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journal or publication title	International Journal of Computer Science and Network Security
volume	12
number	9
page range	55-58
year	2012-09-01
URL	http://hdl.handle.net/2297/35198

Using the N1 Potential for the Analysis of the 2D Optical Illusion Stimulus

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Summary
Recently, the brain science has become one of most attractive and important fields in modern science and technology. Several centuries ago the overarching obstacle in the evolution of vision, especially the visual illusion was documented when George Berkeley pointed out that information in retinal images cannot be mapped unambiguously back onto their real-world sources. In this paper, we construct an experiment that uses the abutting line grating illusion contour stimulus with different number of lines, so that some perceive illusion contours and some do not. Event-related potentials (ERP) involving N1 and power spectra are measured and compared to examine the difference of them when visual illusion stimuli and control stimuli are applied.

Key words:
visual illusion, optical, ERP,N1

1. Introduction

Electroencephalography (EEG) is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain.[1] In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp. In neurology, the main diagnostic application of EEG is in the case of epilepsy, as epileptic activity can create clear abnormalities on a standard EEG study.[2] http://en.wikipedia.org/wiki/Electroencephalography- cite_note-2 A secondary clinical use of EEG is in the diagnosis of coma, encephalopathies, and brain death. EEG used to be a first-line method for the diagnosis of tumors, stroke and other focal brain disorders, but this use has decreased with the advent of anatomical imaging techniques with high (<1 mm) spatial resolution such as MRI and CT. Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis, especially when millisecond-range temporal resolution (not possible with CT or MRI) is required.

Before presenting the experimental details of the work, we first introduce some basic concepts of EEG and visual illusions. Electroencephalography (EEG) is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain [3]. The EEG has been used for many purposes besides the conventional uses of clinical diagnosis and conventional cognitive neuroscience. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20-40 minutes, as recorded from multiple electrodes placed on the scalp. In neurology, the main diagnostic application of EEG is in the case of epilepsy, as epileptic activity can create clear abnormalities on a standard EEG study [4]. A secondary clinical use of EEG is in the diagnosis of coma, encephalopathies, and brain death. EEG used to be a first-line method for the diagnosis of tumors, stroke and other focal brain disorders, but this use has decreased with the advent of anatomical imaging techniques with high (<1 mm) spatial resolution such as MRI and CT. But, electroencephalography (EEG) is still a very important tool for research and diagnosis of brainwaves because it gives millisecond range temporal resolution, and it is impossible for CT or MRI. Therefore, long-term EEG recordings in epilepsy patients are used for seizure prediction. Neuro-feedback remains an important extension, and in its most advanced form is also attempted as the basis of brain computer interfaces. The EEG is also used quite extensively in the field of neuro-marketing. There are many commercial products substantially based on the EEG. Within the brainwave research community, EEG has many characteristics when compared with the functional magnetic resonance imaging tools, such as its significantly lower hardware costs, the relatively tolerant of subject movement, and the higher temporal resolution, etc.

Illusion generally means a percept that fails to agree with the real world measurements made with devices such as photometers, spectrophotometers, rulers, protractors, and so on. Most modern investigators have sought to explain vision, and by the same token visual illusions, in terms of the response properties of neurons in the primary and higher order visual cortices [5]. The general idea is that the responses of neurons encode the biologically useful features of light stimuli that fall on the retina, and ultimately generate percepts that correspond to the physical properties of objects in the real world. In this conception, illusions arise because neurobiological constraints do not always allow this goal to be met [6]. Many aspects of the neuronal responses to visual stimuli

Manuscript received September 5, 2012
Manuscript revised September 20, 2012

are attuned to aspects of natural images that occur with high regularity, and are thus most likely to be useful guides to behavior. Consistent with this idea, some neuronal cell receptive fields in the primary visual cortex (V1) look very much like the filters used to produce the relevant basis functions of images, and the organization of these fields can be predicted from images of natural scenes [7, 8].

In the past, illusions were sometimes considered to be inappropriate objects of study. The nineteenth-century psychologist Oswald Kulpe expressed the intellectual climate of the era when he wrote that perceptual illusions are "subjective perversions of the contents of objective perception" [9]. This is why Exner's experiments on apparent motion[10] in 1875 did not receive a great deal of attention, until Max Wertheimer, defining the Gestalt movement almost 40 years later, re-examined apparent motion in a climate in which the study of illusions had changed[11 ,12].

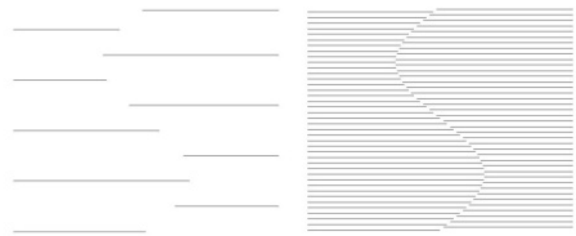
2. Materials and Methods

2.1 Visual stimuli

The visual stimuli were created using Visual C++ and were presented to binocularly to the volunteers. It is a typical line-inducing illusion contours called the abutting line grating illusion contour. The reason why we selected the abutting line grating illusion contour as our visual stimuli is that we can create illusion contours stimuli or control stimuli by just changing the number of the lines. These experimental visual stimuli were composed of two types with different number of dark lines against white background, as shown in Fig. 1. The stimuli of Fig. 1(a) and (b) did not produce illusion contours.

2.2 Experiment Setup

Ten right-handed health volunteers (including five females,mean age 22 years, range 19-25 years, no elderly people,no bad habits such as smoking [20]) with normal or corrected-to-normal vision, who have not participated in the similar experiences before, are employed to implement the experiment. The volunteers put heads on the front of the stereoscope. we used Fig.1 as the stimuli. A portion of misplaced lines can be clearly identified as forming a S in the middle, even when there is no outline of S. In the laboratory, the room is completely closed without noise and turn off the monitor, no light. The display is put on the front, where the distance 50cm of the subjects, and 2 kinds of stimuli appeared alternately. Each stimulus to prompt advance stimulus one second, then signal to stimulate the time 300ms, and then rest 1.2s (Fig. 2).



A B

Fig.1. The Stimulus plans. Fig.1a can only see two groups of parallel lines. Fig.1b, not only can see the parallel lines, also can clearly see the S.

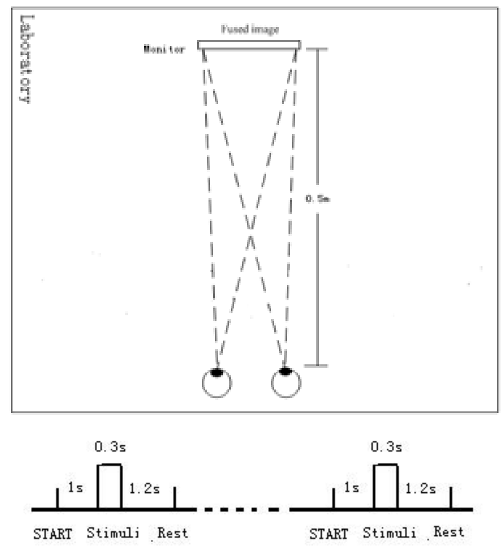


Fig. 2 The model of stereoscope and experimental flow chart

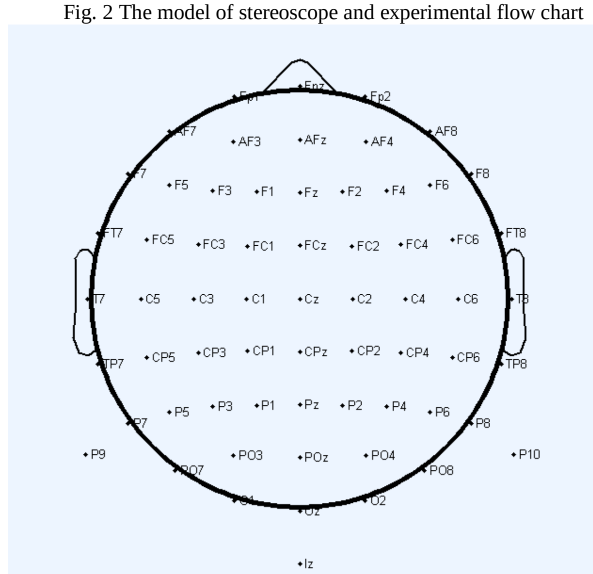


Fig. 3. the location of the electrodes

In this study, the Active Two System produced by BioSemi Inc. with 64 channels (Figure 3) is used to get the signals of the brain activity. The original data is analyzed by the EEGlab which is the toolbox for processing continuous and event-related EEG, MEG and other electrophysiological data using independent component analysis (ICA), time/frequency analysis, artifice rejection, and several modes of data visualization. For filtering the other brain wave which we unused, we insert many events randomly in every trial data and average. To analyze of the data, the first 300 ms after the presentation of each sensed 3D image is further investigated. The results of EEG will show the changes of the whole brain. For further discussion, the electrodes of the occipittemporal cortex involving Pz, and POz [21,22] will be extracted individually (Fig. 3).

3. Results and Discussion

To understand the mechanism of visual illusions of the human brain reflected, we focus on the first occurrence of a negative wave which is called N1.The Visual N1 is a visual evoked potential, a type of event-related electrical potential (ERP), that is produced in the brain and recorded on the scalp. The N1 is so named to reflect the polarity and typical timing of the component. The "N" indicates that the polarity of the component is negative with respect to an average mastoid reference. The "1" originally indicated that it was the first negative-going component, but it now better indexes the typical peak of this component, which is around 150 to 200 milliseconds post-stimulus.However, in our study, we found that, N1 appears in the 30-80ms. The N1 deflection may be detected at most recording sites, including the occipital, parietal, central, and frontal electrode sites.[13] Although, the visual N1 is widely distributed over the entire scalp, it peaks earlier over frontal than posterior regions of the scalp, suggestive of distinct neural and/or cognitive correlates.[14] The N1 is elicited by visual stimuli, and is part of the visual evoked potential – a series of voltage deflections observed in response to visual onsets, offsets, and changes. Both the right and left hemispheres generate an N1, but the laterality of the N1 depends on whether a stimulus is presented centrally, laterally, or bilaterally. When a stimulus is presented centrally, the N1 is bilateral. When presented laterally, the N1 is larger, earlier, and contralateral to the visual field of the stimulus. When two visual stimuli are presented, one in each visual field, the N1 is bilateral. In the latter case, the N1's asymmetrical skewedness is modulated by attention.[15] Additionally, its amplitude is influenced by selective attention, and thus it has been used to study a variety of attentional processes.[16]

Power spectra are showed from figure 4, Each colored trace represents the spectrum of the activity of one data channel. The leftmost scalp map shows the scalp distribution of power at 6 Hz, which in these data is concentrated on the frontal midline. The other scalp maps indicate the distribution of power at 10 Hz and 22 Hz. According to the ERP images, the energy o f the brain become higher at V1 area when the people watching picture different with the beginning of the stimuli happened [17]. These are the complete visual response.

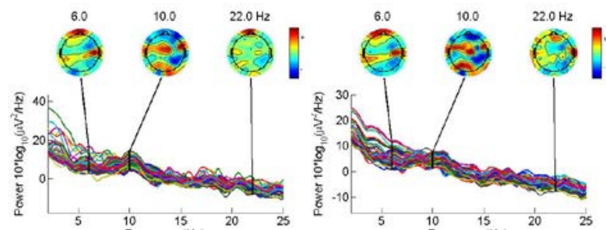


Figure 4 The power spectra of stimuli A and stimuli B

To give light on this problem, the VEP of occipital region (P7, P3, Pz, P4, P8, PO4, PO3, O1, Oz, O2, AFz, F5, F6. F7, FC1, FC2, FT8, C5, C6, TP7, CPZ, TP8) are averaged by EEGlab as shown in figure 5 and figure 6. If the lines are more intense, the tester will be able to see the junction does not exist an S shape. However, if the line is sparse, S will not be seen. From the picture we can find, the first maximum negative energy appeared at about 40ms.This suggests that the brain is beginning to greet changes at 20 ms after the stimulus happened. The human being's visual illusion responses can be considered that the C1 appeared at 110 ms. In the experimental of stimulate A ,the N1 is less obvious, but in the experiment of stimulate B time, in the 30-100ms can clearly observed the N1 wave.

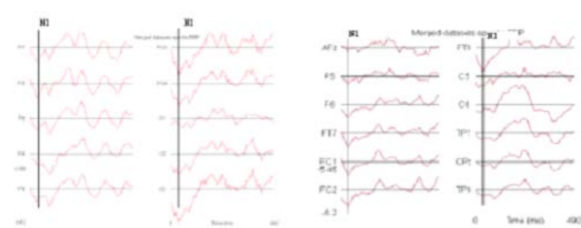


Figure 5 The visual evoked potentials (VEP) of P7,P3,Pz,P4,P8,PO4,PO3, O1,Oz,O2, AFz, F5,F6. F7, FC1, FC2, FT8, C5 ,C6 ,TP7,CPZ,TP8 during the visual illusion of picture A.

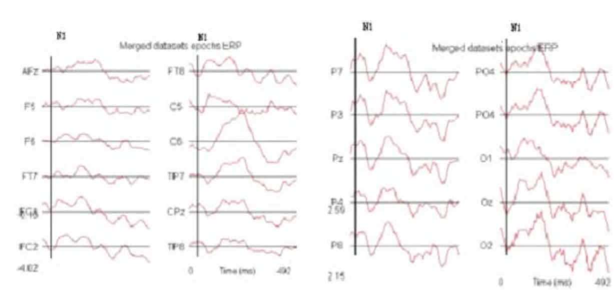


Figure 6 The visual evoked potentials (VEP) of P7,P3,Pz,P4,P8,PO4,PO3, O1,Oz,O2, AFz, F5,F6. F7, FC1, FC2, FT8, C5 ,C6 ,TP7,CPZ,TP8 during the visual illusion of picture B.

4. Conclusions

The purpose of this work was to find out the locations and mechanisms of brainwave when the human beings watch the 2D images of the optical illusion stimulus. we have constructed a new experimental method that used the artificially-created visual stimuli of illusion contours or non-illusion contours, and measured the difference in EEG signals between the stimuli so that we can understand why illusion contours appeared and how such “wrong” computations were performed in human brain.

The results showed that the responds of the optical illusion have different response time and voltage with the different coarseness at the visual area (V1). Comparing the obtained results, we found that the powers of the primary visual cortex (V1) are different. Indicating that the illusion experiment and the Identification experiment have similarities, because we found a negative peak in about 250ms which called Recognition potential (RP). But this requires more experiments to prove. In these experiments, we prove to the existence of the N1. And begin from 30ms to 100ms.With the peak around 40-60ms.

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