Process and methodology leading to the acquisition and analysis of Event Related Potentials with basic sound stimuli

Bruno Giesteira[1], João Travassos[2], Diamantino Freitas[3]

[1] FBAUP/LSS, [3] FEUP/LSS
Universidade do Porto

[2] ESTSP/CEMAH
Instituto Politécnico do Porto

bgiesteira@fba.up.pt, jpctravassos@gmail.com, dfreitas@fe.up

Abstract. *This poster (short paper) has the main purpose to systematize the current working progress study which evaluate the clinical concept of Evoked Potentials using for that visual and auditory stimuli reasoned in the communication visual field and the audiological area, where the stimuli usually used for the clinical tests were recovered in a large spectrum of sounds (Different frequencies, intensities and time with a pure tone sound).*

Our poster communicates the process and methodology that is currently being used to our team to catch similarities of brain response (energy; latency; waveform; et al.) between visual and auditory basic stimuli.

1. Evoked Potentials: Concept and Goals

Evoked Potentials can be used to evaluate cortical and subcortical structures of the brain, such as the visual and auditory cortex and their pathways, which are responsible for the senses of vision and hearing respectively [Chiappa 1997; Niedermeyer *et al.* 2004]. One type of evoked potentials, Event Related Potentials (P300 tests), are also, more recently, being used to evaluate some of the high level characteristics of information processing in the central nervous system [Hruby; Marsalek 2003], such as the cognitive responses of the individual, like his capacity to identify and discriminate a particular battery of stimuli. That gives us an opportunity to acquire electrical cerebral signal corresponding to the brain reaction of some visual and auditory basic properties (colors; frequencies; et al.) as well as more complex and superior mental concepts (scale; depth; movement; et al.) and, through this, infer some stimuli patterns and trends always reasoned in clinical guidelines like through the measuring of peak amplitude and latency (time interval between the presentation of stimulus and the onset of a given peak) [Chiappa 1997; Niedermeyer *et al.* 2004; Blum *et al.* 2007; Walsh *et al.* 2005].

The evoked potentials can be extracted from the background electrical activity through averaging techniques [Chiappa 1997; Blum *et al.* 2007; Walsh *et al.* 2005]. Since the electric manifestation of the brain when exposed to a given stimulus occurs in the same time interval every time the stimulus is presented, and considering that the rest of the electrical activity is random and is not associated to the stimulus, it is possible to extract the desirable signal (Evoked Potential) through the acquirement of one signal per stimulus presented. Then all the signals collected are averaged to suppress the background noise, supposedly random, and to show the evoked potential that is constant [Chiappa 1997; Niedermeyer *et al.* 2004; Blum *et al.* 2007]. For that we developed an algorithm in "*Matlab*" capable to average the manifold cerebral signal responses to visual and auditory stimuli that were presented in tests.

2. Battery of Stimuli: Grounds and Pleas

Our main purpose is to catch possible relations between the basic visual grammar [Dondis, D.; Arnheim, Rudolf; *et al.*] and the perception of unassuming sounds. For that we developed a cluster of images, which are viewed on a computer display, capable to translate objectively the fundamentals of the visual grammar, namely: The three primary light colors; Dot; Line; Texture; Dimension; Scale; Movement.
For the auditory stimuli we selected an audiological grammar (mainly used on clinical exams) since that is scientifically accepted, translating to sound, as far as possible, the same basic visual concepts with the few sound parameters used to clinical purpose namely: Pure Tone with 2, 3, 4, 5, 12 KHz frequencies; Tone Burst; Square Tone; Intensity with -6, -12, 0 db; and Time Intervals.

Figure 1. Example of a visual stimulus: Depth (first level)

The correspondent auditory stimulus of the previous example image is a Pure Tone at 2 KHz varying the intensity of sound in 6db (-6db to -12db). One second with -6db and the same period of time with -12db.
These simple grammars provide us the opportunity to analyze and discuss possible cognitive correlations and differences between visual stimuli and also compares the results with the standard/clinical auditory stimuli, focusing in the morphology of the respective waves and energy generated (potential differences between the active and reference electrodes) [Blum *et al.* 2007].

Our current results in Visual Evoked Potentials already prove that different stimuli produce a different brain response, in a way that one can distinguish some of those stimuli solely based on evoked potentials acquisition signal. We expecting with this similar methodology getting analogous results to the Event Related Potentials (P300 tests).

3. Process and Methodology: Signal Acquisition

All records are acquired using the "*Biopac Systems mp 150*" hardware with the EEG module - "*EEG100C*" - associated to it. The EEG module is set with a gain of 5000, a high pass filter of 0.1Hz, a low pass filter of 35Hz and a Notch filter (50Hz). The software used for the acquisition is "*AcqKnowledge 3.9.0*". All stimuli are processed and presented via "*SuperLab 4.0*" software. The "*AcqKnowledge*" and "*SuperLab*" software are installed on different computers. Averaging techniques are only applied after acquiring the signal with "*MatlabR2008B*".

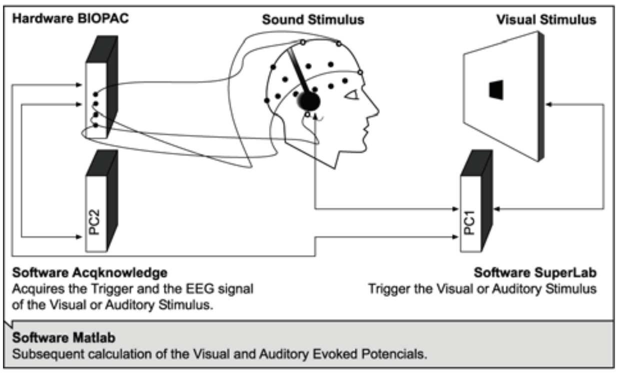

Figure 2. Signal Acquisition Schema

For this study we use two small reusable shielded electrodes - "*EL254s*" - for the two active electrodes, two general purpose shielded electrodes – "*EL258s*" – for the two references and one general purpose unshielded electrode - "*EL258RT*" - that serve as the ground electrode. Three channels are set, two analog channels for the EEG signal and one digital channel for the stimuli input/onset from "*SuperLab 4.0*". Every electrode placement site is previously clean using cotton with alcohol in an effort to reduce electrode-skin impedance, and fixed to the skin with an EEG proper paste "*ELEFIX*".

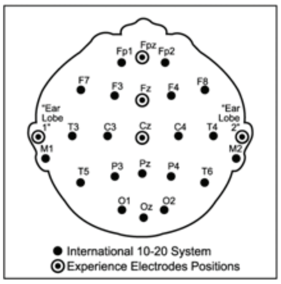

Figure 3. International 10-20 System (Electrodes' Position)

Every electrode is placed according to the international 10-20 System (Fig. 3). The montage used is Cz (Channel 1) and Fz (Channel 2) as the active electrodes, left ear lobe (Channel 1) and right ear lobe (Channel 2) as the reference ones, and Fpz as the ground electrode.

Sampling frequency is set at 1000 samples per second (1000Hz) and 15 stimuli are used per class in a shuffle way. Whenever the individual identifies the visual or auditory stimulus, previously selected, he or she triggers a button on "*RB-730 Response pad by Cedrus Corporation*" that registers on "*Acqknowledge*" his recognition and, subsequently, the EEG Evoked Potential signal. Visual and auditory stimuli are presented, respectively, with 1,5s and 2,0s of duration. The first ones through a display, and the second ones through earphones. During the acquisition time the volunteer was seated, keeping calm and relaxed in a dark and silent room.

All signals are processed and averaged techniques are applied to it using "*MatLab*" software. We used "*MatLab*" software to develop the algorithm due to the fact that it is a more flexible tool and it allows us a deeper degree of analysis.

4. Results: Work in progress

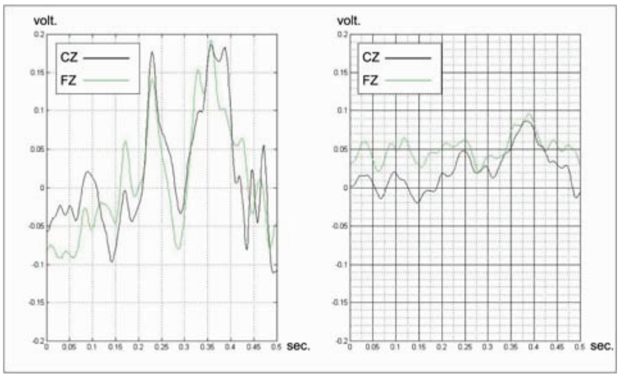

Figure 4. Event Related Potential with both channels overlapped: Pure tone at 4KHz

Insofar as in this poster (short paper) we want to demonstrate our process and methodology regarding to the Event Related Potentials working process study, our team reserve to ulterior time all the results regarding to this research. The image above (Fig. 4) explicit for now as a valid and concrete example an Event Related Potential measurement withdrawn of one set 4 KHz stimulus. Here we can analyze on 500 milliseconds latency window the energy generated per time, waveform, the presence or absence of N2 (or N200) – a negative peak (upward direction) that appears at approximately 200 ms - and P3 (or P300) – a positive peak (downward direction) that appears around 300 ms [Hruby; Marsalek 2003], the amplitude and latency of the waves and, with that, systematize and correlate the different stimuli. So now, we will prosecute the measurements of all samples collected with the same procedures and methodology here described.

6. References

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