September 20th, 2023 09:00 - 11:00

PARALLEL SESSION 1 - BRAIN 1

ID 1001. Estimation of EEG-maturational age in preterm infants using deep learning models

Mr Johannes Mader[1], Mr Manfred Hartman[2], Mis Laura Gschwandtner[2], Dr. Katrin Klebermass-Scherhof[1], Dr. Tobias Werther[1], Dr. Angelika Berger[1], Dr. Tillmann Kluge[2], Dr. Vito Giordano[1]

[1]Medical University Of Vienna, Vienna, Austria, [2]Austrian Institute of Technology, Vienna, Austria

Background:

The brain of preterm infants is developing very rapidly in an environment different form mother's womb. Hence monitoring the neurological development of such patients is important. Since manual EEG analysis is very tedious, research has recently been focusing on automatic recognition algorithms using machine learning. The aim of this study was to train and compare four featureless machine learning models for estimating the EEG maturational age (EMA) of preterm infants using EEG data collected from amplitude-integrated electroencephalography (aEEG) monitors.

Methods:

This was a retrospective data analysis considering 590 EEG recordings from 197 preterm infants with a mean (std) gestational age at birth of 25.8 (2.1) weeks and 30.2 (3.8) weeks post maturational age (PMA) at the day of recording. We excluded patients with major neurological conditions and recordings performed under sedation. The analysis was performed on the raw three-channel EEG (C3-P3, C4-P4, C3-C4) signal recorded with aEEG monitors.

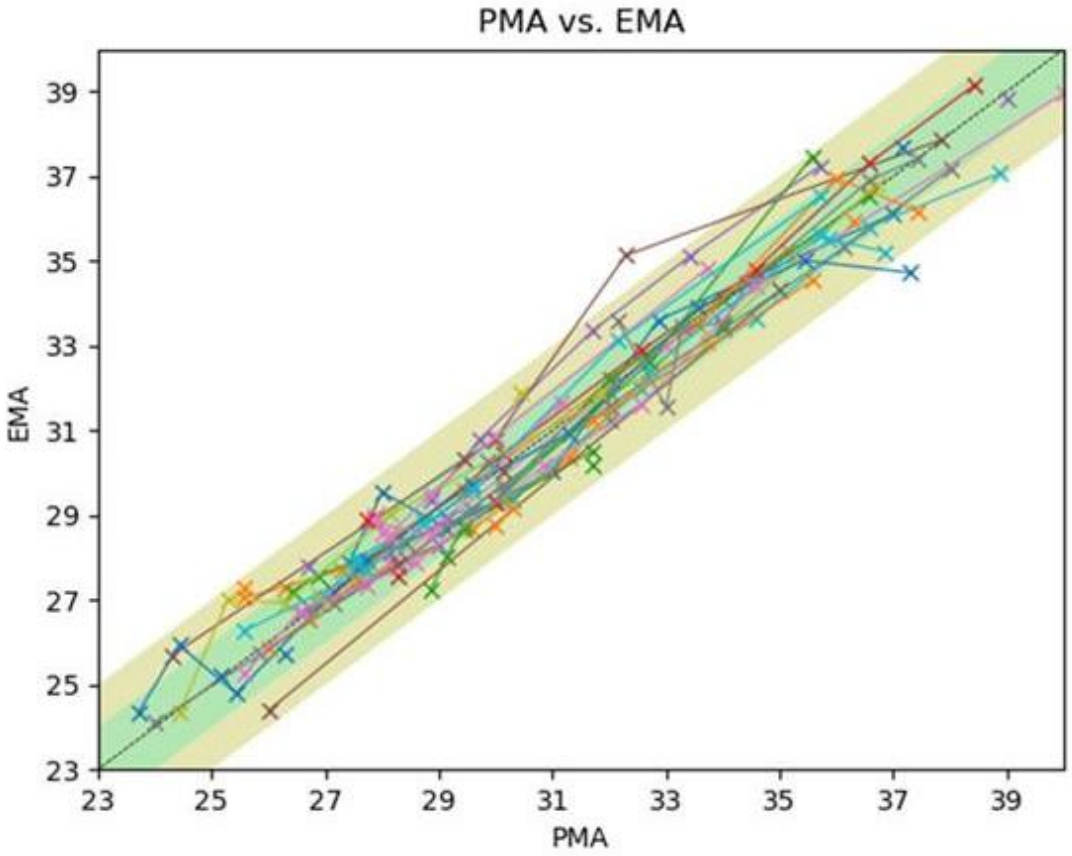
The patient dataset was split into 149 patients for training and 48 patients for testing. Three different convolutional neural network (CNN) models and one hybrid (CNN and long–term memory) model were trained to estimate the PMA based on four channel EEG data using a 6–fold validation. All models were evaluated on the independent test data set to determine the best performing model architecture

Results:

The largest CNN model had the best performance classifying, on average, 74% of all recordings correctly within 1 week of PMA and 95% of all recordings within 2 weeks, see figure 1, outperforming previously published models. The mean standard deviation of that model was 5.9 days within a patient or 6.6 days for all recordings.
Furthermore, we looked at the impact of wide and short convolutional filters in the input layer of the CNN models and found that wide filters have a greater impact on the performance.

Conclusion:

Automated EMA estimation can accurately track the neurological developmental of preterm infants. Using aEEG monitors instead of conventional EEG monitors could improve the applicability of such algorithms in clinical settings, especially when access to EEG experts or multichannel EEG monitors is limited.



PMA and estimated EMA of all recording of the test dataset. Recordings from the same patient are colored the same and are connected by a line.

PMA and estimated EMA of all recording of the test dataset. Recordings from the same patient are colored the same and are connected by a line.

I am imployed via a project funded by the FWF.

ID 913. Early brain activity and development of the central sulcus.

Mr Peter Van De Wetering[1], Dr. Bauke van der Velde[1], Dr. Héloïse de Vareilles[2], Ms. Xiaowan Wang[1], Dr. Jessica Dubois[3,4], Dr. Jeroen Dudink[1], Dr. Manon Benders[1], Dr. Jean François Mangin[4], Dr. Maria Luisa Tataranno[1]

[1]University Medical Center Utrecht, Utrecht, Netherlands, [2]University of Cambridge, Cambridge, UK, [3]University of Paris, NeuroDiderot, INSERM, Paris, France, [4]UNIACT, NeuroSpin, CEA, Paris–Saclay University, Gif–Sur–Yvette, France

Introduction

A delay in the sulcation of the central sulcus in extremely preterm born infants may potentially contribute to impaired motor outcome later in life. Therefore, the identification of early biomarkers that can assist in predicting neurodevelopmental outcomes would be highly advantageous. The current study investigates the relationship between early brain activity and central sulcus maturation between 30 and 40 weeks of gestation in infants born extremely preterm (GA< 28 weeks), without major brain injury.

Methods

In the current study, 26 infants (GA Mean = 26.8, SD = 1.0, Birthweight mean = 948, SD = 179) were included and monitored with continuous two–channel aEEG during the first 72 h after birth and scanned twice using MRI around 30 weeks post–menstrual age (PMA) and term–equivalent age. Theta power was calculated from raw EEGs. Central sulcus (CS) length, and CS surface growth were calculated as the difference (delta) of the CS length and surface between the 30– and 40–weeks MRI scans. Relative CS length and surface growth were calculated by adjusting the absolute values for global gyrification index. Linear correlations were performed between theta power and absolute CS length and surface growth. Correlations were adjusted for GA and age at scan.

Results

Significant correlations were observed between spectral theta power on day two and right hemisphere central sulcus length growth (r = −.478 , p = .021), bilateral length growth (r = −496 , p =.024) and left (r = −.444, p =.034), right (r = −.528, p = .01) and bilateral (r = −.517, p = .012) surface growth.

Conclusion

These results suggest that early spectral theta power may be a possible predictor of central sulcus maturation. Whether these results may provide a new biomarker for early prediction of motor impairment is worth to be investigated in future studies. The ability to predict brain development and subsequent outcomes using non invasive neuromonitoring, early after birth, could be beneficial in providing timely treatment and interventions due to the increased plasticity of the young preterm's brain.

None declared.

ID 657. Maturational trends of neonatal sleep obtained by fully automated sleep analysis

Doctor Anneleen Dereymaeker[1], Ir. Tim Hermans[2], PhD Bieke Bollen[1], Prof. Dr. Katrien Jansen[3], Prof. Ir. Maarten Devos[2], Prof. Dr Gunnar Naulaers[1]

[1]Neonatology, Department of Development and Regeneration, University Hospitals KU LEUVEN, Leuven, Belgium, [2]STATIUS ESAT KU LEUVEN, Leuven, Belgium, [3]Child Neurology, Department of Development and Regeneration, University Hospitals KU LEUVEN, Leuven, Belgium

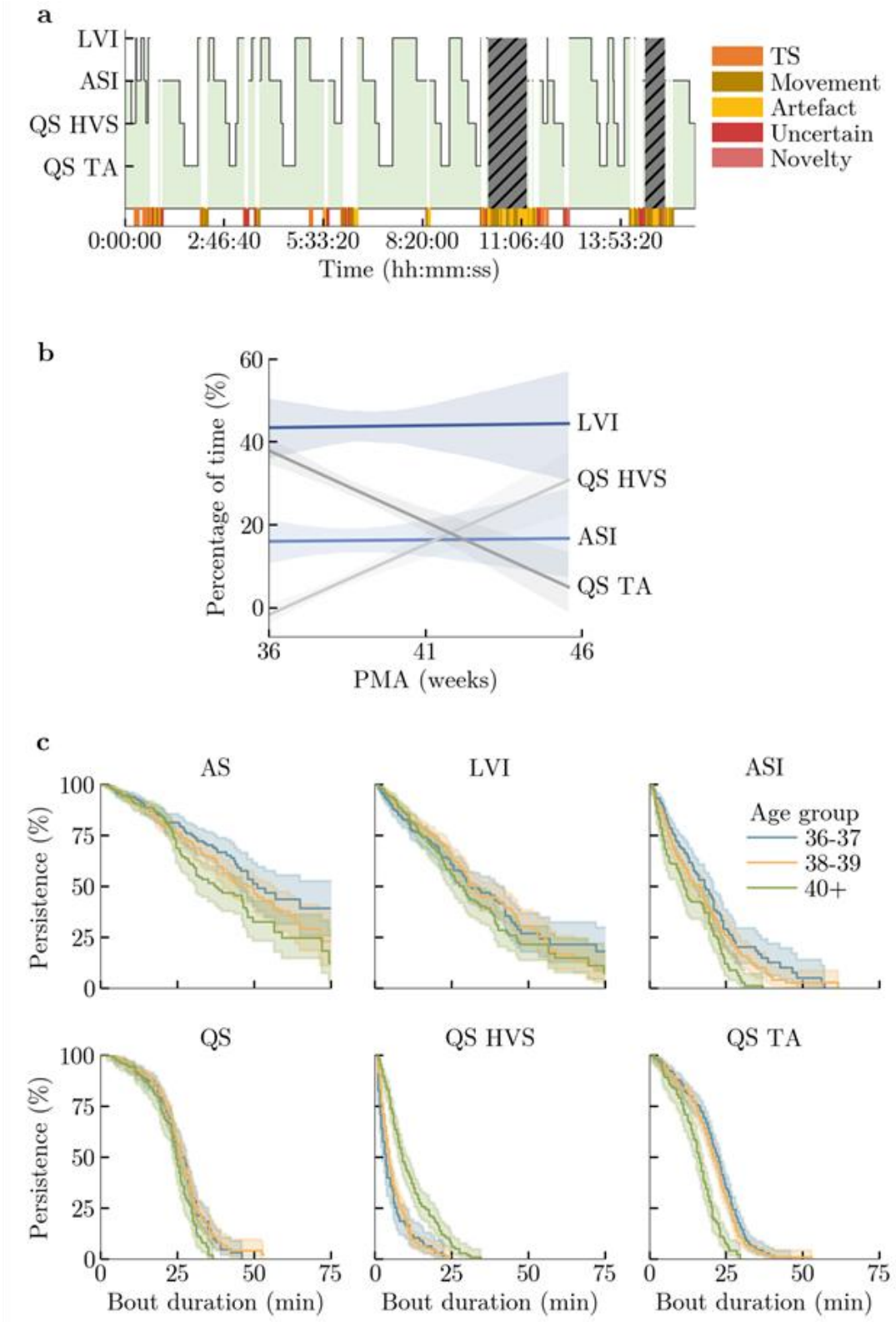
Background: The physiological importance of coherent sleep for our health and wellbeing cannot be overemphasized. Understanding the contextual framework of neonatal sleep in the organization of brain networks carries clinical potential. These neonatal sleep patterns have been described based on visual scoring. This study aims to describe normative results of neonatal sleep using a fully automated sleep staging.

Method: In 79 preterm infants (GA 23 6/7 – 33 6/7 weeks), multichannel–EEG was performed between 36 to 45 4/7 weeks PMA. All infants have a normal BSID– III score at 24 months. Polysomnography was performed overnight (mean duration of 16h (±2h). This sleep staging algorithm consists of five sequential steps: artefact detection, data cleaning, sleep state classification, reliability analysis and hypnogram construction. The sleep staging step classifies each 30–segment as one of four sleep states: LVI, ASI, QS–HVS or QS–TA. The reliability step checks whether predictions are reliable by identifying artefacts and uncertain predictions. Ultimately, during hypnogram construction, each 30–second segment is labeled as LVI, ASI, QS–HVS, QS–TA, Artefact, Uncertain or Transitional Sleep (TS).

Results:

In all age groups (36–37, 38–39, 40+ PMA weeks), approximately two thirds of the recording are labelled as sleep, the remaining as unreliable due to artefacts or uncertainty. Using Kaplan–Meier Survival curves for sleep bouts per age group and the Cox regression model, a significant affect of PMA on sleep bout duration is found for AS, QS–HVS and QS–TA. The QS–HVS state becomes more dominant, whereas time spent in QS–TA decreases. Sleep cycles last a little less than one hour, and the sleep time is around 55 minutes. No differences in duration are found between PMA–age groups. Approximately 60% of a sleep epoch consists of AS and approximately 37% of QS., and 3% is attributed to TS. We observed an increasing percentage of artefacts with PMA, interpreted as a surrogate for movement or awake.

Conclusion: This ‘quantitative sleep’ modeling approach is congruent with visual scoring in literature. This model can contribute to a pipeline for automated reporting of sleep parameters by mapping datasets from different neonatal cohorts, which offers improved diagnostic characterization of neonatal sleep–wake architecture.


a
LVI
ASI
QS HVS
QS TA
TS
Movement
Artefact
Uncertain
Novelty
0:00:00
2:46:40
5:33:20
8:20:00
11:06:40
13:53:20
Time (hh:mm:ss)
b
Percentage of time (%)
60
40
20
0
LVI
QS HVS
ASI
QS TA
36
41
46
PMA (weeks)
c
AS
LVI
ASI
Age group
36-37
38-39
40+
QS
QS HVS
QS TA
Persistence (%)
100
75
50
25
0
0
25
50
75
Bout duration (min)

a. Hypnogram

b. Regression lines (95%CI) for the sleep state distributions as function of PMA.

c. Kaplan–Meier curves for the sleep bout durations for each sleep state per age group

a. Hypnogram

b. Regression lines (95%CI) for the sleep state distributions as function of PMA.

c. Kaplan–Meier curves for the sleep bout durations for each sleep state per age group

None declared

ID 316. Sound(a)sleep - A Pilot study Investigating the acoustic landscape on NICU and its effects on sleep wake cycling in preterm neonates

Miss Magdalena Smolkova[1], Professor Topun Austin[2], Dr Andrea Edwards[2], Ms Lynn Thompson[3], Dr Katherine Beardsall[3], Mr Alex Grafton[4]

[1]School of Clinical Medicine, University Of Cambridge, Cambridge, United Kingdom, [2]Evelyn Perinatal Imaging Centre, Cambridge University Hospitals NHS Foundation Trust, Cambridge, United Kingdom, [3]Department of Paediatrics, University of Cambridge, Cambridge, United Kingdom, [4]Department of Engineering, University of Cambridge, Cambridge, United Kingdom

Background

Impaired sleep–wake cycling has been shown to affect the functional connectivity of the neonatal brain. Preterm infants display impaired functional brain connectivity and disturbance of sleep–wake cycling may further exacerbate it.

Evidence suggests that neonates physiologically respond to sound stimuli, and that sound protection devices and “quiet time” may increase the proportion of time infants spend asleep.

We hypothesised that the native acoustic landscape on NICU would alter sleep behaviour in premature neonates and developed a method to measure this effect.

Methods

A prospective pilot study of 6 preterm infants on NICU was carried out following informed parental consent. Infants were observed for 3 hours each and their behaviour was recorded using an iPad app interface recording each behaviour and its exact timing. This was based on the Behavioural Sleep Stage classification for Preterm Infants (BeSSPI). Sound level was recorded by two sound meters in the cot

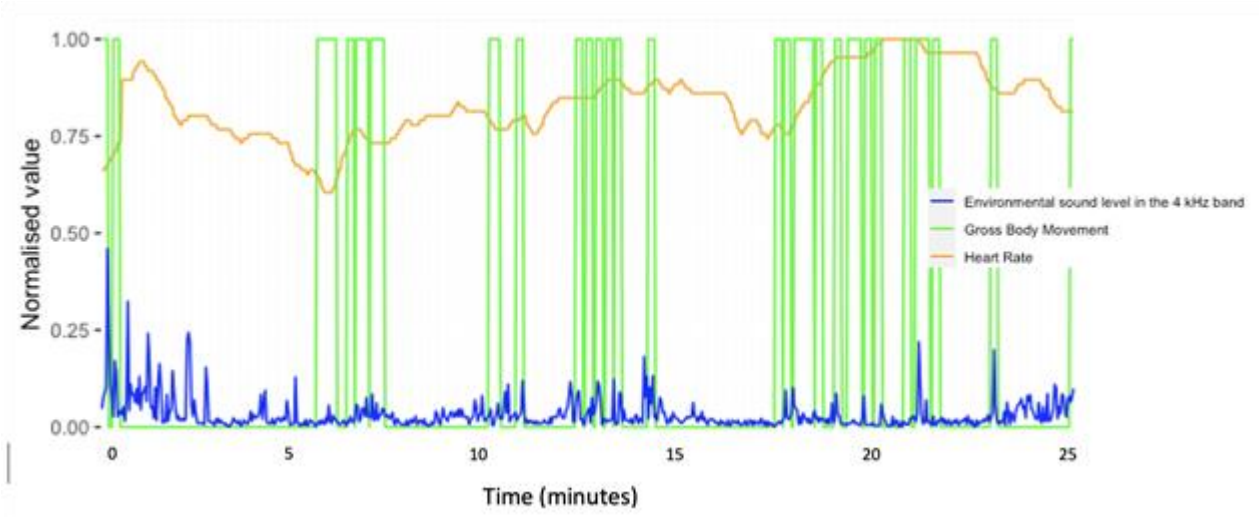
and the environment at a constant distance from the cot. Physiological data were extracted from the monitoring device. Data was analysed on a second–by–second basis using generalised linear modelling for the increased occurrence of gross body movement (GBM) in response to increased sound level of different frequencies. Frequencies used for analysis, 2, 4 and 8 kHz, were shown to best correlate with physiological responses through preliminary analysis of 24–hour recordings.

Results

In three infants, the probability of GBM increased significantly with increasing environmental and cot sound. In two infants, one of whom was in a sound–proof incubator, this relationship was only significant for cot sound. One infant, who was ventilated and sedated at the time of observation, did not show any relationship. 5/6 infants showed a steeper relationship with A–weighted sound, which assigns greater weight to sound audible to the human ear, as opposed to the flat Z–weighted trace. Furthermore, the proportion of time spent performing GBM seemed to increase with A–weighted peak sound pressure level (ns).

Conclusion

This pilot data suggests the native NICU acoustic landscape alters the sleep behaviour of preterm neonates, and a larger prospective study is planned to relate sleep behaviour and the development of functional connectivity.



Example trace showing behaviour–sound correlations. GBM is recorded as either 1 (present) or 0 (absent) with vertical lines representing change. Heart rate and sound level are plotted as normalised values.

Example trace showing behaviour–sound correlations. GBM is recorded as either 1 (present) or 0 (absent) with vertical lines representing change. Heart rate and sound level are plotted as normalised values.

No conflict of interest