

VIDEO NEUROADVERTISING RECOMMENDER SYSTEM

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Abstract

Neuromarketing systems are gaining increasing popularity during the last years. The Video Neuroadvertising Recommender System (ViNeRS) addresses the following problem: improving the efficiency of video ads by integrating biometric, physiological, affective computing, statistical analysis (LOGIT, KNN, MBP, RBP), decision support, recommender, big data and text analytics, categorical, spatial and personalised affective content analysis and self-analysis methods, as well as five multiple criteria analysis methods developed by the applicants (hereinafter referred to as research methods). ViNeRS will include two main subsystems. ViNeRS1, an analysis and assessment subsystem for the impact of online ads (unfinished ad content), will assess the efficiency of ads at each stage of their creation, determine their advantages and disadvantages, and improve them until the most catchy version is achieved. The subsystem will be able to determine how many times a promotional message should be repeated in a certain part of your video to achieve an effective promotional campaign. ViNeRS2, an intuitive online ad serving subsystem (finished ad content), will offer integrated measurements of neurobiological viewer response and real-time selection of the most efficient ad version.

Keywords: Biometrics, VINERS Neuromarketing System, Multiple Criteria Analysis

1. INTRODUCTION

Innovative, real-time, personalized video ad systems are being developed around the world [1-11]. Several patents [12-17] in the field of real-time, personalized video ad systems have been issued and published. Application of personalized video ad systems components lead to research tools and methods that can be quickly customized and tailored to client needs. Real-time, behavior-based personalization constitutes the future regarding neuromarketing content. The customization of neuromarketing based on behaviors, interests and demographics allows systems to take advantage of personalization and its respective power. We developed the Biometric VINERS Neuromarketing System (see <http://iti3.vgtu.lt/viners/>) based on our experience and above systems and patents. The system is presented below.



Fig. 1. Biometric VINERS Neuromarketing System.

2. SUBSYSTEM FOR EFFECTIVENESS MEASUREMENTS OF VIDEO AD FRAME SEGMENTS

Starting from producers handling video ad productions and including creative directors and scriptwriters engaged in making video ads must make decisions in their creative work on how best to affect their viewers over a range and intensity of emotions and evoke certain affective attitudes at different points in the ad. Relevantly the authors of this article have been engaged in studying affective attitudes as well as the emotional and physiological states of passersby in Vilnius City over the past 24 months. Their research studies indicate an array of ever-changing emotions and affective attitudes among people appearing more strongly or more weakly at different times. Thereby an entire range of fluctuating affective attitudes and emotional and physiological states of people under examination are brought into consideration.

The sum level of effectiveness (A_j) of some given video ad reveals a deviance percentage of viewer affective and emotional states and valence and arousal parameters, as planned by advertising professionals, to meet their goals (see Table 1).

The idea is to have a technique that can evaluate effectiveness over the entire process of creating an advertisement. It is important to know exactly where an ad meets predetermined objectives and where it does not. Therefore, corrections made to improve an ad's attractiveness are the most cost effective. The respective director, scriptwriter and producer have pinpointed their preferences regarding the emotions, affective attitudes and physiological states they want viewers to experience. The following equation can help to accomplish such an objective:

$$A_{ej} = 100 * q_i * \frac{\sum_{i=1}^m \sum_{j=1}^n (|d_{esij} - d_{rsij}| / d_{\max sij} + |d_{eeij} - d_{reij}| / d_{\max eij} + |d_{epij} - d_{rpij}| / d_{\max pij})}{3}, i = \overline{1, m}; j = \overline{1, n} \quad (1)$$

where:

- A_{ej} is the overall effectiveness of ad j .
- n is the number of video ads.
- m is the number of criteria.
- j is the video ad under analysis.
- d_{esij} is the value of the i -th criterion in a survey of emotional and affective states relevant to a frame segment of ad j pertinent to predetermined viewer emotions (see Table 1).
- d_{eeij} is the value of the i -th criterion of the biometric evaluation of emotional and affective states for video ad j frame segment derived by the advertising staff indicating the predetermined, biometric, emotional and affective states of viewers.
- d_{epij} is the value of the i -th criterion of the physiological evaluation of the video ad j frame segment by the advertising staff, indicating the predetermined physiological states consisting of breathing rate and left and right pupil sizes of viewers.
- d_{rsij} is the value of the i -th criterion of the survey for assessing video ad j by viewers (see Table 1).
- d_{reij} is the value of the i -th criterion of the biometric measurements of respondent emotions and affective attitudes pertinent to video ad j .
- d_{rpij} is the value of the i -th criterion of biometric measurements of respondent physiological states pertinent to video ad j .
- $d_{\max sij}$ ($d_{\max eij}$ and $d_{\max pij}$) is the greatest value from d_{esij} (d_{eeij} and d_{epij}) and d_{rsij} (d_{reij} and d_{rpij}).

Rates (d_{esij} , d_{eeij} and d_{epij}) that the video-makers, including their creative staff, such as scriptwriters, producers and others, had predetermined should fall within the same range as those provided by the respondents (d_{rsij} , d_{reij} and d_{rpij}). Meanwhile the predetermined rates pertinent to the emotional states

and affective attitudes d_{eeij} and the emotions that viewers experienced should fall between 0 and 1. In the case of valence, the range should fall between -1 and 1.

Eight members of the advertising staff, including producers, designers and account executives, predetermined the average, desired emotional and affective states, which appear in Table 1. These are colour coded in green to represent the actual video ads and in red to represent the realistic emotional and affective states of 99 viewers. Additionally blue indicates the difference by percentage between the predetermined levels of emotional and affective states and the states viewers actually experienced. Ten video ads were under investigation.

The calculation for the sum level of effectiveness (A_e) of the video ad under investigation pertains to Formula 1. Use of this formula establishes how well an ad segment achieves the predetermined objective by degree. The predetermined objective is assumed to be completely reached, assuming the sum level of the ad's effectiveness is $A_e > 90\%$. The video ad requires upgrading whenever $A_e < 80\%$. A result of $A_e = 100\%$ means that viewers have experienced precisely the predetermined state intended by the advertising staff, whether, e.g., by some specific affective attitude like boredom, interest or confusion; an emotion like happiness, sadness, anger, surprise, fear, disgust or a neutral state; valence or an arousal level of low, average or high. In other words, a viewer watched the video ad under examination and experienced the predetermined, desirable feeling. Meanwhile $A_e = 0\%$, whenever viewers experience feelings that are completely opposite of the predetermined, desirable affective attitudes, emotional states, valence or arousal after watching the video ad.

Ad descriptor criterion	Criterion weight, unit of measure, *	Videos (V_j) under comparison									
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Happy (d_{es1j})		X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{110}
Happy (d_{rs1j})		X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}	X_{27}	X_{28}	X_{29}	X_{210}
Happy,	1, %, -	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}	X_{36}	X_{37}	X_{38}	X_{39}	X_{310}
Sad (d_{es2j})		X_{41}	X_{42}	X_{43}	X_{44}	X_{45}	X_{46}	X_{47}	X_{48}	X_{49}	X_{410}
Sad (d_{rs2j})		X_{51}	X_{52}	X_{53}	X_{54}	X_{55}	X_{56}	X_{57}	X_{58}	X_{59}	X_{510}
Sad	1, %, -	X_{61}	X_{62}	X_{63}	X_{64}	X_{65}	X_{66}	X_{67}	X_{68}	X_{69}	X_{610}
Angry (d_{es3j})		X_{71}	X_{72}	X_{73}	X_{74}	X_{75}	X_{76}	X_{77}	X_{78}	X_{79}	X_{710}
Angry (d_{rs3j})		X_{81}	X_{82}	X_{83}	X_{84}	X_{85}	X_{86}	X_{87}	X_{88}	X_{89}	X_{810}
Angry	1, %, -	X_{91}	X_{92}	X_{93}	X_{94}	X_{95}	X_{96}	X_{97}	X_{98}	X_{99}	X_{910}
Surprised (d_{es4j})		X_{101}	X_{102}	X_{103}	X_{104}	X_{105}	X_{106}	X_{107}	X_{108}	X_{109}	X_{1010}
Surprised (d_{rs4j})		X_{111}	X_{112}	X_{113}	X_{114}	X_{115}	X_{116}	X_{117}	X_{118}	X_{119}	X_{1110}
Surprised	1, %, -	X_{121}	X_{122}	X_{123}	X_{124}	X_{125}	X_{126}	X_{127}	X_{128}	X_{129}	X_{12010}
Scared (d_{es5j})		X_{131}	X_{132}	X_{133}	X_{134}	X_{135}	X_{136}	X_{137}	X_{138}	X_{139}	X_{1310}
Scared (d_{rs5j})		X_{141}	X_{142}	X_{143}	X_{144}	X_{145}	X_{146}	X_{147}	X_{148}	X_{149}	X_{1410}
Scared	1, %, -	X_{151}	X_{152}	X_{153}	X_{154}	X_{155}	X_{156}	X_{157}	X_{158}	X_{159}	X_{1510}
Interested (d_{es6j})		X_{161}	X_{162}	X_{163}	X_{164}	X_{165}	X_{166}	X_{167}	X_{168}	X_{169}	X_{16010}
Interested (d_{rs6j})		X_{171}	X_{172}	X_{173}	X_{174}	X_{175}	X_{176}	X_{177}	X_{178}	X_{179}	X_{1710}
Interested	1, %, -	X_{181}	X_{182}	X_{183}	X_{184}	X_{185}	X_{186}	X_{187}	X_{188}	X_{189}	X_{1810}
Confused (d_{es7j})		X_{191}	X_{192}	X_{193}	X_{194}	X_{195}	X_{196}	X_{197}	X_{198}	X_{199}	X_{1910}

Confused (d_{rs7j})	X_{201}	X_{202}	X_{203}	X_{204}	X_{205}	X_{206}	X_{207}	X_{208}	X_{209}	X_{210}
Confused 1, %, -	X_{211}	X_{212}	X_{213}	X_{214}	X_{215}	X_{216}	X_{217}	X_{218}	X_{219}	X_{2110}
Sum level of ad effectiveness (A_e)	X_{221}	X_{222}	X_{223}	X_{224}	X_{225}	X_{226}	X_{227}	X_{228}	X_{229}	X_{2210}
Effectiveness priority	X_{231}	X_{232}	X_{233}	X_{234}	X_{235}	X_{236}	X_{237}	X_{238}	X_{239}	X_{2310}

Table 1. Neuro decision matrix of video ad effectiveness and multiple criteria analysis results (survey respondents included viewers and advertising staff members)

The effectiveness of the video ads under investigation is established by applying Formula 1 along with data shown in Table 1. The calculations presented here only reflect the analyzed percentage differences between the predetermined and the actual viewer experiences of emotional and affective states, which appear in blue. The emotional and affective states aroused by this ad were the closest to those, which the advertising staff had predetermined. The range for A_j fluctuations can fall between 0 and 100%.

The same procedure is applicable for determining the effectiveness of segments of different video frames from the same ad. However, now, Table 1 becomes enlarged by the addition of several columns to denote specific, differing segments of one, singular video ad. Otherwise, there would only be a single column for data from that ad. To illustrate, Video ad V_1 , the first one, e.g., segments into four frames. Therefore, Table 1 will now feature four columns rather than a single one to breakout data on each individually.

3. IDENTIFICATION SUB-SYSTEM OF THE STRONGEST VIDEO AD FRAME SEGMENTS BY IMPRESSIONS AND FEELINGS

Effective advertising is that, which arouses emotions [18]. Among other researchers, Hamelin et al. [19] investigate emotions pertinent to effective advertising. Advertising can also stimulate social improvements. As revealed by Hamelin et al. [19], safe driving attitude scores were higher and more durable when stimulated by very emotional ads in comparison to ads that were not especially emotional. Either positive or negative arousal tends to be high after viewing videos that had been meant to stimulate emotions, and such videos tend to be shared twice as often as videos that do not stimulate much emotion. This holds true for both commercial and non-commercial data [20]. That ads consisting of negative segments will result in a more effective impact than ads containing positive segments was observed by McKay-Nesbitt et al. [21]. However, Nelson-Field et al. [20] find that positive messages appear more frequently in advertising than do negative messages. Therefore ads stimulating positive emotions have the lion's share of the entire video ad market when compared to those stimulating negative emotional reactions.

A means for establishing the level of impressions generated by viewing video ad j is the INVAR technique [22]. It also reveals the ads generating the most intense feelings by establishing the level of utility degree N_j pertinent to some specific video ad.

The greater the N_j ($j=\overline{1, n}$) value, the more intense the emotions and affective attitudes that Video ad j stimulated. The range of N_j value fluctuates between 0 and 100.

Arousal rises while causing greater dilation of eye pupils and increased breathing rates, as worldwide studies have shown. Measurements were taken of average arousal, breathing rate, and left and right pupil size from 99 participants as they watched each video ad. The results of this experiment appear in Table 2. Furthermore the experiment extended to advertising industry experts to establish weights relevant to arousal, breathing rate and left and right pupil size. These weights also appear in Table 2.

Average viewer	Criterion weight, unit of measure, *	Videos (V_i) under comparison									
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Arousal	3, points, +	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{110}
Breathing rate	1, breaths/sec., +	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}	X_{27}	X_{28}	X_{29}	X_{210}
Left pupil size	1, mm, +	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}	X_{36}	X_{37}	X_{38}	X_{39}	X_{310}
Right pupil size	1, mm, +	X_{41}	X_{42}	X_{43}	X_{44}	X_{45}	X_{46}	X_{47}	X_{48}	X_{49}	X_{410}
Utility degree N_j and Priority P_j per ad by impact on impressions and feelings of viewers											
Utility degree N_j		N_{51}	N_{52}	N_{53}	N_{54}	N_{55}	N_{56}	N_{57}	N_{58}	N_{59}	N_{510}
Priority P_j		P_{61}	P_{62}	P_{63}	P_{64}	P_{65}	P_{66}	P_{67}	P_{68}	P_{69}	P_{610}

Table 2. Neuro decision matrix of video ad impact on viewer impressions and feelings and multiple criteria analysis results (Equipment Subsystem gathered data)

The effects on impressions and feelings while viewing the video ads under analysis were established by employing the INVAR technique (Kaklauskas 2016) along with data that appear in Table 2. The effect a segment of a video ad frame has on viewer impressions and feelings can be established using this same process, excepting that, this time, the data found in Table 2 must be expanded. Now each video ad segment requires a number of data columns in Table 2, instead of only one.

4. MEASUREMENT SUB-SYSTEM ON AFFECTING SHORT- & LONG-TERM MEMORY WITH A VIDEO AD

The role of greater ad memorability and its longer recall on advertising effectiveness is a topic studied by numerous researchers, including Mehta [23], Kellaris, Cline [24], Li, Lo [25], Muñoz-Leiva et al. [26]. Among those who are convinced that memorability plays an essential role in ad effectiveness are Li, Lo [25]. Meanwhile Muñoz-Leiva et al. [26] have directed their attention on the visual focus and self-reported memory of participants under analysis in social media. There was a selection of two main measures by Mehta [25] as indicating advertising effectiveness. Intrusiveness is one, which grabs attention, thereby gaining ad memorability. Persuasion is the other one, because it generates interest in purchasing advertised products. The hypothesis tested by Mehta [25] was that buyers with more favourable attitudes towards advertising overall are likely to both remember more ads per day following exposure to them and be more open to persuasion by those ads.

The described Method helps pinpoint the specific segments of a video ad that tend to have better memorability along with the specific sights and/or sounds that stimulate the strongest impressions and feelings. The valence and arousal data taken three times per second serve as the basis to accomplish this. In other words, the recording of these data occurs every third of a second. Thereby this section describes a technique that is capable of establishing the exact time, i.e., the most memorable frame and item therein. The results gained by using this technique correspond with research conducted worldwide. A write-up of such research appears next. Most studies to date focus on the dimension pertinent to the arousal of emotions as the most critical factor contributing to an emotions-enhanced effect on memory [27]. Arousal is involved in the memory process by detecting, retaining and retrieving information. Becoming emotionally aroused by information can lead to a more strongly encoded memory. Then a person can retain and retrieve information more readily [28].

Nonetheless, researches on the dimension of emotional valence reveal, interestingly enough, that emotional valence alone can improve memory. In other words, arousal or not, neutral items are not as well remembered as pieces with positive or negative arousal [29-31]. There is greater retention and accumulation of information, when it links to events causing arousal. Arousal also prompts brighter and

more accurate retrieval or recall of information [32]. Attention selectivity and dwell time influence stimuli to become better encoded for arousal and, thus, such stimuli are better remembered. This was one of the findings in a summary of different findings by Ochsner [29]. Stimuli causing arousal, rather than neutral stimuli, are more suitable for encoding a selective brain, which leads to stronger, long-term memories [33]. That neutral stimuli lead to decreases in memory over time, as compared to arousing stimuli leading to stable or more precise memories, has been a finding noted by numerous researchers in many studies [32, 34, 35]. Evidence additionally validates an enhancement of memory by emotions. Nevertheless, arousal and valence factors influence more specific memories [36]. The frequency a segment of advertising information, found in some area within an ad, must repeat before the advertising campaign can be considered successfully effective, i.e., so the Ae of each frame segment approaches 100%, is a matter that an application of this Method can establish. Then, such information can be used to switch different segments of an ad frame to achieve better recognition and memorability of the ad under consideration.

Arousal can be stimulated in the memory process by detecting, retaining and retrieving information. Better memory encoding can instigate information capable of arousing emotions. Thereby there is an impact resulting in better retention and retrieval of information [28]. Information is better retained and accumulated by the affect from arousing events or information. Not only that, the retrieval and remembrance of arousing information thereby becomes much more clear and precise [32]. Encoded, arousing stimuli tends to be selective and results in stronger, long-term memories, when compared to encoded neutral stimuli [33]. A conclusion can be drawn that the better remembered ad is the one stimulating greater arousal in its viewers. A similar statement is possible about positive or negative valence. Viewers better remember an advertisement the greater is the absolute valence. The impact of video ads under investigation on the short-term and long-term memories of viewers can be established by employing the INVAR technique [22] along with the data presented in Table 3.

Whenever an advertisement's utility degree affects ad memorability by $N_j > 90\%$, then the makers of that video ad can safely say that their objectives have been completely met. Table 3 shows that all video ads under analysis have totally achieved the predetermined memorability objectives set down by their video-makers.

An assumption can be that an ad's utility degree references its impact on ad memorability at $80\% < N_j < 90\%$. This means there has been an average realization of the objectives for this advertisement. However, assuming $N_j < 80\%$, then an improvement of this advertisement is required.

Average viewer	Criterion weight, unit of measure,*	Videos (V_i) under comparison									
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Arousal	3, points, +	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{110}
Valence	3, points, +	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}	X_{27}	X_{28}	X_{29}	X_{210}
Breathing rate	1, breaths/ sec., +	X_{31}	X_{32}	X_{33}	X_{34}	X_{35}	X_{36}	X_{37}	X_{38}	X_{39}	X_{310}
Left pupil size	1, mm, +	X_{41}	X_{42}	X_{43}	X_{44}	X_{45}	X_{46}	X_{47}	X_{48}	X_{49}	X_{410}
Right pupil size	1, mm, +	X_{51}	X_{52}	X_{53}	X_{54}	X_{55}	X_{56}	X_{57}	X_{58}	X_{59}	X_{510}
Utility degree of Ad N_j by ad memorability impact		N_{51}	N_{52}	N_{53}	N_{54}	N_{55}	N_{56}	N_{57}	N_{58}	N_{59}	N_{510}
Ad priority by ad memorability impact		P_{61}	P_{62}	P_{63}	P_{64}	P_{65}	P_{66}	P_{67}	P_{68}	P_{69}	P_{610}

Table 3. Neuro decision matrix of video ad influences on short-term and long-term memories and multiple criteria analysis results (Equipment Subsystem gathered data)

5. NUMERICAL GUIDANCE SUB-SYSTEM RECOMMENDED FOR THE INVAR TECHNIQUE

This is a Sub-system for providing digitalized recommendations, once the INVAR technique has been used. Such digitalized recommendations provide an accurate number of percentage points required to change a video ad's desired criteria, so it can achieve the predetermined priority level. The basis for such numerical guidance recommendations by this Sub-system (see Case Study) consist of the following factors. First, there are the answers to questions from eight members of the advertising staff, generally its account executives, designers, writers and other such experts. Next are the criteria significances that expert studies have helped to establish. Following these are the answers to questions provided by the 99 participating respondents. Finally, there are the assessments of the emotional states and affective attitudes of those 99 participating respondents (an indirect biometric assessment).

Furthermore discussions are expected to follow regarding opportunities generated by the introduction of embedded biometrics into this System. What embedded biometrics involve, as claimed by Rosenstein [37], are both wearable items and technologies that are either biologically integrated parts of a person's body or those found on or near bodies like clothing, wrist bracelets, glasses, augmented reality lenses or implanted medical monitoring devices in capillaries/blood vessels. All these assist in accumulating previously unknown information for understanding consumer behaviour.

6. CONCLUSIONS

The developed Biometric VINERS Neuromarketing System consists of the following subsystems: Subsystem for Effectiveness Measurements of Video Ad Frame Segments, Identification Sub-system of the Strongest Video Ad Frame Segments by Impressions and Feelings, Measurement Sub-system on Affecting Short- & Long-term Memory with a Video Ad, Numerical Guidance Sub-system Recommended for the INVAR Technique. The main markers that show why the Biometric VINERS Neuromarketing System ViNeRS is innovative at the global scale and reflect the ambitious character of the project goals are as follows: about 90% of extra new data was obtained and this was make ad analysis results more relevant and precise; the research was produce unique, integrated data about ads (video, audio, text and others) and viewers (physiological, biometric, affective, demographic and other parameters).

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