INVAR Neuromarketing Method and System*

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Abstract: In recent years, the focus of marketing methods has been the user rather than advertising. A wide range of customer satisfaction surveys, post-screening answers and reviews are a staple of marketing for that purpose. In search for innovative ways to survey customer satisfaction, new concepts have emerged recently and several biometric methods and systems have been developed. This research integrates Damasio's Somatic marker hypothesis, statistical analysis, biometric systems, the neuro-questionnaire, multiple criteria analysis methods and intelligent systems. The objective of this research was to develop the .*INVAR* Neuromarketing method and system. The *INVAR* Neuromarketing method and system can determine: the effectiveness of a video ad and its individual frames; ad frames that make viewers most happy, sad, angry, surprised, scared, disgusted, bored, interested or confused; the effect of a video ad on the short-term and long-term memory; the most positive or negative video ad, etc. This article presents these studies and their results in greater detail.

Keywords: *INVAR* Neuromarketing method and system, Affective attitudes, Emotional and physiological states, Video ads, Multicriteria analysis, Intelligent systems.

1. Introduction

Long-established grouping of potential consumers into market segments is based on demographic aspects: their purchasing history (store scanner data), demographics (age, gender, sex, socioeconomic status), geography (country, climate, population density), and even responses to marketing activities (focus groups or commercials) (Keller, 2008). For organisations advertising a product, the first step is to collect information on possible target market responses to a product. In traditional marketing research, features of the proposed product are evaluated by using focus groups or extensive surveys (Venkatraman et al., 2012).

Consumer attitudes are another aspect now also often considered for segmentation (Yankelovich, Meer, 2006; Venkatraman et al., 2012). Social science studies have recently adopted neurological (positron emission tomography, electroencephalography, functional magnetic resonance imaging, magnetoencephalography) and biological data collection methods (eye tracking, galvanic skin response, facial recognition/facial coding system, heart rate) and related information and intelligent systems (Boz et al., 2017). In their case studies, Boz et al. (2017) provide examples of pricing determined with the help of biological tools such as facial recognition/facial coding system, eye tracking, heart rate and galvanic skin response, and neuromarketing tools such as electroencephalography, magnetoencephalography, positron emission tomography, functional magnetic resonance imaging and connected information and intelligent systems. With these methods and systems combined, data triangulation may become possible, which would ensure higher validity and reliability of data on how consumers perceive prices and pricing (Boz et al., 2017). Kapoor et al. (2007) and Gallego et al. (2010) have demonstrated that experiments which co-measure body signals (e.g., pressure or posture) and physiological signals (e.g., heart rate and skin conductance) make results about emotional states more robust and reliable.

Our neuromarketing studies, as well as those done by other researchers, look at emotional states, valence and arousal (Boz et al., 2017; Golnar-Nik et al., 2019), affective states (Zurawicki, 2010; Gupta, Falk, 2016) and physiological states such as medium respiratory rates (Brown et al., 2010; Gallego et al., 2010, Balanou et al., 2013), heart rates (Brown et al., 2010; Gallego et al., 2010; Balanou et al., 2013; Mileti et al., 2016),

*This paper is an extended version of the paper called "Degree of project utility and investment value assessments", published in the International Journal of Computers Communications & Control, 2016, vol. 11, issue 5, pages: 666–683. DOI: 10.15837/ijccc.2016.5.2679. In the current paper the *INVAR* Neuromarketing method and system has been designed so that it can determine the following: the effectiveness of a video ad and its individual frames; ad frames that make viewers most happy, sad, angry, surprised, scared, disgusted, bored, interested or confused; the effect of a video ad on the short-term and long-term memory; the most positive or negative video ad, etc.

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pupil sizes (dos Santos et al., 2015; Ko et al., 2017; Ungureanu, 2017), and facial temperature (Brown et al., 2010; Balanou et al., 2013; Mileti et al., 2016).

The organization of this manuscript is as follows: Section 2, which follows this introduction, describes the *INVAR* Neuromarketing method and system. Section 3 presents case study. Finally, the concluding remarks appear in Section 4.

2. INVAR Neuromarketing Method and System

This research integrates Damasio's Somatic marker hypothesis (Damasio, 1994), statistical analysis (LOGIT, KNN, MBP, RBP), biometric methods and systems (Kaklauskas et al., 2018a; Kaklauskas, 2015), the neuro-questionnaire method and system (Kaklauskas et al., 2018b), and multiple criteria analysis methods and decision support systems (Kaklauskas, 2015; Kaklauskas, 2016, Kaklauskas, 1999).

Based on the analysis of existing intelligent and smart marketing systems *INVAR* Neuromarketing method and system consisting of an Intelligent Database, Database Management System, Intelligent Model-Base, Model-Base Management System and User Interface were created. Meanwhile the video cameras, FaceReader 7.1, Mirametrix S2 Eye-Tracker Subsystem, infrared camera FLIR A35SC and Respiration Sensor X4M200 comprise the Equipment Subsystem.

The Intelligent Database contains numerous databases. These are the Emotional States Database containing happy, sad, angry, surprised, scared, disgusted and neutral states, valence and arousal; Affective Attitudes Database including boredom, interest and confusion; Physiological States Database storing facial temperature, heart rate and breathing rate; Video Ads with Individual Frames Database; Video Ads and Strongest Frames Database including the frames making the strongest impressions and causing the most intense feelings; Video Ad Effects Database of the ads affecting short-term and long-term memory; Emotional Ad Frames Database including frames that have made viewers the happiest, saddest, angriest and most surprised, scared, disgusted, bored, interested or confused; Most Positive or Negative Video Ads Database; Physiological Viewing States Database for including medium breathing and heart rates, pupil sizes, facial temperatures, valence and arousal while viewing brand-exposing ad frames; Advertisements Instigating Physiological States Database to contain advertisements prompting rising/falling happiness and interest throughout their views; Effectiveness Tips Database supplying tips for making video ads more effective and Correlations Database.

The Intelligent Model Base consists of the following: Model for Measuring the Effectiveness of Video Ads and their Individual Frames; Model for Identifying Video Ads and their Frames with the Strongest Impressions and Most Intense Feelings; Model for the Measuring Video Ad Impacts on Short- & Long-term Memory; Model for Analyzing Ad Frames Causing Most Emotions including viewers becoming the happiest, saddest, angriest and the most surprised, scared, disgusted, bored, interested or confused; Model for Determining the Most Positive or Negative Video Ad; Model for Analyzing Physiological States when viewing brand-exposing ad frames including medium breathing and heart rates, pupil sizes, facial temperatures, valence and arousal; Model for Determining Ads Instigating Rising/Falling Physiological States such as happiness and interest throughout the viewing of an ad; Data Analytics; Model for Suggesting *INVAR* Technique Numerical Guidance; Model for Compiling Biometric, Physiological & Emotional Maps; Model for Visualizing Data and Results.

The *INVAR* Neuromarketing method and system allows stakeholders to determine: a) the effectiveness of a video ad and its individual frames; b) which video ads and frames have made the strongest impression and caused the most intense feelings; c) the effect of a video ad on the short-term and long-term memory; d) ad frames that have made viewers most happy, sad, angry, surprised, scared, disgusted, bored, interested or confused; e) the most positive or negative video ad; f) physiological states (medium breathing and heart rates, pupil sizes, facial temperature), valence and arousal when viewing brand-exposing ad frames; and g) advertisements where physiological states, happiness and interest are rising/falling throughout the advertisement. The System also offers tips on ways to make video ads more effective (see Chapter 2). Based on the above results, the establishment of appropriate market segments by demographic criteria (males

and females at different ages), geographic (the participants of the experiment were from different Lithuanian places) and psychographic and consumer behavior criteria (happy, sad, angry, surprised, scared, disgusted, bored, interested and confused, plus breathing rate and heart rate) is possible. An overview of this System's capabilities follows.

2.1 Model for Measuring the Effectiveness of Video Ads and their Individual Frames

Traditionally, video ads performance is examined based on such core metrics as the number of times a video ad was viewed, average watch time, view rate, plus impressions, engagement and click performance, video ad viewership, reach and frequency, etc. Since we have no access to this kind of data, our research makes use of data on emotional, affective and physiological states. When creating video ads, scriptwriters, directors and producers determine the range and intensity of emotions and affective attitudes these ads have to invoke in their viewers at certain points. The authors of this article have already spent the past 18 months studying the affective attitudes as well as emotional and physiological states of passersby in Vilniaus City. These studies show that people always feel an entire rainbow of ever-changing emotions and affective attitudes, some more strongly and others quite weakly. This technique considers an entire range of affective attitudes as well as emotional and physiological states of people that keep on changing.

The video ad's sum level of effectiveness (A_j) indicates the percentage of deviance of the affective and emotional status, valence and arousal of viewers from the respective parameters foreseen by advertising experts for viewers (see Table 1).

Table 1. The neuro decision matrix of video ad effectiveness and the results of its multiple criteria analysis (the answers to questions by experts and respondents)

Criteria describing the Videos	Weight of criteria, measuring units, *	Compared Videos (Vj)									
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Happy (d_{es1j})		1.859	1.515	1.384	2.131	1.525	1.687	1.475	1.667	1.141	2.081
Happy (d_{rs1j})		3	1.333	1.4	2.2	2	1.714	1.5	2.5	1.2	1.533
Happy,	**1, %, -**	**38.03**	**12.01**	**1.14**	**3.14**	**23.75**	**1.58**	**1.67**	**33.32**	**4.92**	**26.33**
Sad (d_{es2j})		1.202	1.444	1.586	1.061	1.081	1.101	1.081	1.131	1.859	1.091
Sad (d_{rs2j})		1	1	1.8	1	1	1	1	1	2.2	1.133
Sad	**1, %, -**	**16.81**	**30.75**	**11.89**	**5.75**	**7.49**	**9.17**	**7.49**	**11.58**	**15.50**	**3.71**
Angry (d_{es3j})		1.101	1.202	1.141	1.030	1.091	1.051	1.051	1.252	1.364	1.152
Angry (d_{rs3j})		1	1	1	1	1	1	1	1	1	1
Angry	**1, %, -**	**9.17**	**16.81**	**12.36**	**2.91**	**8.34**	**4.85**	**4.85**	**20.13**	**26.69**	**13.19**
Surprised (d_{es4j})		1.455	1.525	1.343	1.758	1.222	1.697	1.485	1.273	1.485	1.768
Surprised (d_{rs4j})		1	1.333	1.8	1.2	1.25	1.571	1.75	1	1.8	1.267
Surprised	**1, %, -**	**31.27**	**12.59**	**25.39**	**31.74**	**2.24**	**7.42**	**15.14**	**21.45**	**17.50**	**28.34**
Scared (d_{es5j})		1.030	1.232	1.172	1.030	1.051	1.030	1.061	1.273	1.353	1.050505
Scared (d_{rs5j})		1	1.333	1	1	1	1	1	1	1.4	1
Scared	**1, %, -**	**2.91**	**7.58**	**14.68**	**2.91**	**4.85**	**2.91**	**5.75**	**21.45**	**3.36**	**4.81**
Interest (d_{es6j})		1.879	2.051	1.636	2.182	1.424	2.131	1.677	1.424	1.636	2.030
Interest (d_{rs6j})		3	1.667	2.2	2.6	2.5	2.429	1.5	2.5	1.8	2.733
Interest	**1, %, -**	**37.37**	**18.72**	**25.64**	**16.08**	**43.04**	**12.27**	**10.55**	**43.04**	**9.11**	**25.72**
Confusion (d_{es7j})		1.131	1.273	1.192	1.131	1.152	1.172	1.232	1.293	1.404	1.232
Confusion (d_{rs7j})		1	2	2.6	1	1	1.143	1	1	1.8	1.133
Confusion	**1, %, -**	**11.58**	**36.35**	**54.15**	**11.58**	**13.19**	**2.47**	**18.83**	**22.66**	**22.00**	**8.04**
Ad's sum level of effectiveness (A_e)		**78.98**	**80.74**	**79.25**	**89.41**	**85.30**	**94.19**	**90.82**	**75.20**	**85.85**	**84.27**
Priority of ad effectiveness		**9**	**7**	**8**	**3**	**5**	**1**	**2**	**10**	**4**	**6**

This technique assesses the effectiveness of an ad at each step of its creation, determines where the ad is good and where it falls short and then improves the ad to make it the most attractive to a user (viewers should preferably experience the emotions, affective attitudes and physiological states as envisioned by the director, scriptwriter and producer). The equation below can help with these goals:

Table 1 presents the average emotional and affective states intended by the advertising eight designers, producers and experts (experts) of the ads (in green) and the actual emotional and affective states experienced by 99 viewers (in red). This table also shows the percentage difference (in blue) between the creator-intended and viewer-experienced emotional and affective states for 10 video ads.

$$A_{ej} = 100\% - \sum_{j=1}^{n}\sum_{i=1}^{m} q_i \bullet (|\, d_{esij} - d_{rsij} \,| : d_{\max sij} + |\, d_{eeij} - d_{reij} \,| : d_{\max eij} + |\, d_{epij} - d_{rpij} \,| : d_{\max pij}) : 3 : \sum_{i=1}^{m} q_i, \qquad i = \overline{1, m};\ j = \overline{1, n}. \tag{1}$$

where A_{ej} is the overall effectiveness of the ad j; n is the number of video ads; m is the number of criteria; j is the video ad j under analysis; d_{esij} is the value of the i-th criterion in a survey of emotional and affective states for the video ad j frame where ad creators, scriptwriters and producers indicate the expected emotions of people viewing ads (see Table 1); d_{eeij} is the value of the i-th criterion of the biometric evaluation of emotional and affective states for the video ad j frame by advertising experts (who indicate the expected biometric emotional and affective states of people viewing ads); d_{epij} is the value of the i-th criterion of the physiological evaluation of the video ad j frame by advertising experts (who indicate the expected physiological states (breathing rate, and left and right pupil sizes) of people viewing ads); d_{rsij} is the value of the i-th criterion of the viewer/respondent survey evaluating the video ad j (see Table 1); d_{reij} is the value of the i-th criterion in biometric measurements of respondents emotions and affective attitudes for the video ad j; d_{rpij} is the value of the i-th criterion of biometric measurements of respondents physiological states for the video ad j; $d_{max\ sij}$ (d_{maxeij} and d_{maxpij}) is the biggest value from d_{esij} (d_{eeij} and d_{epij}) and d_{rsij} (d_{reij} and d_{rpij}).

The rates (d_{esij}, d_{eeij} and d_{epij}) given by the experts (ad creators, scriptwriters and producers) should fall within the same range as those given by the respondents (d_{rsij}, d_{reij} and d_{rpij}). In case of emotional states and affective attitudes d_{eeij}, for instance, the rates given by the experts and emotions were felt by the viewers should be between 0 and 1 (and valence between –1 and 1).

As example, the overall effectiveness of the ads 1 and 6 are found according to first formula (see Table 1). Application of formula (1):

Formula 1 is for calculating the video ad's sum level of effectiveness (A_e). The main objective of this formula is to determine the degree to which a video ad clip has achieved its maker's goals. If the ad's sum level of effectiveness A_e>90%, then it is possible to assert that the ad maker's goals have been completely achieved. As Table 1 shows, Video ads 6 and 7 (A_6=94.19% and A_7=90.82%) have fully achieved the goals of their ad makers. Assuming the sum effectiveness level of the ad is 80%<A_e<90%, then the goals for this ad have been achieved on average (A_2=80.74%, A_4=89.41%, A_5=85.30%, A_9=85.85% and A_{10}=84.27%); however, this video ad requires improvement. If A_e <80%, then it is necessary to improve this ad (A_1=78.98%, A_3=79.25% and A_8=75.20%). For example, if the ad-makers expect viewers to feel some specific affective attitude (boredom, interest or confusion), emotional state (happiness, sadness, anger, surprise, fear, disgust or a neutral state), valence and a strength of arousal (low, average, high) from the video ad under deliberation, and a viewer has ideally felt just such a feeling, then A_e=100%. However, if the affective attitudes, emotional states, valence and arousal, foreseen by the ad-makers, caused a diametrically opposite effect among viewers, then A_e=0%.

By using the Formula 1 and the data from Table 1, the effectiveness of the video ads in question has been determined. Only the percentage differences between the creator-intended and viewer-experienced emotional and affective states (marked in blue) have been analysed in the calculations. It is obvious that the sixth video ad (A_6 = 94.19%) is the most effective, because its creator-intended and viewer-experienced emotional and affective states are the closest match. A_j can vary between 0 and 100%. The lowest impact on viewer impressions and feelings

Ae1 = 100% - (1 • |1.859-3| :3 + 1 • |1.202-1| : 1.202 + 1 • |1.101-1| : 1.101 + 1 • |1.455-1| : 1.455 + 1 • |1.030-1| : 1.030 + 1 • |1.879-3| :3 +1 • |1.131-1| : 1.131) : 7 = 78.98%,
Ae6 = 100% - (1 • |1.687 - 1.714| : 1.714 + 1 • |1.101 – 1| : 1.101 + 1 • |1.051–1| : 1.051 + 1 • |1.697-1.571| : :1.697 + 1 • |1.030-1| : 1.030 + 1 • |2.131-2.429| : 2.429 + + 1 • |1.172-1.143| : 1.172) : 7 = 94.19%.

was made by the eight ad (A_8= 75.20%) making it the least effective one.

The effectiveness of individual video ad frames is determined in the same manner as above, with the only difference that Table 1 has to be expanded by including multiple columns for individual frames of a video ad instead of a single data column of that ad. The first video ad (V_1), for instance, contains four frames. The single column of the first video ad (V_1) in Table 1 then will be replaced with four columns for each frame of the ad.

2.2. Model for Identifying Video Ads and their Frames with the Strongest Impressions and Most Intense Feelings

Evidence shows that aroused emotions can make ads more effective (Biener et al., 2004). Hamelin et al. (2017) analyse the effectiveness of emotions and ads. The findings by Hamelin et al. (2017) show that highly emotional ads have led to a higher safe driving attitude score, compared to less emotional ads, and the score was also more durable. Videos that elicit emotional responses with high arousal (either positive or negative) are around twice more often shared than videos that elicit emotional responses with low arousal. The pattern remains the same both across the commercial and non-commercial data (Nelson-Field et al., 2013). McKay-Nesbitt et al. (2011) suggest that in ad impact negative ad frames will be more effective than positive ad frames. Nelson-Field et al. (2013) believe that negative ad content is produced less often than positive ad content and the share of video ads that stimulate positive emotional responses is considerably higher than the share of those stimulating negative ones.

The *INVAR* technique (Kaklauskas, 2016) can determine which video ad *j* makes the strongest impression and causes the most intense feelings indicated by the level of utility degree (N_j).

Higher N_j ($j = \overline{1,n.}$) value means that the video ad *j* has caused more intense emotions and affective attitudes. N_j can vary between 0 and 100.

Worldwide studies show that when eye pupils dilate and the breathing rate increases arousal increases, too. Table 2 shows the average arousal, breathing rate, and left and right pupil size of the 99 experiment participants for each video ad. Expert examination also has determined the weights of arousal, breathing rate, and left and right pupil size; the weights are presented in Table 2.

The *INVAR* technique (Kaklauskas, 2016) and the data from Table 2 have been used to determine the effect of the video ads being analysed on viewer impressions and feelings. The tenth video ad (N_{10}= 100%) clearly made the biggest impact on viewer impressions and feelings. The lowest impact on viewer impressions and feelings was made by the eighth ad (N_8= 93.4%), 6.6% below that of the tenth ad.The same process is used when the effect of a video ad frame on viewer impressions and feelings has to be determined, but this time Table 2 needs to be expanded. Instead of a single data column for a specific video ad, multiple columns for each individual video ad frame are added. The seventh video ad (V_7), for instance, consists of four frames. Then Table 2 will include four columns for each frame of the seventh video ad (V_7) instead of a single column covering the data of the entire ad.

Table 2. The neuro decision matrix of the impact video ads make on viewer impressions and feelings and the results of its multiple criteria analysis (these data were gathered by the Equipment Subsystem)

Average viewer	Criterion weight, measuring units, *	Compared Videos (*Vj*)									
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Arousal	3, points, +	0.316	0.321	0.305	0.332	0.303	0.312	0.296	0.29	0.32	0.318
Breathing rate	1, breaths per second, +	18.87	18.07	19.25	17.87	17.92	18.12	17.65	17.18	18.38	18.91
Left pupil size	1, mm, +	4.33	4.50	4.32	4.33	4.32	4.31	4.46	4.38	4.46	4.46
Right pupil size	1, mm, +	3.99	4.39	4.13	4.19	4.14	4.21	4.41	4.30	4.41	4.41
The utility degree (*Nj*) and priority (P_j) of an ad based on its effect on viewer impressions and feelings											
Utility degree (*Nj*)		97.6%	99.8%	96.7%	99.9%	95.3%	97.1%	95.5%	**93.4%**	99.8%	**100%**
Priority (P_j)		5	4	7	2	9	6	8	**10**	3	**1**

∗ - The + (–) indicates that either a greater or lower criterion value means greater significance for viewers

The *INVAR* technique (Kaklauskas 2016) and the data from Table 2 have been used to determine the effect of the video ads being analysed on viewer impressions and feelings. The tenth video ad (N_{10} = 100%) clearly made the biggest impact on viewer impressions and feelings. The lowest impact on viewer impressions and feelings was made by the eighth ad (N_8 = 93.4%), 6.6% below that of the tenth ad.

The same process is used when the effect of a video ad frame on viewer impressions and feelings has to be determined, but this time Table 2 needs to be expanded. Instead of a single data column for a specific video ad, multiple columns for each individual video ad frame are added. The seventh video ad (V_7), for instance, consists of four frames. Then Table 2 will include four columns for each frame of the seventh video ad (V_7) instead of a single column covering the data of the entire ad.

2.3 Model for the Measuring Video Ad Impacts on Short & Long-term Memory

Many researchers (Mehta, 2000; Kellaris, Cline, 2007; Li, Lo, 2015; Muñoz-Leiva et al., 2019) examined ad effectiveness focusing on better ad memorability and longer recall. Li and Lo (2015) believe that memorability may be a key player *in ad effectiveness*. Muñoz-Leiva et al. (2019) analyse ad effectiveness in social media and look at the visual attention and self-reported memory of customers. Mehta (2000) selected two key measures as indicators of advertising effectiveness. One of them is intrusiveness that shows the power to get attention and ad memorability, and the other is persuasion that indicates the favourable buying interest for the advertised products. Mehta (2000) aimed to test the hypotheses that consumers whose attitudes toward advertising are in general more favourable would (1) recall more ads the next day after exposure, and (2) the ads would persuade them better.

The Method also assists in determining the more memorable places in a video ad and the objects arousing the strongest impressions and feelings (based on valence and arousal data, determined three times per second). The data on valence and arousal is recorded every third of a second. This means that the technique outlined in this section can determine the exact moment (i.e. frame and object) that should be the most memorable. These correspond with the studies performed worldwide, which are described next. The arousal dimension of emotions has been the focus of most studies to date as being the critical factor that contributes to the effect on memory enhanced by emotions (Cahill, McGaugh, 1995). In the memory process, arousal is involved in information detection, retention and retrieval. When information makes one emotionally aroused, this can lead to better encoded memory, and this, in turn, means better information retention and retrieval (Phelps et al., 2004).

The studies investigating the dimension of emotional valence discovered that emotional valence alone can enhance memory, i.e., items that lack arousal with positive or negative valence are better remembered than are the neutral items (Ochsner, 2000; LaBar, Phelps, 1998; Kensinger, Corkin, 2003). Exposure to arousing events or information enhances the retention and accumulation of information. Arousing information also means more vivid and accurate retrieval or recalling (Jeong, Biocca, 2012). The summary by Ochsner (2000) of various findings suggests that stimuli are more distinctively encoded for arousal by the influences of attention selectivity and dwell time thereby resulting in a more accurate remembrance of those stimuli (Ochsner, 2000). Brain is selective and better at encoding arousing stimuli and that means better long-term memory in contrast to neutral stimuli (Steinmetz et al., 2012). Different scholars discovered that numerous studies indicate a decrease in memory of neutral stimuli over time in comparison to the same or improved memories for arousing stimuli (LaBar, Phelps, 1998; Baddeley, 1982; Kleinsmith, Kaplan, 1963). That emotion enhances memory is substantiated by evidence; however, memory is more specific when it approaches factors of arousal and valence (Adelman, Estes, 2013). The application of this Method makes it possible to establish how often a slice of advertising information requires repetition in a specific place in an ad for the entire advertising campaign to be effective (pursuing an aim to have the A_e of each clip to approach 100%). With such information at hand, it becomes possible to exchange the elements of an ad clip for better recognition and memorability of the ad under transmission.

The memory process involves the detection, retention and retrieval of information for the stimulation of arousal. Information arousing emotions can come from better memory encoding.

Table 3. The neuro decision matrix of the impact video ads make on short-term and long-term memory and the results of its multiple criteria analysis (these data were gathered by the Equipment Subsystem)

Average viewer	Criterion weight, measuring units, *	Compared Videos (Vj)									
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Arousal	3, points, +	0.316	0.321	0.305	0.332	0.303	0.312	0.296	0.29	0.32	0.318
Valence	3, points, +	-0.13	-0.115	-0.107	-0.137	-0.1	-0.123	-0.129	-0.118	-0.13	-0.117
Breathing rate	1, breaths per second, +	18.87	18.07	19.25	17.87	17.92	18.12	17.65	17.18	18.38	18.91
Left pupil size	1, mm, +	4.33	4.50	4.32	4.33	4.32	4.31	4.46	4.38	4.46	4.46
Right pupil size	1, mm, +	3.99	4.39	4.13	4.19	4.14	4.21	4.41	4.30	4.41	4.41
Utility degree of an ad (N_j) by its effect on ad memorability		92.78%	98.03%	98.47%	92.83%	**100%**	94.09%	91.63%	93.01%	94.27%	97.63%
Ad priority by its effect on ad memorability		9	3	2	8	**1**	6	10	7	5	4

∗ - The + (–) indicates that either a greater or lower criterion value means greater significance for viewers

This can influence better retention and retrieval of information (Phelps et al., 2004). Exposure to arousing events or information strengthens the retention and accumulation of information. Additionally arousing information is retrieved or remembered more vividly and accurately (Jeong, Biocca, 2012). The arousing stimuli, which are encoded, are selective and, thereby, produce better, long-term memory results than do the encoding of neutral stimuli (Steinmetz et al., 2012). It can be asserted that an advertisement is better remembered the greater the arousal it stimulates in a viewer. The same can be stated about positive or negative valence. The greater the absolute valence is the better a viewer can recall the ad watched.

By using the *INVAR* technique (Kaklauskas, 2016) and the data presented in Table 3, the impact of the video ads being analysed on the short-term and long-term viewer memory has been determined. The fifth video ad (N_5 = 100%) made the biggest impact on the short-term and long-term memory of the viewers. The lowest impact on the short-term and long-term viewer memory was made by the seventh ad (N_7 = 91.63%), 8.37% below that of the fifth ad.

If the utility degree of an advertisement by its effect on ad memorability N_j >90%, then it is likely to state that the advertisement developer's objectives have been entirely realised. As Table 3 displays, all video ads have completely attained the memorability goals of their video advertisement developers.

Supposing the utility degree of an ad by its effect on ad memorability is 80%< N_j <90%, then the objectives for this advertisement have been realised on average. If N_j <80%, then it is needed to improve this advertisement.

2.4 Model for Suggesting INVAR Technique Numerical Guidance

This Model involves provisions of digitalized recommendations, which are obtained by employing the *INVAR* technique. The number of percentage points needed to change the desired criteria of a video, for it to change into the desired priority level, can be accurately determined by using these digitalized recommendations. Suggesting of numerical guidance according to this Model (see Case Study) based on: answers to questions posed to eight participating advertising designers, producers and experts; criteria significances established with the help of studies by experts; answers to questions posed to the 99 participating respondents; evaluations of the emotional states and affective attitudes of the 99 participating respondents (indirect biometric evaluation).

2.5 Model for Compiling Biometric, Physiological & Emotional Maps

Compilations of biometric, physiological and emotional maps based on the developed neuro decision matrices (Kaklauskas et al., 2019) are accomplished. This Model is for analyzing emotional, affective and physiological signals collecting from viewers. Such signals constitute

the basis for the Model, which comprises maps developed emotionally, biometrically and physiologically. Furthermore it groups advertising contents by age, gender, educational level and other traits of viewers.

Maps can be drawn of what each clip in an ad can evoke: the emotional state, valence and arousal, affective and physiological status (medium breathing and heart rates, pupil sizes, facial temperature). Such maps can be visualized in different forms and dimensions (augmented reality or 3, 4, 5, etc. dimensional forms).

2.6 Model for Visualizing Data and Results

A visualisation of data and results is presented as multiple criteria statistics of different layers of gathered data quantitatively defined and analysed.

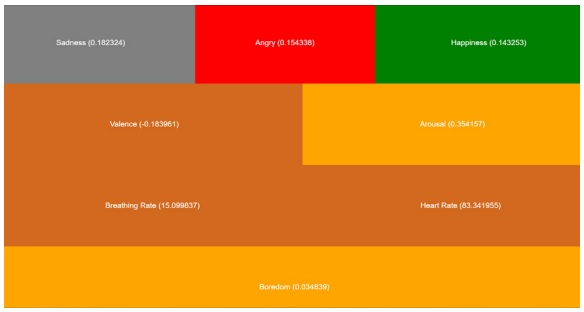

Figure 1. Affective attitude, emotional and physiological data of respondents measured during experiment in real time, characterized by colours

In the Model for the visualising data and results, data and results are visualised as quantitative representations (charts, tables, and circles of trends and relationships, plus evaluations and interconnections represented in diagrams) and conceptual representations (texts describing the quantitative part and the comparisons, multiple criteria analysis, evidence, and causality). This way various neuromarketing video ads can be presented from multiple perspectives. The outcomes of the analysis are also demonstrated visually in colour in real time. Figure 1 displays a picture of the affective attitude, emotional and physiological data of respondents.

3. Case Study: Identifying the most positive video ad

Global research shows that happy customers with their shopping experience full of positive emotions usually come back, spend more money and tell their families and friends about the items they bought. Enthusiastic and happy viewers are expected to at least engage with video ads.

Zaichkowksy (1985) believes involvement is bound to be rather low belief, if an advertisement is unappealing, not providing its viewers with a positive feeling. The goal of all advertisers must be to make their customers happy. A happy customer is likely to be a repeat customer (Jafeta, 2018). The purchase of a product that becomes an actual, pleasant, emotional experience is gravely important, as Metha and Purvis (2006) state. Positive, happy emotions in advertisements similarly encourage more positive attitudes among viewers, added personal involvement and, most importantly, greater purchase intentions. Stimulating consumer attraction and engaging attachments to brand names require adequate use of emotions in advertising, from love to humor, from happiness to excitement (Kamran, Siddiqui, 2019). Emotional advertisements will be likely to provoke client positive sense regarding purchase (Albers-Miller, Royne Stafford, 1999). Different studies find that advertisements enhancing satisfaction, trust and commitment, the positive consumption emotions, influence the intentions of their customers for repeat purchases and word-of-mouth advertising (Abbasi et al., 2018). Therefore, it can be said, use of positive emotions in a marketing campaign would specifically aim at convincing people to experience these positive emotions by buying certain products or by changing behavior, such as, e.g., buying tickets to Disneyland just to evoke smiles on the faces of loved ones (Edell, Burke, 1987).

Based on the above ideas, this section presents a case study of how the *INVAR* Neuromarketing method and system determines the most positive video ad.

The endeavor of this Case Study was to compare the answers to the questions provided by the 8 participating designers, producers and experts in advertising with the sum of video analysis results (responses from 8 ad experts and 99 respondents to the questions (direct evaluation) and the emotional states and affective attitudes of the respondents (indirect biometric evaluation)) for determining the overlap of opinions by means of a video positive emotions multicriteria analysis.

In our experiment, the purpose of screening is to assess and compare different video ads

looking for the best options for all markets (i.e. that the ads being analysed would make nearly anybody interested). Throughout the screening we analyse whether the target clients will get value from the video ads being analysed. Subjects were recruited for that purpose based on geographic, demographic, psychographic and consumer behaviour criteria. This way our experiment involved viewers from different segments (university students and lecturers) by geographic criteria (subjects came from various parts of Lithuania), demographic criteria (males and females of different ages), and psychographic and consumer behaviour criteria (happy, sad, angry, surprised, scared, valence, arousal, interest, boredom, confusion). Our research goals required commercials and social video ads with different content and of different duration. Looking for video ads that can interest as wide audience as possible, we selected viewers who watched the video clip prior to the study as well as viewers who have never watched the video. Our objective was to determine which video ads are the most rational option in all markets.

The participants were 99 healthy male and female volunteers, ages ranging from 18 to 62 years old, native Lithuanians and with no history of neurological or psychiatric disturbances. Advance information about testing procedures were disseminated to all participants two or three days prior study start. The explanation of the actual procedure was near to the experimental setup. After a 2-minute concentration break, the tests proceeded. Informed consent was obtained in all cases. The test procedures lasted three working days, starting at 9 am and lasting until 2 pm. The manager regulated the frequency of the experiments to avoid any possible crowding from behind, which was not allowed. No additional people were allowed present during a test procedure.

The advertising designers, producers and experts had to mark their replies to their questions on which the emotional states and affective attitudes of the respondents a video ad clip was meant to evoke in viewers.

The designers, producers and experts fill in the questionnaire where they indicate the emotions ad viewers are supposed to experience in ten video ads. Respondents were shown these ten video recordings during the test. These clips were meant to evoke different emotional states and affective attitudes: ad about "Book Fair" (V_1), ad by the Road Administration regarding road dangers (V_2), ad on aid with Food Packages for the Poor (V_3), ad on "Kaziuko Fair" (V_4), ad by Gintarinės Pharmacy for senior citizens (V_5), ad on "Studies opportunities" at Šiauliai State College (V_6), ad on ETNO herbs and spices (V_7), by the Norfa supermarket chain about Mažylių sausage sales (V_8), ad on "Help for Women" (V_9), ad about "Heating Utility Company of Vilnius" (V_{10}) (see Table 4).

All the evaluations were ranked by 1 to 3 points for each clip. Then the points were totalled, and an average was taken for each valence, emotional and affective status level. Finally a neuro decision matrix was compiled of the overall evaluations of valence, emotional and affective status for all ten video recordings (see Table 4). Analogically the 990 tables that had been filled out by the 99 respondents serve as the basis for compiling an integrated table on the average answers by students and lecturers (see Table 4).

In the same way, with the help of the Equipment Subsystem, 990 neuro-tables were filled out by 99 respondents, which included data on scared, arousal, boredom, confusion, arousal, valence, breathing rate, left and right pupil sizes. These served as the basis for compiling an integrated table on average emotions of students and lecturers. The neuro decision matrix presents data describing all three positive emotions tests of video ads (see Table 4).

Data summarizing all three positive emotions tests based on the performance of a multicriteria analysis was (see Table 4) according to the COPRAS method. Consequently a comparison was performed between the answers to the questions per the 8 advertising designers, producers and experts (experts) participating in the survey and the integrated evaluation (by answers to questions by 8 advertising experts and 99 respondents (direct evaluation) as well as the emotional states and affective attitudes of respondents (indirect biometric evaluation)). Thus the overlays in opinions were established.

The evaluations of Video ads 1, 2, 4 and 9 by positive emotions (emotional states and affective attitudes), as per the experts and per the sum totals, coincided according to level of priority. Meanwhile the evaluations of Video ads 5, 6 and 10 by positive emotions, as per the experts

Table 4. Identifying the most positive video ad

Criteria describing the video ads and its weight, measuring units, *	Compared Videos (Vj)									
	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
Research 1: Average emotional states and affective attitudes of respondents established with help of FaceReader 7.1										
Scared, C1, -, points, 0.25	0.009	0.018	0.009	0.011	0.007	0.009	0.005	0.01	0.016	0.009
Arousal (Ari) , C2, +, points, 0.25	0.316	0.321	0.305	0.332	0.303	0.312	0.296	0.29	0.32	0.318
Boredom, C3, -, points, 0.25	0.287	0.236	0.175	0.21	0.369	0.093	0.45	0.22	0.127	0.169
Confusion, C4, -, points, 0.25	0.001	0.033	0.014	0.006	0.001	0.061	0.002	0.038	0.033	0.055
Research 2: Average emotional states and affective attitudes of respondents established with help of the questionnaire										
Happy,+, points, 0.125	1.859	1.515	1.384	2.131	1.525	1.687	1.475	1.667	1.141	2.081
Sad, -, points, 0.125	1.202	1.444	1.586	1.061	1.081	1.101	1.081	1.131	1.859	1.091
Angry, -, points, 0.125	1.101	1.202	1.141	1.030	1.091	1.051	1.051	1.252	1.364	1.152
Surprised, +, points, 0.125	1.455	1.525	1.343	1.758	1.222	1.697	1.485	1.273	1.485	1.768
Scared, -, points, 0.125	1.030	1.232	1.172	1.030	1.051	1.030	1.061	1.273	1.353	1.051
Interest, +, points, 0.125	1.879	2.051	1.636	2.182	1.424	2.131	1.677	1.424	1.636	2.030
Confusion, -, points, 0.125	1.131	1.273	1.192	1.131	1.152	1.172	1.232	1.293	1.404	1.232
Valence, +, points, 0.125	1.354	1.515	1.343	1.475	1.182	1.394	1.222	1.263	1.333	1.475
Research 3: The results of a video ads designers, creators and experts survey with the emotions expected from respondents as they watch ads										
Happy, +, points, 0.125	3	1.333	1.4	2.2	2	1.714	1.5	2.5	1.2	1.533
Sad, -, points, 0.125	1	1	1.8	1	1	1	1	1	2.2	1.133
Angry, -, points, 0.125	1	1	1	1	1	1	1	1	1	1
Surprised, +, points, 0.125	1	1.333	1.8	1.2	1.25	1.571	1.75	1	1.8	1.267
Scared, -, points, 0.125	1	1.333	1	1	1	1	1	1	1.4	1
Interest, +, points, 0.125	3	1.667	2.2	2.6	2.5	2.429	1.5	2.5	1.8	2.733
Confusion, -, points, 0.125	1	2	2.6	1	1	1.143	1	1	1.8	1.133
Valence, +, points, 0.125	3	1.667	2.2	2.2	1.857	1.75	1.75	1.75	2.6	2.067
The results of the multiple criteria analysis										
Significance of the video	0.350	0.258	0.292	0.348	0.322	0.29	0.312	0.282	0.258	0.288
Priority of the video by positive emotions	1	10	5	2	3	6	4	8	9	7
Utility degree of the video by positive emotions (%)	100%	74%	83%	100%	92%	83%	89%	81%	74%	82%
Priority of the video by positive emotions as per experts	1	10	8	2	4	5	7	3	9	6
Utility degree of the video by positive emotions (%) as per experts	100%	69%	73%	91%	88%	87%	84%	89%	71%	85%

and per the sum totals, differ by only one level of priority. Therefore, as the results provided in Table 4 show, either priority levels 7 of 10 differ by one level of priority, or their utility degrees differ by 3.64%, on average. Analogically all the evaluations of the video ads by positive emotions, as per the experts and per the sum totals, differ by 4.88% on average. The low percentile difference between the video evaluations, as per the experts and as per respondents, shows that the results are reliable. Digital recommendations can be provided in order to increase the positive emotions evoked by the video ads and, at the same time, improve the positive emotions priority level of a video ad by the sum total of positive emotions (additionally evaluating the negative emotions as well). A neuro decision matrix provides the recommendations. Table 5 shows, for instance, that Video 4 (a_4) had the highest rating as per respondents for Happy ($x_{5\ 4}$=2.131) as compared to the other videos. Meanwhile Video 1 (a_1) had a rating per respondents for Happy of 1.859 ($_{x5\ 1}$=1.859). If the goal is to reach the level of Video 4 (a_4) per respondent for Happy (X_5), Video 1 must increase its index rate by 14.67%.

Thus, the position of Video 1 (a_1) in the overall ranking of the videos would improve by 0.61%. These results were obtained by employing the *INVAR* method (Kaklauskas, 2016). Other ways to improve the ratings of the other video can be analyzed as follows.

Table 5. Fragment of digital tips on ways to create the most positive video ad

Criteria describing the video ads and its weight, measuring units, *	Compared video ads: Value of the analyzed criterion Possible improvement of the analyzed criterion by % Possible market value growth of video ads by % as first impacted by criterion value growth									
	1 video	2 video	3 video	4 video	5 video	6 video	7 video	8 video	9 video	10 video
Research 1: Average emotional states and affective attitudes of respondents established with help of FaceReader 7.1										
Arousal, 0.25, points, +	0.316	0.321	0.305	0.332	0.303	0.312	0.297	0.290	0.320	0.318
	5.06%	3.63%	8.86%	0%	9.74%	6.63%	12.05%	14.46%	3.71%	4.50%
	0.42%	0.30%	0.74%	0%	0.81%	0.55%	1.00%	1.20%	0.31%	0.38%
Research 2: Average emotional states and affective attitudes of respondents established with help of the questionnaire										
Happy, 0.125, points, +	1.859	1.515	1.384	2.131	1.525	1.687	1.475	1.667	1.141	2.081
	14.67%	40.67%	54.01%	0%	39.74%	26.35%	44.52%	27.88%	86.73%	2.43%
	0.61%	1.69%	2.25%	0%	1.66%	1.10%	1.86%	1.16%	3.61%	0.10%
Interest, 0.125, points, +	1.879	2.051	1.636	2.182	1.424	2.131	1.677	1.424	1.636	2.030
	16.13%	6.40%	33.33%	0%	53.19%	2.37%	30.12%	53.19%	33.33%	7.46%
	0.67%	0.27%	1.39%	0%	2.22%	0.10%	1.26%	2.22%	1.39%	0.31%
Valence, 0.125, points, +	1.354	1.515	1.343	1.475	1.182	1.394	1.222	1.263	1.333	1.475
	11.94%	0%	12.78%	2.74%	28.21%	8.70%	23.97%	20%	13.64%	2.74%
	0.50%	0%	0.53%	0.11%	1.18%	0.36%	1.00%	0.83%	0.57%	0.11%

4. Conclusion

The *INVAR* Neuromarketing method and system can determine the emotional, affective and physiological status of viewers; the effectiveness of a video ad and its individual frames; video ads and frames that make the strongest impression and cause the most intense feelings; the effect of video ads on the short-term and long-term memory; ad frames that make viewers the most happy, sad, angry, surprised, scared, disgusted, bored, interested or confused; the most positive or negative video ad; physiological states (medium breathing and heart rates, pupil sizes, facial temperature), valence and arousal when viewing brand-exposing ad frames; and advertisements where physiological states, happiness and interest are rising/falling throughout the advertisement. The System also offers tips on ways to make video ads more effective (see Chapter 2). Above results makes it possible to determine appropriate market segments by psychographic and consumer behaviour criteria (happy, sad, angry, surprised, scared, disgusted, bored, interested and confused, plus breathing rate and heart rate), geographic (the participants of the experiment were from different Lithuanian places) and demographic criteria (different sex and different age).

The *INVAR* Neuromarketing method and system permits evaluating the video ad's sum level of effectiveness (A_e) during each stage of its development and assisting in the determination of an ad's strengths and weaknesses (see Section 2.1). Consequently an ad can be improved until it reaches the most attractive variation for a consumer. This is an iterative process for ad improvements. Testing of each enhancement of an ad on viewers continues until the ad reaches the level desired by some certain consumer. Therefore, the constant enhancement of an ad based on precise and scientific testimony from the customers under analysis is a vital objective.

The System also assists in determining the more memorable places in a video ad and the objects arousing the strongest impressions and feelings (based on valence, arousal, right and left pupil sizes data, determined three times per second). Valence and arousal data is recorded every third of a second, hence the technique presented in this section pinpoints the exact time interval (i.e. frame and object) that should be the most memorable (see Section 2.3).

The results from the video positive emotions multicriteria analysis of the experiment show that the evaluations of the ten video ads by the advertising designers, producers and experts (experts) and integrated evaluation (affective attitudes and emotional states of respondents and the answers to questions by experts and respondents) are similar.

Digital recommendations were submitted by *INVAR* Neuromarketing system seeking to increase the positive emotions (emotional states and affective attitudes) evoked by a video ad and, at the same time, improve the priority of that video according to the sum total of positive emotions evoked during testing (while, at the same time, evaluating the negative emotions as well) (see Case Study).

Improvements to the developed *INVAR* Neuromarketing method and system are foreseen in three directions. The authors of this article also employ other biometric devices for various of their tests including voice emotions analysis (QA5 SDK) and brain signals (Enobio Helmet) biometric analysis devices. Supplemental use of these named biometric devices is expected in the future to realize an improved *INVAR* Neuromarketing method and system. The authors of this test have already been working with such an augmented reality for a number of years already. Therefore augmented reality technologies are expected to be used in the developed System in the future with a goal of optimizing consumer experiences.

Furthermore deliberations on the opportunities posed by introducing embedded biometrics into this System are foreseen. According to Rosenstein (2018), embedded biometrics involve both wearables and technologies that are either integrated biologically as parts of our bodies or reside around our bodies (clothing, wrist devices, glasses, augmented reality lenses, implanted medical monitoring devices in capillaries/blood vessels) in order to capture new information to assist with understanding consumer behavior.

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