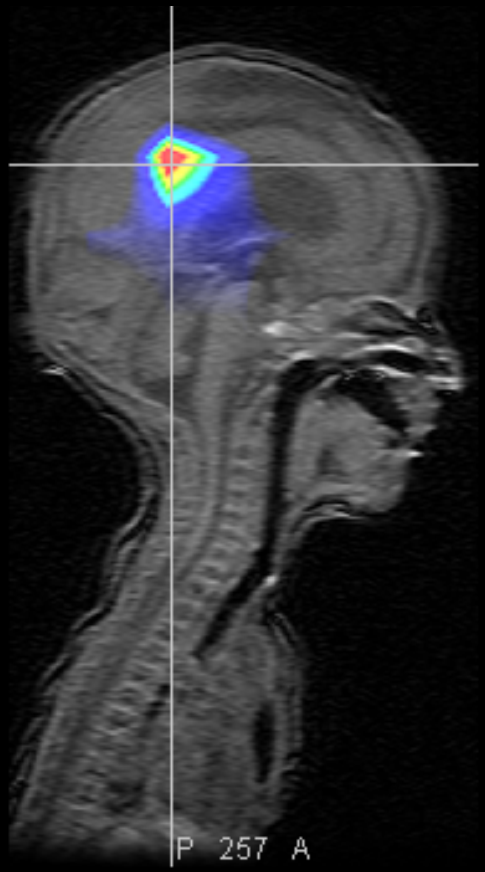


High resolution EEG in premature

What's new

ANR Maia

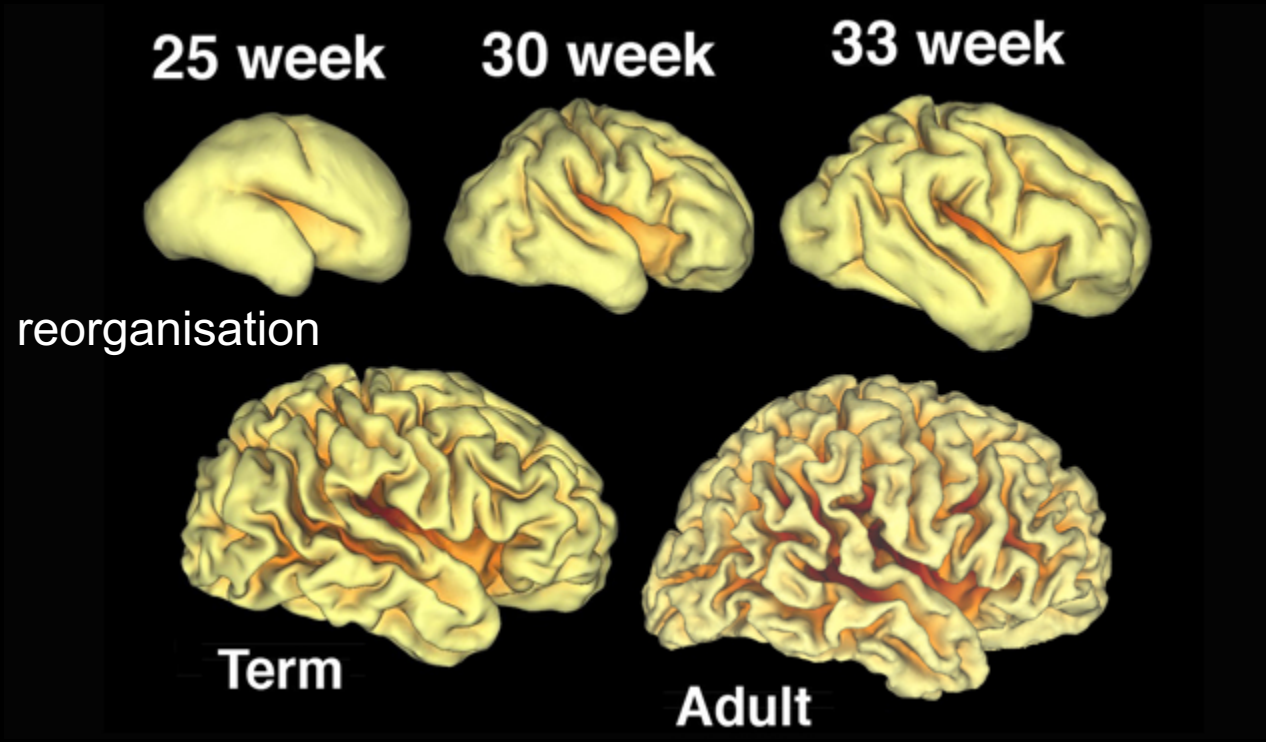
GRAMFC

Inserm UMR 1105

Groupe de Recherche sur l'Analyse Multimodale de la Fonction Cérébrale

Cerebral maturation in foetus

- Celular proliferation
- Cellular Migration
- Cellular differentiation
- Synaptic selection and reorganisation
- Gyration
- Myelinisation



Cerebral maturation in foetus

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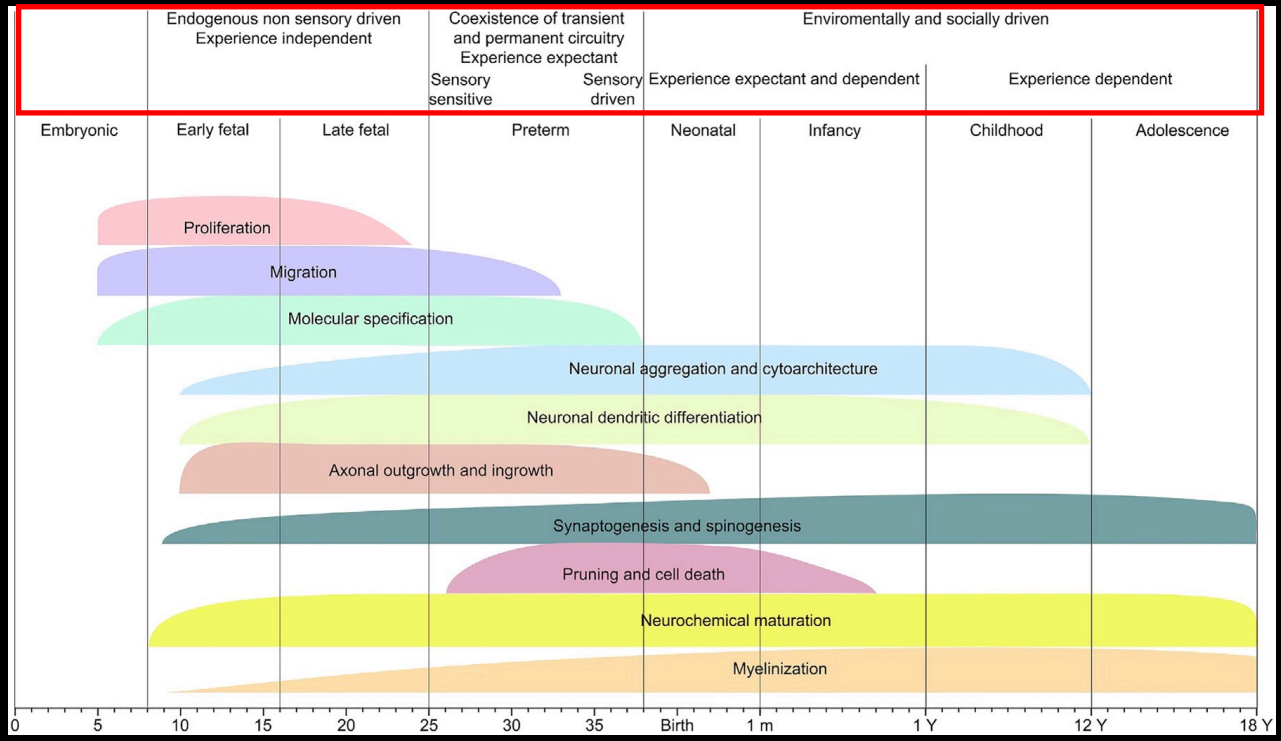
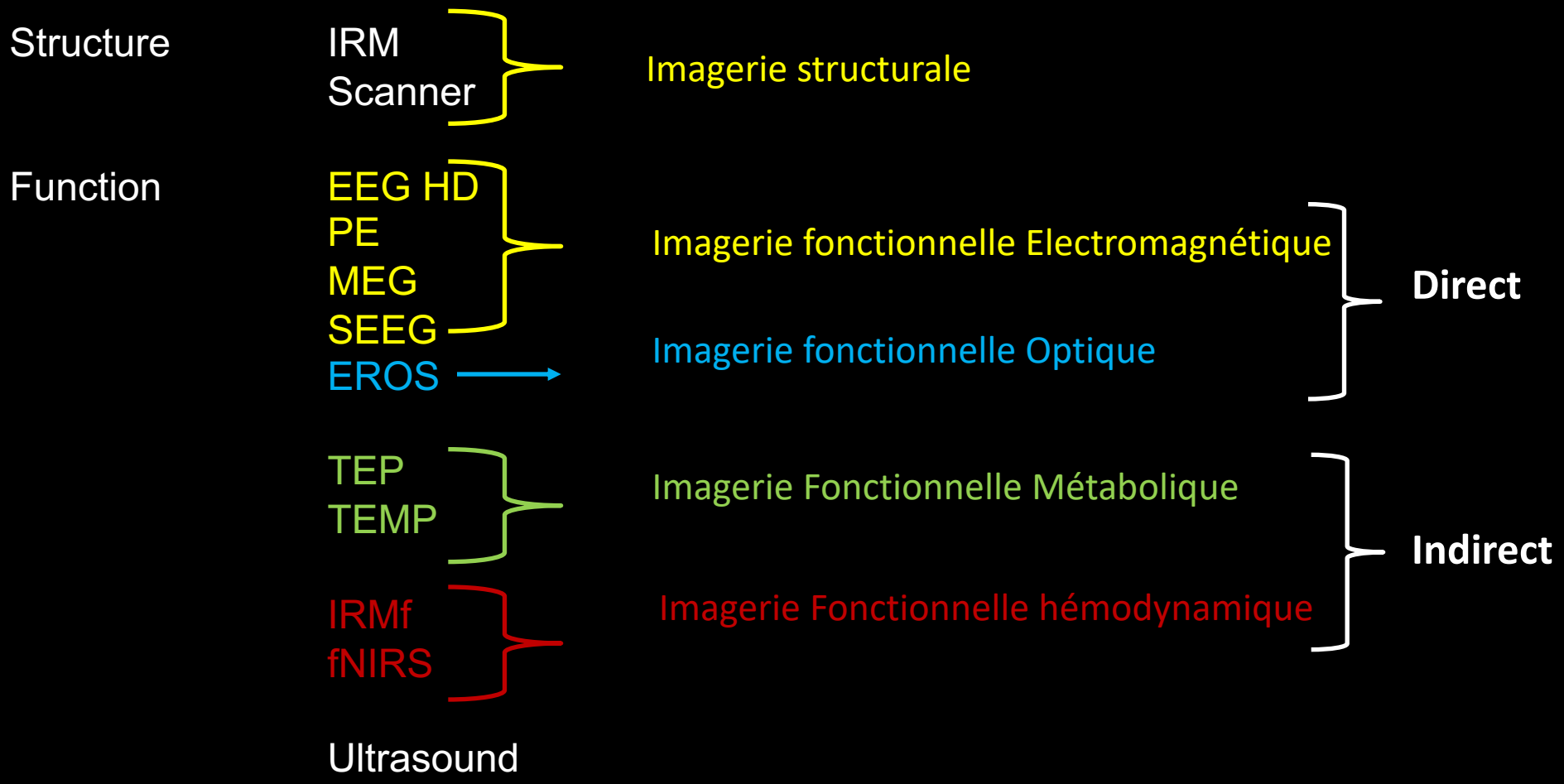


Quels outils pour analyser la fonction cérébrale



n. Pyramidal
Perp. Surface
Nb Important
Synchro.
Resolution msec
Champs élect (EEG, PE)
Champs magnét (MEG)

Neur, Astrocytes
Membranes
No Orientation,
No synchro
Msec

Neur and astrocytes
No orientation
No synchro.
Couplage neurovasc
HbO, HbR (fNIRS)
HbR (IRMf)
msec (IfNIRS), sec (IRMf)

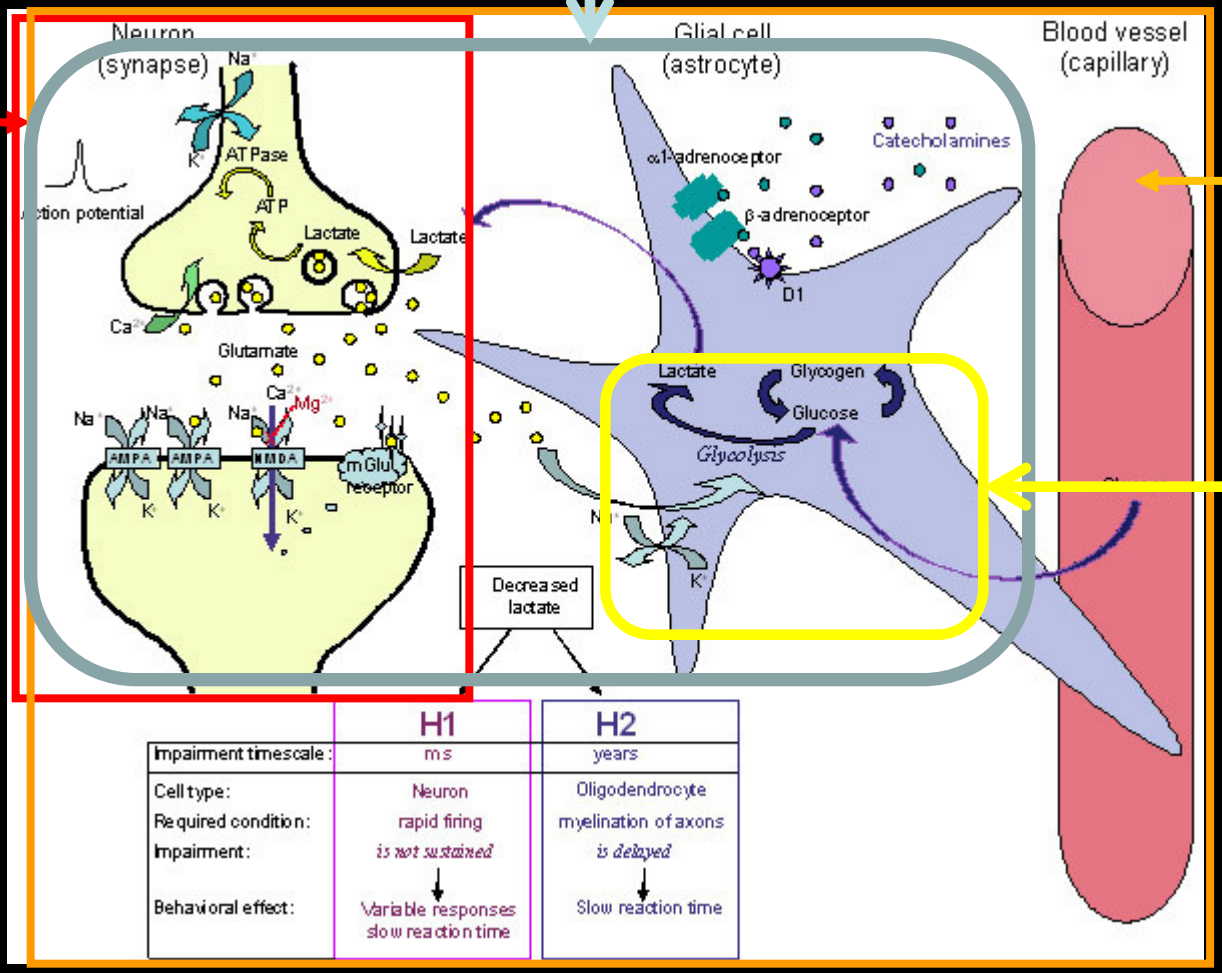
EROS, Fast NIRS

EEG MEG PE

fNIRS
IRMf

TEP
SPECT

Métabolisme
Glucose
Min.

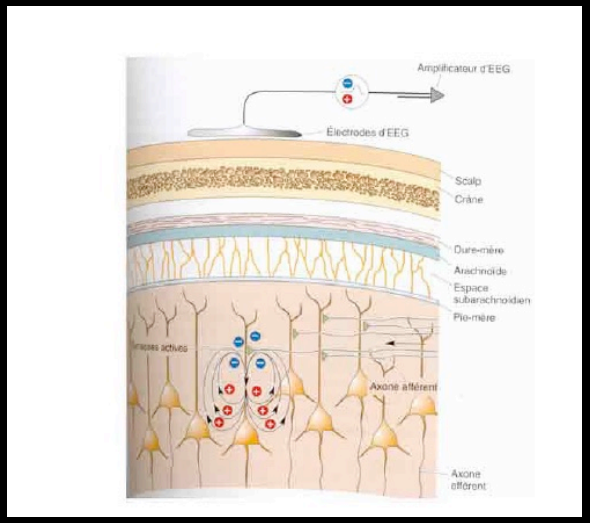


	H1	H2
Impairment timescale :	ms	years
Cell type:	Neuron	Oligodendrocyte
Required condition:	rapid firing	myelination of axons
Impairment:	*is not sustained*	*is delayed*
Behavioral effect:	↓ Variable responses slow reaction time	↓ Slow reaction time

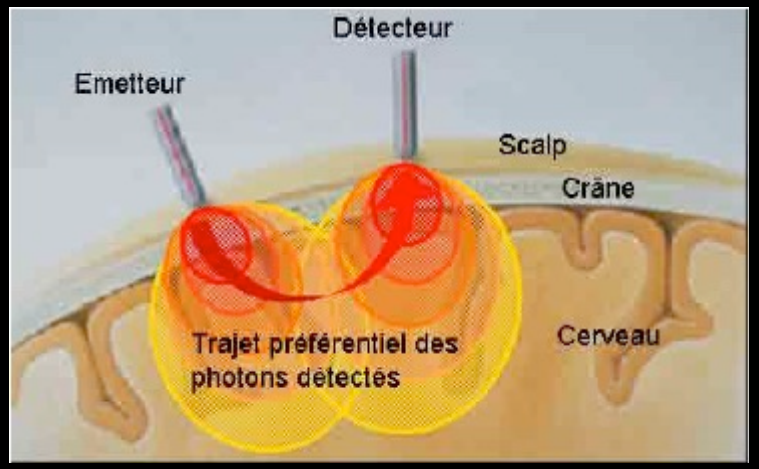
A – Analysis of brain development in premature

Tools for the analysis of brain function

Structure	MRI Scanner		
Function	EEG NIRS MEG TEP SPECT IRMf Ultrafast Ultrasound	EEG NIRS	Electric Hemodynamic

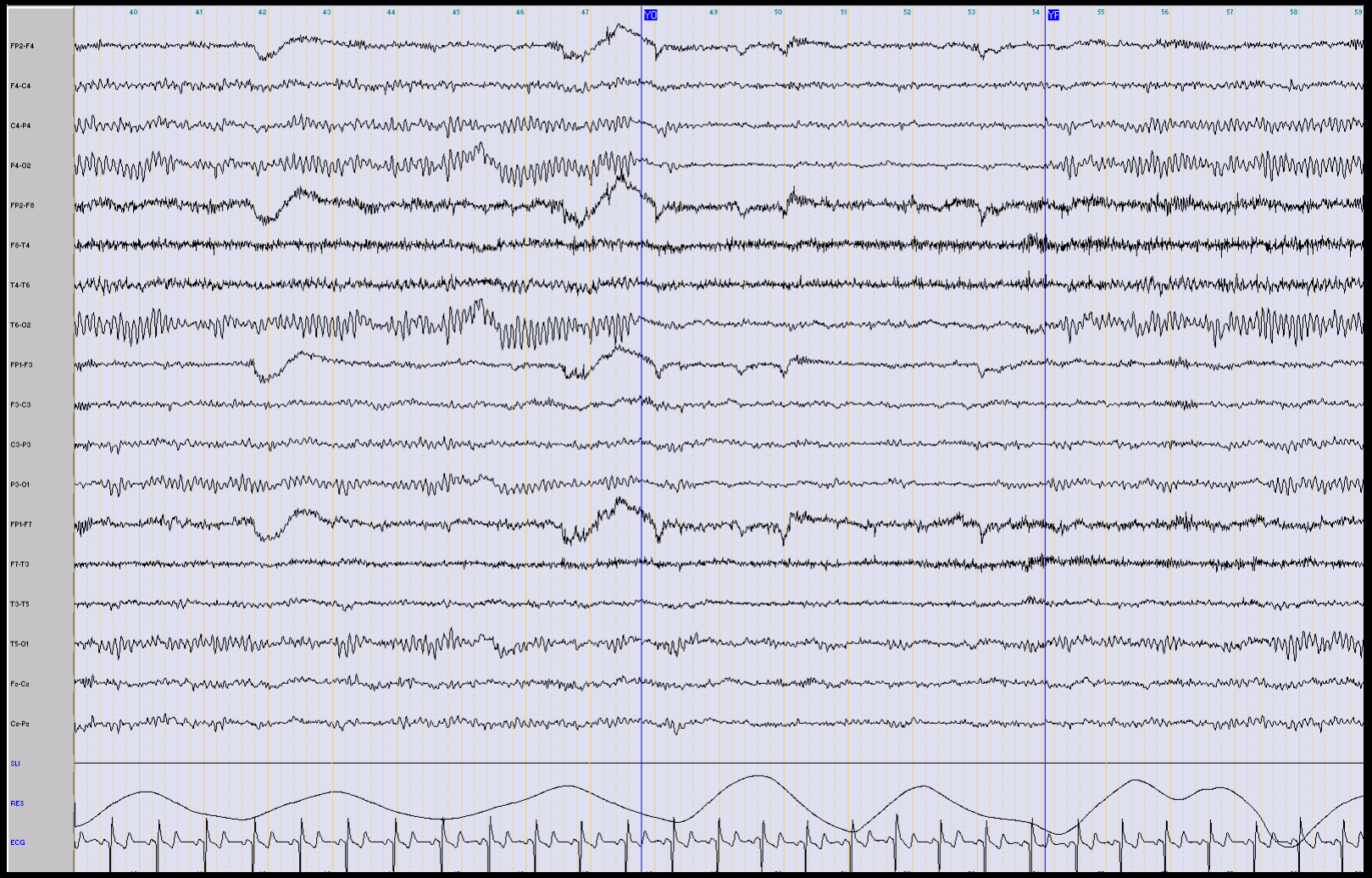


EEG

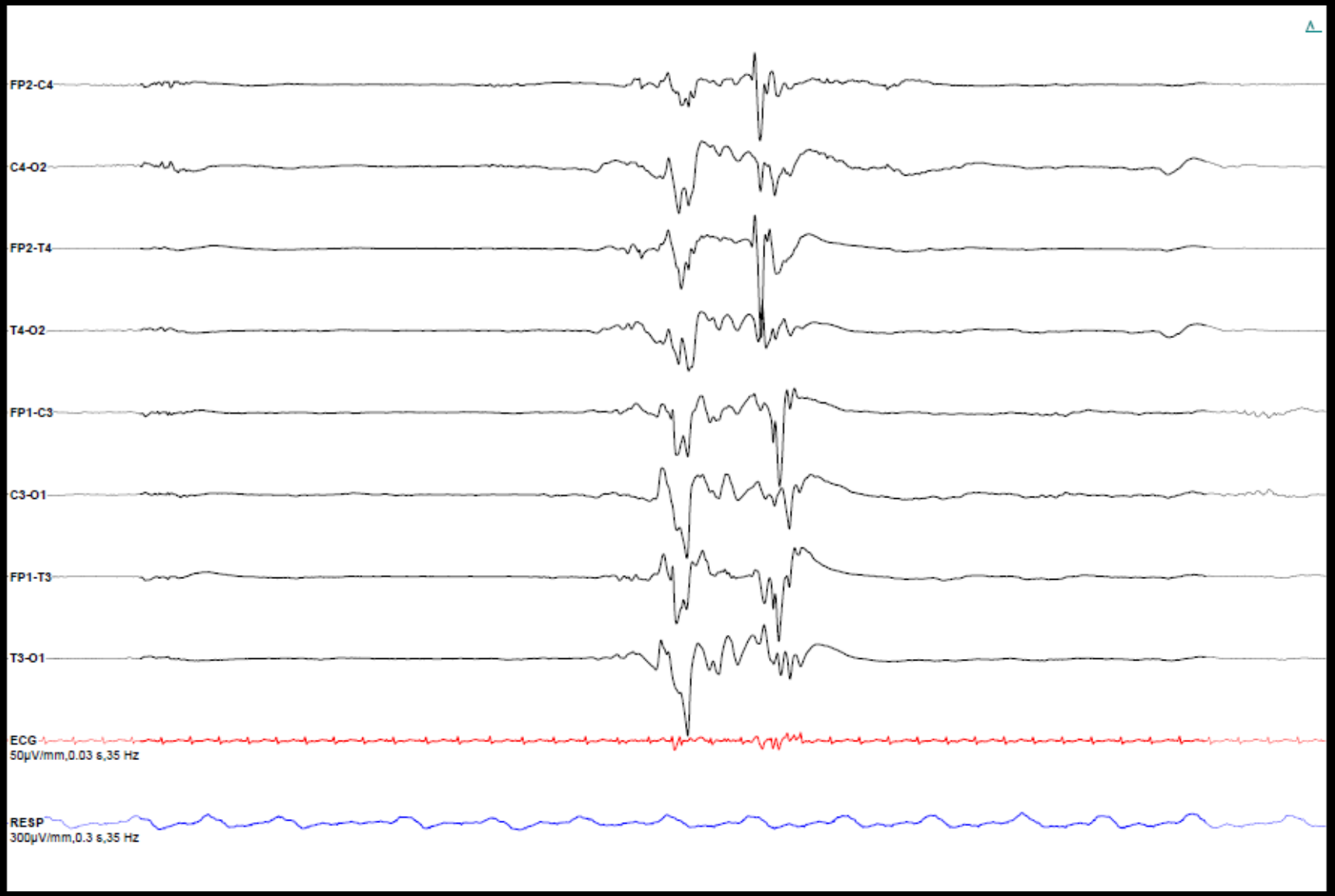


NIRS

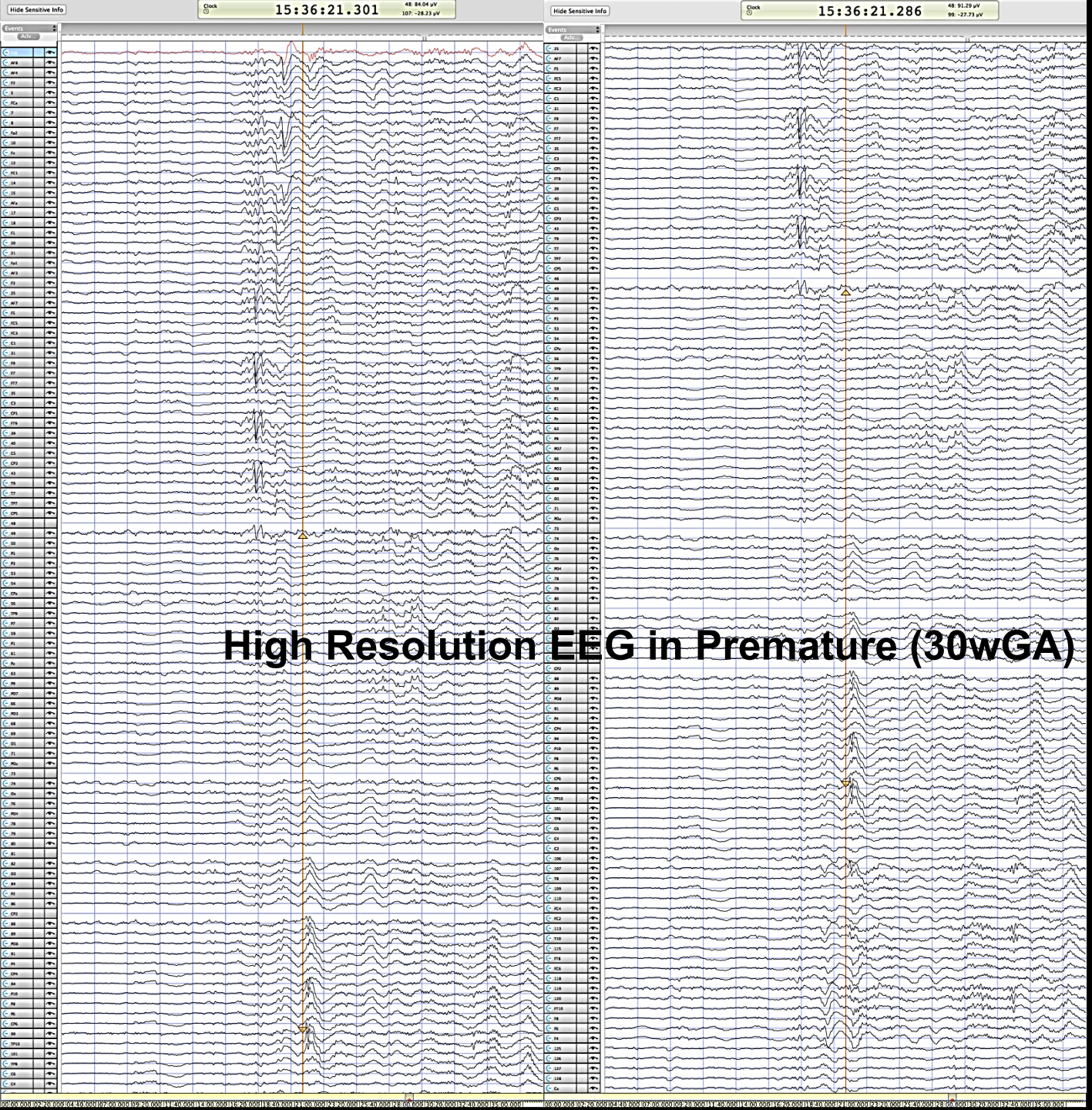
A – Analysis of brain development in prematures
EEG in 16 Y old children



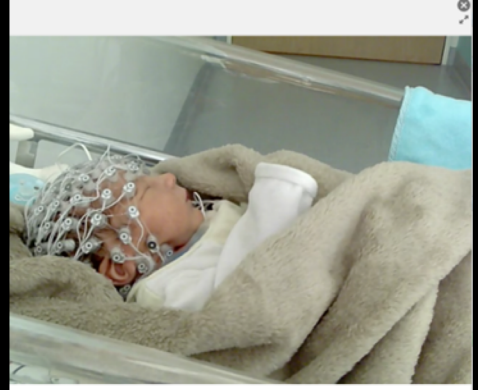
A –Analysis of brain development in prematures
EEG in 25 wGA premature

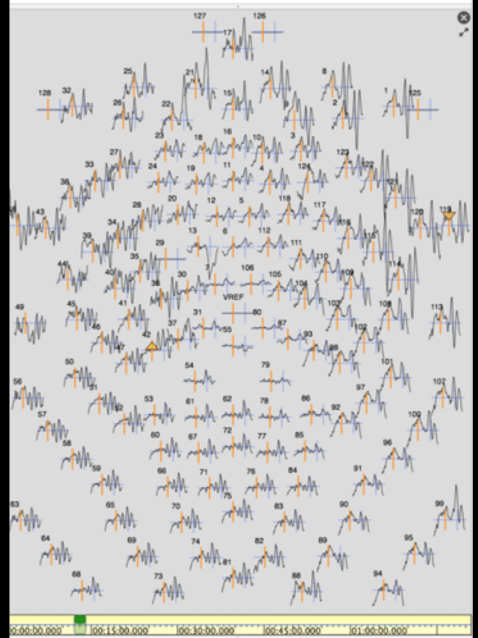


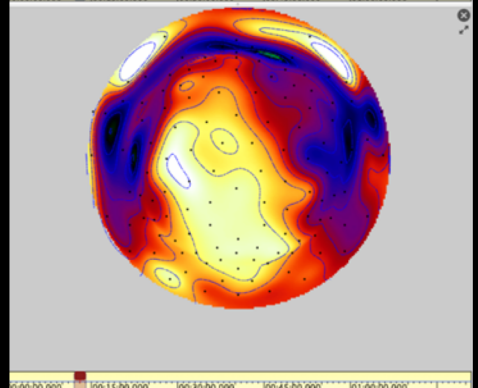
The XXI century in neonatal EEG



High Resolution EEG in Premature (30wGA)







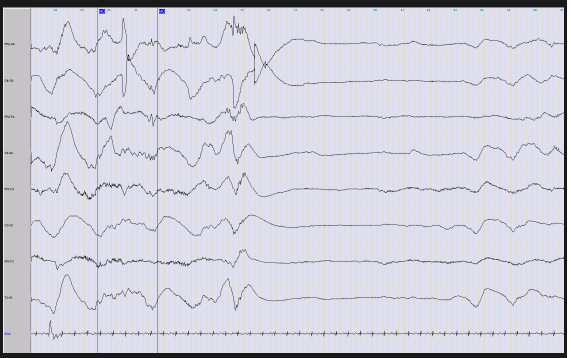
A – Analysis of Brain Development in prematures

A2: rational

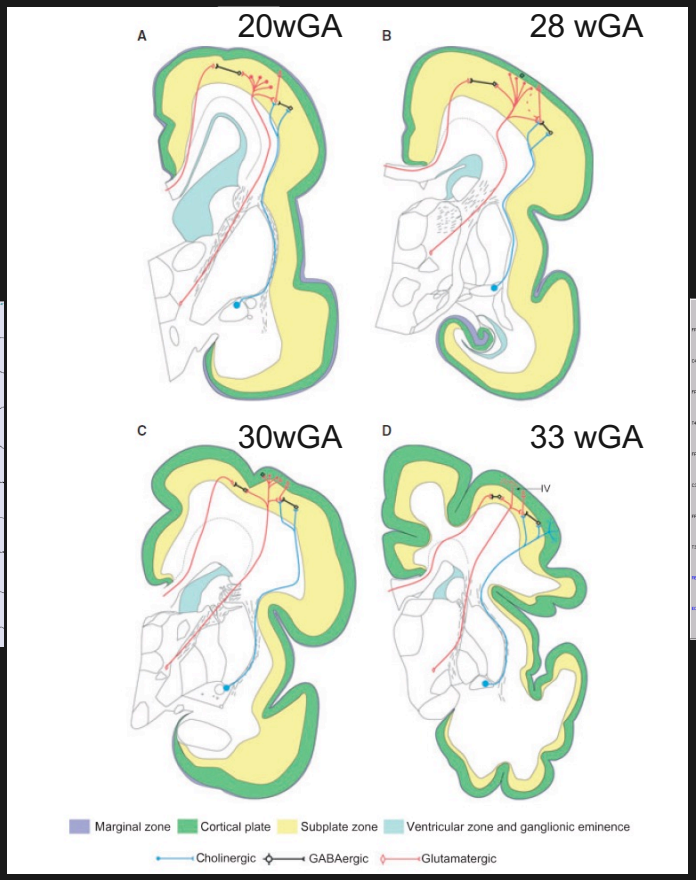
The immaturity of the cortex between 28 and 32 wGA

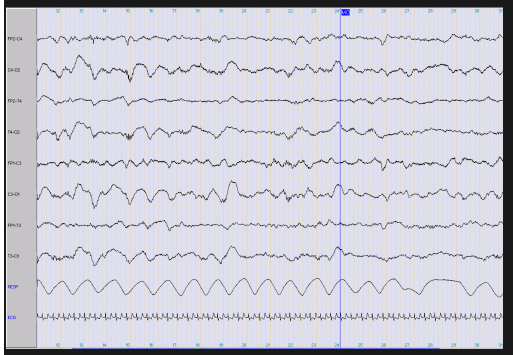
Mesoscopic level

The subplate



28 wGA





33wGA

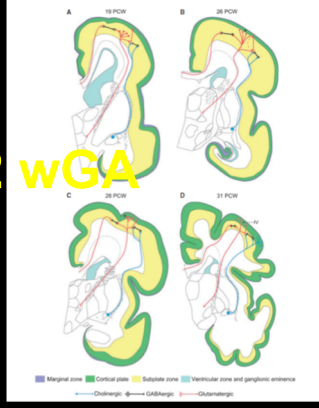
20-26wGA the subplate receive thalamocortical afferents
26-28wGA the first afferents reach the cortical plate
28-30wGA the first synapses occur in the cortical plate

Kostovic, 2010

A – Analysis of Brain Development in prematures

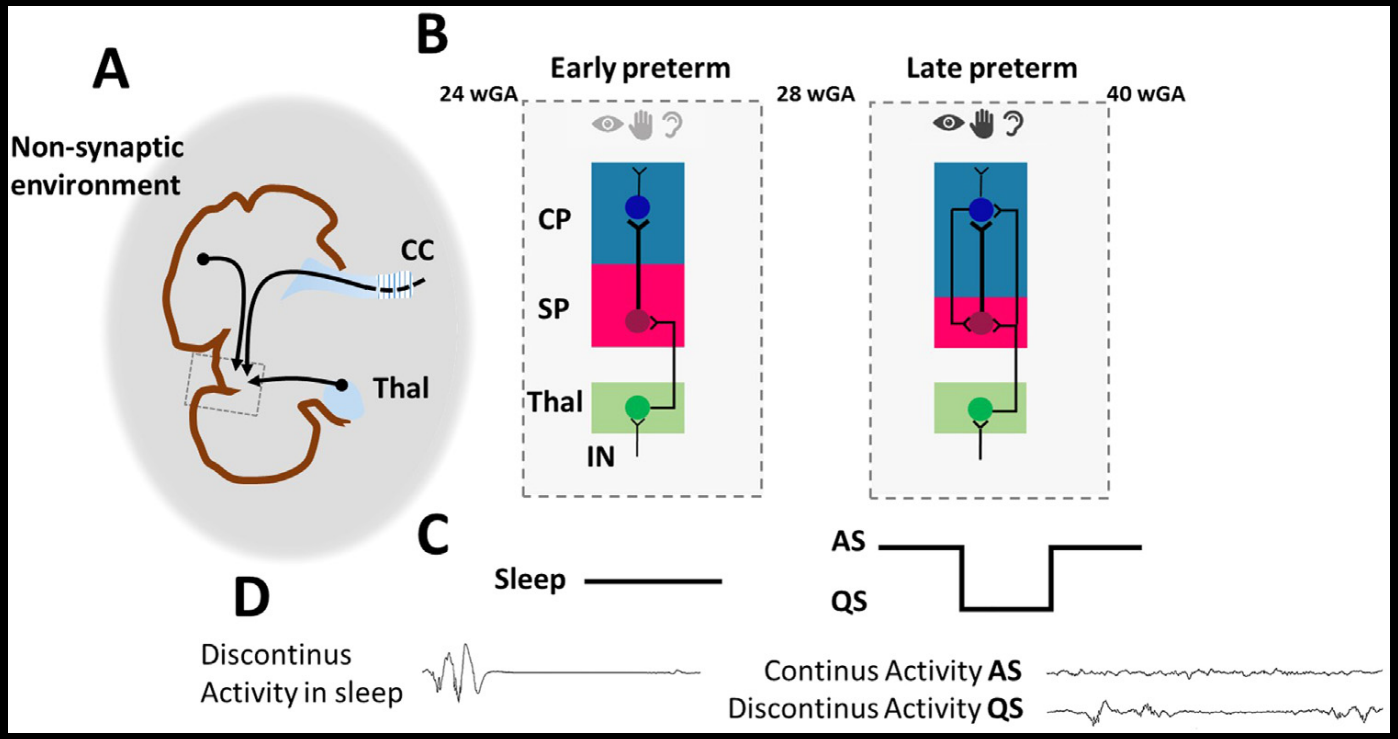
A2: rational

The immaturity of the cortex between 28 and 32 wGA



Mesoscopic level

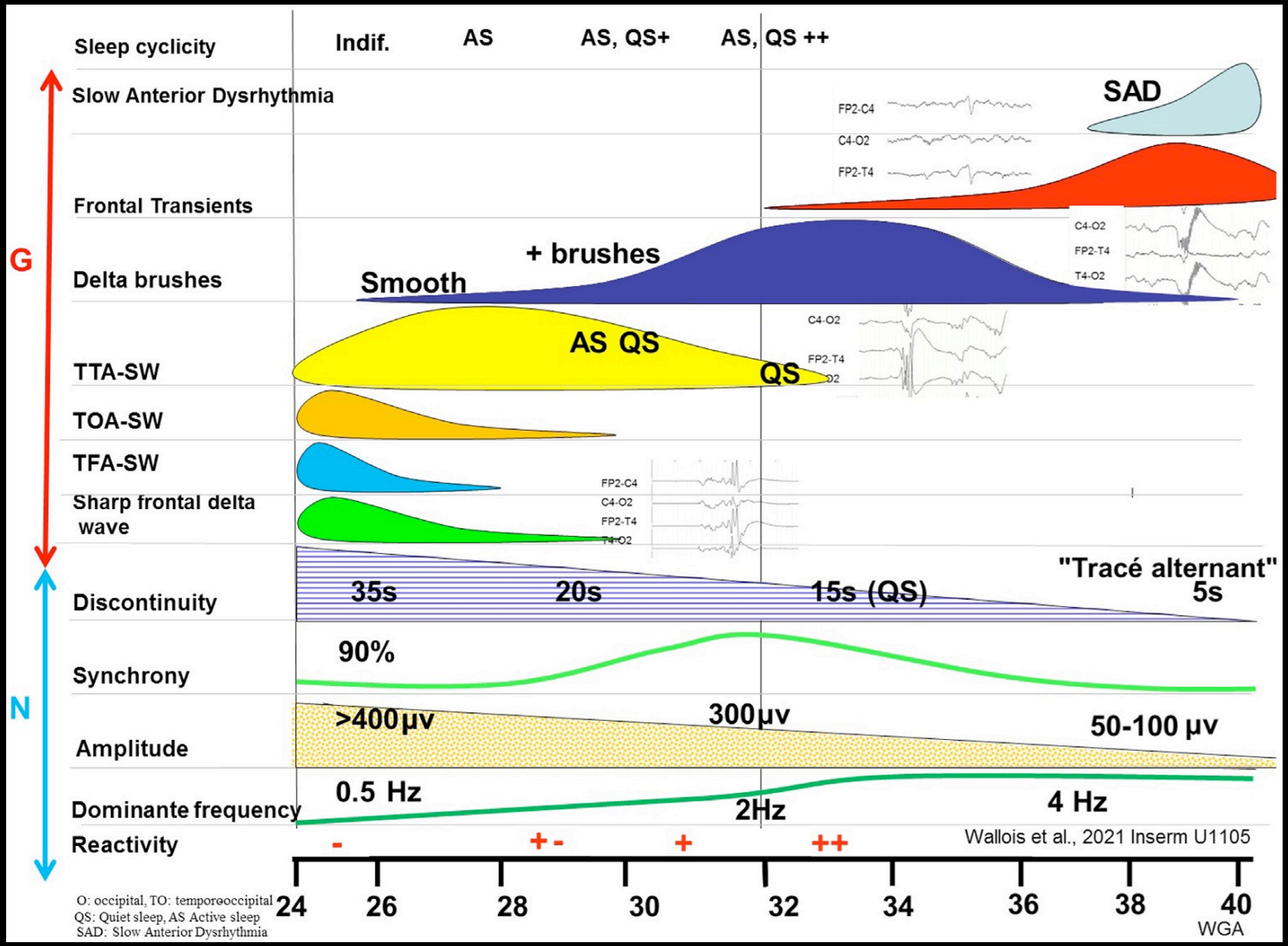
The subplate



Wallois et al., 2021

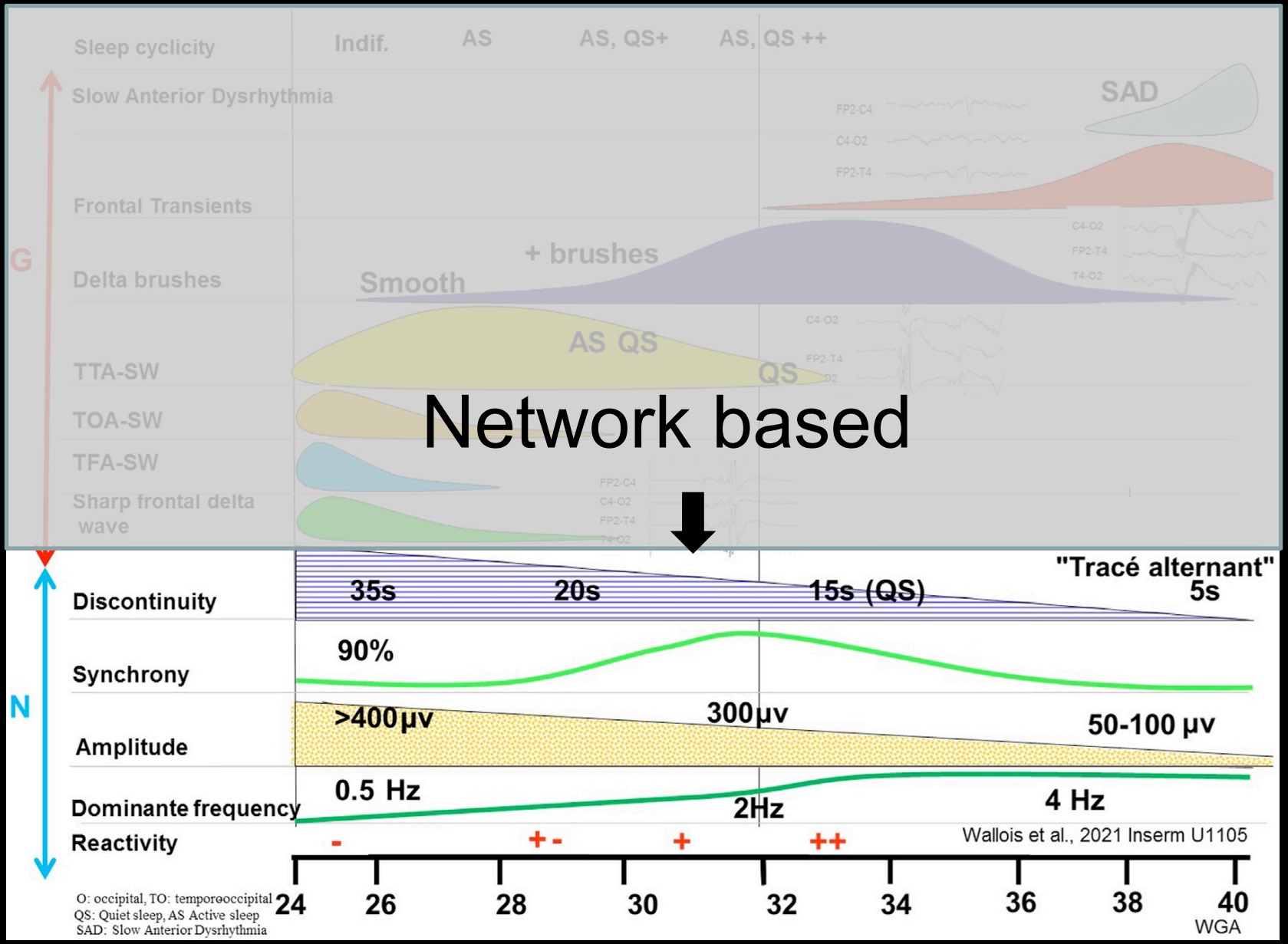
Complex structural and functional relationship?

The synopsis of functional electrical activitis of the immature brain



Wallois et al., 2021

The synopsis of functional electrical activitis of the immature brain

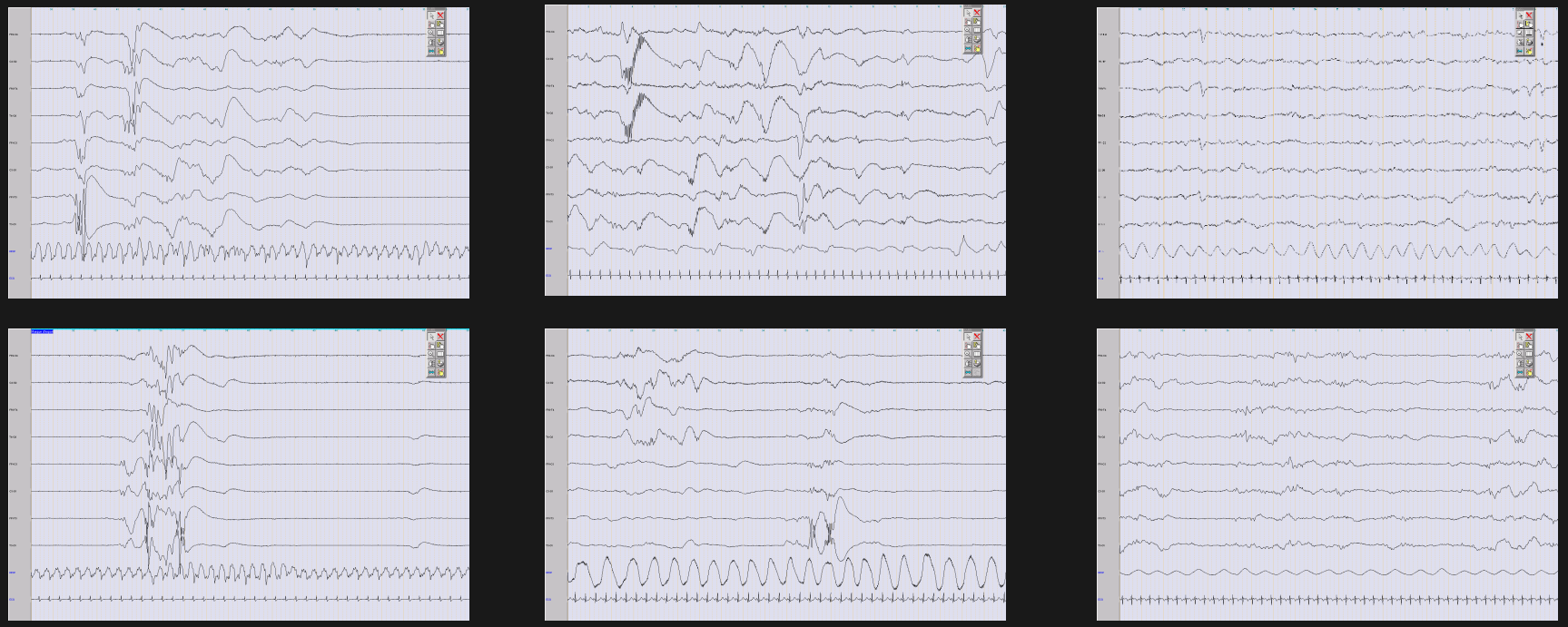


Wallois et al., 2021

B – Analysis of Brain Development in prematures
B2: rational

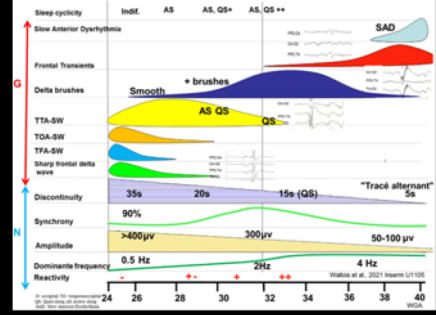
The immaturity of the cortex in 28-32 w GA premature

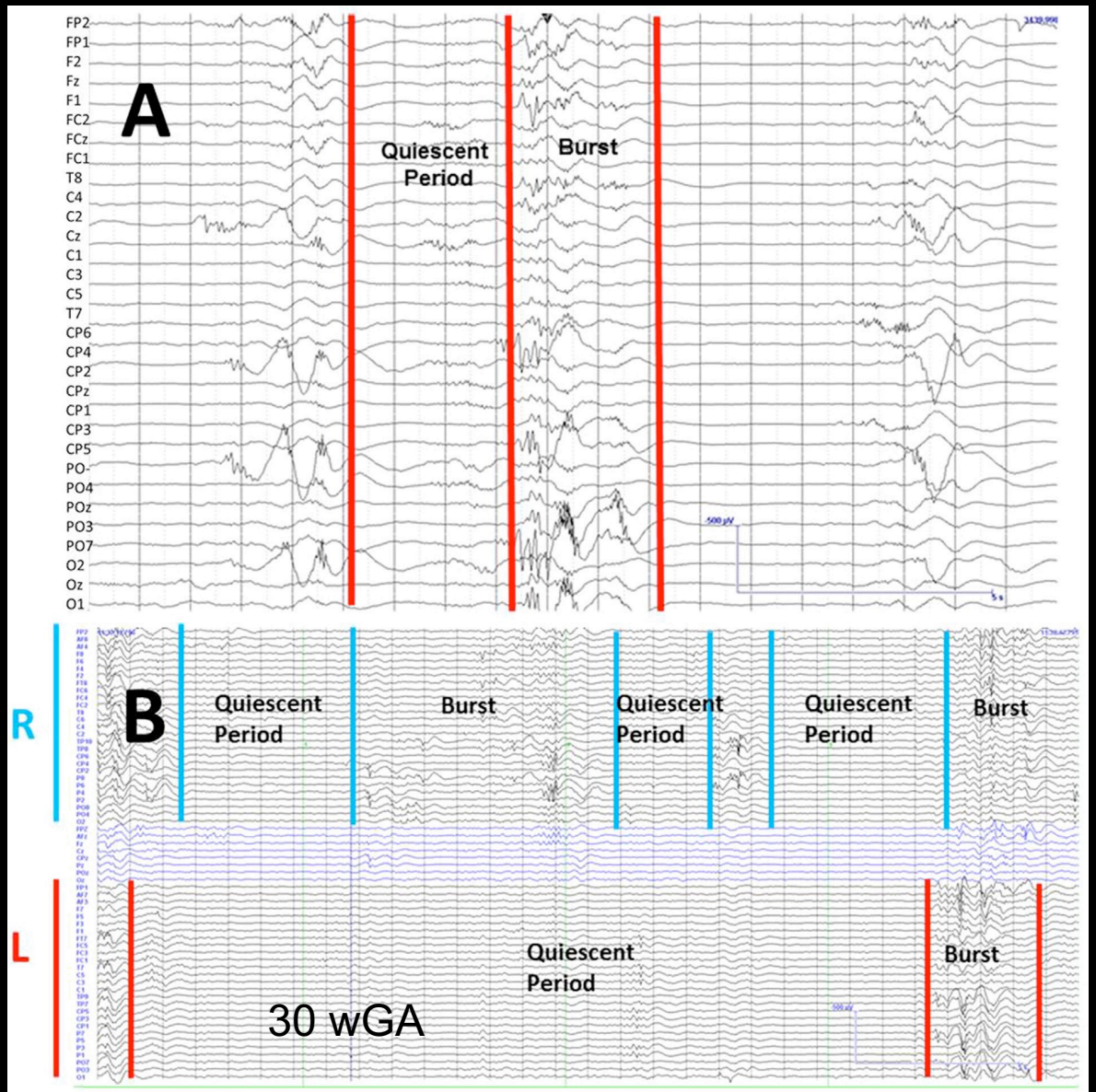
EEG in preterm is the marker of functional immaturity of the brain

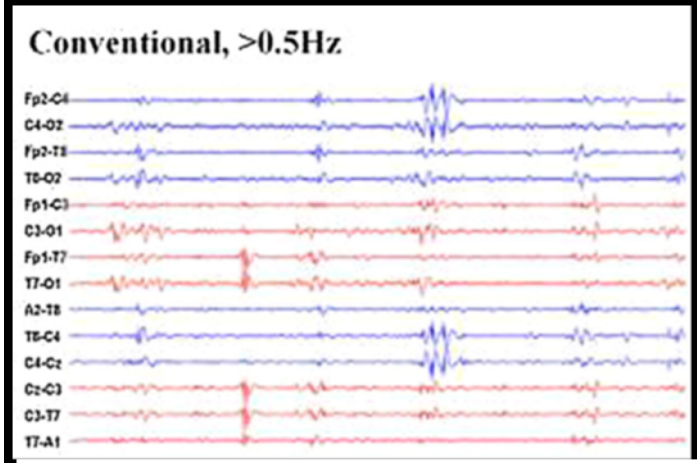


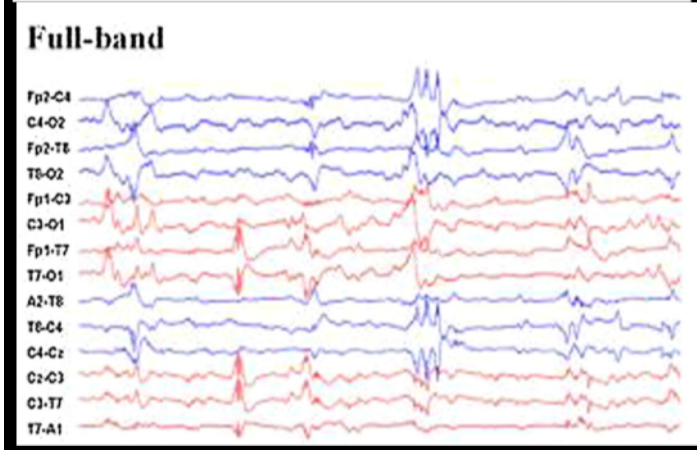
The discontinuity suggests that some generators are modified with the development
The occurrence of sleep stage suggests functional input from the reticula

The synchrony, the quiescence, the bursts



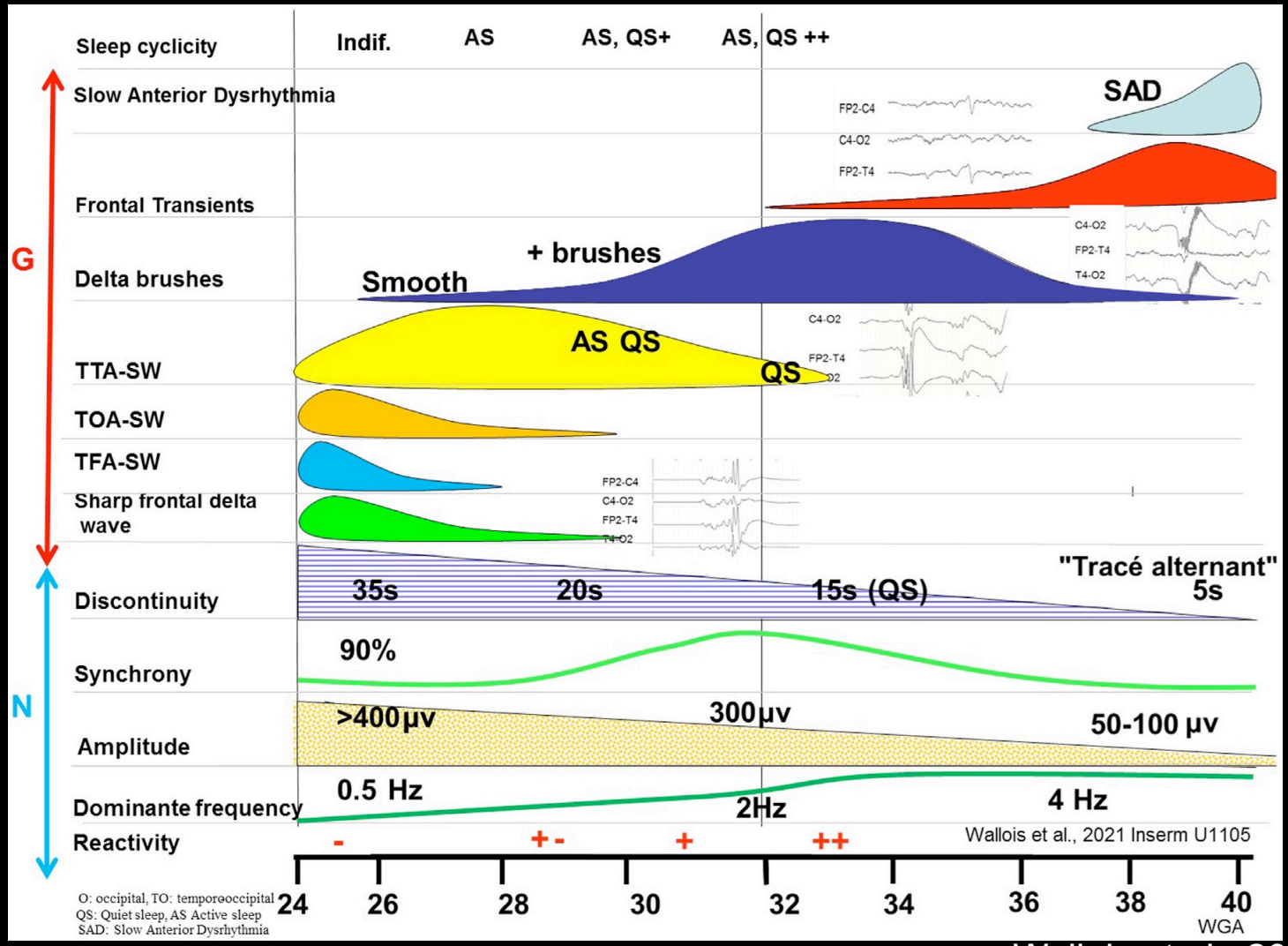






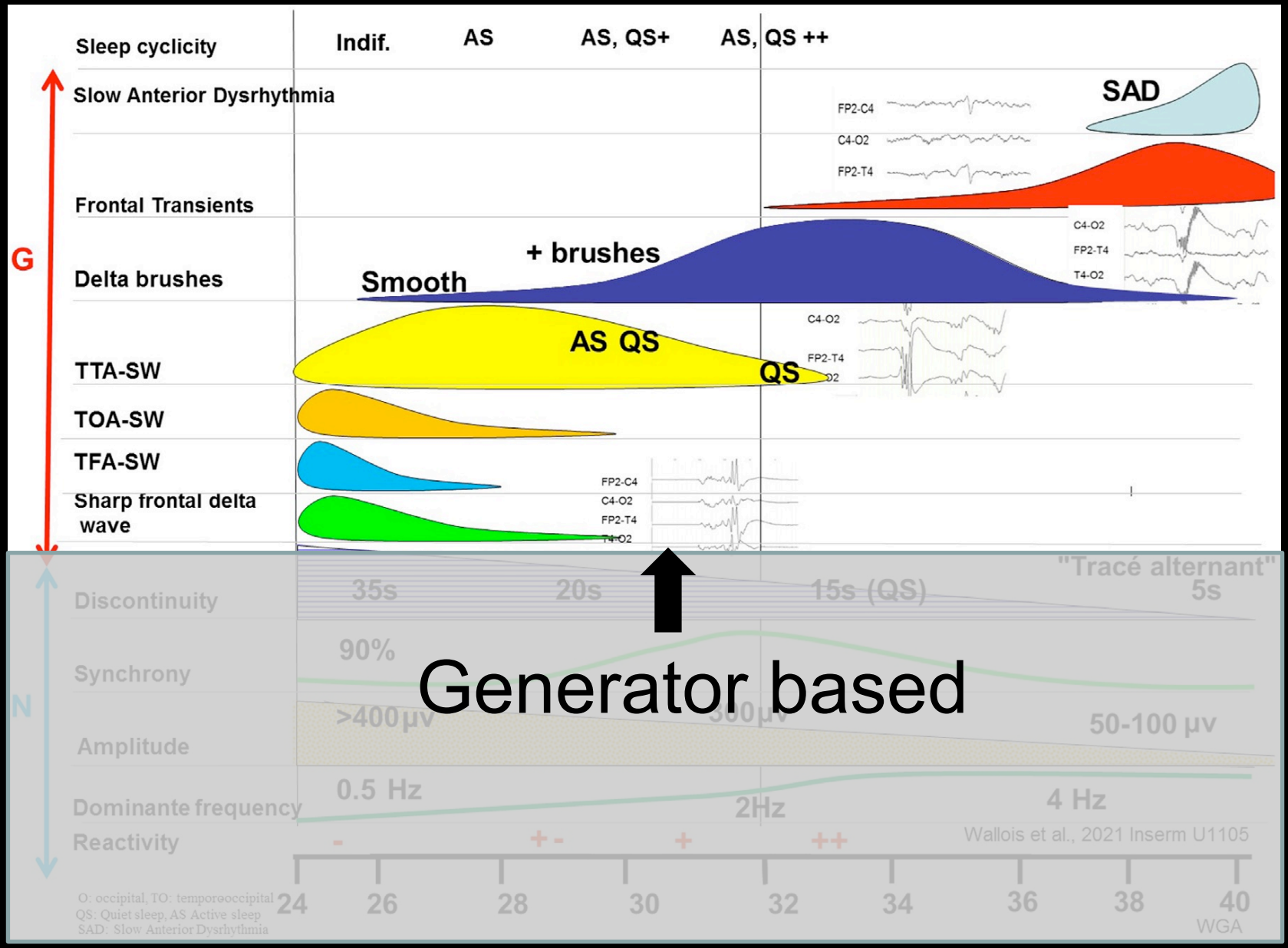
Wallois et al., 2021

The synopsis of maturation



Wallois et al., 2021

The synopsis of functional electrical activitis of the immature brain

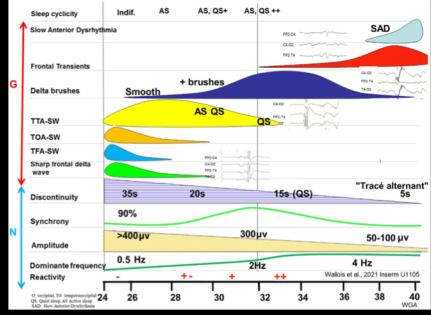


Wallois et al., 2021

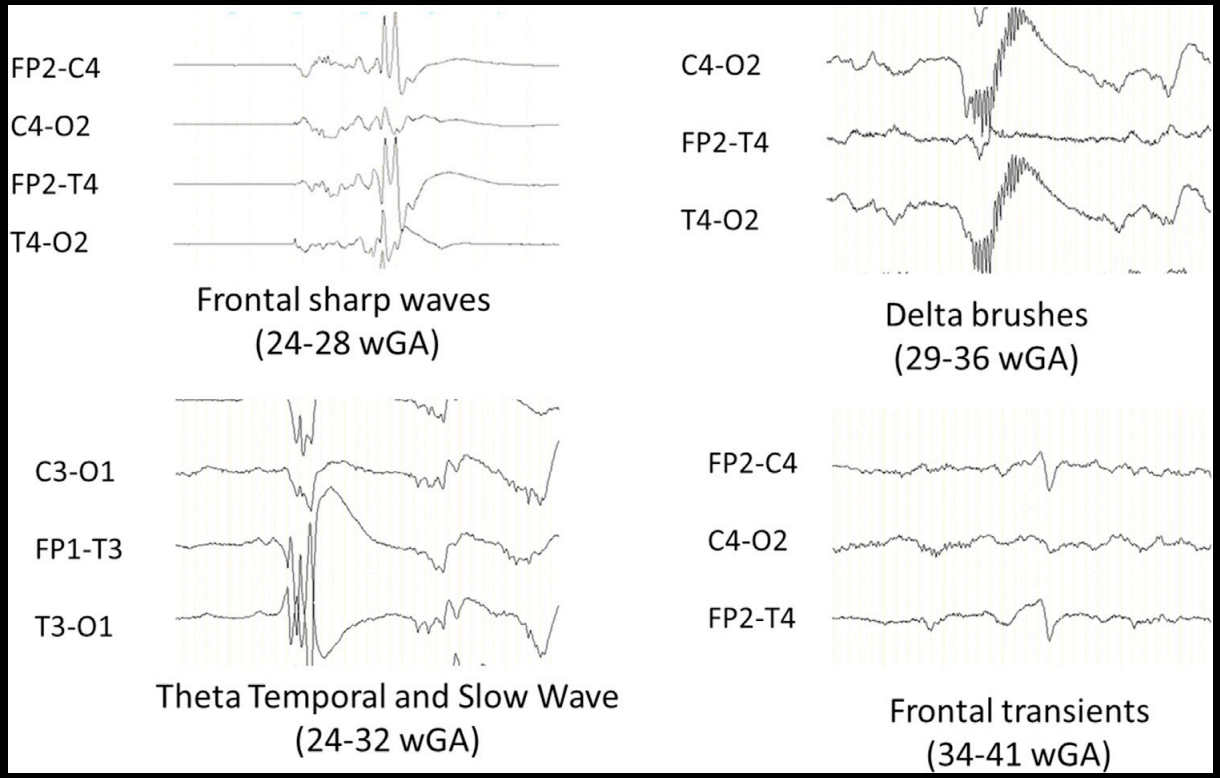
B – Analysis of Brain Development in prematures

B2: rational

The immaturity of the cortex



Specific features appear and disappear according to the development



Wallois et al., 2021

Specific coupled or coalescent oscillators appear and disappear or are masked

B – Analysis of Brain Development in prematures

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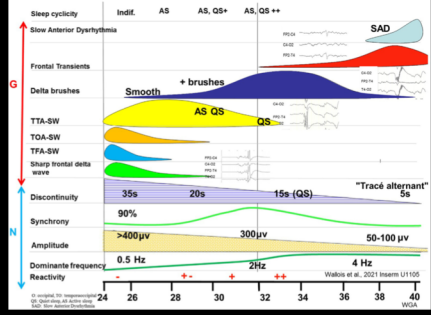
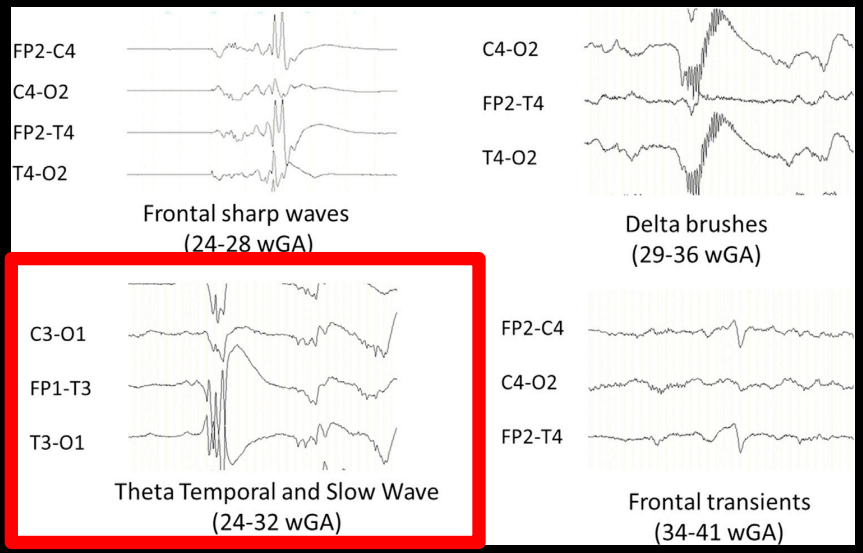
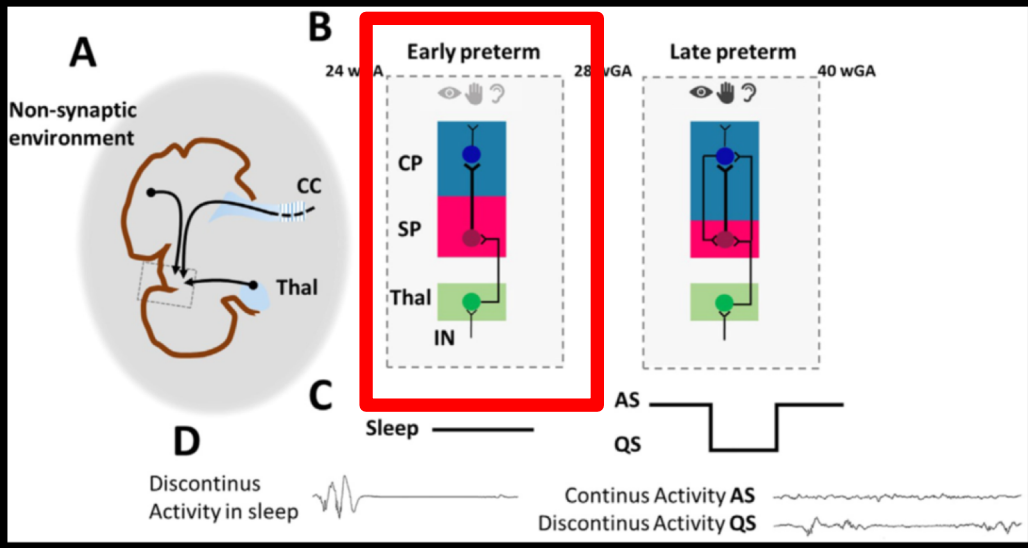


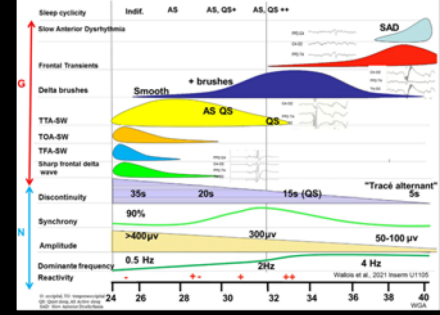
The internal world



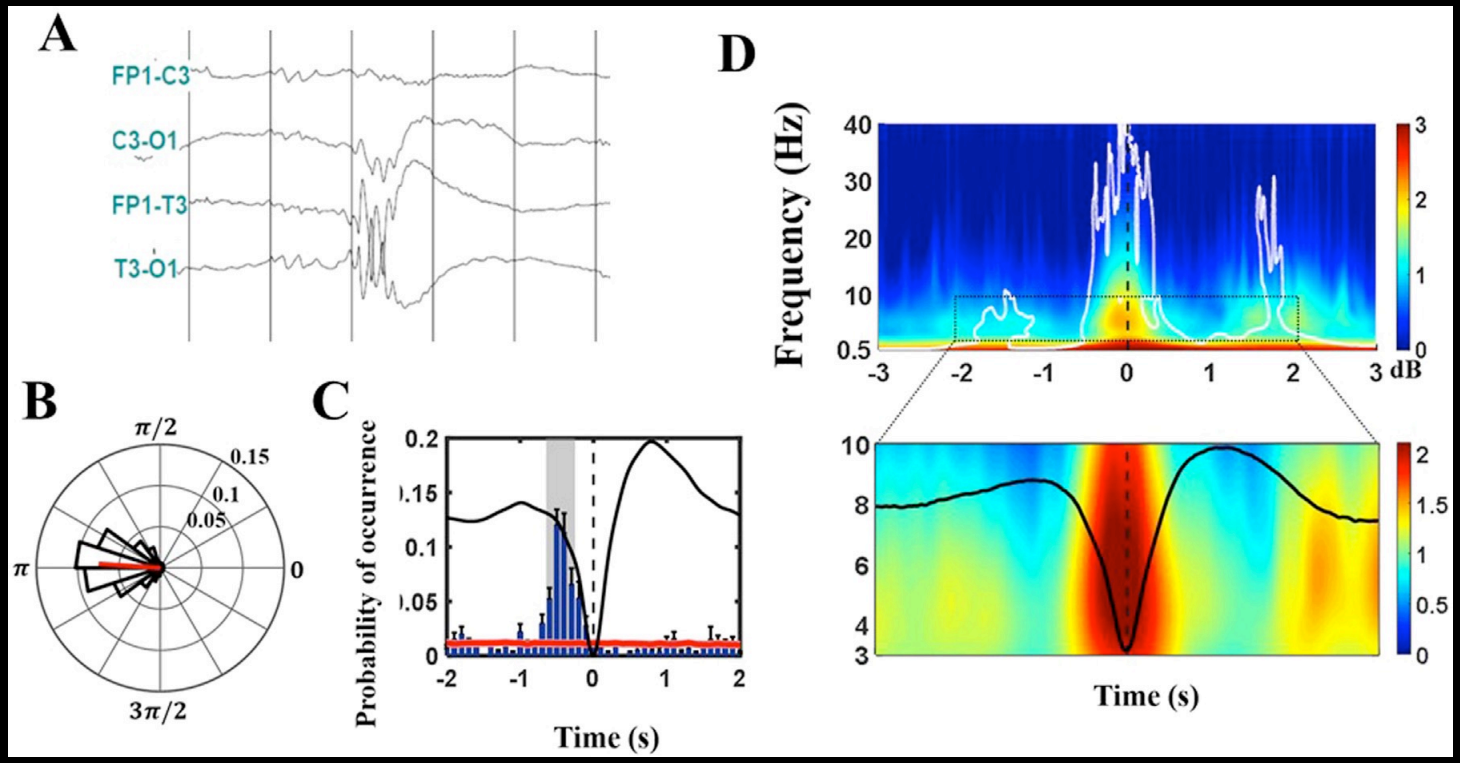


Specific coupled or coalescent oscillators appear and disappear or are masked

The coalescence with slow wave



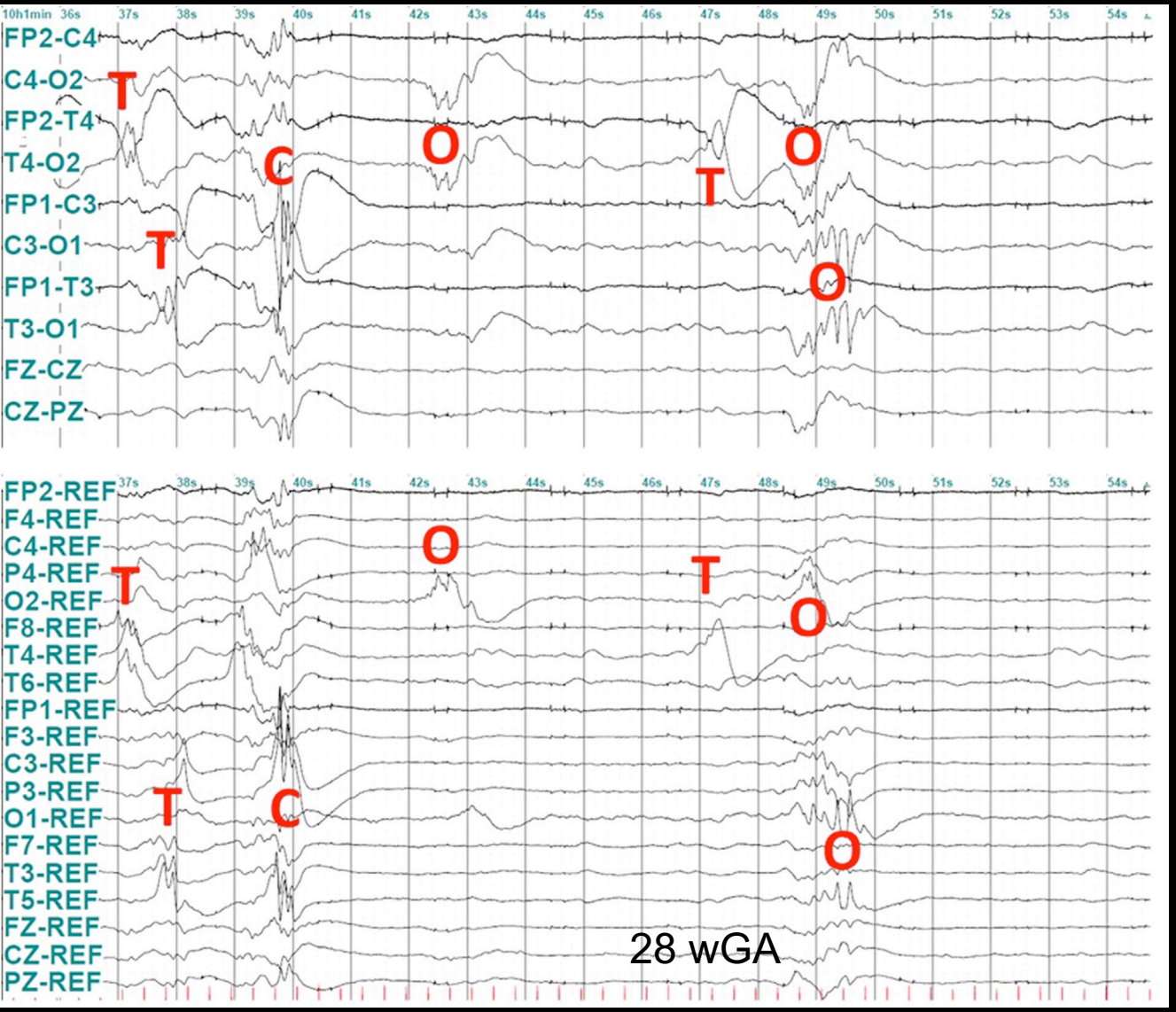
TTA-SW

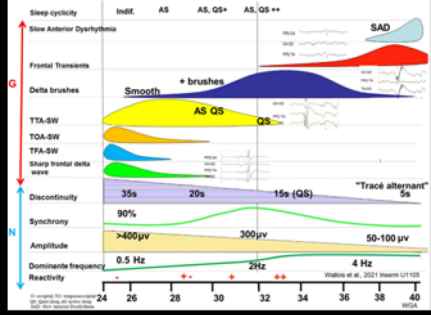


Moghimi et al., 2020

The coupling between 2 oscillators: An index of fine tuning within the immature cortical network

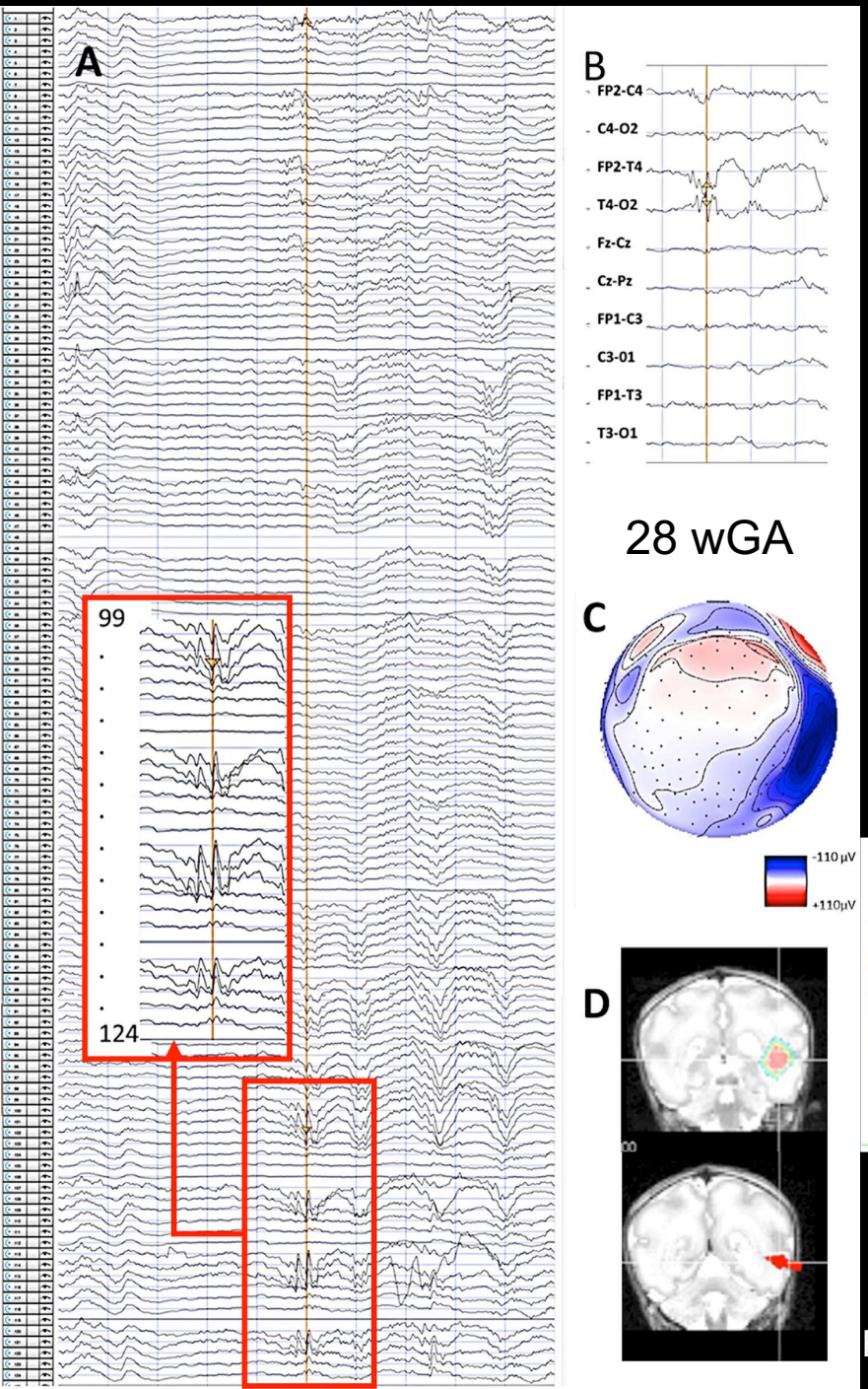
The coupling between 2 oscillators: An index of fine tuning within the immature cortical network



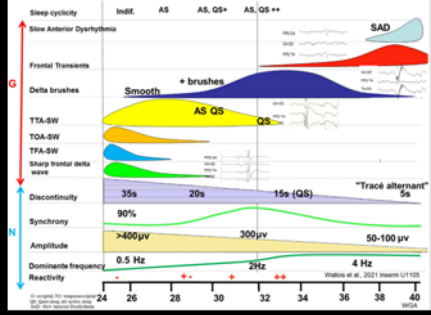


Rather specific to the sensory cortices

Wallois et al., 2021



28 wGA



TTA-SW

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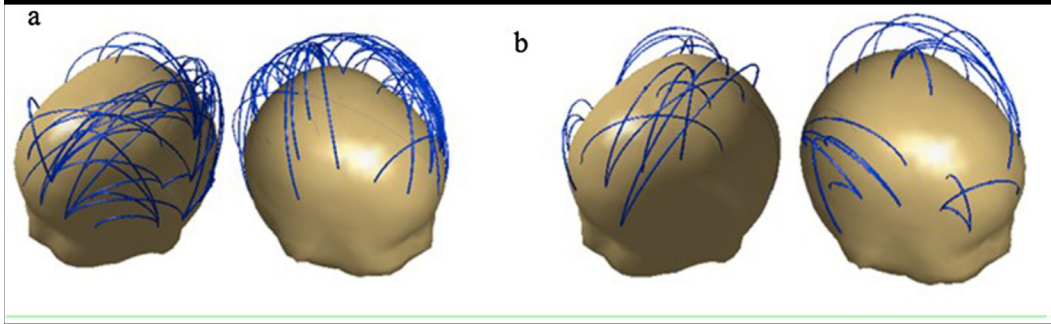


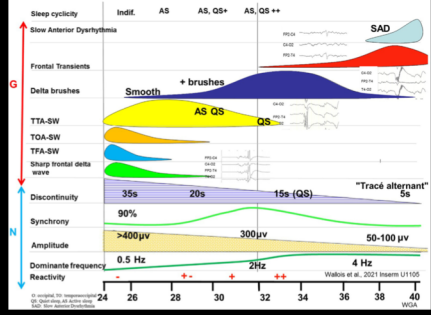
The wiring of perisylvian areas is in progress

Routier et al., 2017, Adebimpe et al., 2018, Wallois et al., 2021

B – Analysis of Brain Development in prematures

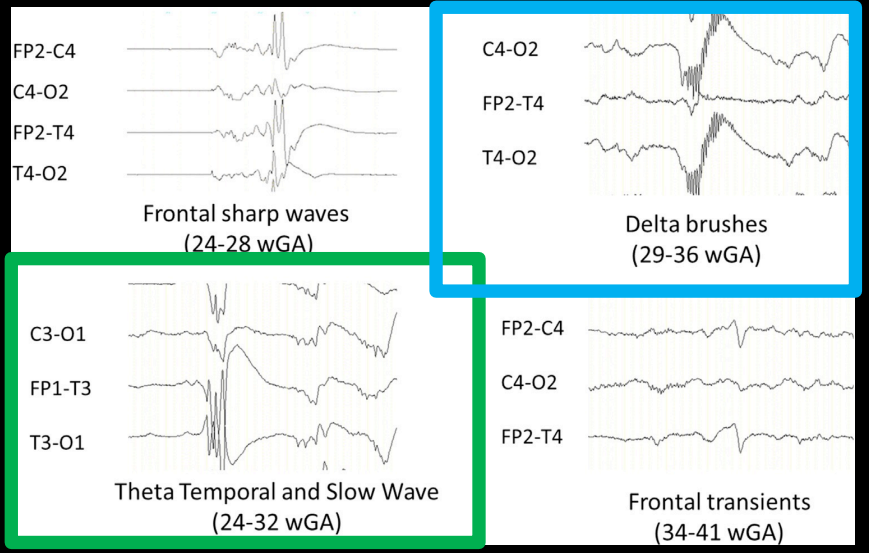
B2: rational

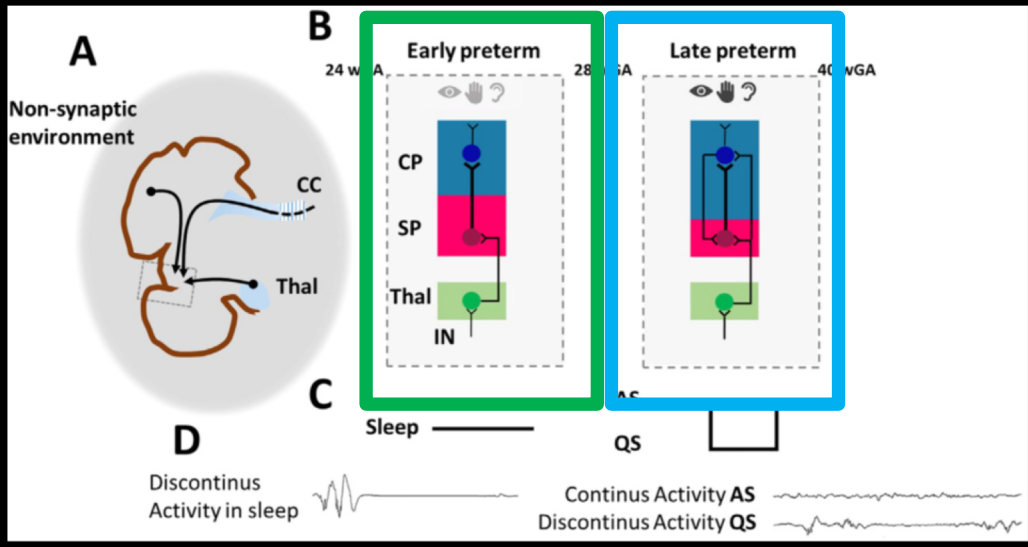
The immaturity of the cortex



The transition

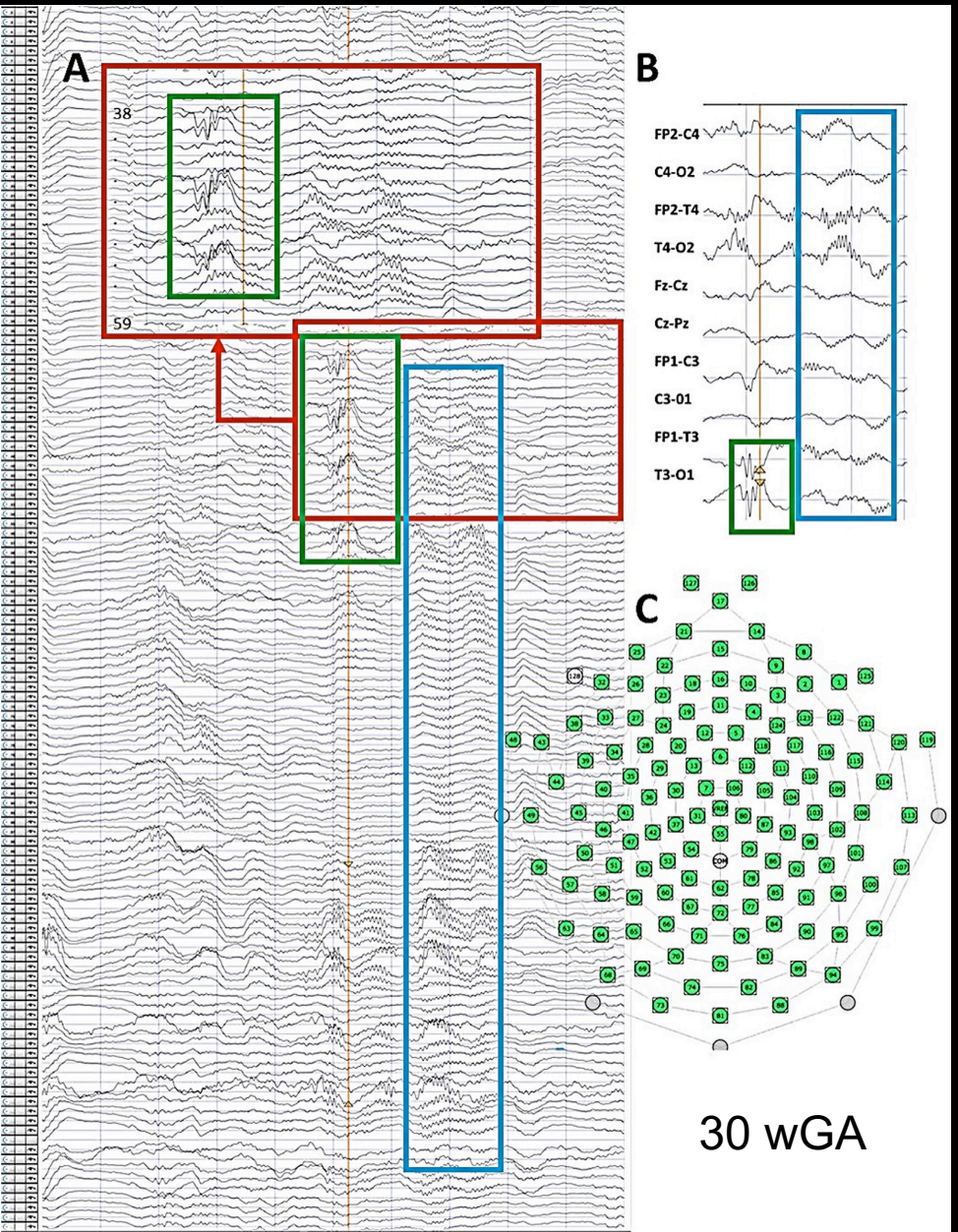
The connection with the external world

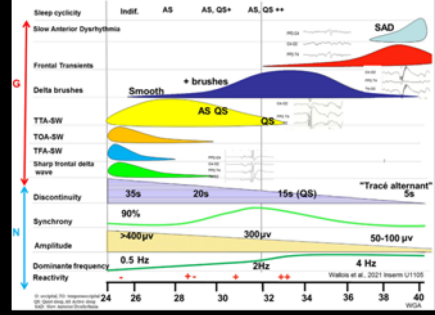




Specific coupled or coalescent oscillators appear and disappear or are masked

The connection with the external world





TTA-SW

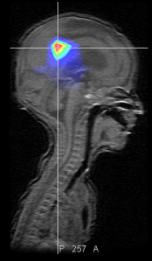
And

Delta brushes

The transition from endogenous activity not sensory driven to generators modulated by exogenous stimulation

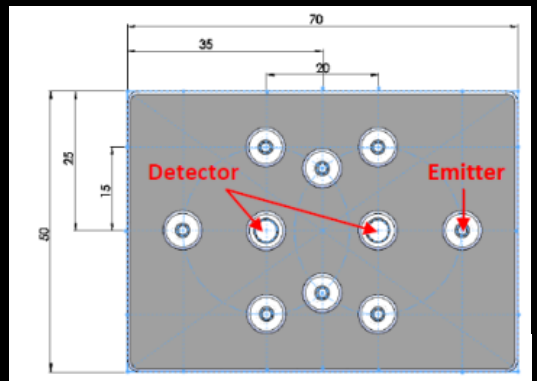
Wallois et al., 2021

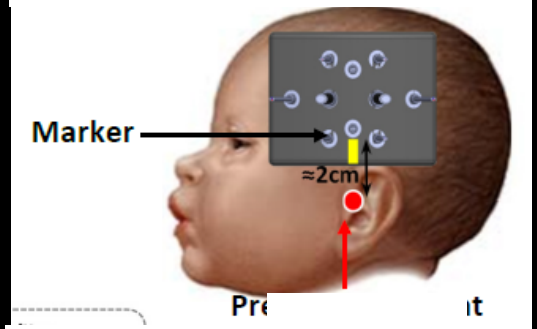
C – ElectrOptical application in Language Maturation

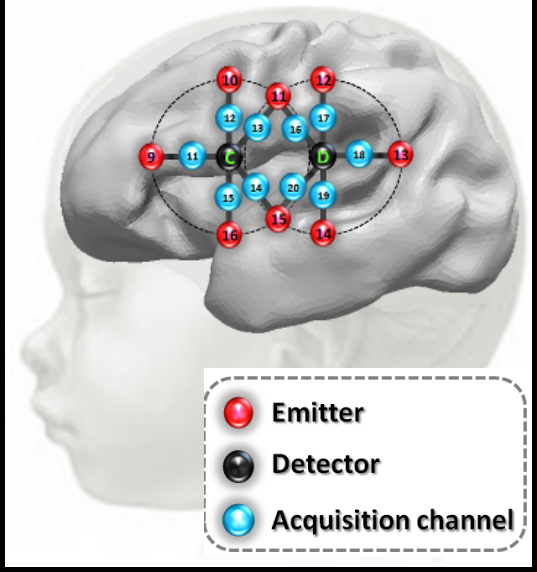


NIRS

- A probe, especially designed to to preterm head.
- 16 emitters (8 : each hemisphere)
- 4 detectors (2 : each hemisphere)
- It covers perisylvian areas



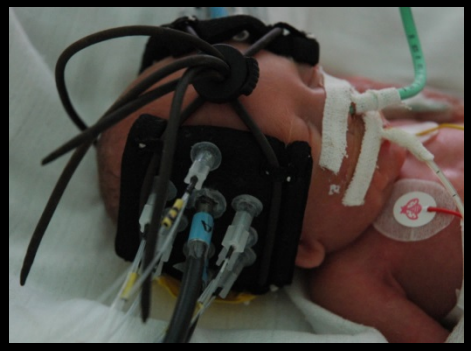




EEG

- A cap, especially designed to to preterm head.
- 64 channels electrodes
- It covers the whole head

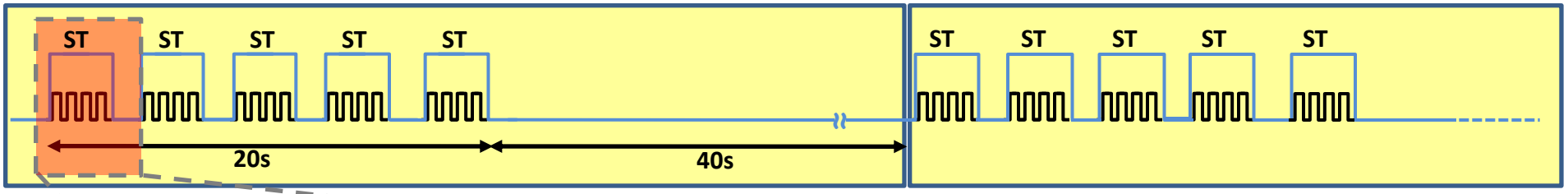
- 12 prematures 28-32 wGA
- Recorded during sleep
- Syllable stimuli
  - Standard
  - Deviant voices
  - Deviant phonemes



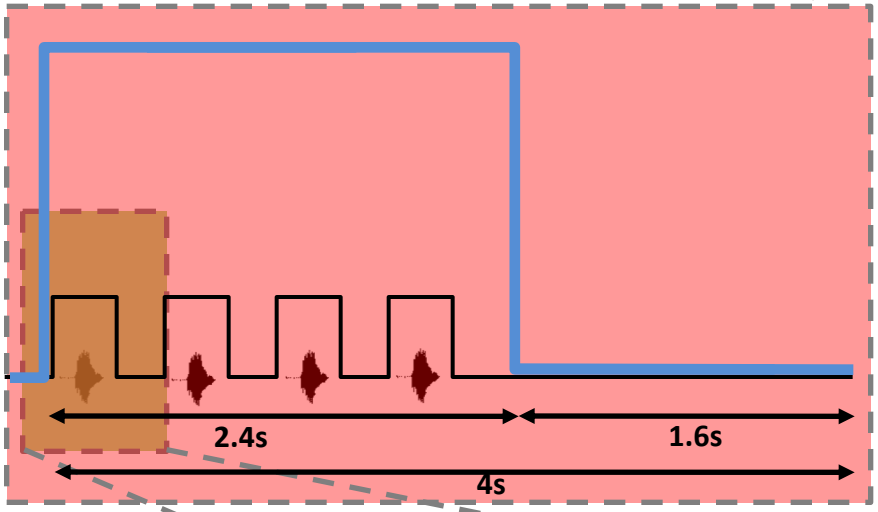
Mahmouddzadeh et al., PNAS 2013

- 19 healthy premature
- Recorded during sleep
- Stimulated with the same paradigm
  - Standard
  - Deviant phonemes
  - deviant voices

Mahmouddzadeh et al., Cerebral Cortex 2016



A

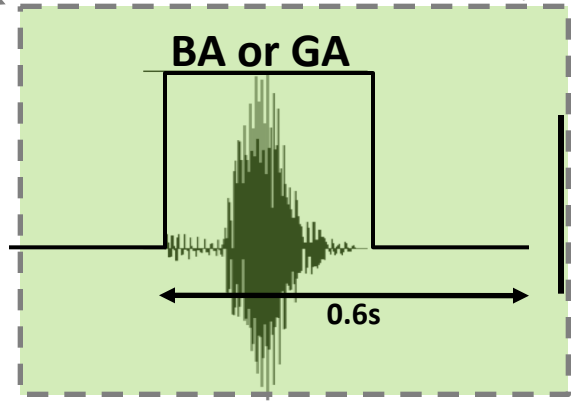


B

ST : Stimulation trial

Experimental Design

- Duration: **108 blocks**
- Auditory stimulation: **20 sec**
- Silence: **40 sec**
- Phoneme change: **ba/ga**
- Voice change: **male / female**

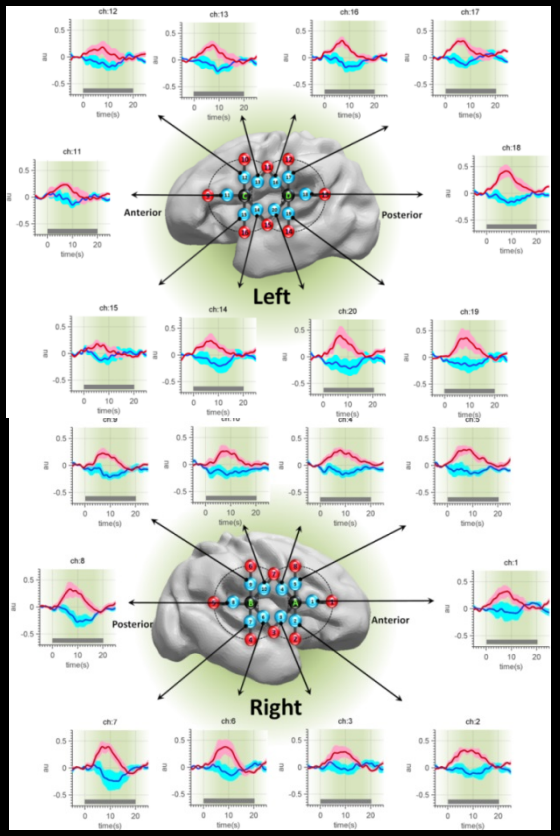


C

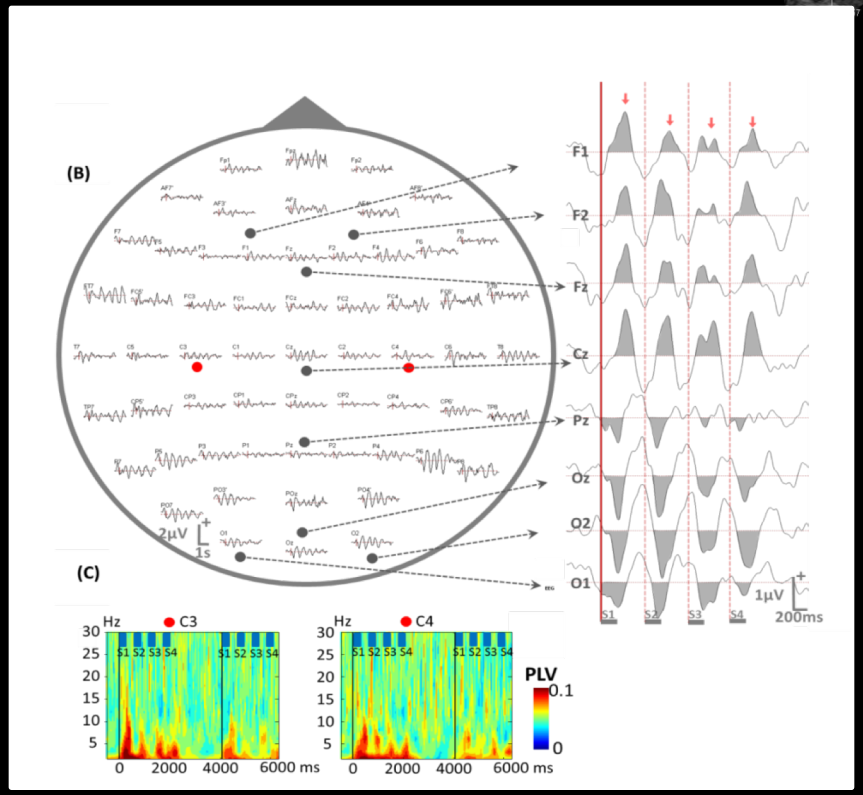
C – ElectrOptical approach in Neurodevelopment

Typical responses (all conditions)

HD NIRS



HR EEG



Phonems induced a typical neurovascular coupling to block stimulation in perisylvian areas (HD NIRS) and a typical Evoked potential to single stimulation (HR EEG)

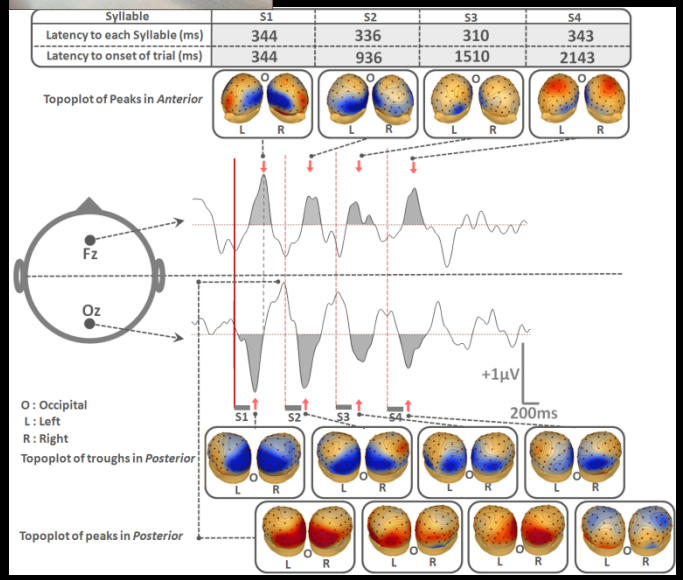
HR EEG ➔ Synchronization and habituation are functional in prematures

HD NIRS ➔ Neurovascular coupling is functional in prematures

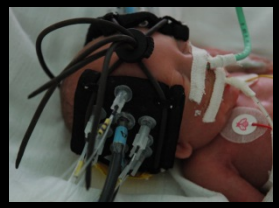
C – ElectrOptical approach in Neurodevelopment

Objectif: To characterize the ability of the communication areas in prematurs using the adavantage of both HR EEG and HD NIRS

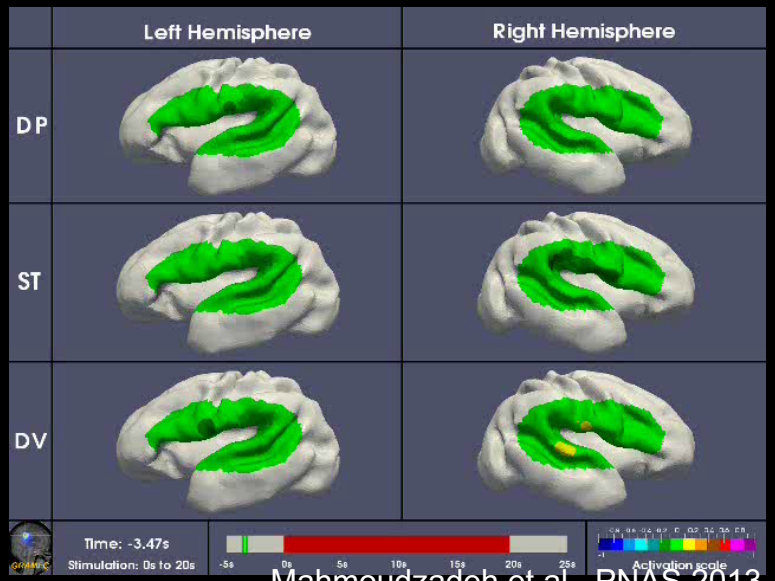
EEGHR



Mahmoudzadeh et al., Cerebral Cortex 2016

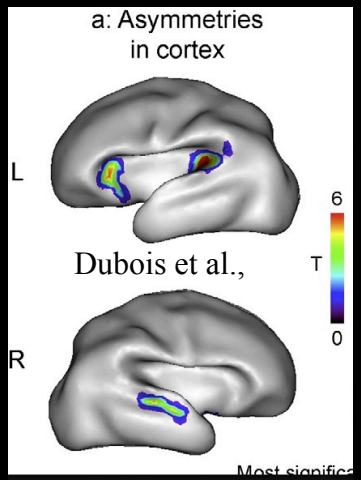


NIRS HD



Mahmoudzadeh et al., PNAS 2013

Relation structure/fonction



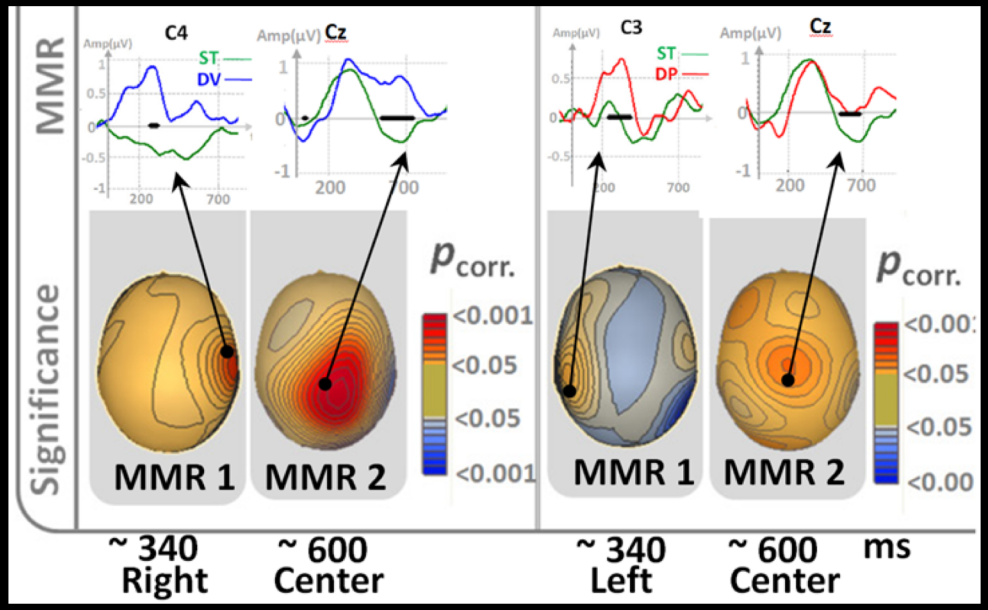
Results:

HR EEG provides mostly temporal informations

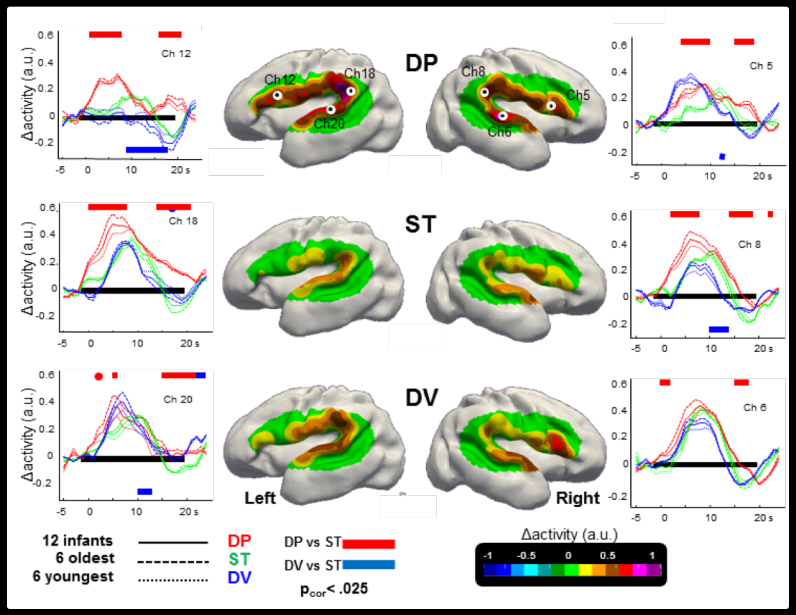
HD NIRS provides mostly spatial informations

C – ElectrOptical approach in Neurodevelopment

HR EEG Mismatch (msec)



HD NIRS Discrimination (100 msec)



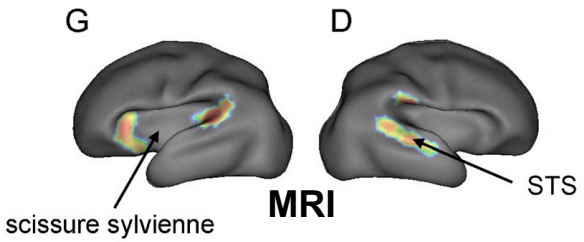
HR EEG provides temporal information about the strategy of the neuronal networks (Habituation Mismatch) and to a lesser extent spatial informations of at least the laterality of the Mismatch in temporal structure. Limitation: Volume conduction effect of the EEG

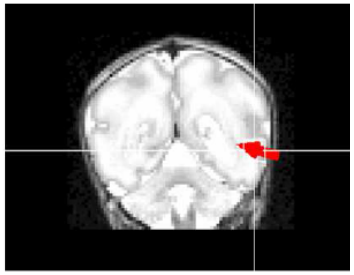
HD Nirs provides spatial informations about the perisylvian structures involved but also the relative timing of activation of these structures. Limitation: Hundreds of milliseconds in NIRS

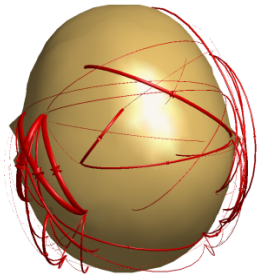
Both technics show that the premature at 28 wGA is able to discriminate between phonems and voices in structures similar to those involved in adults

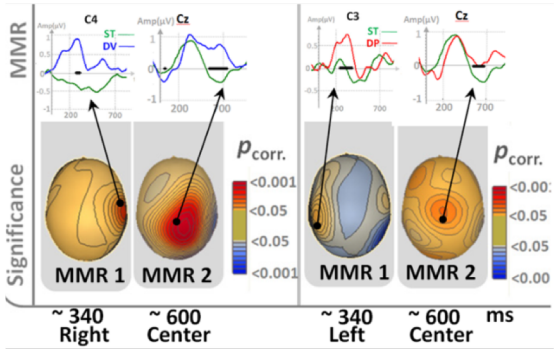
Congruency of information = Body of evidence

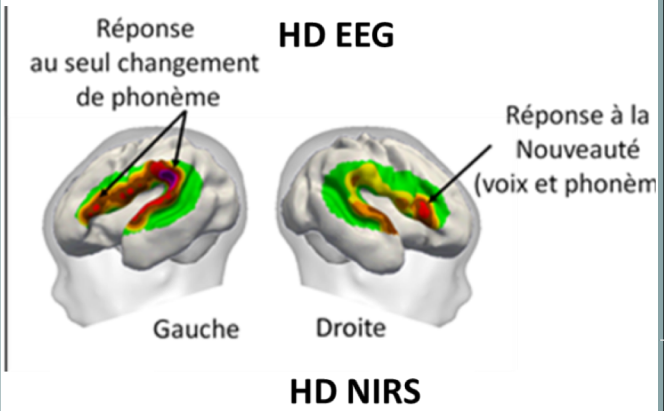
d: Asymétries inter-hémisphériques précoces









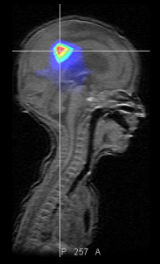


Anatomical substrate
Anatomical assymetry
(Dubois et al., 2012)

Endogenous generators
and
Functional connectivity
Network wiering
(Routier et al, In revision HBM)
Adebimpe et al., submitted)

Habituation
and
Mismatch
Cellular network strategies
(Mahmoudzadeh et al., Cer. Cort, 2016)

Disrimination in
specific areas
Pre functional wirering
(Mahmoudzadeh et al., PNAS 2013)

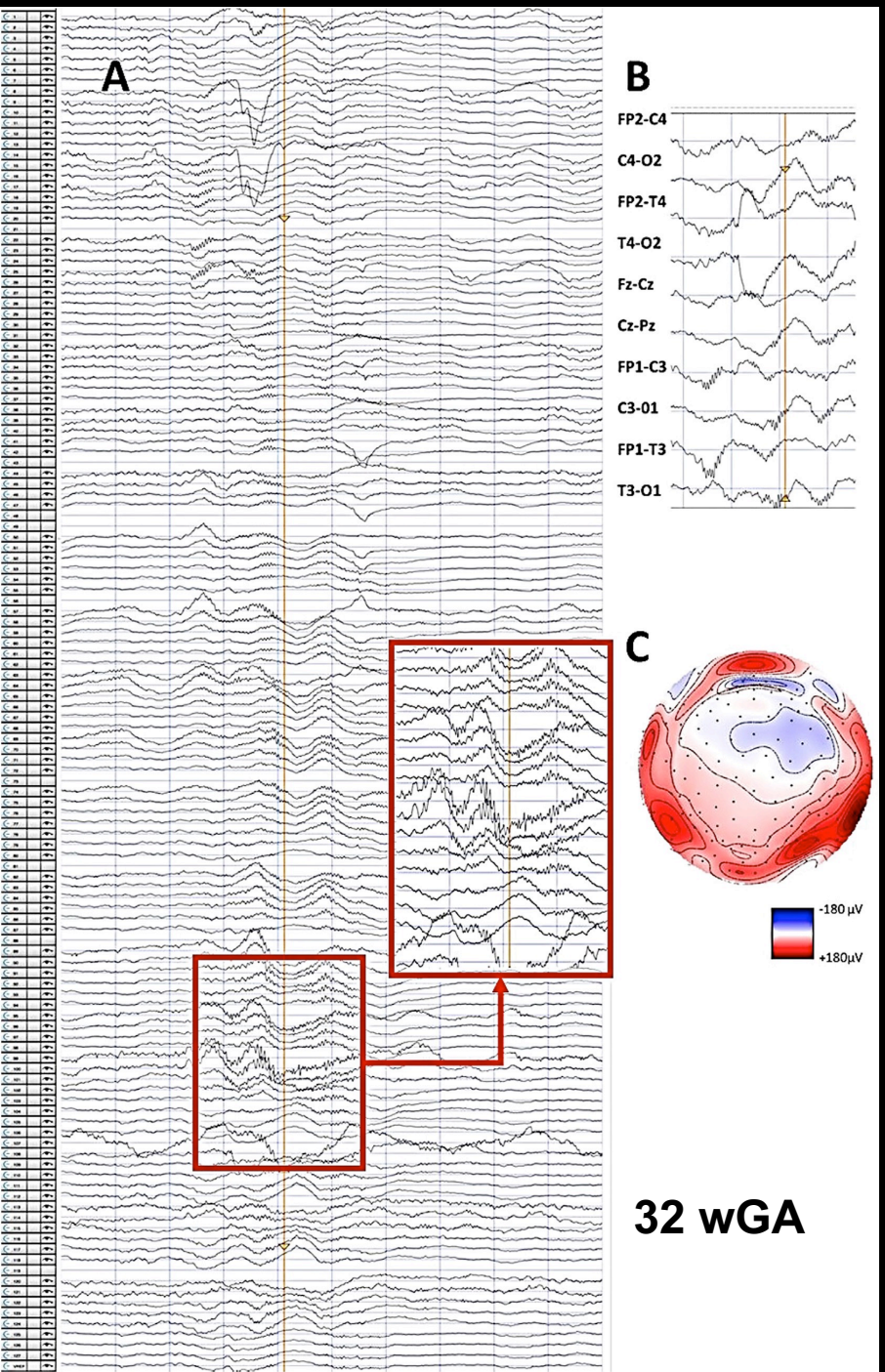


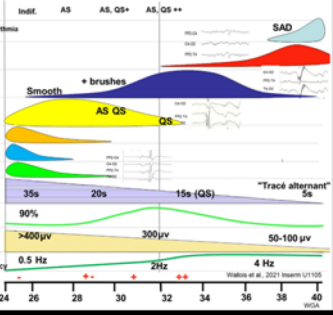
At the onset of thalamocortical connection (28wGA)

Before learning

Genetic fingerprint

Not so Immature





Delta brushes

-1- The disappearance of spontaneous endogenous activity

-2- The optimisation of the connections with the external world

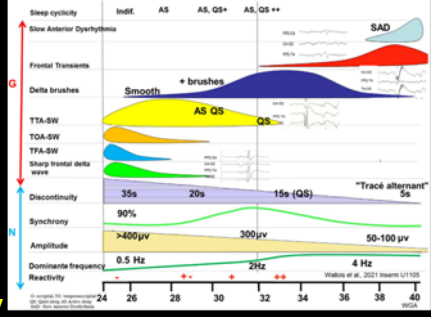
Wallois et al., 2021

Delta brushes

-1- The disappearance of spontaneous endogenous activity

-2- The optimisation of the connections with the external world

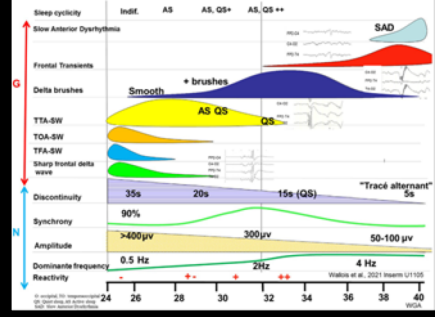
-3- The wide wiring of the brain



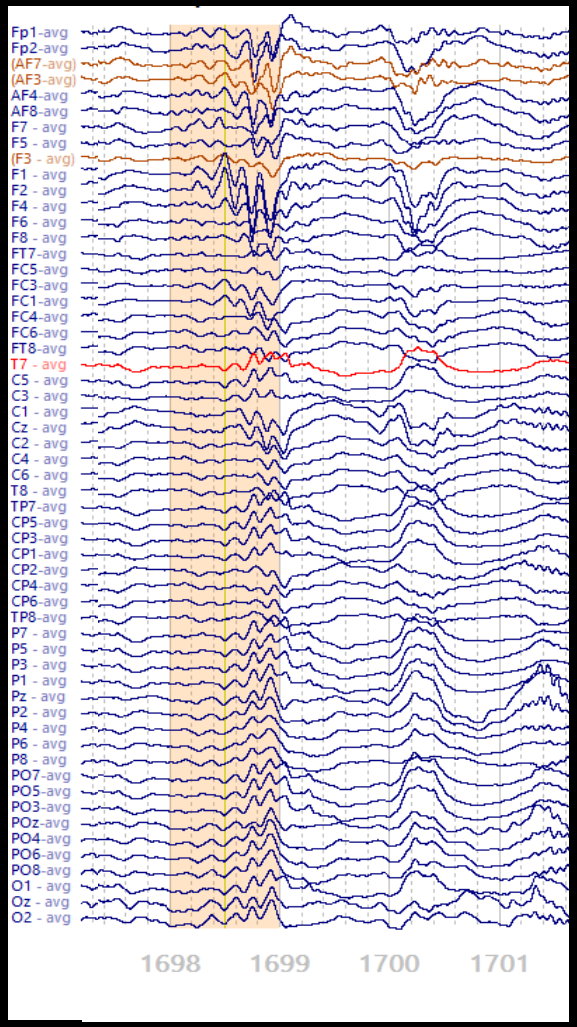
Wallois et al., 2021

32 wGA

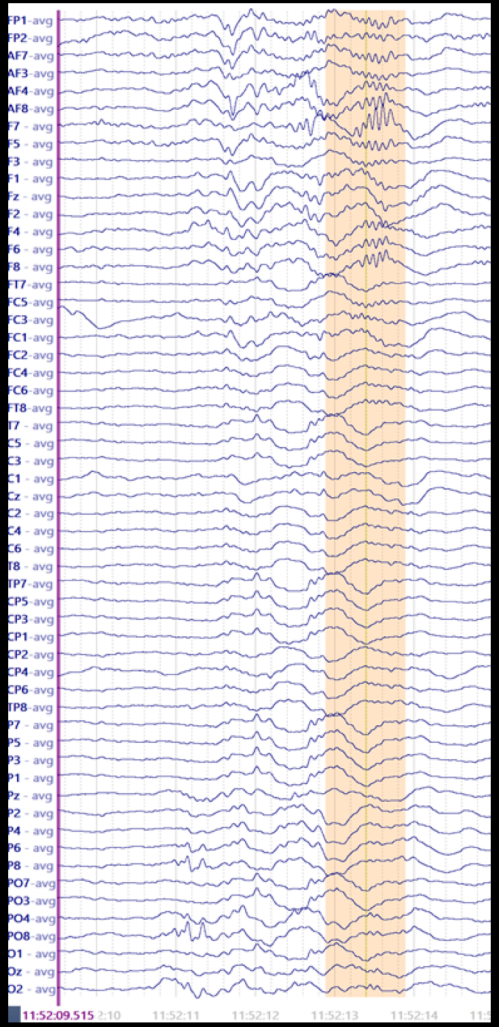
Functional electrical maturation of the frontal lobe during development



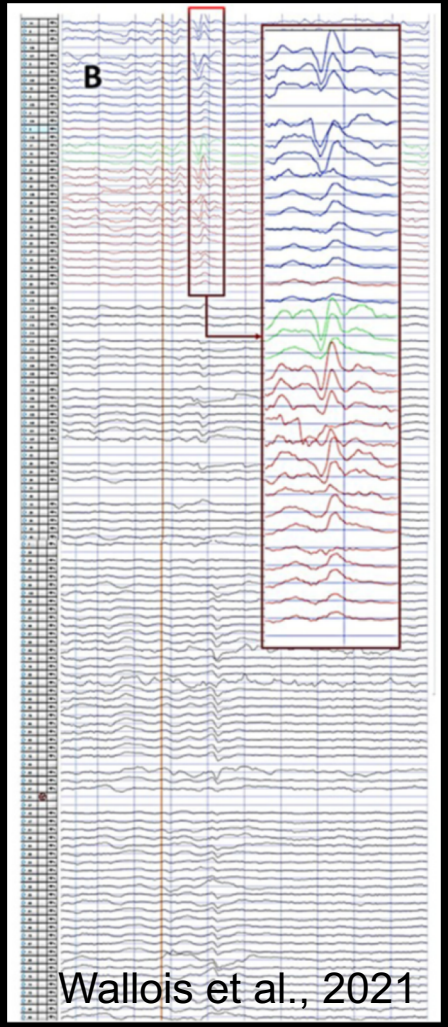
27 wGA

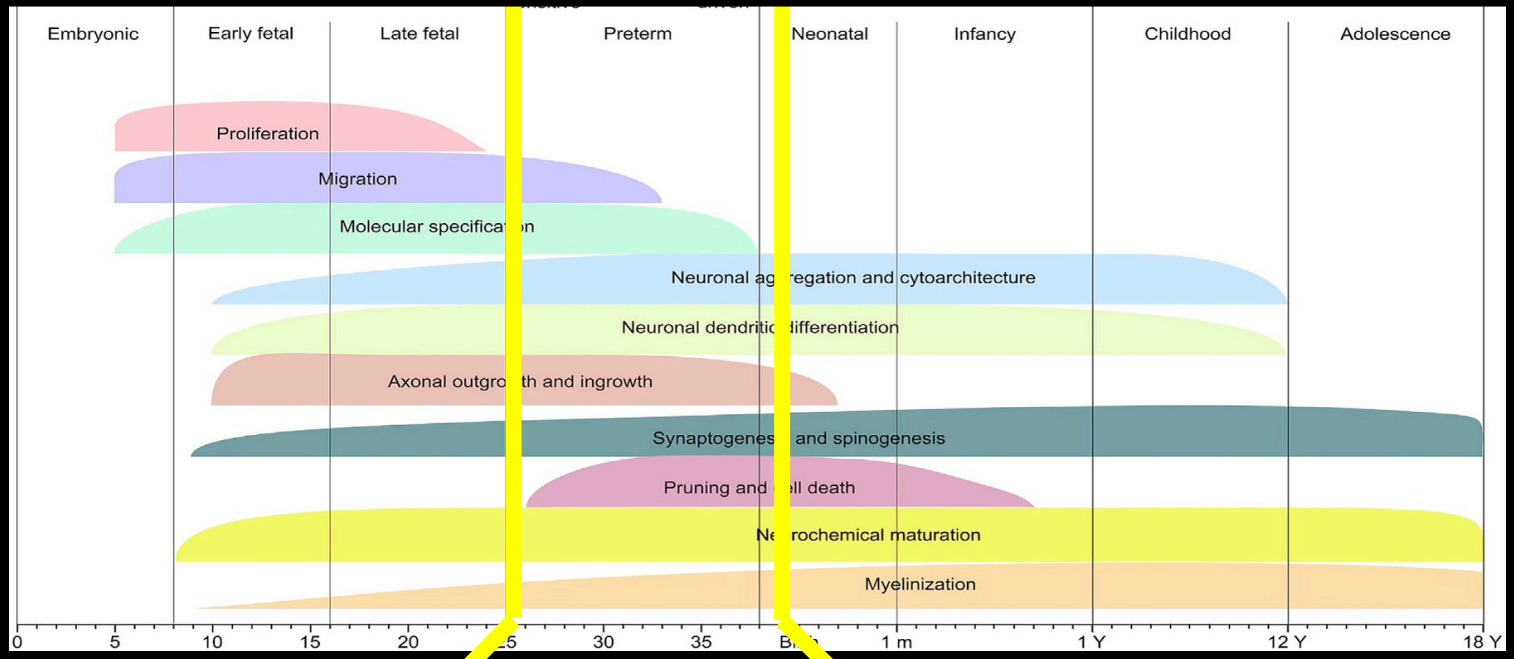


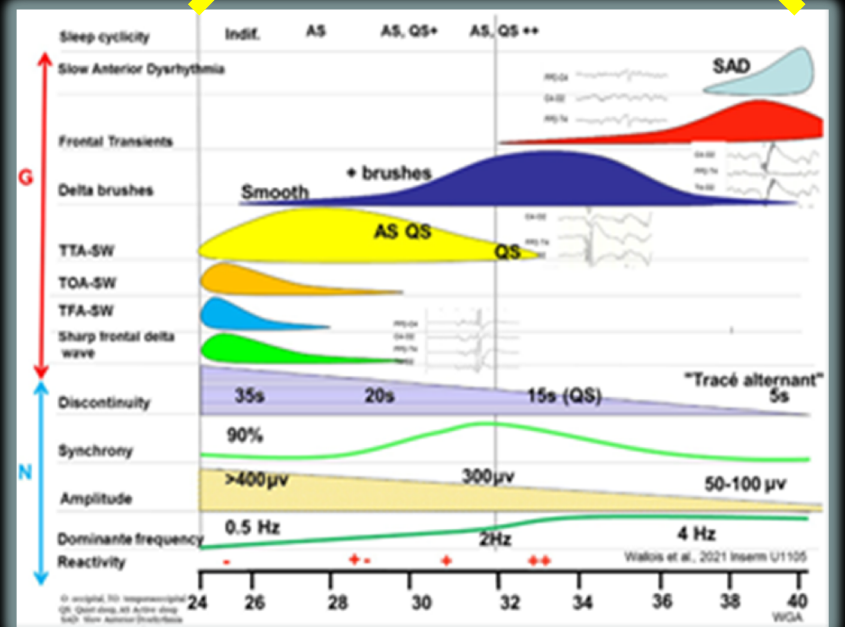
32 wGA



40 wGA

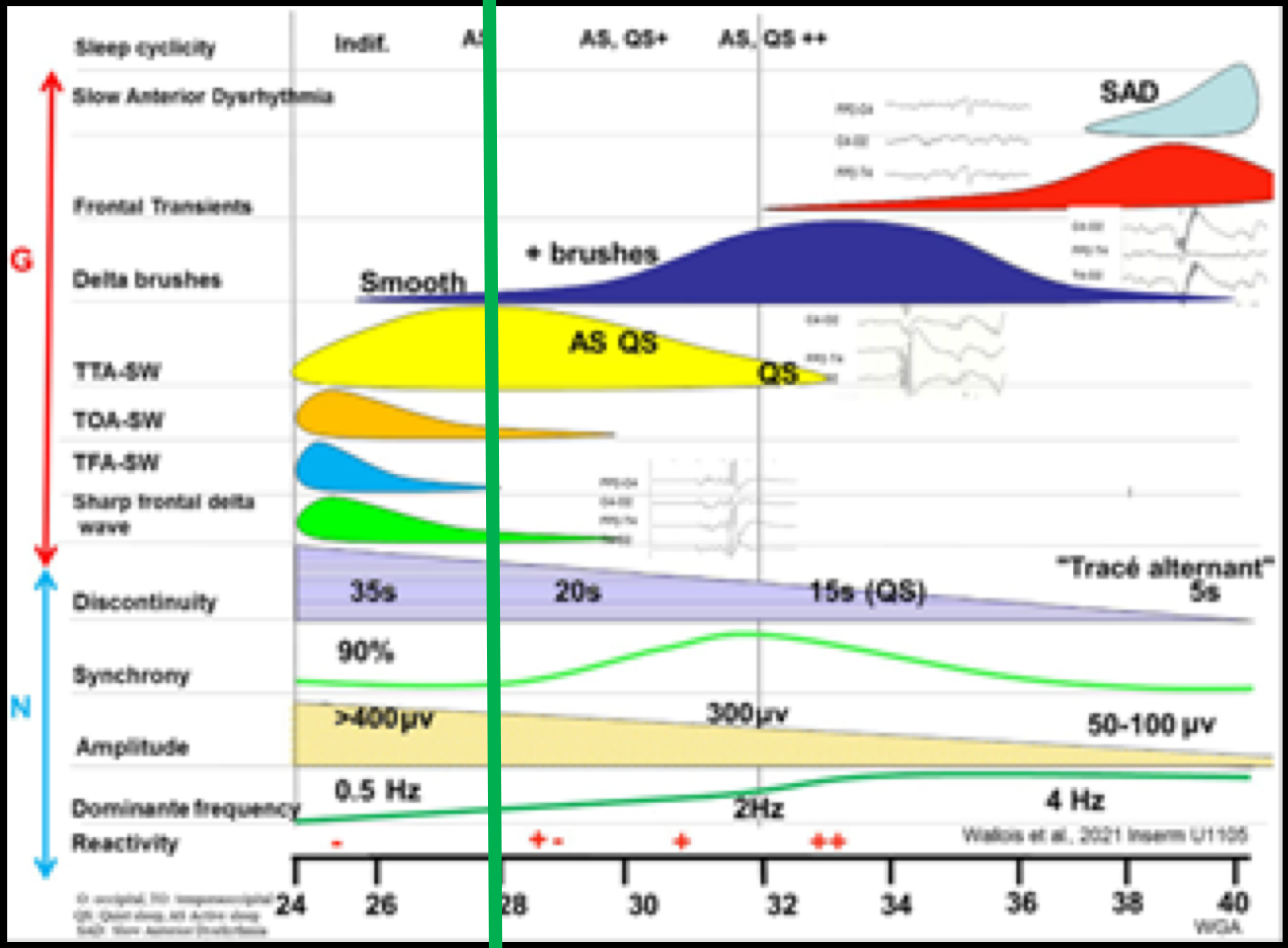






Structure and Function

Conclusion



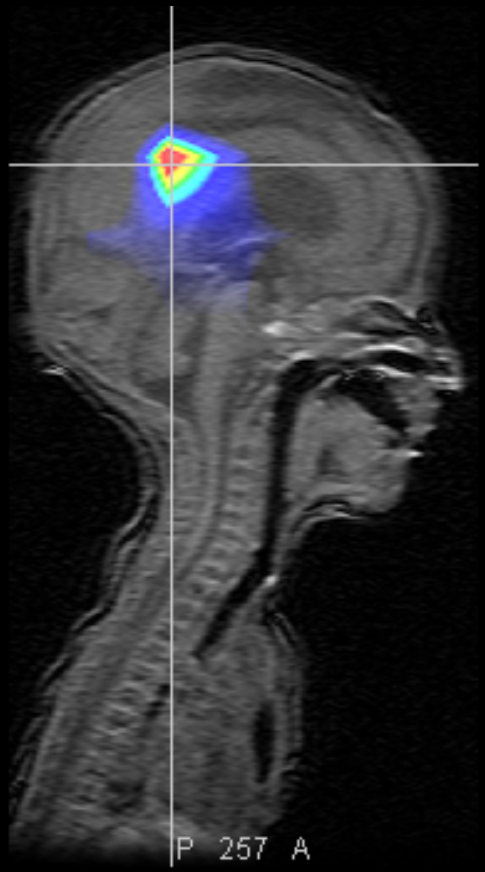
Endogenous non sensory driven
Experience free
Sensory free

Coexistence of transient and permanent circuitry
Experience expectant
Sensory sensitive

Sensory driven

What's about consciousness ?

Nature and Nuture ?
Consciousness ?



FUNCTIONAL IMAGING OF THE HUMAN BRAIN IN EARLY INFANCY

ANR Maia

Merci beaucoup

GRAMFC

Inserm UMR 1105

Groupe de Recherche sur l'Analyse Multimodale de la Fonction Cérébrale