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Simultaneous EEG-fNIRS to explore somatosensory prediction in the premature neonate brain

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fNIRS 2022
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Poster PS3-62-335

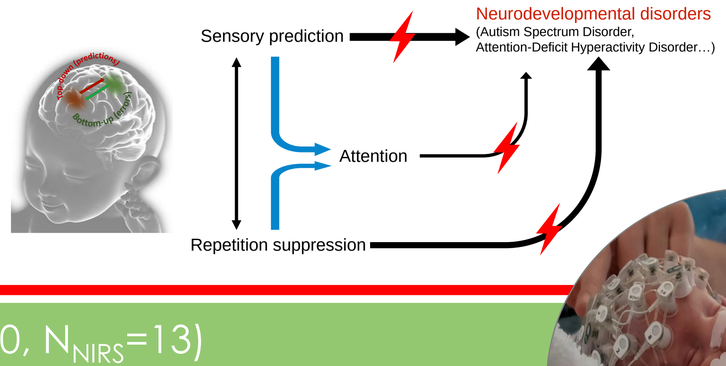
01 THEORETICAL BACKGROUND

Predictive coding

- **Predictive coding** proposes that the brain is inherently predictive about the environment (Friston, 2005). These predictions can be observed through various phenomena such as:
  - **sensory prediction,** the neural anticipation of future stimulation on the basis of previous sensory inputs
  - **repetition suppression**, the decrease of cerebral activity to a repeated stimulus after a stable representation is formed, thus correctly predicted
- Predictions are **necessary to optimize** behavioral responses and the use of **attentional** and **energy resources**
- Sensory prediction and repetition suppression can be **altered in neurodevelopmental disorders** (NDD) like attention deficit disorders (Gonzalez-Gadea *et al.*, 2015)
- Predictive abilities were recently described in preterm infants in the tactile modality (Dumont *et al.*, 2022)

Tactile modality

- Somatosensory inputs are numerous from birth and touch ontogenetic anteriority makes it the **foundation of neurosensory integration, and motor, cognitive and affective development** (Cascio, 2010)
- The tactile modality and the cognitive functions relying on it are often **altered in NDD** (Zoenen & Delvenne, 2018)



02 AIM & HYPOTHESIS

Describe somatosensory prediction and repetition suppression in preterm neonates

Hypotheses

- Neonates will show **repetition suppression in the somatosensory and frontal cortices :** decrease of the neuronal activation between the **familiarization** and the **control** phases of the tactile stimulation sequence.
- Neonates will show a larger **early response** in the **somatosensory cortex** and **a late frontal response** to **deviance** (rare stimuli in the sequence).
- Neonates will have an **increase of HbO** during the **omission** in the somatosensory cortex**,** and **a late frontal response on EEG**.

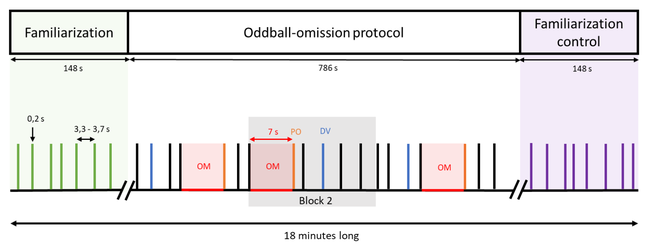
03 MATERIAL & METHODS

Current population

N = 30 of 90 (32,64 ± 2,24 SA at birth, 13 ♀), 13 had simultaneous EEG/fNIRS

Oddball-omission protocol

Counter-balanced **standard** *vs.* **deviant** stimulation on the custom-made vibratory matrix, then placed on a fully-equipped preterm neonate



40 Familiarizations 120 Standards 30 Deviants 30 Omissions 30 PostOmissions 40 Familiarizations control

fNIRS acquisition and preprocessing

fNIRS at 690 & 830 nm (Imagent, ISS, Champaign IL, USA), 1 detector, 4 sources over fronto central areas

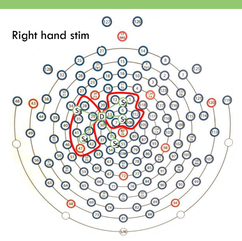
Intensity to OD → Artifact detection and rejection → Filtering (Bandpass and PCA) → Block average → OD to Concentration → Preprocessed data

EEG acquisition and preprocessing

128 channels EEG (Magstim EGI, Eugene OR, USA), sampling rate : 1000 Hz

Bandpass filtering 1-20 Hz → Segmentation -100 to 900 ms → Artifacts removal 200 µV exclusion and hand-screening → Baseline correction 100 ms before stimulus → Common average Referencing to full scalp → Preprocessed data

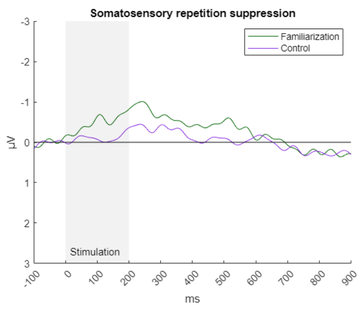
04 PRELIMINARY RESULTS (N_{EEG}=30, N_{NIRS}=13)



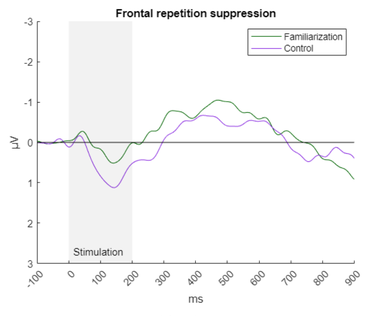
Somatosensory cortex ⇩

Frontal cortex ⇩

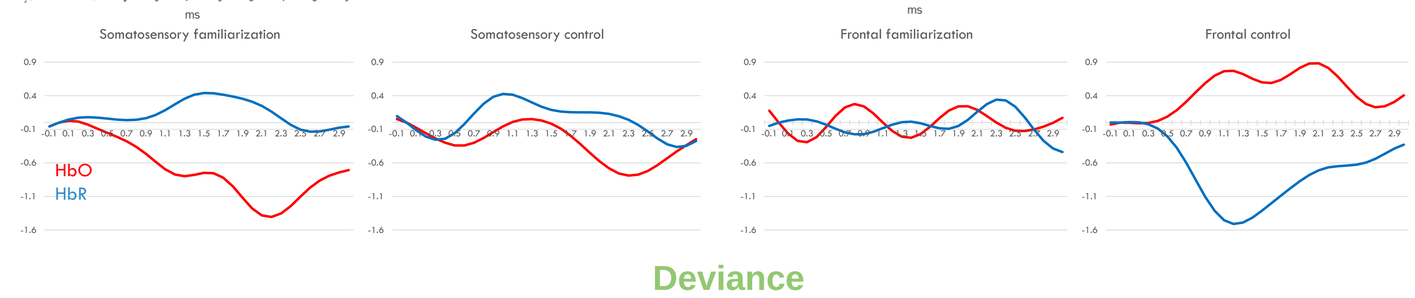
Repetition suppression



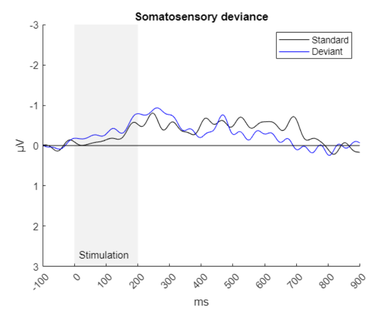
RS between the last 40 stimulations (Control) and the first 40 stimulations (Familiarization) in the somatosensory cortex.



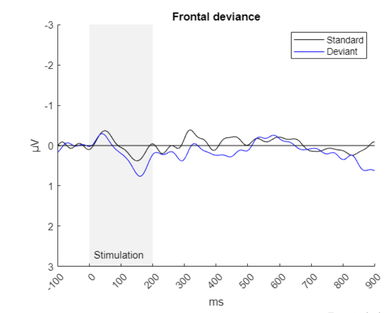
SEP amplitude for the last 40 stimulations (Control) and the first 40 stimulations (Familiarization) in the frontal cortex.



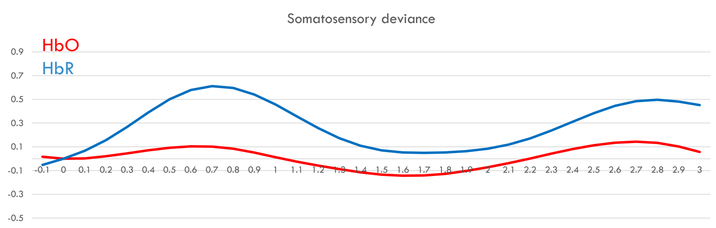
Deviance

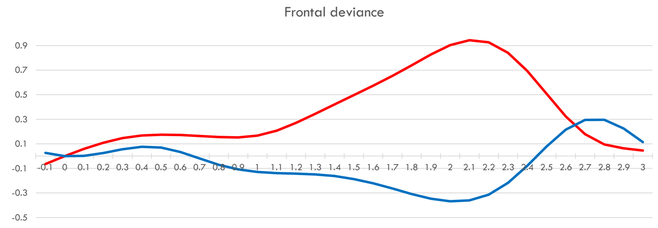


N200 ⇗ for the **deviant** stimulations compared to the **standard**

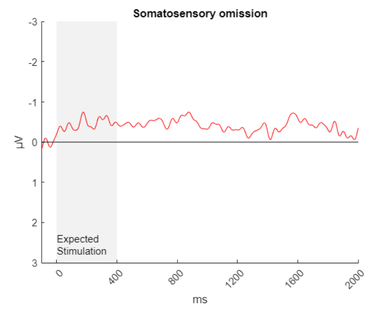


P100 ⇘ for the **deviant** stimulations compared to the **standard**

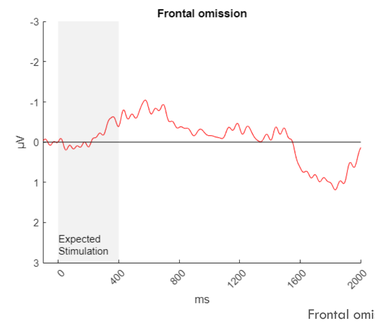




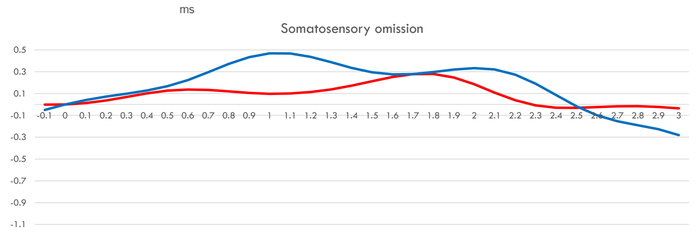
Omission

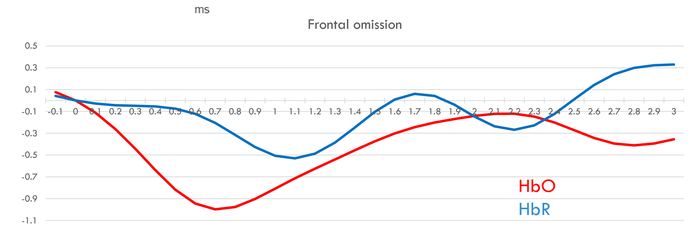


No change during the **omission** in the somatosensory cortex.



Early negative components and late positive components ⇗ during the **omission** in the frontal cortex.





05 DISCUSSION

- Repeated stimulations elicit weaker HbO changes in the somatosensory cortex but increased HbO changes in the frontal cortex. We expected activation and not deactivation in the somatosensory cortex. In the frontal cortex, fNIRS and EEG show RS and are consistent with hypotheses.
- Deviance elicited a strong increase in HbO as well as an increased early electrical response in the frontal cortex. An increase in neuronal activity was observed only on EEG in the somatosensory cortex. Future measurements are needed to interpret fNIRS data.
- Omission elicited no change in the somatosensory cortex but elicited a decrease in HbO in the frontal cortex coupled with neuronal activity on EEG.

Conclusion

Preterm neonates form predicitons and detect an error in the tactile environment.

The late negative components found on EEG during the deviance and the omission in the frontal cortex suggest that these prediction mechanisms could rely on a common frontal process as suggested by the predictive coding theory.

fNIRS measurement provide complementary information on tactile processing but more participants are needed to interpret fNIRS data further.

REFERENCES

Basirat A, Dehaene S, Dehaene-Lambertz G. (2014). A hierarchy of cortical responses to sequence violations in three-month-old infants. *Cognition*. 132(2).137-50. doi: 10.1016/j.cognition.2014.03.013

Dehaene-Lambertz, G., & Dehaene, S. (1994). Speed and cerebral correlates of syllable discrimination in infants. *Nature*, *370*(6487), 292-295. https://doi.org/10.1038/370292a0

Cascio, C. J. (2010). Somatosensory processing in neurodevelopmental disorders. *Journal of Neurodevelopmental Disorders*, *2*(2), 62-69. https://doi.org/10.1007/s11689-010-9046-3

Dumont, V., Giovannella, M., Zuba, D., Clouard, R., Durduran, T., Guillois, B., & Roche-Labarbe, N. (2022). Somatosensory prediction in the premature neonate brain. In Developmental Cognitive Neuroscience (Vol. 57, p. 101148). Elsevier BV. https://doi.org/10.1016/j.dcn.2022.101148

Friston, K. (2005). A theory of cortical responses. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *360*(1456), 815-836. https://doi.org/10.1098/rstb.2005.1622

Gonzalez-Gadea, M. L., Chennu, S., Bekinschtein, T. A., Rattazzi, A., Beraudi, A., Tripicchio, P., Moyano, B., Soffita, Y., Steinberg, L., Adolfi, F., Sigman, M., Marino, J., Manes, F., & Ibanez, A. (2015). Predictive coding in autism spectrum disorder and attention deficit hyperactivity disorder. *Journal of Neurophysiology*, *114*(5), 2625-2636. https://doi.org/10.1152/jn.00543.2015

Nelson, C., Ellis, A., Collins, P., Lang, S. (1990). Infants neuroelectric responses to missing stimuli: can missing stimuli be novel stimuli ? *Developmental neuropsychology. 6*(4), 339-349.

Spackman, L. A., Towell, A., & Boyd, S. G. (2010). Somatosensory discrimination : An intracranial event-related potential study of children with refractory epilepsy. *Brain Research*, *1310*, 68-76. https://doi.org/10.1016/j.brainres.2009.10.072

Zoenen, D., & Delvenne, V. (2018). Treatment of sensory information in neurodevelopmental disorders. *Reve Medicale de Bruxelles*, *39*(1), 29-34. https://doi.org/10.30637/2018.17-073

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