warm 15. Modern 16. Surprising <p>Cronbach's Alpha = 0.822</p>
<p>ATTENTION Attentional index – AI</p>	<ol style="list-style-type: none"> 1. Awareness 2. Memorable 3. Standing out 4. Learned something new 5. Shows a positive side of life 6. What is said interests me 7. Different from others in the category <p>Cronbach's Alpha = 0.862</p>
<p>COGNITION (Ad / Brand evaluation) Cognition Index - CI</p>	<ol style="list-style-type: none"> 1. Brand Attribution 2. Communication performance 3. Suitability of actors 4. Recognition 5. Believable 6. Understandable message 7. Clearly demonstrates brand benefits 8. Imminent that is for this brand <p>Cronbach's Alpha = 0.806</p>
<p>BEHAVIOR Behavioral intention - BI</p>	<p>Buying intention Copy Recommendation</p> <p>Cronbach's Alpha = 0.857</p>
<p>Advertising Effectiveness Index ADI Index™</p>	<p>Average value of items across four constructs; Emotion – Attention – Cognition – Behavior</p> <p>N = 4 (indexes), Cronbach's Alpha = 0.927</p>

Notes: R = reverse coded items