Brain-Computer Interfaces, 2015
Vol. 2, No. 4, 193–201, http://dx.doi.org/10.1080/2326263X.2015.1103591

Investigation of engagement of viewers in movie trailers using electroencephalography

Dayoon Kang[a], Jinsoo Kim[a], Dong-Pyo Jang[b], Yang Seok Cho[c] and Sung-Phil Kim[a]*

[a]*Department of Human and Systems Engineering, Ulsan National Institute of Science and Technology, Ulsan, Republic of Korea;* [b]*Department of Biomedical Engineering, Hanyang University, Seoul, Republic of Korea;* [c]*Department of Psychology, Korea University, Seoul, Republic of Korea*

(*Received 13 April 2015; accepted 1 October 2015*)

Brain-computer interfaces (BCIs) have been focused on providing direct communications to the disabled. Recently, BCI researchers have expanded BCI applications to non-medical uses and categorized them as active BCI, reactive BCI, and passive BCI. Neurocinematics, a new application of reactive BCIs, aims to understand viewers' cognitive and affective responses to movies from neural activity, providing more objective information than traditional subjective self-reports. However, studies on analytical indices for neurocinematics have verified their indices by comparisons with self-reports. To overcome this contradictory issue, we proposed using an independent psychophysical index to evaluate a neural engagement index (NEI). We made use of the secondary task reaction time (STRT), which measures participants' engagement in a primary task by their reaction time to a secondary task; here, responding to a tactile stimulus was the secondary task and watching a movie trailer was the primary task. NEI was developed as changes in the difference between frontal beta and alpha activity of EEG. We evaluated movie trailers using NEI, STRT, and self-reports and found a significant correlation between STRT and NEI across trailers but no correlation between any of the self-report results and STRT or NEI. Our results suggest that NEI developed for neurocinematics may conform well with more objective psychophysical assessments but not with subjective self-reports.

Keywords: reactive brain-computer interface; secondary task reaction time; neurocinematics; electroencephalography; neural engagement index

1. Introduction

Brain-computer interfaces (BCIs) aim to establish an artificial system that uses brain activity as a direct input to control external devices through non-muscular channels.[1] This type of BCI, often referred to as active BCIs, focuses on clinical applications by providing a means of voluntary communication functions to the disabled.[2] However, BCI researchers have recently recognized the potential to expand the scope of BCIs to non-medical uses by monitoring user states to build cognitive and affective human-computer interfaces. This broader view of BCIs embraces seven distinct application areas: device control, user-state monitoring, evaluation, training and education, gaming and entertainment, cognitive improvement, and safety and security.[3] According to Zender et al. (2011), many BCI applications for healthy users can be extended and categorized into active BCI, reactive BCI, or passive BCI. Specifically, reactive BCIs infer output from brain activity in response to external stimuli.[4] An example of reactive BCIs can be found in the well-recognized research field neuromarketing, which aims to understand consumer behavior from implicit and unconscious information in consumers' brains.[5,6]

Neurocinematics, which can be viewed as one of the neuromarketing applications, studies how viewers' neural activity and associated cognitive and affective states flow while they are watching a movie. In other words, it investigates how a movie influences neural responses in viewers to develop novel evaluation tools for the effect of the movie on the viewers' cognitive and emotional states.[7,8] Studies reported that more brain regions were coherently activated when individuals watched the same movie.[9] The correlation between viewers' neural activity in response to scenes and the degree to which those scenes were encoded in their memories were also reported.[10] One study developed a neural marker for the commercial success of movies by predicting population preference using electroencephalography (EEG).[11]

Neurocinematics can be applied not only for fully released movies but also for movie trailers. A movie trailer has a clear marketing purpose: to capture viewers' attention and to make them keen to see the movie later.[11] The effectiveness of a movie trailer has been typically evaluated using traditional marketing methods such as surveys. Only recently attempts were made to evaluate movie trailers using the neurocinematics methodology. For instance, a neuromarketing firm,

*Corresponding author. Email: spkim@unist.ac.kr

MindSign (San Diego, USA), demonstrated relevant changes in brain activity measured by neuroimaging techniques such as functional magnetic resonance imaging (fMRI) while viewers watched a movie trailer. A study based on electrical brain activity measured by EEG estimated how much viewers concentrated on a movie trailer while they watched various trailers.[12]

One of the cognitive states neurocinematics studies particularly seek to probe is related to engagement, since the degree to which a medium can engage viewers may be connected to the success of the movie. Hasson et al. showed that it was possible to find the most engaging movie by analyzing inter-subject correlations (ISCs) and that ISCs were affected by the way a film was edited.[7,9] In cases when the brain activity in single viewers was investigated independently, previous studies attempted to find a neural correlate of engagement in a more direct way. Among many reported neural correlates of engagement, the modulation of brain oscillations in specific frequency bands is often implicated in the engagement of viewers. In particular, EEG alpha activity decreased as attentional demands increased and beta activity increased during active cognitive processes.[13]

Neurocinematics aims to address the limitation of subjective self-reported data with low reliability by harnessing brain signals to measure viewers' emotional and cognitive states more objectively based on the assumption that viewers cannot explain their emotional and cognitive state precisely after watching movies. Often, neural indices of emotional and cognitive states such as the neural index of engagement are developed to assess changes in relevant mental states during the watching of a movie. However, to confirm the validity of such neural indices, many studies have compared them with self-report data by examining how close developed neural indices are to self-reports. For instance, a study examined correlations between brain activity while watching TV commercials and subjective interests in them.[14] This is somewhat contradictory as the goal of neurocinematics is to develop independent and objective assessments for the media using neural information to address the problem of subjective self-reports. In other words, neural information is supposed to provide a means of movie assessment distinct from self-report information. For instance, the success of new songs in the market was predictable from neural responses while listening to music, whereas self-reports of song preference failed to predict it.[15]

Therefore, in the present study, we aimed to investigate how to evaluate neural indices for neurocinematics, addressing a problem of a direct comparison of them with subjective self-reports. To this end, we measured another engagement index using a psychophysical method, secondary task reaction time (STRT), in addition to brain activity and self-reports. STRT is commonly used to measure situational awareness or attentional demands.[16,17] STRT assumes that reaction to a secondary task becomes slower as more cognitive resources are used in a primary task.[18] We developed a secondary task by presenting a tactile stimulus unpredictably to viewers while they were watching a movie trailer, which was regarded as the primary task. Then, we measured STRT as well as EEG during the watching of movie trailers and self-reports after watching them. We assumed that trailers with more engagement of viewers would cause a slower STRT as well as increases in the neural index of engagement. Here we developed a neural index of engagement on the basis of spectral power differences in the alpha and beta frequency bands. We also evaluated correlations between three different measures – neural index, STRT and self-report – to investigate how these objective and subjective measures were related to each other.

2. Methods

2.1. Participants and materials

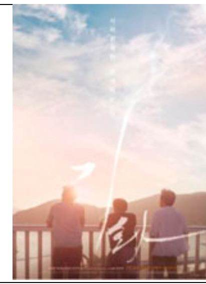
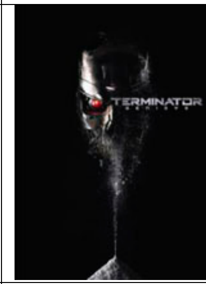
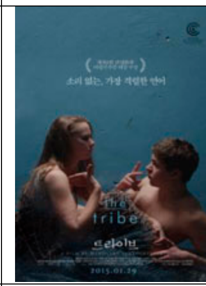
Eleven university students (mean 22.4 ± 0.89 years old; five female) with right-hand dominance participated in the experiment. All participants had no neurological disorder and normal or corrected to normal vision. The institutional review board of Ulsan National Institute of Science and Technology (UNISTIRB-15-04-C) approved the present study and all participants provided informed consent prior to the experiment.

Eight movie trailers that were supposed to be released in Korean theaters after the day of the experiment were used as stimuli (S1: The Salt of the Earth, Brazil, France, and Italy, 2014; S2: Project Almanac, Back to the Beginning, USA, 2014; S3: Gi-Hwa, Korea, 2015; S4: Terminator Genesis, USA, 2015; S5: C'est Si Bon, Korea, 2015; S6: The Avengers: Age of Ultron, USA, 2015; S7: Dog eat Dog, Korea, 2015; and S8: Plemya, The Tribe, Ukraine, 2014; see Table 1). In addition, we used a 90-s-long video clip consisting of white noise only as a control stimulus. Each trailer had a different running time, ranging from 70 to 152 s (mean 107.625 ± 30.142 s). In order to minimize an unexpected effect from the participants' preference for or aversion to a specific genre, stimuli were chosen from five different genres (S1: Documentary; S2, S7 and S8: Thriller, S3 and S5: Melodrama; and S4 and S6: Science Fiction). Trailers were edited as an official version in Korea in which Korean subtitles were provided in the trailer if the movie was made outside Korea. All participants were native Koreans and had no deficit in reading or hearing the Korean language. None of participants watched the whole movie or any trailer before the experiment except two of them who reported that they had watched the trailer S6 before.

Brain-Computer Interfaces 2015.2:193-201.

Brain-Computer Interfaces 2015.2:193-201.

Table 1. The title, official poster, genre, and running time of the eight movie trailers selected in the study.

S1 : The salt of the Earth	S2 : Project Almanac, Back to the beginning	S3 : Gi-Hwa	S4 : Terminator Genisys
			
Documentary, 112 sec	Thriller, 82 sec	Melodrama, 120 sec	Science fiction, 145 sec
S5 : C'est Si Bon	**S6 : The Avengers : Age of Ultron**	**S7 : Dog eat dog**	**S8 : Plemya, The Tribe**
			
Melodrama, 98 sec	Science fiction, 152 sec	Thriller, 82 sec	Thriller, 70 sec

2.2. *Experimental paradigm*

The experiment consisted of nine sessions in each of which the participants were shown one of the eight movie trailers or the control video clip (Figure 1). Before the experiment, participants received an explanation about the experimental procedure and experienced the tactile stimulation for practice. Each session began with a 5-s fixation period where a cross appeared at the center

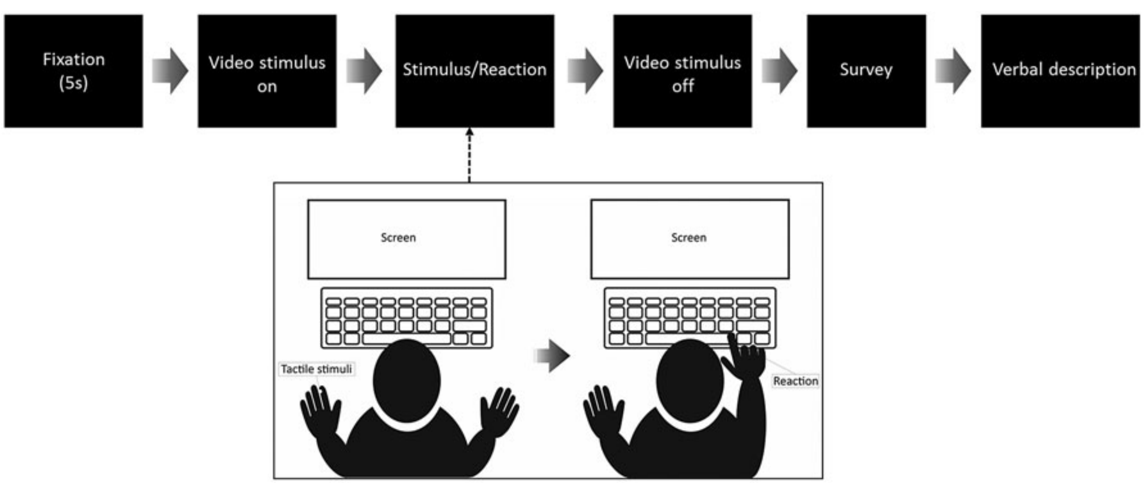


Figure 1. An illustration of the experimental procedure. A black screen appeared for 5 s for fixation. After the fixation period, a movie trailer stimulus was presented. The duration of the stimulus presentation varied over trailers (see the text). During the stimulus presentation, a tactile stimulus was given to the left index finger of participants. Participants pressed a keyboard button as soon as possible when they perceived this tactile stimulus. The stimulus presentation ended at the end of the trailer regardless of participants' responses. After each stimulus presentation, participants were asked to express their subjective responses to each trailer following a questionnaire.

of the screen to let the participants fixate their eyes on it. After the fixation period, a movie trailer or control clip was presented. In the middle of the video presentation, a tactile stimulus was given to the left index fingertip of the participants to measure STRT.[16,18] The participants were asked to respond as soon as possible when they perceived the stimulation by tapping the space bar on the keyboard with their right hand. The reaction time for every session was measured as the difference between the time of keyboard pressing and the time of tactile stimulus onset. The time to present the tactile stimulus was randomly set for each participant within a range from 15 to 60 s after the onset of the video to provide sufficient time for participants to follow the trailer. This relatively large range of the tactile stimulation onset was designed to prevent participants from estimating anticipatory tactile stimulation while watching a trailer. The average tactile stimulation time was 32 ± 15 s after the onset of the video. The stimulus presentation time was pre-determined for each trailer at a point at which an independent group of viewers had reported the most absorbing scene in the trailer; it was 31, 18, 20, 48, 32, 60, 15 and 31 s after the onset of video for S1, S2, S3, S4, S5, S6, S7 and S8, respectively. There was no correlation between the stimulus presentation time and any evaluation result reported in this study. The stimulus was presented at 30 s after video onset for the control clip. Every participant received the tactile stimulus at the identical moment for the same video clip. The video clip was continuously played to the end of the trailer regardless of the tactile stimulation.

At the end of each session, we asked participants to report (1) how fun the trailer was, (2) how absorbing the trailer was, and (3) how eagerly they anticipated seeing the film after having watched the trailer, except for the control video clip. The Likert 11-point scale (1–11) was used to assess the degree of fun, attentiveness, and anticipation. After all the sessions ended, participants were asked to rank the trailers in order of preference. In order to maintain the participants' attention to the video clip, participants were asked to verbally describe the trailer they had watched at the end of every session.

2.3. Experimental apparatus

During the experiment, the EEG signal of every participant was recorded using a wireless EEG headset equipped with 21 dry sensors (DSI-20, Wearable Sensing, San Diego, USA). Twenty EEG electrodes were positioned in accordance with the international 10/20 system locations: Fp1, Fp2, Fz, F3, F4, F7, F8, Cz, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2, A1, and A2. The electrodes at the locations A1 and A2 (left and right earlobes) were used as the reference electrodes. An additional common-mode follower sensor was located at Pz, used as the ground electrode. The analog EEG signals were digitized at a 300-Hz sampling rate. The movie trailers were presented on a 27-inch monitor (QH270-IPSM, Achieva Korea, Incheon, Korea) with a speaker (BOS-BS100, BonoBos, Seoul, Korea). The entire experiment was conducted in the shielding room. The tactile stimulus was a weak 50-Hz vibrotactile stimulus that lasted 0.5 s. It was generated by a vibrotactile transducer (TL002–14-A, TactileLabs, Montreal, Canada).

2.4. Data analysis

Independent component analysis (ICA) was applied to raw EEG signals to remove putative sources of artifacts such as eye blinks.[19,20] Then, the reconstructed EEG signals were band-pass filtered with a frequency range between 0.1 and 50 Hz. The filtered EEG data were split into non-overlapping 1-s segments and windowed (using the hamming window). The spectral power of each windowed data sample was calculated using short-time Fourier transform (STFT) with respect to two non-overlapping frequency bands that covered parts of the frequency bands of alpha and beta oscillations: 7–10 Hz (alpha) and 12–14 Hz (beta).

As previous studies have shown that EEG alpha activity decreases as attentional demands increases and beta activity increases as emotional and cognitive processes are invigorated,[14–16] we determined a neural correlate of engagement (NCE) using alpha and beta activities from EEG as follows:

$$\begin{aligned}&\text{Neural Correlate of Engagement (NCE)}\\&\quad = (\beta - \alpha)/(\beta + \alpha)\end{aligned} \tag{1}$$

where β represents the spectral power within the beta band and α represents that within the alpha band. We measured the NCE at frontal cortical areas, Fp1 and Fp2, according to the previous reports on dominant frontal cortical responses to movie trailers.[12] Then, we defined a neural engagement index (NEI) as a temporal change of the NCE from the initial 3-s period after movie trailer presentation to the last 3-s period right before tactile stimulation, in order to evaluate how much a movie trailer modulated engagement-related neural activity. It was calculated simply by subtracting the NCE in the initial period from the NCE in the last period. Hence, positive values in the NEI indicated increases in the NCE during movie trailer presentation while negative NEI values indicated decreases in the NCE.

The self-report data for each participant were normalized by subtracting the mean and dividing by the standard deviation in order to eliminate potential differences between each participant's subjective rating scales. We quantitatively assessed the self-report data in terms of three categories: fun, attentiveness, and anticipation. The trailer ranking data based on preference in each

Brain-Computer Interfaces 2015.2:193-201.

participant were converted into integer values between 1 and 8 such that the preference for the first-ranked trailer was evaluated as 8, the last as 1.

A statistical analysis of differences in reaction time among stimuli was performed using a repeated-measures ANOVA with the stimulus type as a factor. Pairwise multiple comparisons of reaction time following the ANOVA were performed with Bonferroni correction. The same repeated-measures ANOVA analysis was applied to find differences in the NEI, fun, attentiveness, anticipation, and preference data.

We also evaluated correlations between the different NEI, STRT, and self-report data. Linear (Pearson) correlation coefficients were calculated between all possible pairs of six measures (thus, a total of 15 pairs). The statistical significance of each correlation coefficient was assessed by the F-test ($p < .05$). Note that the data from the control stimulus were only included for the correlation coefficient between the reaction time and NEI since no data were acquired on the control stimulus for the self-report and preference ranking.

3. Results

The repeated-measures ANOVA analysis showed that STRT as well as the self-reports of fun and anticipation were different across the movie trailers ($p < .05$) but no difference was observed in NEI and attention. The average reaction time for the control video clip was 1.01 ± 0.16 s whereas the movie trailers yielded times from 1.22 ± 0.21 (shortest, S3) to 1.29 ± 0.15 (longest, S8) seconds. The post hoc multiple comparison analysis showed that the reaction times for the trailers, except S1 and S3, were longer than that for the control clip (Bonferroni correction, $p < .05$). Figure 2 also describes the relationship between the reaction time and other self-report data such as the rank and the anticipation score. The anticipation score tended to increase as the rank increased (correlation coefficient, $r = .76$; see Table 2). Notwithstanding the anticipation score, the reaction time did not show a correlation with the rank or the anticipation score. In fact, as highlighted in Figure 3, the reaction time was not significantly correlated with any of the self-report data (i.e. anticipation, fun, attentiveness, and rank scores). Since other self-report data were highly correlated with the anticipation score, we have only depicted the anticipation score along with the reaction time in Figure 2 as a representative self-report result.

The correlation analysis result is illustrated in Figure 3 between the 15 pairs of all six variables: NEI, STRT, rank, fun, attention, and anticipation. The correlations among the self-report data including the rank, fun, attentiveness, and anticipation scores were fairly strong ($0.70 < r < .95$, $p < .05$). However, none of these self-report scores showed a significant correlation with STRT ($0.05 < r < .50$, $p > .05$). The weakest correlation was found between STRT and the rank ($r = -.002$, $p > .05$). In contrast, STRT exhibited a relatively significant correlation with the NEI ($r = .72$, $p = .047$). No significant correlation between the NEI and any self-report data was observed ($0.30 < r < .61$, $p > .05$). The correlation analysis result is summarized in Table 2.

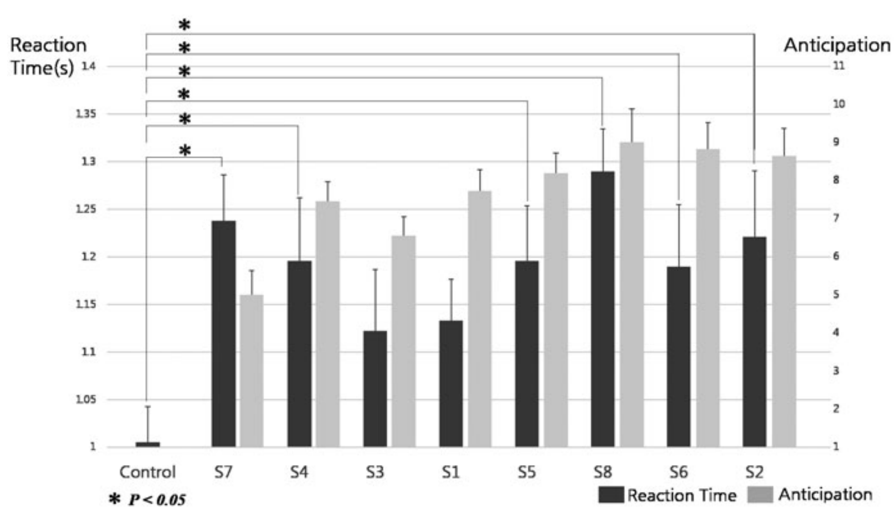


Figure 2. The average of the reaction time and the self-reported anticipation score (i.e. how eagerly participants anticipated seeing the original movie after having watched its movie trailer). Note that the movie trailers (S1–S8) were arranged horizontally in ascending order of the preference ranking resulting from the survey; S7 was least preferred and S2 most preferred. The control movie clip was a simple white noise display. The dark bars and the vertical lines represent the average and standard error of the reaction time for each trailer. The light bars represent the average of the anticipation score. The left vertical axis shows the reaction time while the right one shows the anticipation score.

Brain-Computer Interfaces 2015.2:193-201.

Table 2. Summary of correlation coefficients and p-values of neural engagement, reaction times, and self-reported data. Significant correlations are marked as underlined ($p < .05$).

	Neural engagement	Reaction time	RANK	FUN	ATTENTION	ANTICIPATION
r						
Neural engagement	1.000					
Reaction time	<u>.714</u>	1.000				
RANK	.369	−.002	1.000			
FUN	.605	.426	.441	1.000		
ATTENTION	.595	.470	.534	<u>.822</u>	1.000	
ANTICIPATION	.528	.240	<u>.764</u>	<u>.839</u>	<u>.744</u>	1.000
p						
Neural engagement	1.000					
Reaction time	<u>.047</u>	1.000				
RANK	.369	.996	1.000			
FUN	.112	.293	.274	1.000		
ATTENTION	.120	.240	.173	<u>.012</u>	1.000	
ANTICIPATION	.179	.567	<u>.027</u>	<u>.009</u>	<u>.034</u>	1.000

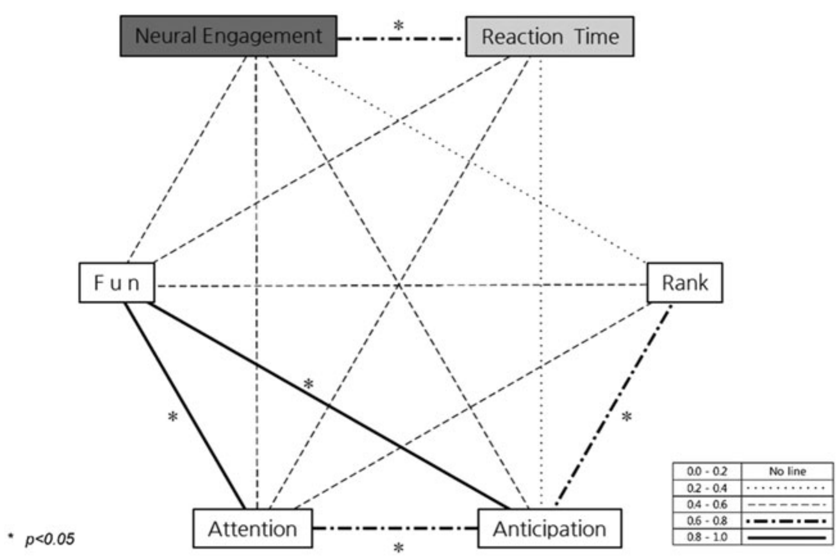


Figure 3. A diagram representing correlations between neural (dark gray box), psychophysical (light gray box), and self-reported data (white box): i.e. the neural engagement index, reaction time, ranks, fun, attentiveness, and anticipation scores. Different line types denote the strengths of the correlation (refer to the table insert). The statistical significance of each correlation is marked by asterisks ($p < .05$).

The results of the NEI for each trailer and its relationship with STRT are shown in Figure 4. Note that the NEI represented the changes in the neural correlate of engagement (i.e. the difference between the beta and alpha band power) from the beginning of the trailer to the middle of the trailer just before the tactile stimulus was given (see Methods for more details). The movie trailers producing longer STRT also increased the NEI. A significant correlation was found between the NEI and STRT ($r = .85$, $p < .05$). Even when we excluded the data from the control clip, the correlation remained significant ($r = .714$, $p < .05$). In particular, the NEI for the control clip as well as the trailer with the shortest reaction time (S3) were negative, indicating that the participants' engagement level might even decrease over time while watching S3 or the control clip.

4. Discussion

We measured viewer's responses to eight movie trailers using three different methods, secondary task reaction time (STRT), neural engagement index (NEI), and

Brain-Computer Interfaces 2015.2:193-201.

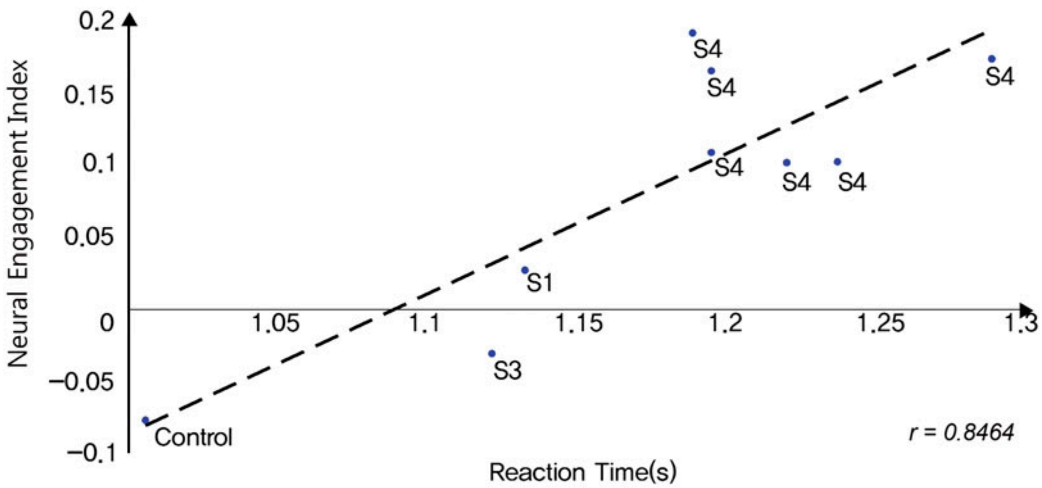


Figure 4. A linear relationship between reaction time and neural engagement. The x-axis denotes reaction time and the y-axis denotes the neural engagement index. The circles indicate the eight movie trailers plus the control video clip.

self-report, in the present study. From the correlation analysis between the evaluation results by the three methods we found that the NEI results were significantly correlated with the STRT results but showed no correlation with the self-report results. The STRT results were also not correlated with the self-report results. Our results suggest the need for alternative measurements instead of self-reports in order to validate the neural index developed for neurocinematics studies. The lack of correlation between self-report (specifically for attentiveness) and either STRT or NEI demonstrates a potential limitation of viewers' subjective statements to report their cognitive responses to movie trailers. On the other hand, NEI based on a reactive BCI with a higher correlation with STRT implies that NEI may be able to reflect viewers' unconscious cognitive states of engagement in movie trailers.

In this study, we observed that STRT to tactile stimuli during the watching of a control video clip was significantly less in comparison with those during the watching of movie trailers. Such a short STRT while watching the control clip shows that the content of video clips might affect attentional resource allocation in the brain.[16,21] Thus, different STRT values with individual movie trailers can be used as an indirect means of assessment of how much a movie trailer engages viewers' attention. That is, a longer STRT may indicate a higher engagement level while watching a trailer. Interestingly, self-reported data were not correlated with STRT. This discordance between the subjective ratings and STRT may indicate that self-reported data might not be suitable to reflect more autonomous and unconscious immersion of viewers in trailers.[11] Unlike the self-reported data, the NEI significantly correlated with STRT, demonstrating conformity between two objective measures of the viewer's engagement in trailers. These results also seemingly demonstrate a possible discrepancy between conscious and non-conscious responses in viewers while watching movie trailers, which is a primary issue that neurocinematics aims to address.[5,11]

Previous studies used subjective self-reported data to validate neural indices of cognitive states.[10,14,15] However, it is a paradox that neural indices are verified with self-reported data since the original purpose of developing neural indices is to overcome the limitation of subjective self-reported data and find a more objective measurement. For these reasons, we adopted a psychophysical measure, STRT, which could measure viewers' engagement in a more objective way, and evaluated the NEI using this psychophysical measure. Our results indicate that the NEI developed in this study may reflect viewers' engagement in movie trailers more objectively than traditional self-reports, validated by other behavioral data. However, there is a possibility that STRT and neural responses produced incorrect results and self-reports in fact provided true responses from participants. Our results rather point out that assessments in neurocinematics or more broadly in neuromarketing may be applied differently depending on which information one wants to extract; neural data may better represent more autonomous and non-conscious responses of viewers such as immersion or engagement in a movie while self-reports may better represent more rational and conscious responses of viewers such as interests or anticipation.

Our results demonstrate that the NEI may help us measure objectively viewers' engagement in a movie trailer. A previous study also identified the possibility of predicting the commercial success of the movie from the EEG data recorded during the watching of a movie trailer.[11] In contrast to this report, our study did not address the prediction of the commercial success of a movie from neural responses to its trailer. We rather focused on finding a specific index regarding viewers' engagement in the pursuit of developing a solid evaluation measure for neurocinematics.

There are potential issues to address to complement the current study. Firstly, we conducted surveys on the four categories fun, attentiveness, anticipation, and rank. On the other hand, neural data measured only engagement, which is largely related to the attentiveness survey results. We measured only engagement using EEG since STRT cannot measure the magnitude of fun or anticipation. However, it will be possible to assess other viewer responses such as fun from the neural data if we measure other implicit behavior such as facial expression or eye blinks. Secondly, we used only two EEG channels to develop the NEI. But it is possible that there exist different channels and frequency bands that can represent engagement better for each participant. We will pursue such an individual neural engagement index in a future study. Thirdly, only 11 people participated in this experiment, so the generalizability of the NEI can be questioned. However, as Parra et al. reported that the assessment of TV drama in laboratory settings was successfully applied to population assessment,[22] we envision that the experimental results of the NEI in our study may have the potential to be applied to population-level evaluation. Additionally, previous studies similar to ours have also collected data from a similar number of subjects.[8,9,12,23] Also the main purpose of this study was to prove the utility and feasibility of using STRT as well as the neural engagement index to evaluate movie trailers. Finally, our tactile perception method to measure STRT interrupted the watching of a movie in the middle even though it measures viewers' implicit statements. We will continue to seek better secondary tasks to reliably assess viewers' engagement.

One may utilize our index in addition to other neural and behavioral responses to evaluate the overall effectiveness of a movie trailer. Or, one can apply our index in editing movie trailers. For a given trailer in the editing phase, we can vary the time of a secondary task and use STRT and NEI to identify which scenes of the trailer engage the viewers the most. We will continue the investigation of this application of neurocinematics techniques in the follow-up studies. We will also extend the NEI to assess viewers' engagement during a whole movie or TV commercials.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the IT R&D Program of Ministry of Science, ICT and Future Planning/Korea Evaluation Institute of Industrial Technology, "Development of cultural evaluation technology based on real-time bio signals in human populations"[10045461].

ORCID

Dayoon Kang http://orcid.org/0000-0003-2287-1256

References

[1] Wolpaw JR, Birbaumer N, McFarland DJ, et al. Brain–computer interfaces for communication and control. Clin. Neurophysiol. 2002;113(6):767–791.
[2] George, L, Lécuyer, A. An overview of research on" passive" brain-computer interfaces for implicit human-computer interaction. In International Conference on Applied Bionics and Biomechanics ICABB 2010-Workshop W1" Brain-Computer Interfacing and Virtual Reality". 2010
[3] van Erp JB, Lotte F, Tangermann M. Brain-computer interfaces: beyond medical applications. Computer. 2012;45 (3):26–34.
[4] Zander TO, Kothe C. Towards passive brain–computer interfaces: applying brain–computer interface technology to human–machine systems in general. J. Neural Eng. 2011;8(2):025005.
[5] Ariely D, Berns GS. Neuromarketing: the hope and hype of neuroimaging in business. Nat. Rev. Neurosci. 2010;11 (4):284–292.
[6] Morin C. Neuromarketing: the new science of consumer behavior. Society. 2011;48(2):131–135.
[7] Hasson U, Landesman O, Knappmeyer B, et al. Neurocinematics: the neuroscience of film. Projections. 2008;2 (1):1–26.
[8] Kwon M, Lee M. Emotion understanding in movie clips based on EEG signal analysis. In Neural Information Processing. Springer Berlin Heidelberg, 2012, January. 236–243.
[9] Hasson U, Nir Y, Levy I, et al. Intersubject synchronization of cortical activity during natural vision. Neuron. 2004;303(5664):1634–1640.
[10] Hasson U, Furman O, Clark D, et al. enhanced intersubject correlations during movie viewing correlate with successful episodic encoding. Neuron. 2008;57(3): 452–462.
[11] Boksem MA, Smidts A. Brain responses to movie-trailers predict individual preferences for movies and their populations-wide commercial success. Journal of Marketing Research. 2015;52(4):482–492.
[12] Wang PS, Huang SR, Tsai CW, et al. Attention drawing of movie trailers revealed by electroencephography using sample entropy. J. Biosci Medicines. 2014;2(4):6.
[13] Ray WJ, Cole HW. EEG alpha activity reflects attentional demands, and beta activity reflects emotional and cognitive processes. Science. 1985;228(4700):750–752.
[14] Smith ME, Gevins A. Attention and brain activity while watching television: components of viewer engagement. Media. Psychol. 2004;6(3):285–305.
[15] Koelsch S. Brain correlates of music-evoked emotions. Nat. Rev. Neurosci. 2014;15(3):170–180.

Brain-Computer Interfaces 2015.2:193-201.

[16] Baumann, MR, Rösler, D, Krems, JF. Situation awareness and secondary task performance while driving. In Proceeding of the 7th International Conference on Engineering Psychology and Cognitive Ergonomics, 2007;4562:256–263.

[17] Cepeda-Benito A, Tiffany ST. The use of a dual-task procedure for the assessment of cognitive effort associated with cigarette craving. Psychopharmacology. 1996;127 (1–2):155–163.

[18] Wróbel A. Beta activity: a carrier for visual attention. Acta Neurobiol Exp. 2000;60(2):247–260.

[19] Delorme A, Makeig S. EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. J. Neurosci. Methods. 2004;134(1):9–21.

[20] Hyvärinen A, Oja E. Independent component analysis: algorithms and applications. Neural Net. 2000;13 (4–5):411–430.

[21] Wickens CD. Processing resources in attention, dual task performance, and workload assessment (No. EPL-81-3/ ONR-81-3). ILLINOIS UNIV AT URBANA ENGINEERING-PSYCHOLOGY RESEARCH LAB Urbana – Champaign;1981.

[22] Dmochowski JP, Bezdek MA, Abelson BP, et al. Audience preferences are predicted by temporal reliability of neural processing. Nat. commun. 2014,5. doi:10.1038/ncomms5567

[23] Yanagisawa K, Iida T, Amasaka K. Constructing a model for creating movie trailers increase customers' desire. Res. Appl. Econ., 2014;6(1):73–85.

Brain-Computer Interfaces 2015.2:193-201.