Electrophysiological Answer to a Checkerboard Stimulus

A Pilot Study

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Academic Background

- PhD student in Biomedical Engineer (in development, FCT – UNL)
- Master in Neuropsychology (2015, ICS- UCP)
- Bachelor in Occupational Therapy (2004, ESSA)

Professional experience

- Adjunct Professor at the Higher School of Health - Polytechnic Institute of Beja (since 2017, ESSA - IPBeja)
- Occupational Therapist in a Pediatric Hospital, working with infants and children with developmental disorders (from 2007 until 2018, CHULC)

Scientific areas of interest

Biomedical recorder data I Visual skills I Electrophysiology

Neurodevelopmental disorders I Aquatic therapy

Literature review

Materials and methods

Results

Conclusion and future work

1. Goals

- Present an integrated experimental setup to assess the evolution of visual system development in preterm infants;
- Present and analyze the results of a pilot application with two preterm infants.

Contribute to know

How does visual and electrodermal signal change in preterm born infants during the first months of life?

2. Literature review – VEP

- Electroencephalography is used in neuroscience to explore the electrical activity of living neurons [1]

- Visual Evoked Potentials (VEP) are massed electrical signals generated by occipital cortical areas in response to visual stimulation [2].

- The most used pattern is a checkerboard with black and white squares [3]. The pattern is alternated without change in the luminance at a specific reversal rate [2].

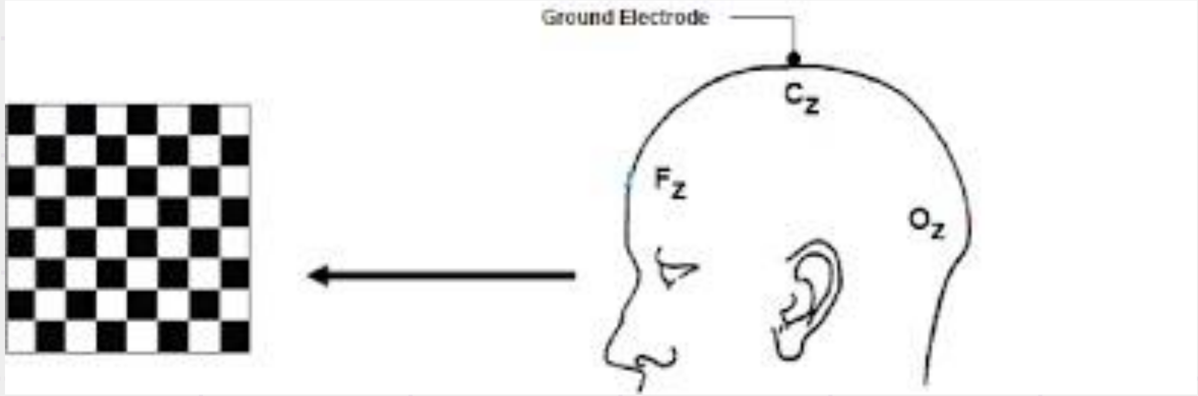


Figure 1: Electrodes positioning in VEP

2. Literature review – VEP

Figure 2: Infant in incubator
(representation)

Peripheral structures not completely formed [4]

Myelinization occurs latter [5]

Early visual stimulus exposure [6]

2. Literature review – EDA

The Electrodermal Activity (EDA) signal is an electrical manifestation of the sympathetic innervation of the sweat glands;

A recent study with newborns has shown that EDA parameters seem sensitive in detecting sympathetic regulation changes in early postnatal life [7];

The skin biomarkers of preterm birth could be seriously altered [8];

BUT

The EDA of PT infants has not ben measured when associated with a visual stimulus!

How does visual and electrodermal signal change in preterm born infants during the first months of life?

1. Literature review
2. **Materials and methods**
3. Results
4. Conclusion and future work

3. Materials and methods

experimental protocol

Recruitment in neurodevelopmental appointment

parents give informed consent

Timeline 4 Mths 6 Mths

Quiet room with low level of natural light.

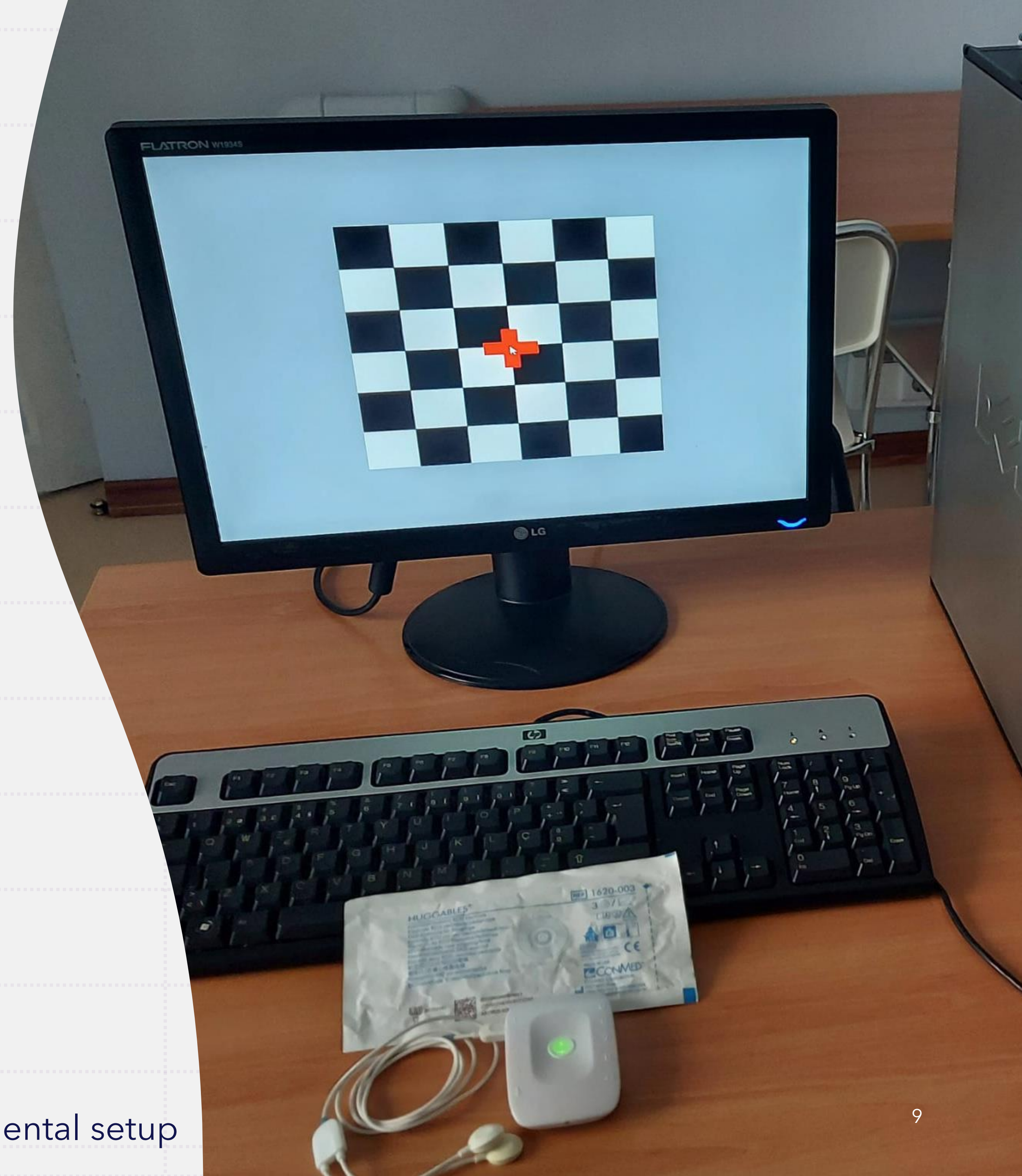


Figure 3: Equipment in experimental setup

3. Materials and methods

– experimental protocol

- Preparation ≈15 M
- Baby is seated on the parent's lap »»» seated 70 cm from the screen
- EDA signals »»» 2 electrodes (external side of the left foot)
- VEP signal - cap on infant's head with electrodes

Figure 4: Positioning electrodes for EDA collection

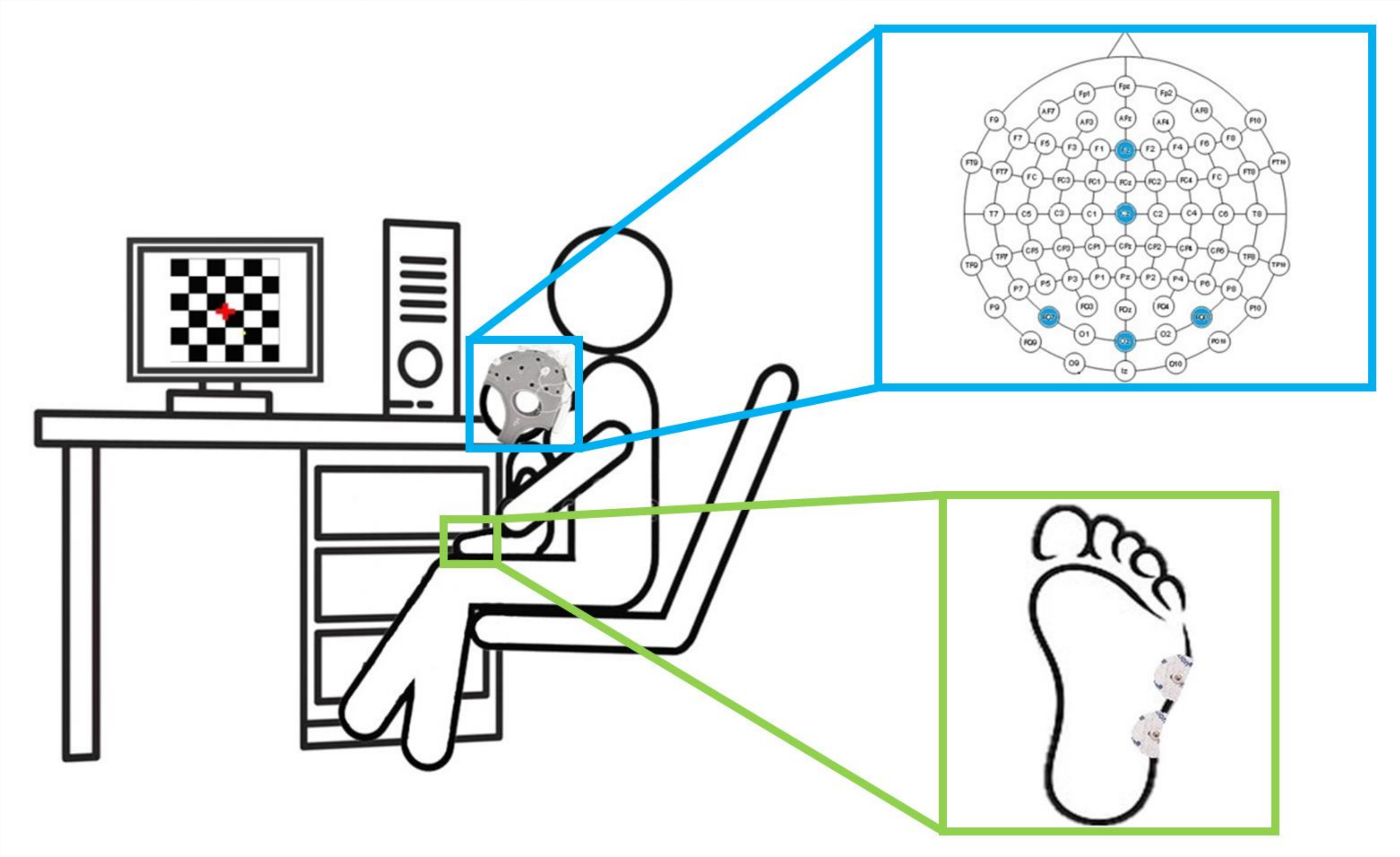


Figure 5: Experimental setup

3. Materials and methods - stimuli

Checkerboard pattern

(squares black and white)

⇩

Inverted every 1s

⇩

total of 120s

⇩

red cross

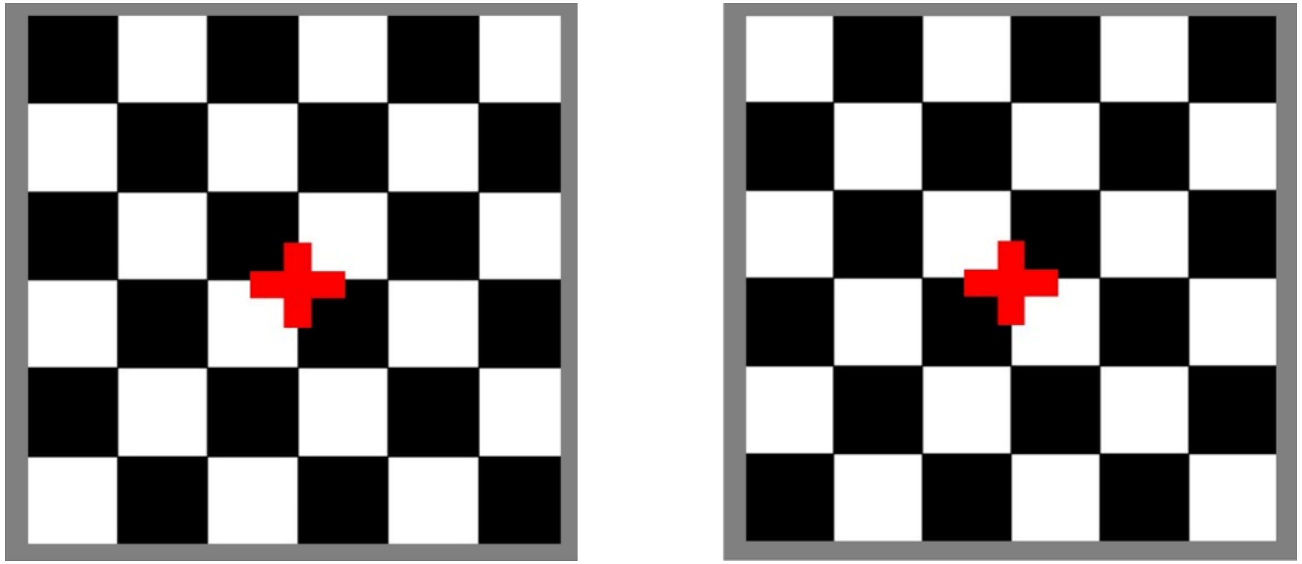


Figure 6: Checkerboard pattern

3. Materials and methods – data collection

BABY BINOCULARITY

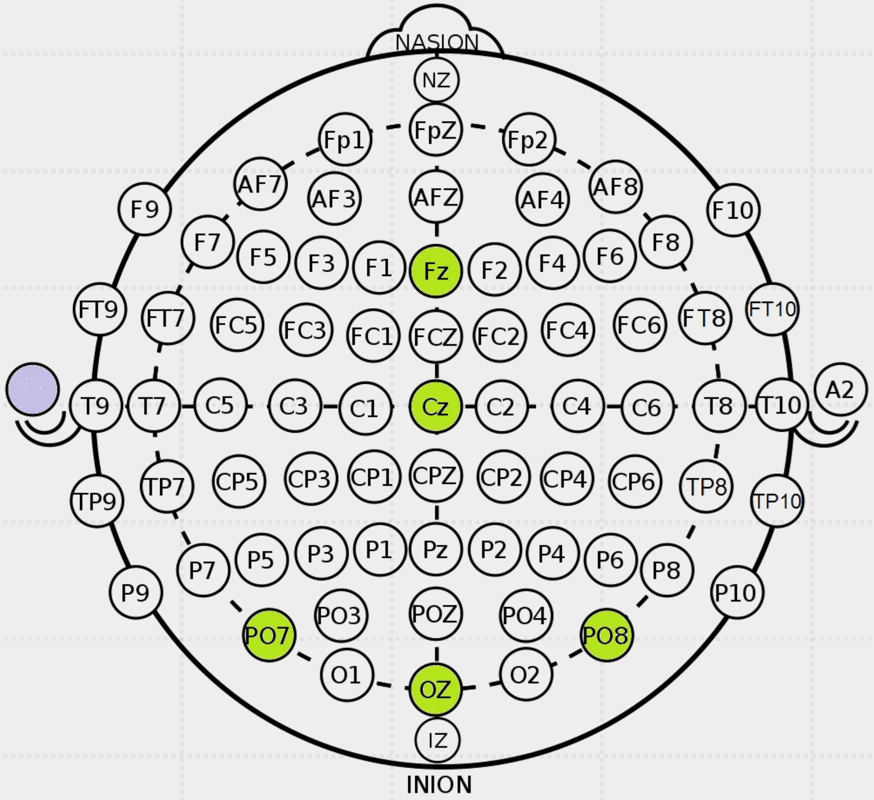


Figure 7: Positioning of electrodes used

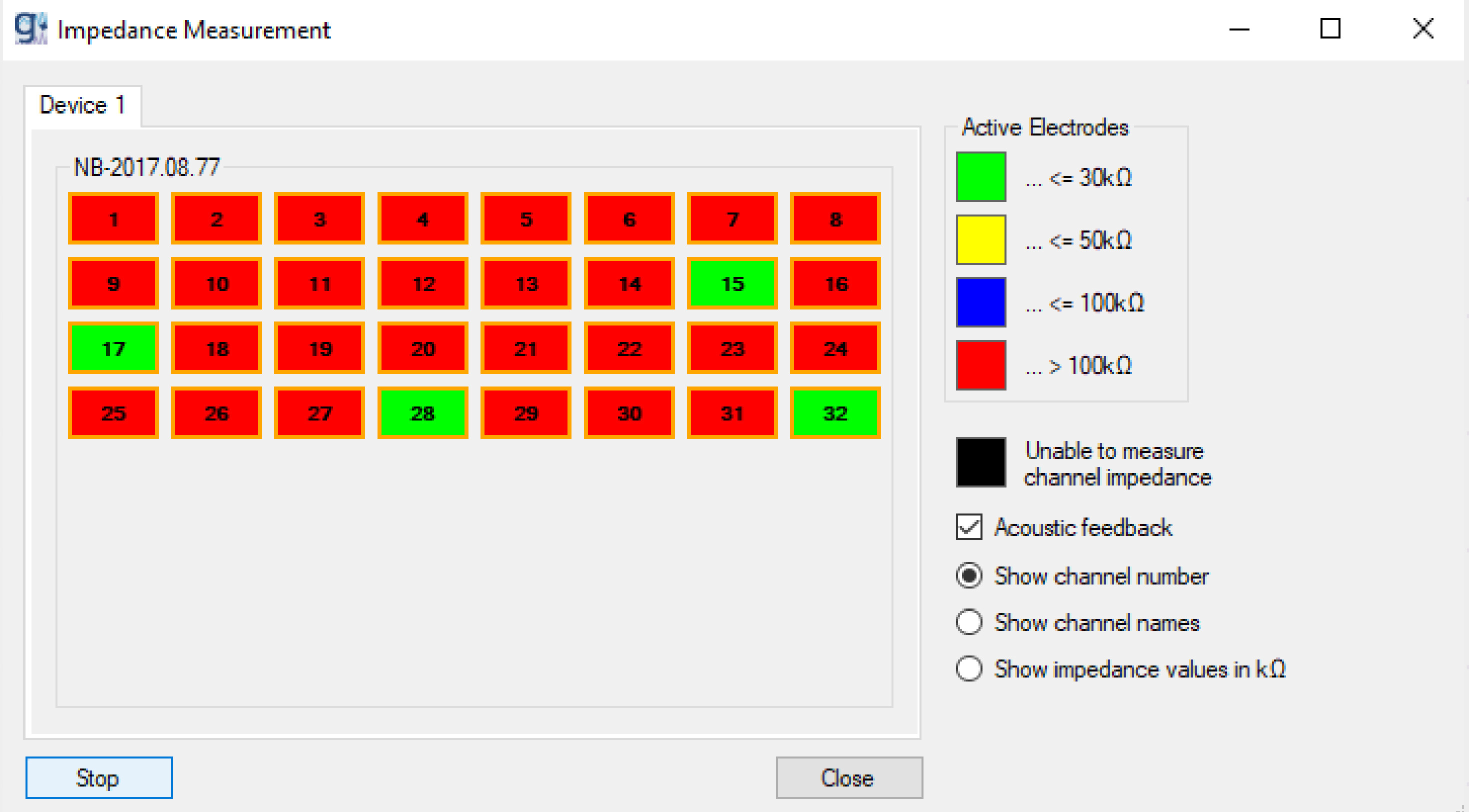


Figure 8: Impedance measure in gRecorder software

3. Materials and methods – VEP data processing

① Removing direct current

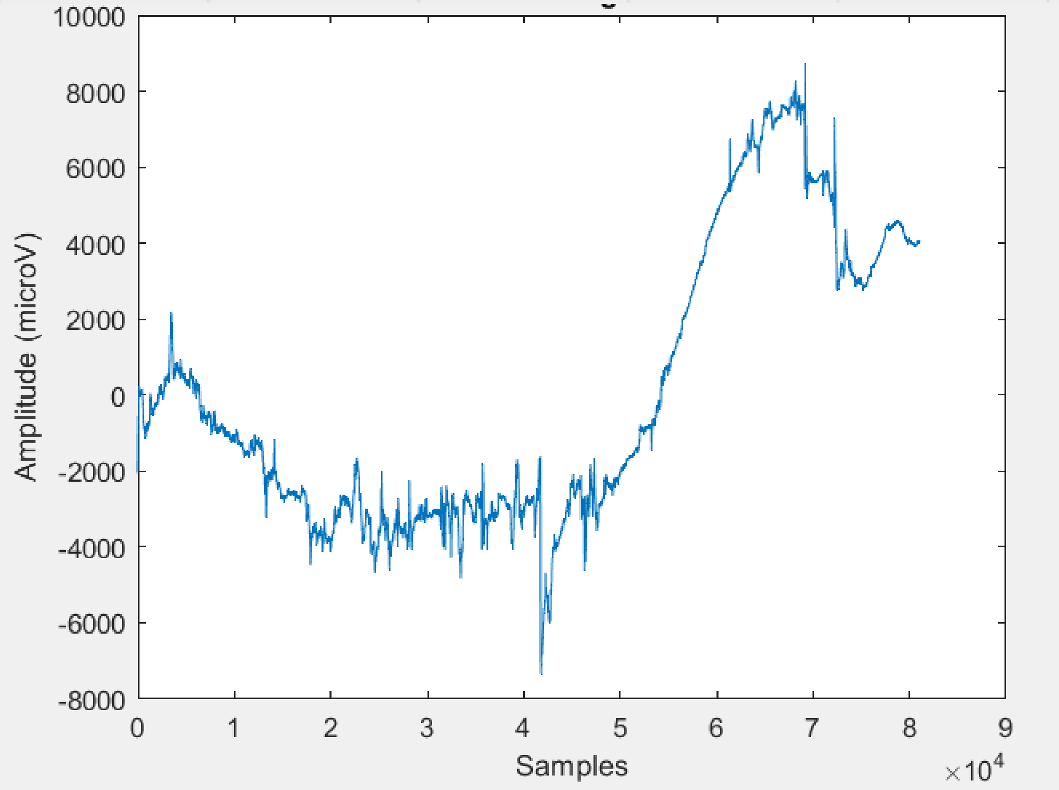


Figure 9 : Signal after DC remove

② 4^{th} order butterwort bandpass filter 2 - 30 Hz

Apply Filtfilt function [9]-[11]

3. Materials and methods – VEP data processing

③

Signal division 120 epoch
Cut:
100ms before stimuli 700ms after [12]-[13]

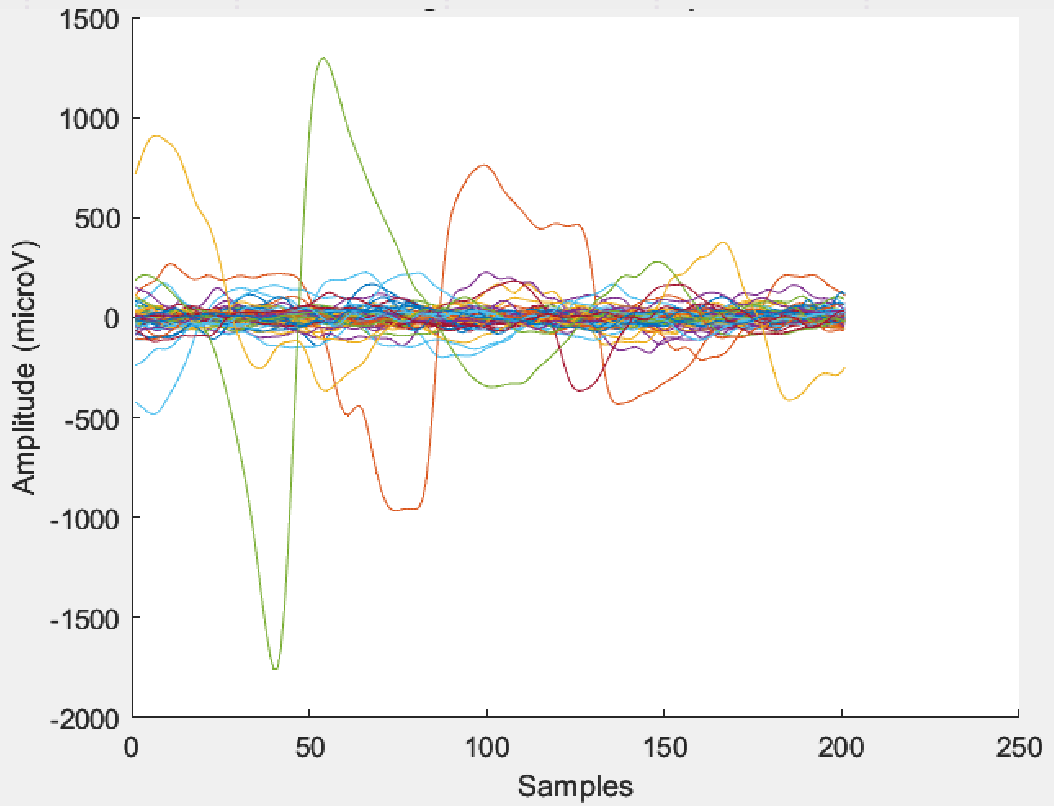


Figure 10: Signal division in 120 epoch

3. Materials and methods – VEP data processing

④ Filtfilt function
4th order low filter 10 Hz [14]

⑤ Removing artifacts based on standard deviation 0.6 [15]

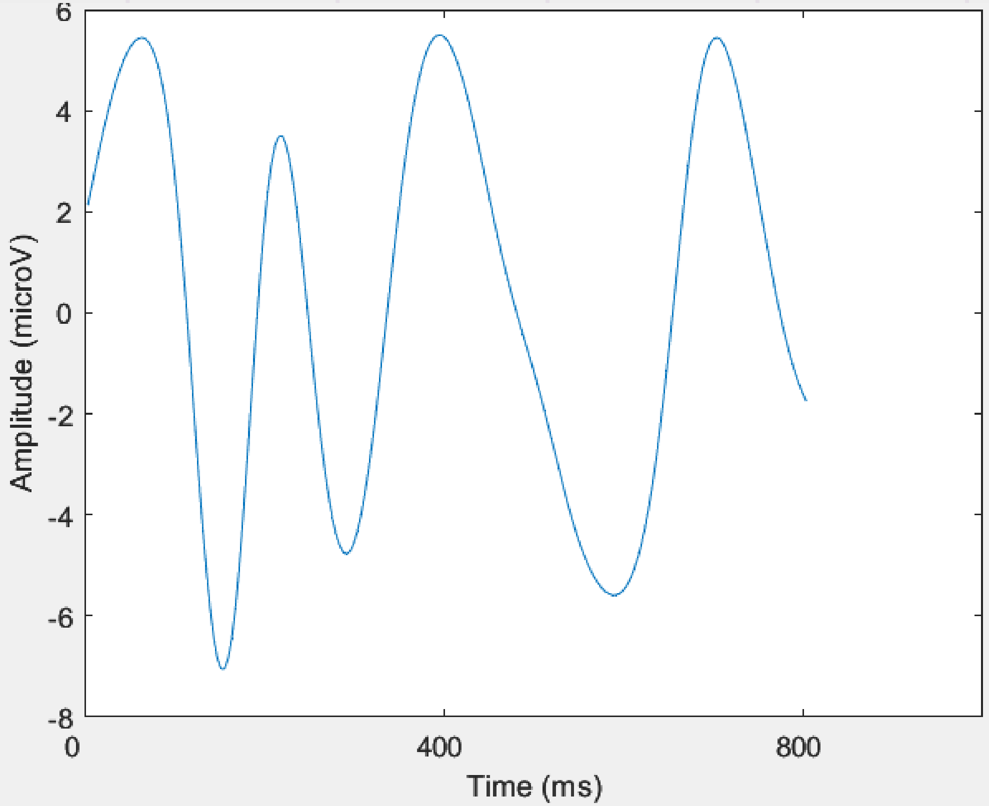


Figure 11: Signal after apply the 4th order low filter 10 Hz

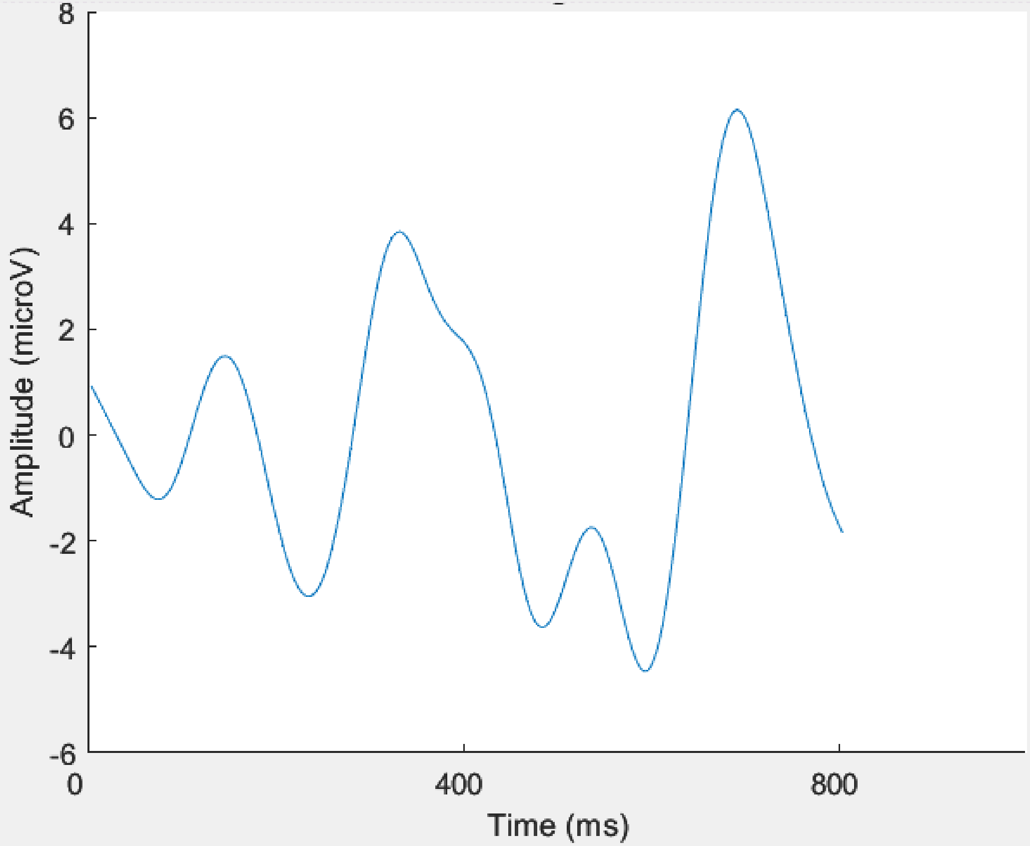


Figure 12: Signal after removing artifictas

3. Materials and methods – EDA data processing

- Reading the .txt file and .hdf5zfile;
- Downsampling signal (500 Hz «« 100Hz)

- Move average filter - window of 50 sample points;
- DDA-phasic and tonic components [16]

- Parameters extraction

(n° responses, latency time, amplitude, area and conductance level)

- Time window 0,5 to 1s from each stimulus and amplitude above 0.01 [17]

3. Materials and methods – EDA data processing

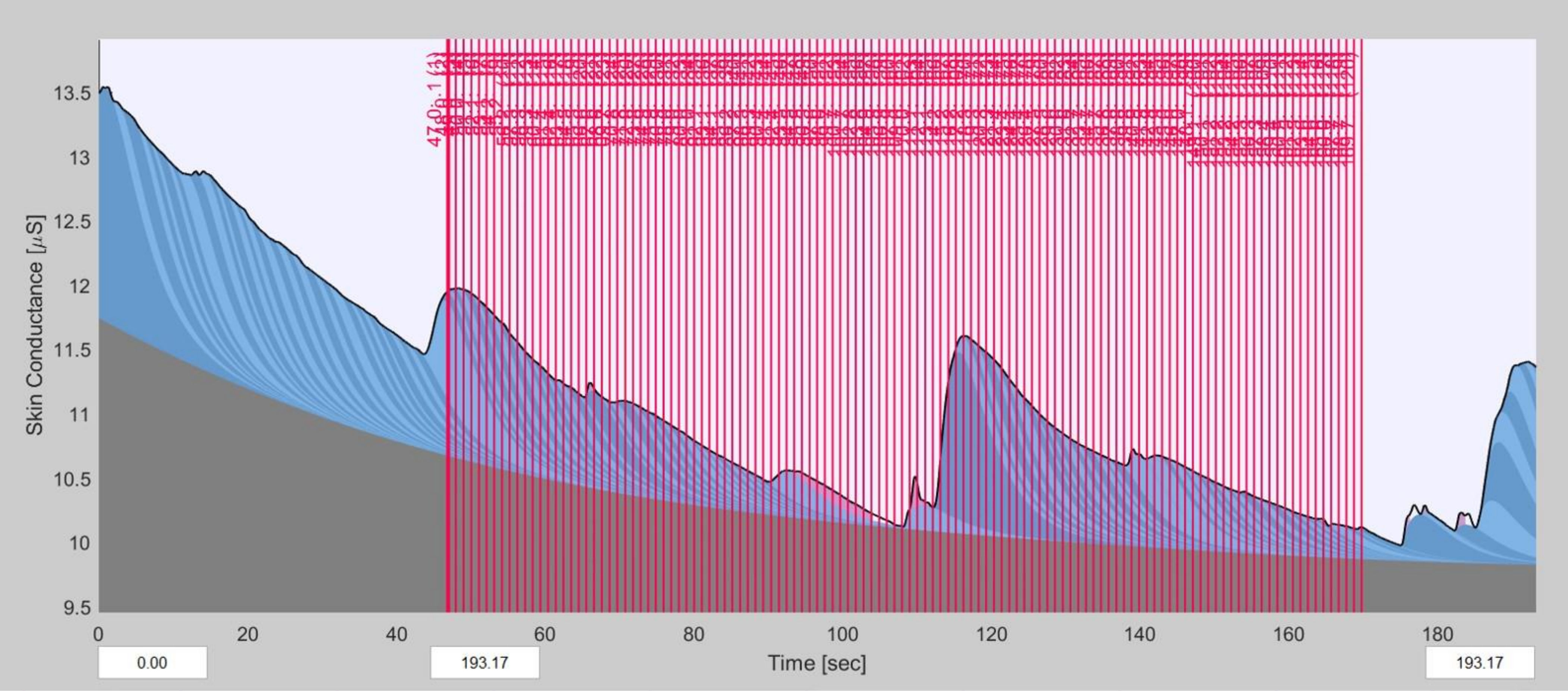
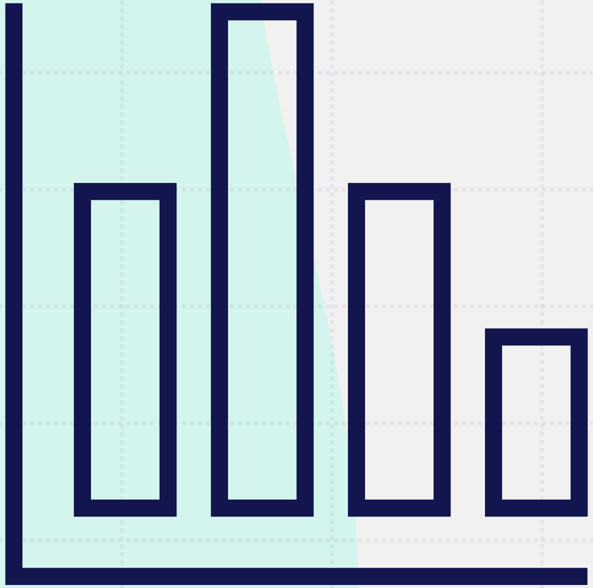


Figure 13: Discrete decomposition analysis

3. Materials and methods – sample

	P. 1	P. 2
Gestational age	30 W + 6D	24W+5D
Birth weight	1945g	685g
Correct age	4M	6M
Weight T. Assessment	6485g	7330g



1. Literature review
2. Materials and methods
3. **Results**
4. Conclusion and future work

VEP

4. Results

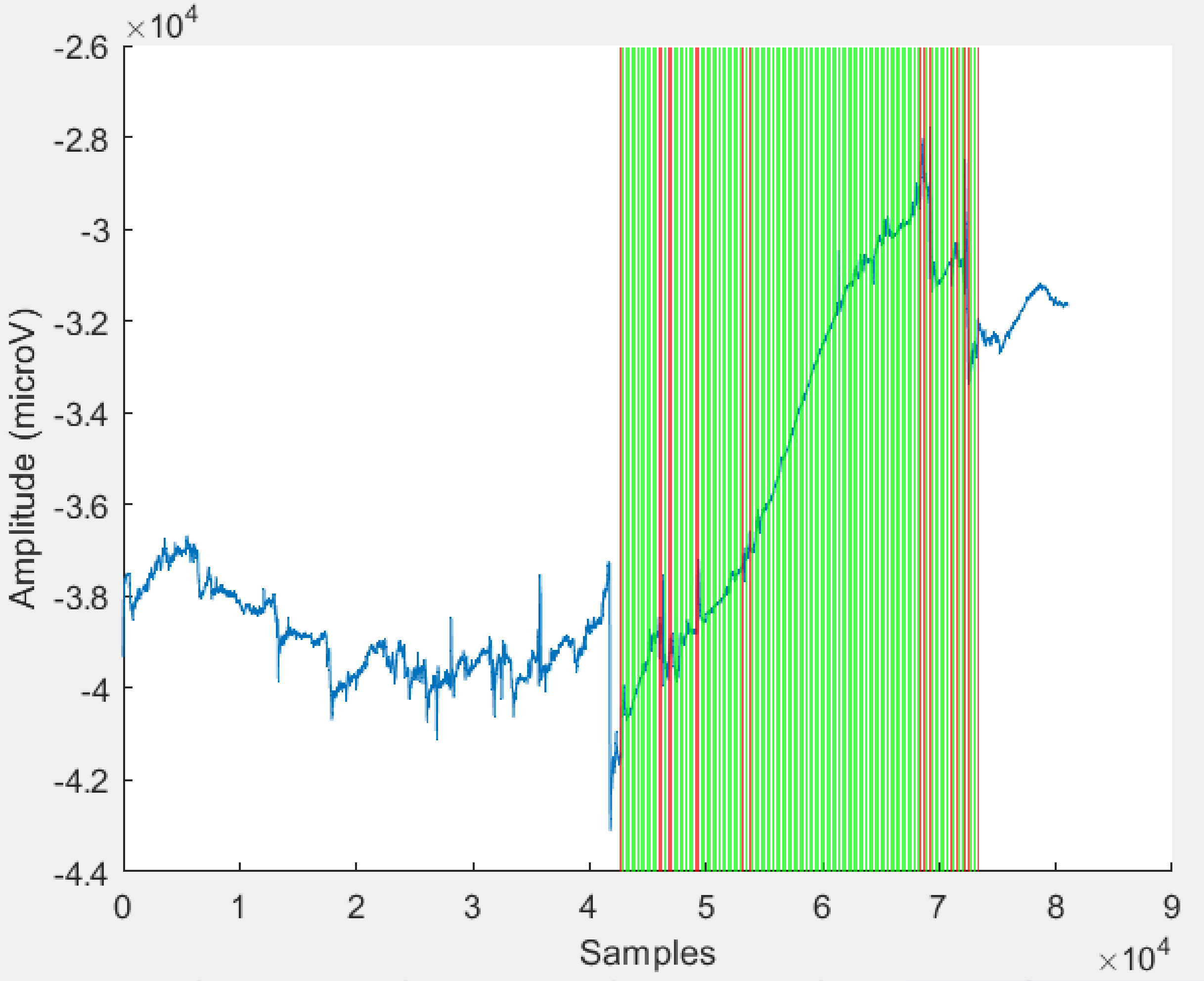


Figure 14: Selection of the signal epochs to use for processing

4. Results

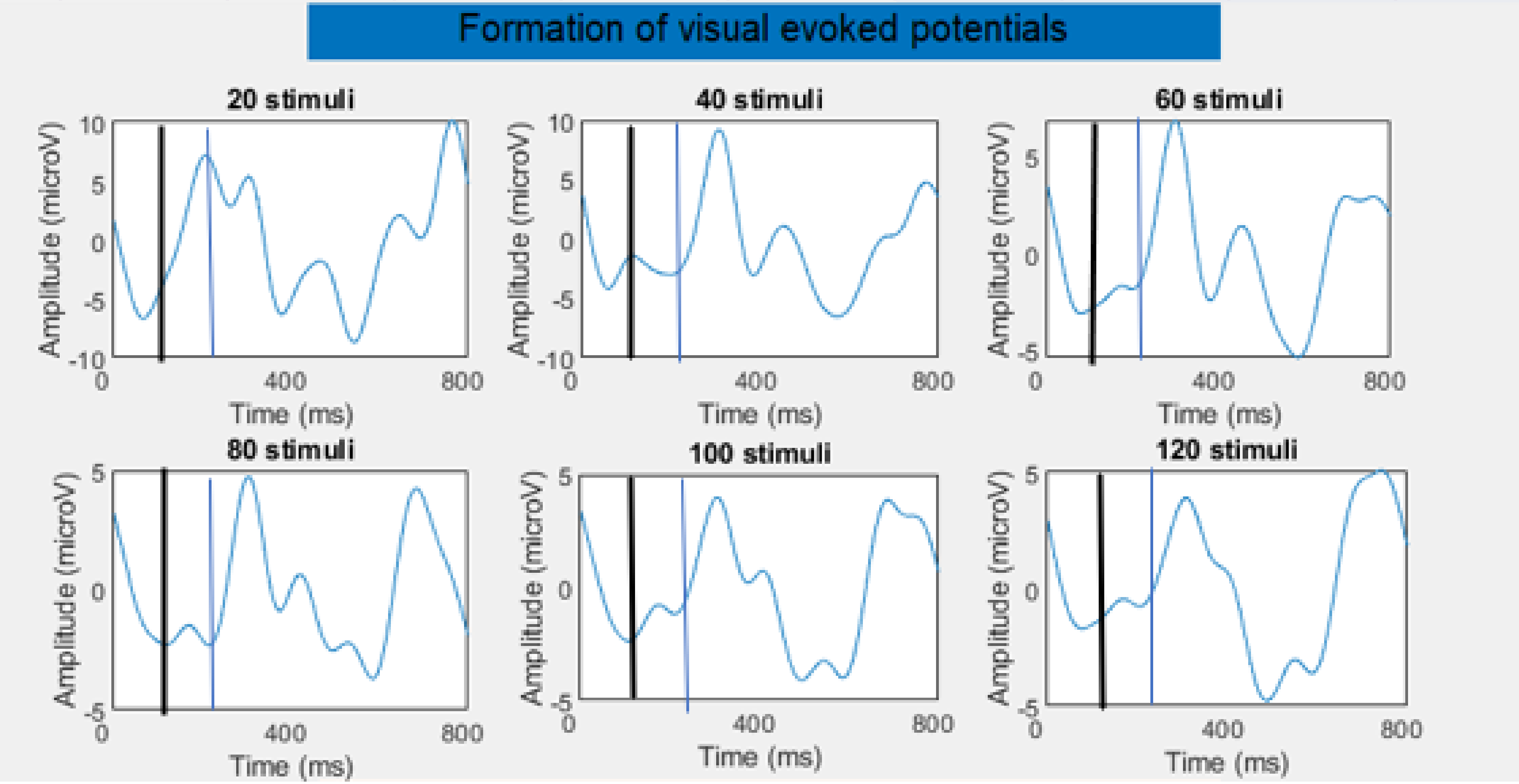


Figure 15: VEP changes during sample collection using GUIDE interface for a 6-month-old infant

4. Results

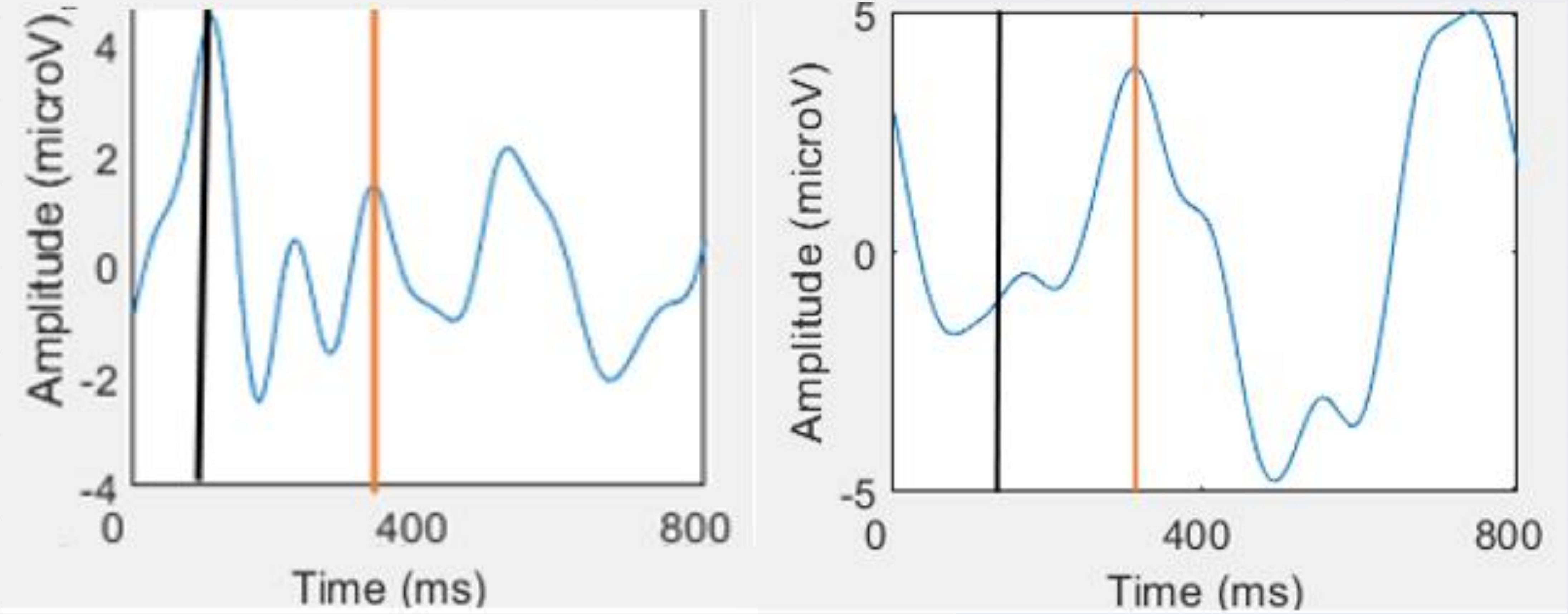


Figure 16: PO8 of four (left) and a six-month (right) old infants

4. Results

EDA

TABLE II – PARAMETERS EXTRACTED FROM LEDALAB

	N. responses	**Amplitude** (µS)	**Area** (nS^2)	**Latency time** (s)	**Skin conductance level** (µS)
P.1 (4 M)	29	8.68	48.87	0.79	6.39
P.2 (6 M)	38	4.51	37.11	0.75	10.15

4. Results

Figure 17: Infant performing the evaluation

Latencies for the older child are lower, as her visual system is more mature, which aligns with the previous literature [18].

The shape of the potentials for the two infants is "larger" than would be predicted for an adult, which is in agreement with the consulted literature [2] [12].

The arousal state is one of the behavioral characteristics that could influence good-quality pattern VEP recordings [2];

In this way, it is expected that negative components preceding and following positivity appear at 2-4 months of age, and the waveform is adult-like by 68 months of age [19].

4. Results

- Results of the pilot application are coherent with results obtained for other types of stimulation;

- The older infant presents a higher number of responses to the stimuli, a lower amplitude [20], a lower latency time [21], and a higher skin conductance level [22] in comparison to the younger one.

- These are all related to the maturation of the nervous system and, consequently, greater reactivity to the stimuli.

5. Conclusions and future work

- The experimental setup could be used to study VEP and EDA in infants, helping compare recordings from different age groups;

- This experiment has shown that visual stimuli affect visual and electrodermal responses that can be corresponded to the infants' age;

The combined analysis may correlate more effectively with infant development.

5. Conclusions and future work

Integrate electrophysiological data with clinical and developmental data

Holistic longitudinal assessment with collections of signals in premature and full-term infants: compare the two groups and their evolution over time.

Integration of data from statistically significant sample sizes in biomedical health records

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