Can a $300 EEG be used for neuroscience research?

Evaluation of Emotiv EPOC neuroheadset performance in Readiness Potential detection

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Many consumer-grade EEG devices have been developed and introduced to the market during last five years. Those are primarily aimed to serve as gaming or neurofeedback devices, but since the access to raw EEG data is usually possible, can they be employed in neuroscience? Emotiv EPOC, one of most advanced gaming EEG headsets, is being tested.

Event-Related Potentials

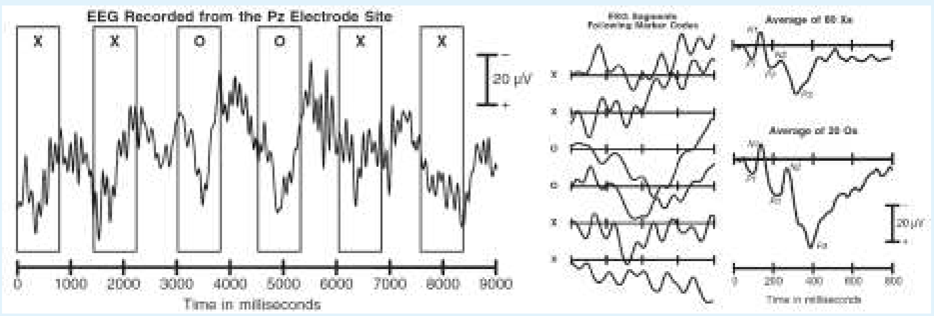


Fig.1 - Event-Related Potentials (Luck, 2005)

ERPs are a powerful technique for investigating a brain activity related to a specific stimulus (reference event). It improves a signal-to-noise ratio by averaging eeg signal over multiple trials (see Fig.1).

While sought signal is a function of time (averaged epochs are time-locked to stimuli), noise is distributed randomly. The s/n ratio rises with a square root of number of trials, which allows the researcher to see even the potentials with amplitude below the noise level.

Notice the inverted polarity in Fig.1 (minus is upward), which is a common practice in ERP.

Emotiv EPOC

Neuroheadset was introduced in 2009 as a brain-computer interface device.

Specifications:

- 14 Saline Solution Sensors (+CMS/DRL references)
- Channel locations: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, Af4 (Ref. P3/P4)
- Sampling rate: 128Hz (2048Hz internally)
- Resolution: 14bit
- Input dynamic range: 8400µV
- Proprietary wireless connection (2,4GHz)
- $300 / $750 (with access to raw data)

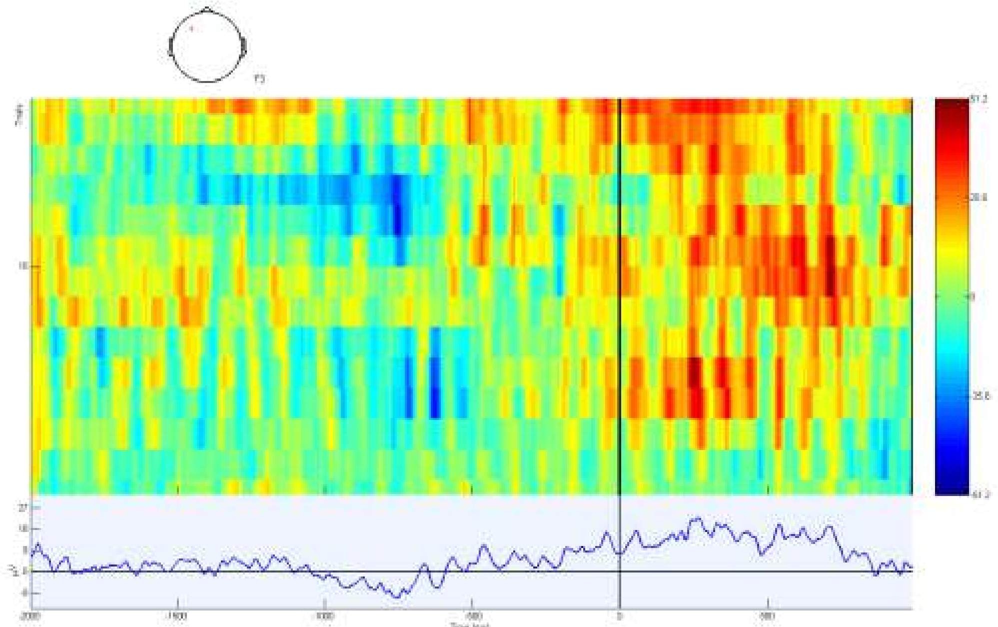


Fig.3 - ERP Image of Pilot Experiment

Issues encountered

- **Sensor locations:** Electrodes of EPOC headset are located on fixed positions. It is possible to slightly tilt the headset, but some locations (such as Cz) are unreachable.
- **Input impedance:** While saline solution electrodes are easy to set-up, their impedance can grow up to 1M? (compared to few k? of medical and research-grade devices) and is unstable due to drying.
- **Artifacts:** Electrodes mounted on plastic springs are more vulnerable to shift along scalp than electrodes installed in supportive cap, causing unwanted artifacts. EPOC also lacks electrooculography inputs normally used in eye artifact suppression.
- **Timing:** Since the muscular movement is detected through computer keyboard press and not electromyography as is usual in Readiness Potential experiments, timing is much less precise. Delay between onset of muscle stretch and detection of keypress can reach up to 500ms.

Readiness Potential

Readiness potential, also known as Beratschaftpotential, is a slow negative slope preceeding a voluntary motoric movement.

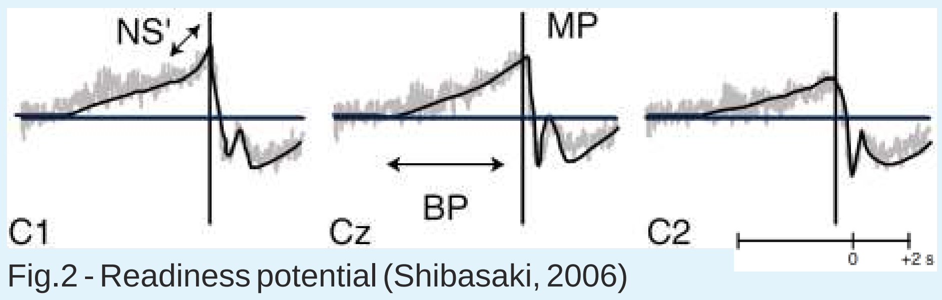
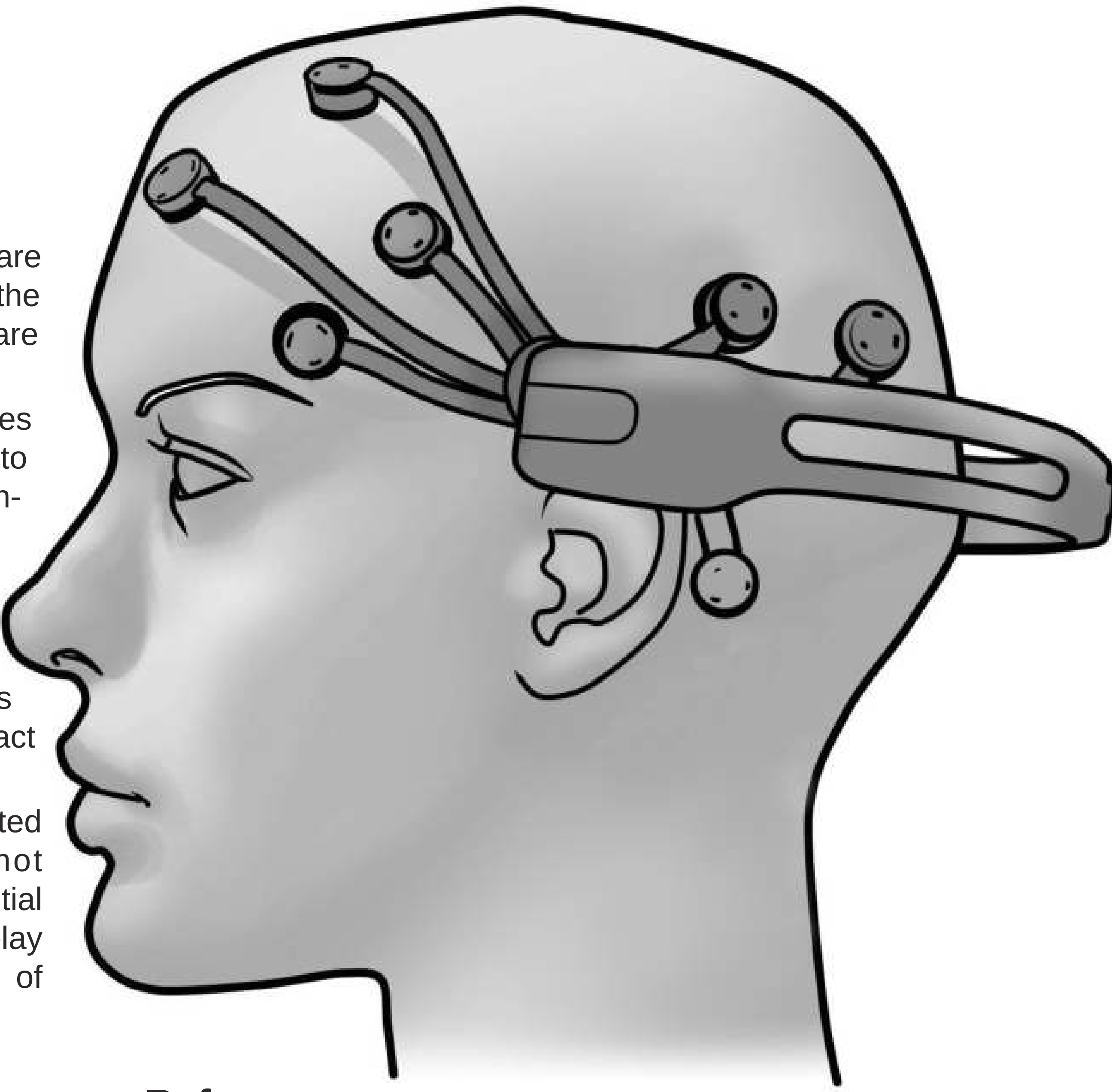


Fig.2 - Readiness potential (Shibasaki, 2006)

It consists of two main components: Early BP (marked as BP on the Fig.2) is symmetrical, strongest at the top of the head and precedes the movement onset by about 2s. Late BP (NS') is lateralized, maximal at C1, C2, C3 or C4 location (depending on task).



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