Analysis Of Effect Of Stimulation On Trasient VEP Using Spectral Components

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Citation

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Abstract

Transient Visual Evoked Potential (TVEP) has been used as one of the valuable diagnostic tool in the clinical environment. Various types of analysis have been performed on TVEP recordings for identifying diagnostically significant information. Conventional methods of detection of visual anomalies, based on TVEPs require long periods of testing and averaging. Hence, the problem of patient fatigue affects the accuracy of the results. A spectral component based method is proposed to identify the effect of rate of stimulation on the spectral components and change in P100 latency value for normal subject TVEP. The spectral components are identified using Welch's averaged periodogram and latencies are identified using the averaging method. Using the method proposed here one could identify the latency with lesser period of testing irrespective of the rate of stimulation.

INTRODUCTION

TVEP is an important diagnostic test for specific ophthalmological and neurological disorders (Misra et al 1999, AbdelMageed 2002, Lauritzen et al 2004, Momose et al 2004, Suttle and Turner 2004). The clinical use of TVEP is mainly based on the peak amplitude and latency of P100 (Nogawa et al 1991, Xu et al 1992). In general, the stimulation rate used for the recording is 1Hz. But it requires minimum of 50-60 trials for calculating P100 value. Usually, it takes minimum of 30 minutes for completing the entire procedure and the fatigue condition affects the procedure. Higher rate of stimulation is preferred to reduce the procedure time and also to reduce fatigue levels in patients. But at higher rate of stimulation, identification of P100 peaks becomes very difficult and there is also an increase in the latency compared to that of the latency obtained using the 1Hz stimulation rate. All the previous studies confirmed that the as the rate of stimulation increases there will be a change in the latency (Misra et al 1999, Heravian et al 1999) and none of the studies have shown the correlation between the rate of stimulation and the change in TVEP P100 latency.

In this paper, a spectral component based method has been proposed to identify the effect of rate of stimulation on the spectral components and change in P100 latency value for normal subjects TVEP.

MATERIALS AND METHOD

SUBJECTS

Experiments were carried with subjects in the Neurology Department of a leading Medical Institute from 2003 to 2004. Experiments were carried out with 300 normal subjects (19 – 62 years old, 125 females and 175 males). Patients have been chosen in such a way that all subjects have the latency value exactly 100 msec.

TVEP RECORDING

TVEP was performed in a specially equipped electro diagnostic procedure room (darkened, sound attenuated room). Initially, the patient was made to sit comfortably approximately one meter away from the pattern-shift screen. Subjects were placed in front of a black and white checkerboard pattern displayed on a video monitor. The checks alternate black/white to white/black at a rate of approximately twice per second. Every time the pattern alternates, the patient's visual system generates an electrical response that was detected and was recorded by surface electrodes, which were placed on the scalp overlaying the occipital and parietal regions with reference electrodes in the ear. The patient was asked to focus his gaze onto the center of the screen. Each eye was tested separately (monocular testing). Only the rate of stimulation is changed. Other parameters remained constant (brightness, contrast, stimulation pattern size etc.,). The response of each

stimulation rate was done for 30 cycles and stored and similarly responses repeated for remaining rate of stimulation also (2Hz, 3Hz, 4Hz, 5Hz and 6Hz stimulation).

DATA ANALYSIS

For each patient P100 latency value were identified manually by moving the cursor over the averaged waveform. The analogue signal is digitized at a sampling rate of 1024 samples/sec. Using Welch's averaged periodogram method the spectral components of the sampled data were identified. The relations between the rate of stimulation and P100 latency, rate of stimulation and spectral components are also identified.

RESULTS

EFFECT OF RATE OF STIMULATION ON P100 LATENCY

The primary results show that as the rate of stimulation increases the P100 moves towards higher value. For 1Hz stimulation rate, P100 value has been observed at 100msec (Figure-1) and for 2Hz stimulation rate, it has been found that the P100 value increased to 105 (Figure-2). For 3Hz stimulation rate, P100 value has been observed at 110msec and for 4Hz stimulation rate, it has been observed at 115msec (Figure 3). The results show that as the rate of stimulation increases, the P100 peak value moves towards higher value. Up to 4Hz stimulation rate, the P100 latency value has been clearly observed and after 4Hz stimulation, P100 peak completely disappears from the waveform and almost the waveform becomes sinusoidal (Figure 4). Table - 1 shows the P100 latency value at different rates of stimulation. It has been found that there was a strong positive correlation between rate stimulation and P100 latency value (correlation coefficient r= 0.96).

Figure 1

Figure 1

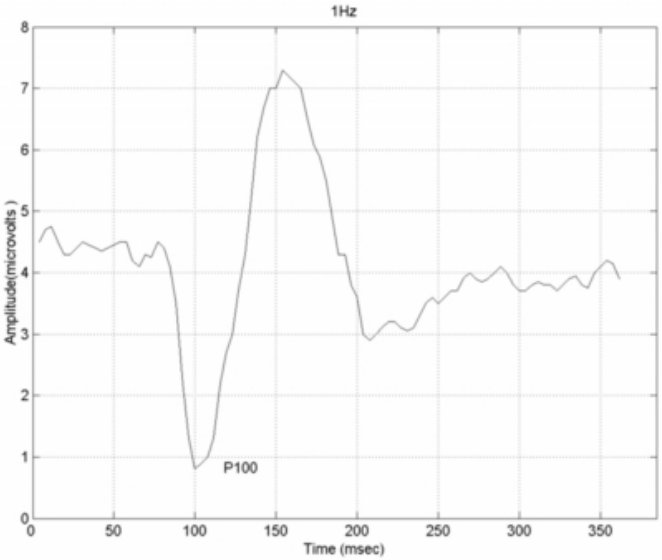


Figure 2

Figure 2

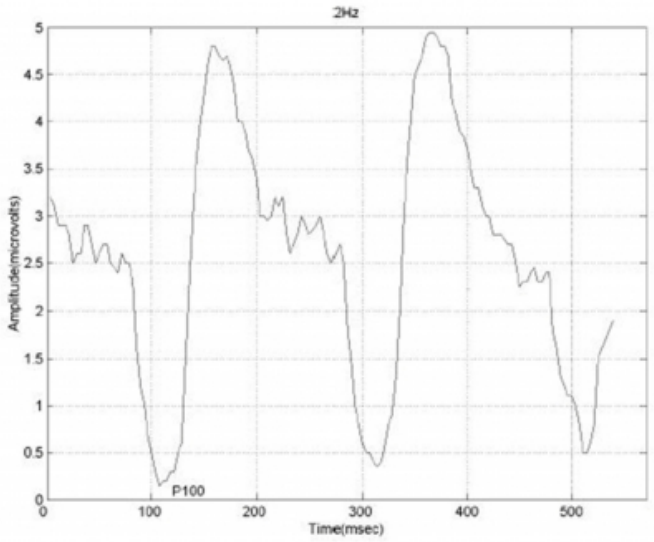


Figure 3

Figure 3

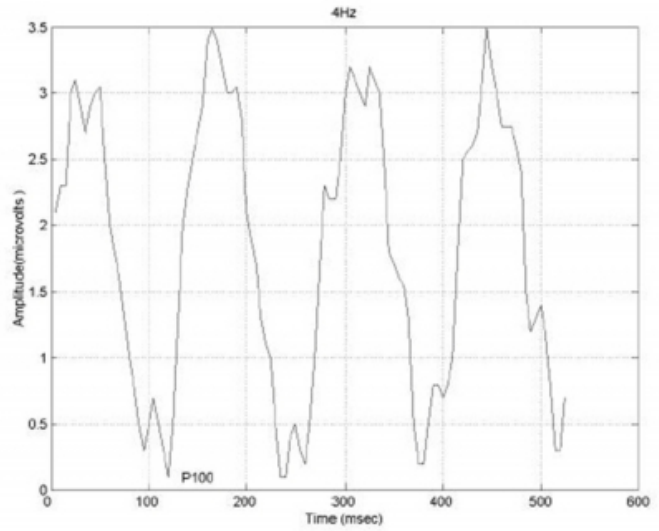
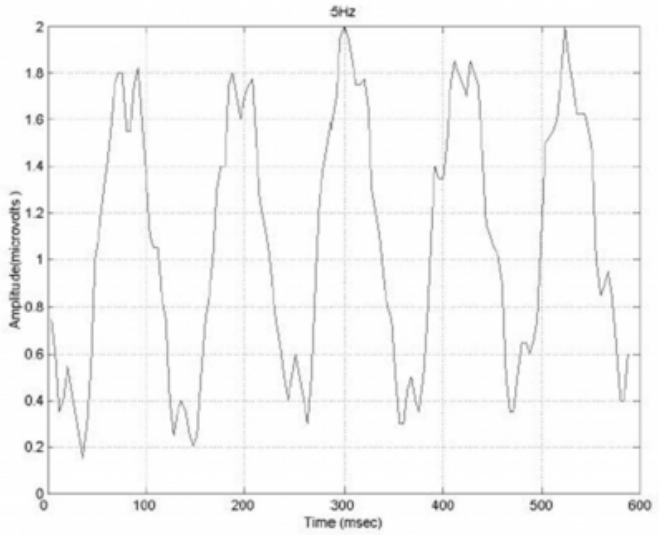


Figure 4

Figure 4



EFFECT OF RATE OF STIMULATION ON SPECTRAL COMPONENTS

Primary results indicate that the spectral components have been observed in the frequency range of 2Hz - 6Hz values. For 1 Hz stimulation rate (Figure 5), the peak frequency has been observed at 2Hz (Figure 6), for 2Hz stimulation rate, the peak frequency has been observed at 3Hz. For 3Hz, 4Hz and 5Hz stimulation rate, the respective peak frequency has been observed at 4Hz, 5Hz and 6Hz respectively (Figure 7, 8). Beyond the 4Hz stimulation rate, it has been found that the spectral component value exactly at the stimulation rate. It has been found that as the rate of stimulation increases the spectral component moves towards the higher frequencies.

Figure 5

Figure 5

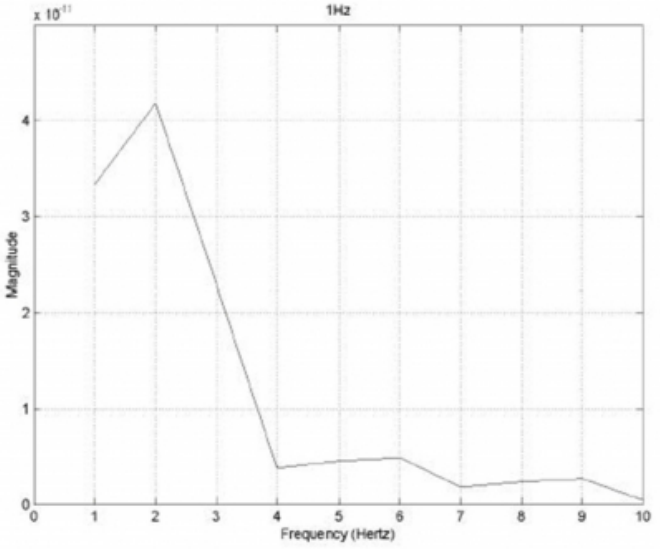


Figure 6

Figure 6

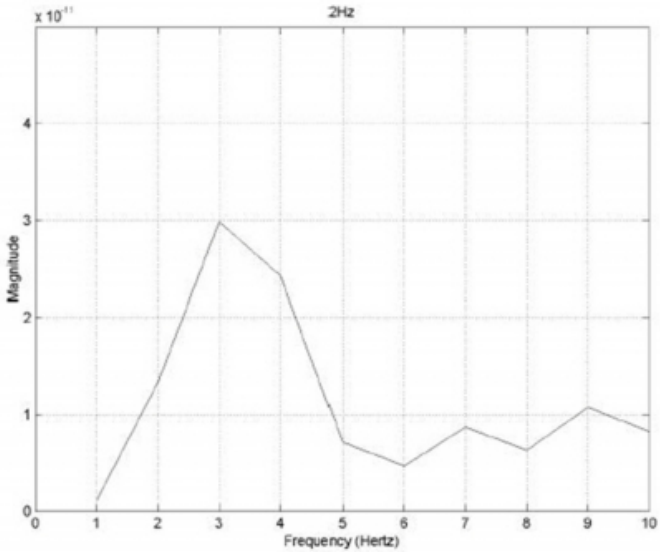


Figure 7

Figure 7

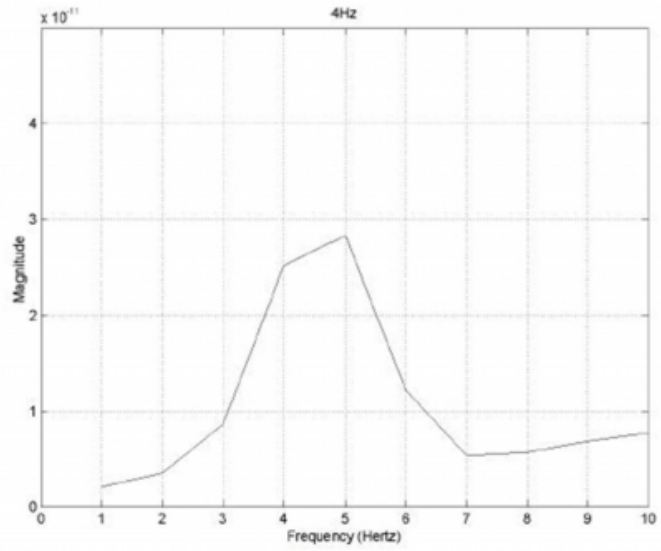


Figure 8

Figure 8

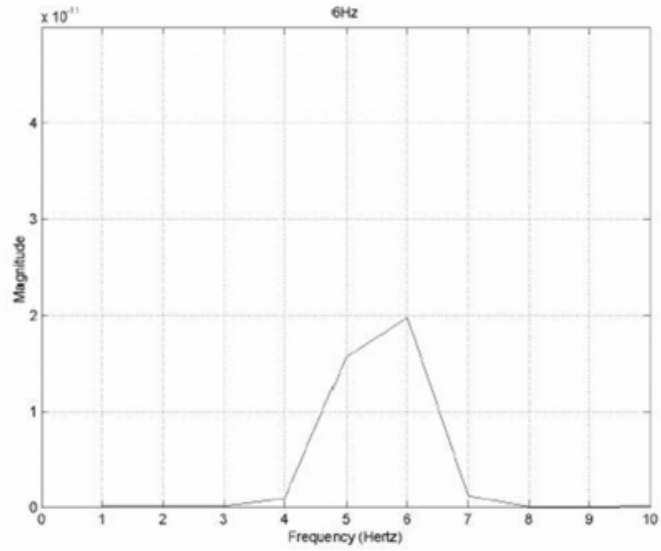


Table 2 shows the spectral components for different rates of stimulation. It has been found that as the rate of stimulation increases the VEP P100 amplitude decreases (Table 3). There has been a strong correlation between the spectral components and the rate of stimulation (r=0.98).

DISCUSSION

In the earlier studies, many methods have been used for TVEP P100 latency analysis and those methods have adopted only time domain analysis. In time domain analysis, at higher rate of stimulation, it is very difficult to identify the exact P100 values due to the irregular peaks. As the rate of stimulation increases, the visual system will not get time to come back to the original state before the next stimulation. Because of this reason, the responses will overlap, thus making it difficult to measure the exact P100 value. At the higher rate of stimulation, the TVEP is almost similar to sinusoidal waveform (Heravian et al 1999) and it is called SSVEP. Many researchers have utilized the frequency domain analysis for SSVEP (Tobimatsu et al 1996, Nakayama 1994, Suttle 2001, Marreli et al 2001). In our previous studies (Sivakumar and Ravindran 2002, Sivakumar and Ravindran 2004), the frequency domain method has been utilized for TVEP analysis for a constant stimulation rate (1Hz). In this study, TVEP waveforms have been analyzed at different rate of stimulation. Up to 4Hz stimulation, the P100 latency value has been clearly observed and after 4Hz stimulation P100 peak completely disappears from the waveform and almost the waveform becomes sinusoidal. Beyond the 4Hz stimulation rate, it has been shown that the spectral component value observed exactly at the stimulation rate. This result exactly coincides with the previous SSVEP spectral components analysis results (Tobimatsu et al 1993, Johansson et al 2000).

In our previous studies (Sivakumar and Ravindran 2002, Sivakumar and Ravindran 2004), it has been shown that for 100msec, the spectral components were observed at 2Hz. For 120, 140,160 etc., it has been shown that the spectral components values at 3,5 and 6 Hz respectively. But in this chapter, due to the different rate of stimulation, for the 110msec TVEP waveform, the spectral component has been observed at 3Hz. For 115msec, the spectral component has been observed at 4Hz. It has been found that as the rate of stimulation increases, the P100 value moves towards higher value in a linear fashion up to 5Hz. After 5Hz, the spectral components follow the stimulation frequency. These results exactly coincide with the earlier results presented by Misra and Kalith (1999).

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