

Analysis of Neurophysiological Reactions to Advertising Stimuli by Means of EEG and Galvanic Skin Response Measures

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This article demonstrates how marketing may benefit from neurophysiology. The authors discuss a particular research case concerning the analysis of a skin care product advertisement. Pretests of 2 versions of this TV ad revealed that, although the versions were almost identical, each of them generated significantly different impact. Their influence was assessed using both cognitive measures (benefits and key benefits recall) and behavioral measures (shelf test). The only difference between these 2 versions of the ad was in a single scene that contained a particular gesture by a female model. Of note, the gesture appeared to enhance the effectiveness of the ad. The authors tested whether neurophysiological measures can capture differences in consumer reactions to slightly different marketing stimuli. Indeed, by using electroencephalography and electromyography and by monitoring skin conductance, the authors were able to register significant differences in neurophysiological reactions to an altered scene, even though the difference was not consciously seen. The authors believe that neurophysiological measures soon will be widely acknowledged and used as a complimentary method in classical marketing research.

Keywords: marketing, neuromarketing, EEG, advertising, consumer research

Research Context

An international corporation asked a market research company to pretest two versions of their TV spot. The research demonstrated that, although the two versions were almost identical, their effects on brand and product perception were significantly different, and these differences were even more pronounced in a behavioral test. These results were a great surprise both to the corporation and to the research company. How could such a subtle change between two versions, almost

impossible to notice consciously, make such a difference in ad effectiveness?

The differences in the two versions had been developed intuitively by the director and his crew during the shooting. The major difference concerned the way in which a female model was presented during one particular scene that took place between the 21st and 25th seconds of the spot. In Version 1, only the model's face was presented; conversely, in Version 2, the viewers saw her face from a slightly different angle (for 2.5 s), and then she made a particular manual gesture (for 1.5 s). First, she touched her face with the back of her right hand, and then when viewers could see her whole body, she made a delicate hand movement and touched her stomach. It is interesting that the difference between the ads was almost undistinguishable on the conscious level (as was depicted in a postexperimental interview).

The laboratory experiment performed by the marketing research company had been conducted on 120 women, ages 20–55, who had been recruited randomly from the product category target

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group. Forty women watched Version 1 of the ad (model's face only), another 40 watched Version 2 of the ad (model's face and the gesture), and the final 40 women were allocated to the control group (did not watch the tested ad at all). A cover story procedure was used to induce low-involvement processing of the presented ads (Ohme & Pyl, 2006). Respondents were asked to watch a TV show and then to participate in a discussion. The program was interrupted by three commercial breaks, each containing 16 TV ads (all of them—besides the tested ad—serving as distracter stimuli). All ads were presented twice (the two tested ads were placed within the first and third commercial breaks).

We did not find significant differences between the responses of the two experimental groups in ad recall (see Figure 1). There were, however, differences in the level of knowledge regarding product benefits and key benefits (see Table 1). The second version (with the manual gesture) produced significantly higher scores for all these dimensions. Moreover, it had a greater impact on the results of a behavioral test (administered as the last stage of the study). Respondents who saw the second version chose the advertised product as a complimentary gift (out of a choice of three brands from the category) significantly more often than those who were in the control group (see Figure 2).

The results of the ad pretest showed that even a slight difference, of a noninformative nature and thus not explicated in the strategic positioning of the product, can significantly enhance marketing communication.

Are there any instruments that allow us to study such minor creative alterations? Because people

are not able to consciously detect the difference, they would not be able to give opinions about it. Increasingly more marketers are starting to realize that traditional marketing methods face tremendous problems in terms of measuring the subconscious, intuitive, and purely emotional aspects of communication with consumers (Braidot, 2005; Kenning, Plassmann, & Ahlert, 2007). We believe that, to better explore consumer emotions, attention, and memory, we must reach to the very core of the human cognition system; that is, directly to the human brain (Damasio, 1994; LeDoux, 1996; Zaltman, 2003).

On the basis of the aforementioned findings, one might conclude that, although respondents were unaware of it, their brains must have registered slight differences between the two versions of the ad to eventually produce such behavioral results. To verify this assumption, we decided to conduct an exploratory study in which we would compare neurophysiological reactions of respondents to one particular moment differentiating the two versions of the ad. We were concerned with respondents' emotional reactions and arousal level induced by the altered scene. As we were to investigate a 4-s fragment of a TV advertisement, we decided to apply brain waves, facial muscle analysis, and skin conductance (SC) analysis. Electroencephalography (EEG) has the benefit of very high temporal resolution; therefore, changes in brain activity can be monitored second by second.

Theoretical Background

The main method used in this study is EEG. It registers variations in brain waves produced by the cortex. Interest in using EEG for market research goes back to the early 1970s; but the first regular studies started to appear during the 1980s. In 1985, Linda F. Alwitt published a study on advertisement content using EEG. She concluded that "the results of this analysis are an encouraging first look at the relationship between ongoing events and EEG-recorded brain reactions. The topic certainly warrants future research" (Alwitt, 1985, p. 216). EEG research on advertising has provided empirical evidence that certain aspects of consumer cognition and emotional response to advertisement messages (even below the level of conscious awareness) can be monitored successfully in real time and analyzed. However, Olson and Ray (1985) posited that EEG responses to

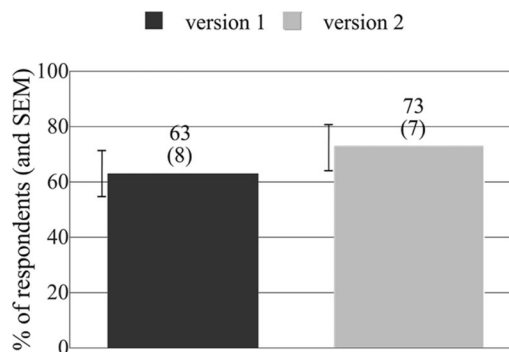


Figure 1. Ad recall.

Table 1
Percentages of Respondents With Knowledge of Benefits

Unaided opinions specification	Version 1		Version 2		Base value	
	Benefits	Key benefits	Benefits	Key benefits	Benefits	Key benefits
Benefit 1	56.1	31.7	69.2	48.7	15.0	10.0
Benefit 2	41.5	14.6	64.1	43.6	7.5	5.0

advertising only provide useful information if they test specific hypotheses about the processes used by viewers of TV advertisements. Thus, EEG was not considered to be helpful as a general evaluative measure of advertising effectiveness.

The difference between these early studies and the current status of research lies in the ease with which information can be both obtained and analyzed. Nowadays, computers are much more advanced, and we have considerably more sophisticated statistical programs, one of which is MATLAB, a high-level technical computing language and interactive environment for data visualization, analysis, and numeric computation. New technical possibilities are a great contribution to both basic and applied EEG research. More recently, EEG has been applied to assess marketing stimuli such as media involvement (Swartz, 1998), the processing of TV commercials (Rothschild, Thorson, Reeves, Hirsch, & Goldstein, 1986), and the prediction of memory for components of TV commercials (Rothschild & Hyun, 1990).

Now, 80 years after its first public demonstration by Hans Berger, EEG is a very popular method used by cognitive neuroscientists, neurologists, psychophysicologists and, most recently, neuromarketers, as a noninvasive and

relatively inexpensive method for measuring brain activity. It must be noted, however, that EEG has limited anatomical specificity, and only can gather information from the cortex. Nevertheless, a great advantage of this method lies in its very high temporal resolution. Other techniques (e.g., functional magnetic resonance imaging) have time resolution down to a few seconds, whereas the EEG has submillisecond resolution (Huettel, Song, & McCarthy, 2004). This enables researchers to precisely detect changes in brain activity that are connected with rapidly changing stimuli (as in TV commercials).

The second method described in the study is facial electromyography (EMG), a technique used to evaluate the physiological properties of facial muscles. The three muscles that are studied the most extensively are the corrugator supercili, zygomaticus major, and orbicularis oculi. EMG has been considered a powerful instrument to test voluntary (zygomaticus) and involuntary (corrugator and orbicularis) facial muscle movements, which may reflect the conscious and subconscious expression of emotions, respectively (Dimberg, Thunberg, & Elmehed, 2000; Larsen, Norris, & Cacioppo, 2003). Facial EMG has been used as a method to study emotional expressions and social communication.

Some researchers have managed to successfully adapt EMG to track down consumer reactions to advertising. For instance, Bolls, Lang, and Potter (2001) showed that zygomaticus muscle activity is stronger during radio advertisements with a positive emotional tone, whereas corrugator muscle activity is greater during ads with a negative emotional tone. Hazlett and Hazlett (1999) compared emotional reactions to TV advertisements measured by facial EMG versus results from self-report scales. They concluded that, overall, facial EMG is a more sensitive indicator of emotional

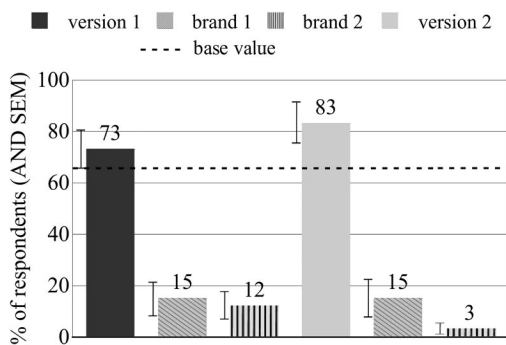


Figure 2. Shelf test (behavioral choice).

reactions to TV advertisements than self-report and that facial EMG responses are closely related to emotion-congruent events during ads. Their results also indicate that, when compared with self-reports, facial EMG measures are more related to brand recall measures administered 5 days later.

In our research, we decided to use one additional measure of neurophysiological reactions—the measurement of skin conductance (SC). This method is based on the analysis of subtle changes in galvanic skin response when the autonomic nervous system (ANS) is activated. Because an increase in the activation of the ANS is an indicator of arousal, SC can be used as a measure of such arousal (Ravaja, 2004).

In advertising research, the measurement of SC has been scarce. Some advertising researchers, while testing other emotion measurement methods, have used SC measurement merely as a validation tool (Aaker, Stayman, & Hagerty, 1986; Bolls et al., 2001). On the basis of interviews with market researchers who have applied SC on one hand and practitioner case studies on the other hand, LaBarbera and Tucciarone (1995) concluded that, overall, SC seems to predict market performance better than self-report measures. They formulated important guidelines concerning equipment and statistical formulas that need to be taken into consideration when designing SC research.

Moreover, LaBarbera and Tucciarone (1995) argued that many previous SC studies in advertising (mostly conducted during the 1960s) failed to identify any effects of SC because they lacked adequately sensitive equipment and accurate statistical protocols. Therefore, these researchers were unable to separate “noise” from true arousal response. Also, individual variation is apparent when analyzing SC. Fortunately, today, technological advancements and more complex statistical programs help to overcome such difficulties. The major limitation of SC that remains unsolved is that it cannot determine the direction or the valence of an emotional reaction. It merely measures the degree of arousal, which can be either positive or negative in valence: Both very pleasurable and very repellant advertising stimuli can evoke large SC responses (Hopkins & Fletcher, 1994).

Theoretical Framework

In this chapter, we briefly describe Davidson's model of emotion, which provides a theoretical framework for studying emotions with EEG measures, as well as Cacioppo's and Dimberg's research on the relationships between facial muscle activity and the valence of experienced emotions.

Almost 30 years ago, Davidson and his colleagues (Davidson, Schwartz, Saron, Bennett, & Goleman, 1979) suggested a model of emotion in which they argued that emotions are (a) organized around approach–avoidance tendencies, and (b) differentially lateralized in the frontal region of the brain. Generally speaking, the left frontal area is involved in the experience of positive emotions such as joy, interest, and happiness; the experience of positive affect facilitates and maintains approach behaviors. The right frontal region is involved in the experience of negative emotions such as fear, disgust, and sadness; the experience of negative emotions facilitates and maintains withdrawal behaviors.

Using EEG measures to index ongoing frontal brain electrical activity during the processing of different affects, Davidson and Fox found substantial empirical support for the model in adults and infants (for a review, see Davidson, 1993a, 1993b; Davidson & Rickman, 1999; Fox, 1991). Greater relative left frontal EEG activity is routinely associated with the processing of positive affects (e.g., while viewing film clips containing pleasant scenes), whereas greater relative right frontal EEG activity is consistently linked with the processing of negative affects (e.g., while viewing film clips containing unpleasant scenes; Jones & Fox, 1992). In addition, the motivational tendencies of approach and avoidance that underlie different types of emotion are known to be distinguishable on frontal EEG asymmetry measures. Sutton and Davidson (1997), for example, found that adults with greater relative left frontal EEG activity are likely to score high on psychometric measures of approach-related tendencies.

To date, numerous studies have examined the relationship between emotion or emotion-related constructs and asymmetries in EEG activity over the frontal cortex. A review of these studies clearly suggests the existence of asymmetries in frontal EEG activity, including resting levels of activity and state-related acti-

vation. These asymmetries are ubiquitous and involved, both in trait predispositions to respond to emotional stimuli related to moderating function of the prefrontal cortex and in changes in emotional state, which can be treated as a marker of emotional intensity (Coan & Allen, 2003).

Moreover, Richard Davidson pointed out that much of the research on frontal EEG asymmetry has examined the correlates of variations in asymmetry with self-report measures:

While these reported associations have been interesting, they typically are not informative with regard to mechanisms, because the specific types of process affected by prefrontal function are likely themselves to be opaque to self-report. Thus, while they influence self-report (like variations in the time to recovery following a negative event), they are not themselves consciously accessible; consequently, such self-report measures ultimately would be uninformative if we hope to construct a neurologically driven theory. (Davidson, 2004, p. 230)

EMG also has a long history of research in the context of emotions. Several researchers have scientifically validated the EMG method as a signal of both emotional valence and the intensity of emotions (Cacioppo, Petty, Losch, & Kim, 1986). EMG measurements have been conducted with different stimulus types: for example, pictures (Cacioppo et al., 1986; Dimberg, 1986; Dimberg, Hansson, & Thunberg, 1998; Lang, Greenwald, Bradley, & Hamm, 1993), subliminal priming (de Groot, 1996; Dimberg et al., 2000; Rotteveel, de Groot, Geutkens, & Phaf, 2001), sounds (Bradley & Lang, 2000; Dimberg, 1990), words (Hietanen, Surakka, & Linnankoski, 1998), and imagery (Schwartz, Fair, Salt, Mandel, & Klerman, 1976). A common reaction pattern has been obtained. More intensive corrugator activity and less zygomaticus activity are obtained as a reaction to negative stimuli versus positive stimuli.

Method

We conducted the present study using EEG, EMG, and SC measurements to analyze whether there are any significant differences in frontal cortex, facial muscle activity, and arousal level on watching two versions of the stimulus material.

We hypothesized that a statistically significant difference would be apparent between the

“gesture” and “no-gesture” scenes in terms of respondents’ emotional reactions and arousal level. Emotional reactions were expected to be indicated by changes in electric activity within the left and right frontal cortex and in facial muscle activity (zygomatic, corrugator, and orbicularis). Arousal level was expected to be registered by changes in SC. Because of the study’s exploratory nature, only bidirectional hypotheses were proposed.

The two versions of the scene formed an independent variable, described on two levels: special gesture (Version 2) and no special gesture (Version 1). Dependent variables comprised EEG, EMG, and SC data.

For the recordings, we used a 16-channel Contact Precision Instruments amplifier. Electrodes were located in accordance with the 10–20 International Electrode Placement System (Cacioppo, Tassinary, & Berntson, 2000). Recordings were obtained from the prefrontal, frontal, temporal, parietal, and occipital regions. The EEG signal was recorded continuously with a sampling rate of 1000 Hz during presentation of the TV spots. The signal was filtered (0.1-Hz to 40-Hz bandpass filter and a 50-Hz notch filter). Independent component analysis was applied to remove artifacts generated by muscles or any external sources. As a next step, data were down-sampled to 512 Hz. Artifact-free and down-sampled data were transformed into a time-frequency domain by means of fast Fourier transformation (Hanning window, nonoverlapped) providing estimates of the power spectral density with 1-Hz resolution within the frequency domain. The power spectral density for each EEG channel was then computed, both for the whole ads and for their specific sequences.

The EMG was measured by miniature Ag/AgCl electrodes from the corrugator supercilii, zygomaticus major, and orbicularis oculi muscles on the left side of the face. The electrodes were placed in a bipolar fashion, in accordance with directions published by Fridlund and Cacioppo (1986). Muscle activity signals were digitalized and preprocessed (filtered, smoothed, and down-sampled to 32 Hz). Artifact rejection was based on the physical properties of the registered signal, as well as on statistical analysis within and between partici-

pants. Muscle activity was evaluated both for the whole ads and for specific sequences.

The SC was measured using standard 9-mm diameter Ag/AgCl electrodes placed on the distal phalanx of both the forefinger and middle finger of the left hand. A reference electrode was placed on the left forearm. Preprocessing included filtering and down-sampling to 32 Hz. Differential analysis, wavelet transformation, and other mathematical and statistical tools were used to transform the signal.

Procedure

The research was conducted on 45 female respondents, ages 25–35, with above-average incomes. The income was at least 2,000 PLN and above; the respondents were recruited by meeting the minimal amount (2,000 PLN). To enhance the practical value of our research, we wanted to ensure that the study was conducted on the target group for the advertised product. Respondents were invited to participate in a study on neurophysiological reactions to advertising, and they were paid for their participation. They were asked to watch a series of advertisements while their EEG, EMG, and SC responses were registered. A within-participant design was used; each participant was presented with two versions of the tested ad and 10 distracter ads, with a 15-s black screen in between. All ads (including distracters and both versions of the tested ad) were presented randomly, and the versions' order of appearance was rotated. We undertook special precautions not to place the two alternative versions near each other. Before the exposition of each ad, a baseline was measured as a reaction to the black screen. The experiment was conducted in a room adapted to neurophysiological studies, and all ads were shown on a computer screen. During exposition of the stimuli, respondents were left alone; however, their behavior was monitored constantly by a video camera. The participants' only task was to watch the films presented on the screen. On completion of the test, participants were interviewed and thoroughly debriefed.

Results

We analyzed results by comparing both versions of the ad in time (second by second), as well as by comparing the results for the whole

differentiating scene. Before these comparisons, we conducted an analysis to identify any possible differences in responses to the scenes from this ad that occur before the altered scene. As these parts were identical in both versions, no significant differences in EEG, EMG, and SC activity were discovered. Reactions to the differentiating scenes were analyzed using Student's *t* tests and Pearson's linear correlation analysis. The results from these analyses are presented here.

We focused on comparing the emotional response to both versions of the ad, measured (in accordance with Davidson's model) by the difference in the amount of alpha between the left and right hemispheres taken from the frontal and prefrontal electrodes (Davidson et al., 1979). When analyzing emotional brain reactions to each second of the spot, we obtained a significant difference during the 22nd second of the ad, $t(43) = 2.047$, $p < .01$; see Figure 3). The scene from Version 1 (only the model's face) evoked more positive emotions than the scene from Version 2 (the model's face and the hand gesture). There were no significant differences in the scenes that followed the altered scene. We observed a very strong, negative correlation between the two ad versions at the 23rd second (Pearson's $r = -0.92$, $p < .001$), whereas the correlation between the ad versions taken as a whole also was significant but positive and quite weak ($r = .13$, $p < .001$; see Figure 4).

The results of EMG reveal a trend toward a significant difference in electrical facial activity while watching the alternative scenes of the ad. We obtained a difference within the activity of the corrugator supercili. During the differentiating scene (from the 23rd second until the end of the spot), the second version of the ad provoked a higher level of corrugator muscle activity than did the first version, $t(48) = 1.717$, $p = .09$ (see Figure 5). However, for other muscles, there were no differences.

Analysis of SC revealed differences in the average level of arousal across the entire differentiating scene (from 21.5 to 24.5 s). We observed significantly greater arousal during this scene in the second ad version, $t(43) = 2.047$, $p < .05$ (see Figure 6). When analyzing the trace of arousal in time, similar results were observed during the 22nd second of the ad. The difference between the versions did not reach

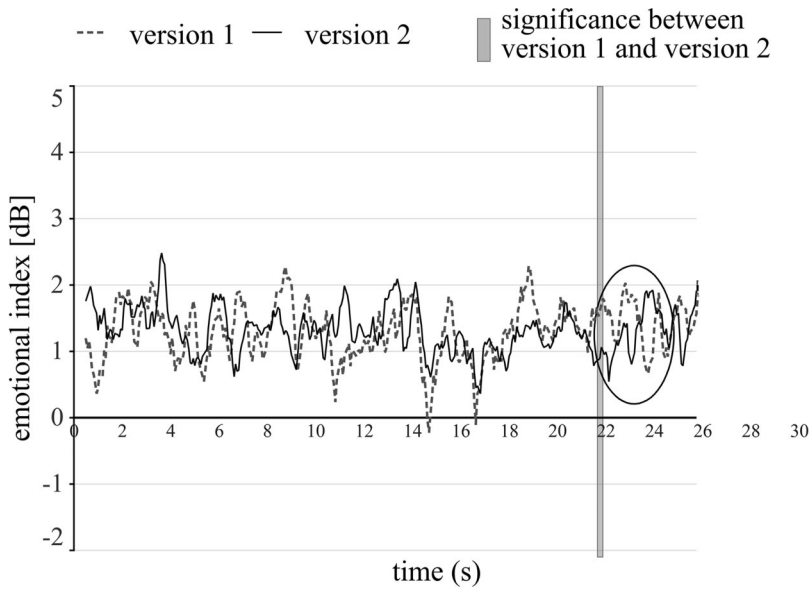


Figure 3. Electroencephalography trace of emotional response.

statistical significance but did show a trend, $t(43) = 1.826$, $p = .07$ (see Figure 7).

Discussion

At a general level, the results confirmed our hypothesis that the brain can register even small differences between the ads and that this can be captured by the apparatus we used.

The registration of EEG, EMG, and SC signals enabled identification of different neurophysiological patterns of functioning of the brain and facial muscles connected with emotions and arousal during contact with two minimally different versions of the same ad. Our study shows that a consumer's brain can produce different reactions to incoming marketing stimuli, even if, at the conscious level,

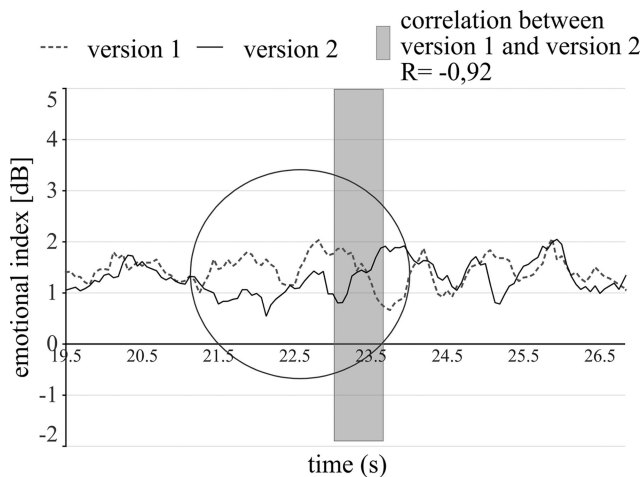


Figure 4. Electroencephalography trace of emotional response correlation for the 23rd second.

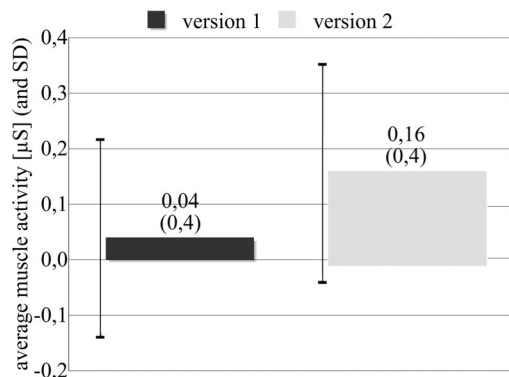


Figure 5. Electromyography corrugator response (averaged response from 23 to 35 s).

people do not recognize any difference between them.

Because of the exploratory nature of the study, its results must be considered observational. A detailed discussion, including possible explanations concerning particular reaction patterns and their theoretical implications, would be premature at this time. Having said this, we already have launched procedural and conceptual replications, so that we ultimately may provide more conclusive results and more advanced discussion (i.e., at an interpretative level) in the near future. At this point, however, anything that goes beyond systemic observation might be entering controversial and speculative grounds.

Three conclusions of a more general nature stem from our research. First, we managed to confirm Alwitt's (1985) notion that EEG research in the advertising field can provide meaningful empirical evidence and that certain aspects of consumer emotional responses to advertising messages can be monitored successfully in real time and analyzed. It has been shown that EEG, EMG, and SC indeed can track down very subtle alterations occurring at high speed during a TV advertisement.

Second, we believe that Olson and Ray's (1985) opinion that EEG reactions are not likely to be helpful as a general evaluative measure of advertising effectiveness should be modified. Their belief may be true but only when one tests a single ad without any reference objects at hand. However, when such reference objects do exist (e.g., alternative shooting of the same scene

or use of a different soundtrack), it may be possible to identify which one induces a greater degree of emotional response or arousal. Therefore, we may, to some extent, evaluate creative or strategic solutions used in TV advertisements. In other words, EEG, at this point of its development, still cannot serve as an absolute measure; however, it already may provide useful direction as a reference measure.

Finally, we suggest that EEG be applied in parallel with EMG and SC. Combining EEG with EMG again confirmed Davidson's concept of emotions and yielded proof that EEG analysis is a valid measure of emotional valence. In turn, combining EEG with SC enables us to determine not only the intensity but also the direction of arousal (see discussion by Hopkins & Fletcher, 1994).

Practical Implications

We believe that EEG, EMG, and SC may well serve as complimentary tools to fMRI in the analysis of the quality of marketing communications (Cacioppo et al., 2000). Unlike neuroimaging approach, which is mostly spatially oriented, EEG and EMG may provide information of a temporal nature. Therefore, marketers would be afforded an instrument with which to evaluate their TV advertisements, not only at a synthetic, general level but also at an analytic, sequential level. They also might be able to venture beyond consumer declarations.

However, as posited by Plassmann, Ambler, Braeutigam, and Kenning (2007), it is important

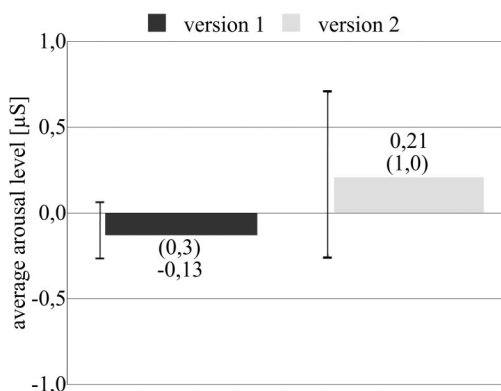


Figure 6. Arousal level (averaged skin conductance response from 21.5 to 24.5 s).

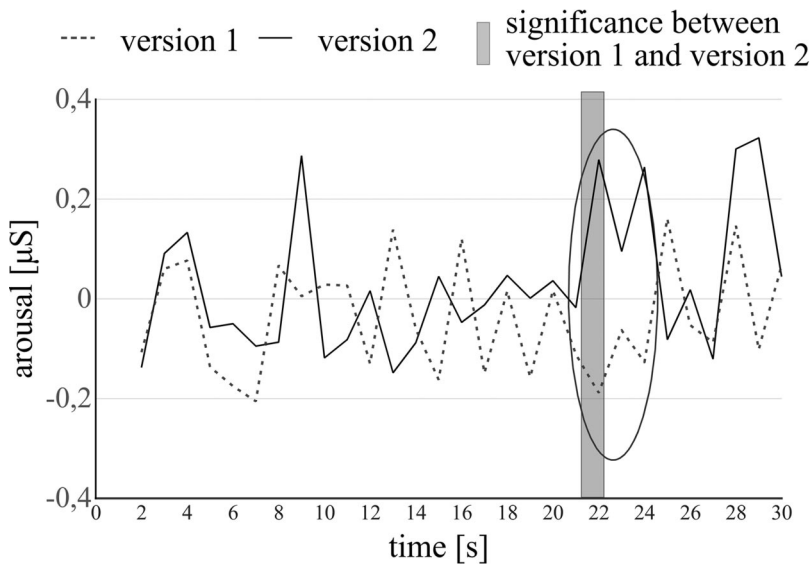


Figure 7. Arousal level (trace of skin conductance response during the exposition of the spots).

that market researchers keep in mind that numerous research techniques remain in their infancy, at least in terms of their application in marketing research, and that further basic research is necessary to facilitate the confident application of these techniques to marketing. In this context, the research presented in this article has served as a pilot to a comprehensive project, Exploring the Consumer's Mind, which began in Poland in 2007. On the basis of the findings from the project Exploring the Consumer's Mind, it should be possible to diagnose, in the precampaign stage, whether new ads (before emission) can induce desirable consumer reactions. Eventually, this research should help to establish the optimal number of ad exposures and their time dynamics during the campaign.

In conclusion, neurophysiological measures seem to be an objective supplement to subjective, declarative data. When combined, these two forms of modality may enable marketers to portray both conscious and subconscious consumer reactions to persuasive advertising (Damasio, 1994; LeDoux, 1996; Zaltman, 2003).

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