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EEG Preprocessing Standards for Studying the Infantile Visual-Attention Network

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Cognitive functions are supported by complex brain networks which can be measured during resting or task-state [6]. In literature, brain networks are usually investigated via f-MRI [3]. However, high-density EEG is becoming a more popular choice to study brain networks at-rest, especially in infants, due to the fact that it is cheaper, easily applicable in awake non-sedated infants, with less motor-artifacts [11]. In addition, the high-temporal-resolution of EEG can provide more valuable results for network analysis [5]. Also, cross-frequency-coupling is considered appropriate to study the non-linear brain development [8].

It is generally agreed that EEG preprocessing analysis should follow different standards in adults and in infants due to the fact that their brain is still developing and several of their EEG characteristics appear differently. In addition, different steps for artifact identification, rejection and correction are needed, as often their limited recording-time has more motor artifacts [3]. However, there are still no generally accepted preprocessing EEG standards, especially for infants.

Based on our literature review, we concluded in certain EEG preprocessing standards for our study of the visual-attention (VA) network in infants from 5 months until 2 years of age. Notably, VA has been associated with alpha-gamma coupling [1]. We will use high-density EEG (128 electrodes) at-rest, and the preprocessing analysis will be realized in the EEGLAB MatLab.

Firstly, we chose to follow the same order of steps with the recently created EEG infant pipelines [2, 3, 4]; filtering, artifact detection, bad channel rejection, wavelet-enhanced ICA, principal component analysis (PCA), independent component analysis (ICA), epoching, post-segmentation artifact correction, interpolation of epochs, re-reference, baseline correction. Secondly, as in most infant studies [12, 13, 14], the frequency ranges will be set lower than in adults; 6-9 Hz (alpha), 20-50 Hz (gamma). These ranges will not be affected by the normal frequency development as literature has shown that between 5 months and 2 years of age these frequencies will not exceed the above set limits [9]. Thirdly, we chose to perform a low-pass filtering at 50 Hz and instead of high-pass filtering, as it is not suggested for connectivity analysis [15], we will perform piecewise detrending in the SIFT EEGLAB plugin. Also instead of notch-filtering we will perform multi-taper regression via the CleanLine program. Fourth, we decided to follow APICE's [3] -the most recent infant pipeline- artifactual correction process as it is the most methodical and in-depth one, and performs artifact correction, in contrast with most EEG studies, before and after segmentation, with multiple cycles, different algorithms each time, and more flexibility in what is considered an artifact. Fifth, we decided to follow 4-sec epoching as it provides stability and is considered the basis for connectivity analysis [7]. Sixth, we will perform a Common-Average Re-reference as several studies have reported that REST (re-reference at infinity) and the Common Average Reference (CAR) are the best choice for connectivity analysis, providing the most objective functional connectivity [7]. In fact, a recent EEG infant study, which investigated functional connectivity, used CAR [11].

In conclusion, we described the certain key points of the EEG preprocessing standards when studying the development of infantile brain networks. The need to have universally accepted EEG preprocessing steps in infants stems from the fact that better understanding of the typical developmental trajectory of the immature brain is essential in order to create standards that would measure healthy brain development, the consequences of various clinical interventions and predict the potential academic performance.

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