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BRIEF COMMUNICATION

Electronic evaluation for video commercials by impression index

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Abstract How to evaluate the effect of commercials is significantly important in neuromarketing. In this paper, we proposed an electronic way to evaluate the influence of video commercials on consumers by impression index. The impression index combines both the memorization and attention index during consumers observing video commercials by tracking the EEG activity. It extracts features from scalp EEG to evaluate the effectiveness of video commercials in terms of time–frequency-space domain. And, the general global field power was used as an impression index for evaluation of video commercial scenes as time series. Results of experiment demonstrate that the proposed approach is able to track variations of the cerebral activity related to cognitive task such as observing video commercials, and help to judge whether the scene in video commercials is impressive or not by EEG signals.

Keywords Video commercials · Impression index · EEG signal · Neuromarketing · General global field power

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Introduction

There are many ways to promote a company's product and brand, for example, by video, radio and newspaper. However, as the technology of internet and wireless communication developing, video commercials appear not only in traditional TV but in the newest media such as mobile TV, web and cell phone. They widely affect the behavior of consumers. However, how to evaluate the effect of video commercial on consumers in detail is a big challenge. For decades, marketing research methods have aimed to explain and predict the effectiveness of video commercials. The traditional way is depending on consumers' willingness and competency to describe how they feel when they are exposed to the advertisement either in a confidential setting such as a face-to-face interview, or in a group setting such as a focus group. The fact that this traditional method may hide or overestimate the real strength of the commercial is more and more convinced by the marketing community (Plassmann et al. 2012).

Neuromarketing is an novel application of neuroscience to consumer psychology, especially for advertising, has received considerable attention both in academic research and business practice recently (Walter et al. 2007). It is a methodology based on measuring brain waves activity and also combining clinical psychology to develop insights into how people respond to products, brands and advertisements (Lee et al. 2007). It would soon significantly enrich marketing research portfolio and help marketers to go beyond verbal declarations of their consumers.

Neuromarketing usually use two medical technologies-fMRI and EEG to study the brain's response to marketing stimuli (Plassmann et al. 2010; Lee et al. 2007). Yoon et al. used fMRI to discover that brain areas involved in making judgments about human traits for people didn't overlap with brain areas involved in making judgments about human traits for brands (Yoon et al. 2006). Klucharev et al. suggested that increased brand recall for expert endorsement was related to stronger activation during encoding of memory structures of the left hemisphere, the dlPFC and medial temporal lobe structures, and it usually accompanied by stronger engagement of the bilateral striatum (Klucharev et al. 2008). Ohme's study yielded a conclusion that frontal asymmetry measure may be a diagnostic tool in examining the potential of advertisements to generate approaches related tendencies (Ohme et al. 2010). Concerning EEG, researchers focused on estimation of cortical cerebral activity during the subject observing TV commercials. Astolfi et al. studied memorization status during observing TV commercials by tracking the cortical activity and the functional connectivity changes in normal subjects with high resolution EEG (Astolfi et al. 2008). Fallani et al. evaluated the characteristics of brain functional network during the successful memory encoding of TV commercials by calculating the global-efficiency (E_g) and local-efficiency (E_l) (Fallani et al. 2008). Vecchiato et al. noted that temporal and frequency patterns of EEG signals could convey information about the cognitive and emotional processes in subjects observing TV commercials (Vecchiato et al. 2011a).

It has been proved that EEG oscillations in the theta band reflect memory performance (Colliaux et al. 2009). Furthermore, power synchronization in theta band and power desynchronization in alpha band are related to episodic memory and attention respectively (Summerfield and Mangels 2005; Klimesch 1999). So we can believe that the investigation of signals' power distribution in these two bands will tell the difference between the video scenes that were impressive to the consumers or not. There are two popular ways to calculate the power in particular band. One is power spectral density (PSD) and the other is global field power (GFP) (Hamburger and Burgt 1991). Each method has its pros and cons. Though the PSD method has a high spatial resolution, its time resolution is relative poor. Despite the GFP method has a good representation in both time and spatial resolution, but without considering the fact that different brain areas have different influences in the corresponding cognitive task. In this paper, we proposed an index to evaluate impressive scenes in video commercials for subjects. Impressive scenes are scenes that the subject can tell after observing video commercials without any thinking. They are always corresponding to the duration which the subject is in the state of both high attention and good memorization. Besides, We considered the different weight for each channel on the performance of memorization and attention (Kong et al. 2012). Hence, we proposed General global field power (G^2FP) to reflect the impression index which is weighted-GFP(w-GFP) in theta band subtracting w-GFP in alpha band.

Materials and methods

Experimental design

EEG signals were recorded from 20 voluntary and healthy subjects (10 males and 10 females, age 22 $\sim$ 25 years). They had no personal history of neurological or psychiatric disorder and they were free from medications, alcohol and drugs abuse. For the EEG data acquisition, subjects were comfortably seated on a reclining chair in a quiet room and asked to pay attention to what they watched without being aware of the aim of the experiment. When the EEG signals begin to record, the subject is firstly asked to stare at the point on the screen for 2 min. After that, they would be exposed to the observation of a neutral documentary about nebula for 8 min. In the middle of the documentary, 6 video commercials about 30 s for each are inserted. And these 6 commercials are 3 standard international brands namely Nick, CK and Apple, each has two different advertisements, one is broadcasted in China, and the other is in Italy (Each one is mainly with pictures, music and little words). Make sure that none of the advertisements has been watched by all subjects.

We collected the EEG data by a 16-channel system with the g.USBamp amplifier (g.Tec medical engineering GmbH) at a sampling rate of 256 Hz while the impedances kept below 5 kΩ. The electrode cap we used was built according to the 10–20 international system. 16 electrodes are: FPz, Fz, Cz, Pz, Oz, AF3, Af4, F3, F4, T7, C3, C4, T8, P3, P4 and EKG. The EKG electrode is placed in the pulse position on left wrist to record the EKG data. Right ear was used as reference.

After EEG signals recording, subjects were told to do an interview immediately. During the questionnaire, the interviewer would ask subjects questions according to the protocol steps. Firstly, subjects were asked which advertisements they can remember briefly. Then they were requested to describe plots of advertisement in detail what was remembered. Meanwhile, the interviewer should write down every detail that subjects said. Each advertisement has a length of 30 s, for each second, we captured one segmentation and listed on a paper. If the scene is similar for the continuous several seconds, these segmentations are classified as one group. Take the scene segmentation for Nike in Fig. 1 as an example. According to what the subject described, the interviewer should pick out consistent scenes on the list paper. It helps to ascertain the corresponding segmentation of EEG series for analyzing.

EEG signal pre-processing

Firstly, the EEG data related to commercial video scenes has been extracted and segmented with a length of 1 s. And

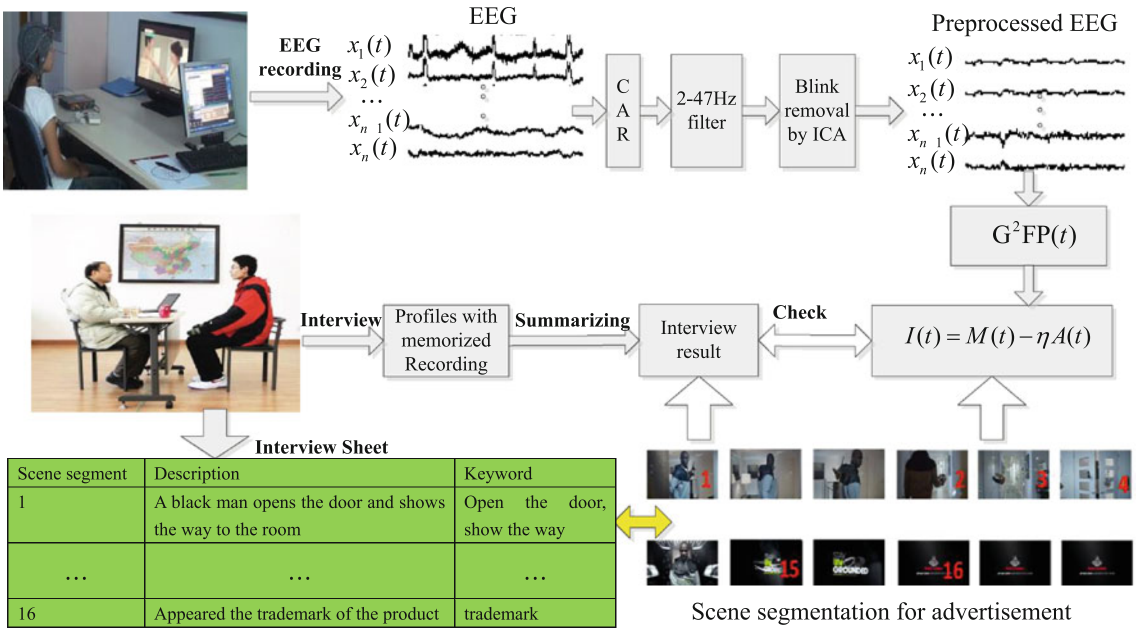

Fig. 1 The flow chart of the proposed method

the EEG data was spatial filtered by common average referencing (CAR). Then, the EEG signal were band pass filtered to 2–47 Hz, and independent component analysis (ICA) was applied to detect and remove eye blinks in signals. Finally, the PSD for each channel can be computed. In this paper, we have 20 subjects and the Individual Alpha Frequency (IAF) (Klimesch 1999) varies from one to another. So it is necessary to precisely calculate IAF for each subject to define the alpha band and theta band.

For the IAF, there are basically two methods to confirm. The first is that find the peak frequency of spectral component within 7.5–12.5 Hz (the traditional alpha frequency range). The second one is a gravity style. When there are multiple peaks in the alpha range, the second appears to be more adequate and easier than the first for IAF estimating.

General global field power (G^2FP) and impression index

Global field power (GFP) in neuromarketing (Vecchiato et al. 2011b) is used to quantify the amount of activity, and it is computed as the mean of all absolute potential differences in the field corresponding to the spatial standard deviation. However, it is not reasonable to compute the evaluating index using the same weight for different electrodes. In this paper, we assign different weights for different electrodes. The weight of each EEG channel was defined as following:

$$w(i) = \frac{\sum_{f=f_1}^{f_2} P_i(f)}{\sum_{i=1}^{N} \sum_{f=f_1}^{f_2} P_i(f)} \quad (1)$$

where N denotes the number of channels and $P_i(f)$ denotes the PSD of the i-th channel at frequency f. There are two weights $w_1(i)$ and $w_2(i)$ to be calculated. $w_1(i)$ is for memorization, so $[f_1, f_2]$ is theta band [(IAF-6,IAF-4)]. And $w_2(i)$ is related to attention, so the corresponding $[f_1, f_2]$ is alpha band [(IAF-4,IAF + 2)].

As mentioned before, the memory processing performance increases in theta band power and attention processing performance decreases in alpha band power. Impression is corresponding to the duration which the subject is in the status of both high attention and good memorization. To calculate the impression index, we should consider both the memorization and attention of subjects together. So the impression index should be the following style:

$$I(t) = M(t) - \eta A(t) \quad (2)$$

where $I(t)$, $M(t)$ and $A(t)$ are impression, memorization and attention index respectively, and η is a regulatory factor.

In this paper, specifically, the impression index is G^2FP. Hence, according to Eq. (2), G^2FP was computed by the following equation:

$$G^2FP(t) = \sum_{i}^{N} w_1(i)(x_i^{\theta}(t))^2 - \eta \sum_{i}^{N} w_2(i)(x_i^{\alpha}(t))^2 \quad (3)$$

$x_i^{\theta}(t)$ denotes the EEG data of channel i at time t and the data has been filtered to theta band. Similarly, $x_i^{\alpha}(t)$ denotes the data which has been filtered to alpha band.

Finally, the impression index will be checked with the result of interview sheets. The outline of the proposed method is shown as in Fig. 1.

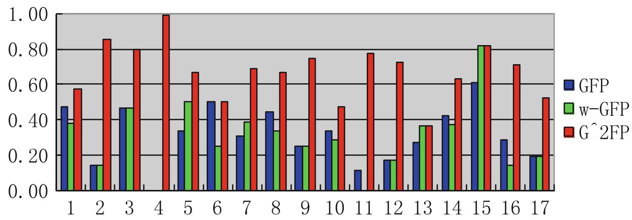

Fig. 2 The result of the match ratio for 17 subjects on 3 different methods

Experiment results

Individual experiment

In order to compare the performance of different methods, we introduce a recall match ratio R to represent the capability for the proposed index. Specifically,

$$R = {}^{Nc_{aa}}/_{Nc_{tr}} \tag{4}$$

where Nc_{aa} is the number of remembered scenes in video commercials whose index value is above the average of evaluating index, and Nc_{tr} is the total number of scenes remembered by the subject.

Totally 20 subjects are involved in the experiment, however, 3 of them didn't remember any plots of advertisements. Hence, we have 17 valid EEG data recordings with subjects exposed to the same video commercials. We vary the regulatory factor η from 0.1 to 2.4. Following the principle of maximizing the recall match ratio and minimizing the standard deviation, we select 2.0 as the value of η for the impression index in our experiments.

Figure 2 shows a histogram of match ratio for 17 valid subjects. From the Fig. 2, it's obvious that the match ratio of GFP and w-GFP is more or less the same, and the G^2FP method is much higher than the other two methods. It demonstrates that G^2FP can reflect impression better than GFP and w-GFP.

Population experiment

In order to obtain a description of the phenomena for the entire population investigated, the G^2FP should be normalized to eliminate the individual differences by the following formula.

$$G^2FP_{norm} = \frac{\sum_i^N w_1(i)(x_i^\theta(t))^2 - \eta \sum_i^N w_2(i)(x_i^\alpha(t))^2}{\sum\limits_t^M \left(\sum\limits_i^N w_1(i)(x_i^\theta(t))^2 - \eta \sum_i^N w_2(i)(x_i^\alpha(t))^2 \right)} \tag{5}$$

where M denotes the number of temporal samples of the waveform $x_i^2(t)$. For the sake of extracting a common feature from the entire population investigated, all segments have been finally averaged in 17 subjects.

In Fig. 3, we show the time-varying changes of the average of normalized G^2FP during 17 subjects observing video commercial of Nike shoes. And the red line in the figure is the average of curve as baseline. Contrast this figure with the subjects' questionnaire sheets, we can basically find two significant conclusions. (1) G^2FP_{norm} waveform can reflect the population impression index during the observation, for scenes with large value of G^2FP_{norm} were remembered by more subjects than scenes with small value of G^2FP_{norm}. According to the interview sheet, we find that scenes around the peak of G^2FP_{norm} are almost renembered by about 10 subjects, while scenes around the trough of G^2FP_{norm} are remembered by no more than 5 subjects, and even some only remembered by one.

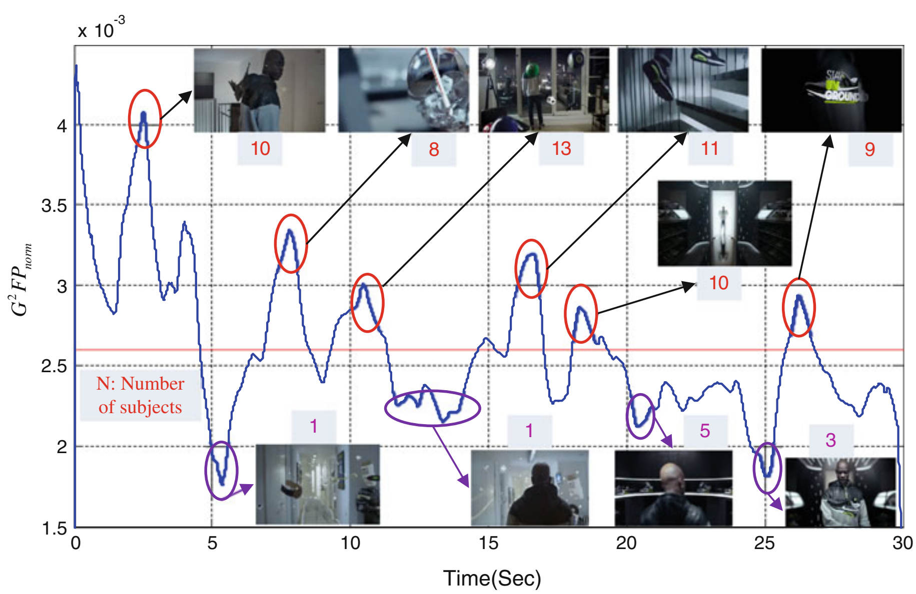

Fig. 3 Representation of the averaged and smoothed normalized impression index (G^2FP_{norm}) for 17 subjects during the observation of the video commercial about Nike shoes

The most impressive segments according to the questionnaire mentioned by 13 subjects happened around 10–11 s in which the man stood in a room where everything around him is floating in the air. (2) Some interesting and peculiar scence can impress the viewers. There are peaks around 8, 10 and 26 s, the corresponding scenes show interesting or magical. The first one shows a glass of water floating in the air. And in the second scence, many billiards are floating in the air. The last one shows the close-up about a man wearing the shoe in black background with sharp contrast.

Conclusion and discussion

In this paper, we proposed a new index called as impression index to evaluate video commercials. The impression index combines both memorization and attention index during the observation of video commercials by tracking the cortical activity. It is different form classical methods to average the GFP of all the channels, the weight of each channel was employed to caculate the time-varying power in theta and alpha band in consideration of the activity of diverse brain areas will be different during certain cognitive task. The results of experiment both from individuals and populations demonstrate the proposed method can reflect the subject's impression and can help to estimate the video commercial scenes to some extend. However, it still remains challenges in EEG-based neuromarkeing. For GFP-based methods have the constraints of rhythms, so it is hard to set a threshold to evaluate the commercials directly. And people should investigate new features to represent impression to overcome the shortage of rhythms for EEG signals. Furthermore, better interview protocol should also be considered to valid the EEG index for commercial evaluation more precisely.

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