ABSTRACT BOOK

fNIRS Italy

6-7 July 2023

University of Padua
Department of Developmental Psychology and Socialization

Welcome to Padova!

The fNIRS community has reached a critical mass in Italy and beyond, making it timely to organize a meeting. From the many excellent contributions, we have aimed to arrange a program that will spur discussions and inspire everyone to produce new and exciting work in the field. We hope you enjoy the setting here in Padua for this year's conference and wish you a great time!

Silvia Benavides-Varela

Sabrina Brigadoi

Simone Cutini

Judit Gervain

HOST

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Dipartimento di Psicologia dello Sviluppo e della Socializzazione

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PROGRAM IN GLANCE

FULL PROGRAM

July 6 2023

Welcome and Introduction: 09:15 - 09:30

Invited speaker: 09:30 - 10:30

Session Chairs: **Judit Gervain & Silvia Benavides-Varela**, University of Padova

09:30 – *Using fNIRS to investigate the development of functional connectivity and its relationship with early adversity,* **Chiara Bulgarelli**, Birkbeck University

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Oral Session 1: 10:30 - 11:30

Session Chair: **Jessica Gemignani**, University of Padova

10:30 – *Are babies' cries already language?* **Caroline Nallet**, University of Padova

10:45 – *Effects of Maternal Gaze on Infant Brain Activity and Word Segmentation,* **Monica Vanoncini**, University of Potsdam & University of Vienna

11:00 – *Detecting cerebral hemodynamics oscillations using Time Domain fNIRS,* **Letizia Contini**, Politecnico di Milano

11:15 – *Tuning into harmony: unveiling the influence of social music listening on pleasure and Inter-Brain Synchrony*, **Federico Curzel**, Université de Lyon

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Coffee Break: 11:30 - 12:00

Oral Session 2: 12:00 - 13:00

Session Chair: **Ana Flo**, University of Padova

12:00 – *Cortical Correlates of the Egocentric-Allocentric Spatial Switching Ability: an fNIRS Study,* **Renato Orti**, University of Campania “L. Vanvitelli”

12:15 – *The reproducibility of infant fNIRS studies: a meta-analytic approach,* **Jessica Gemignani**, University of Padova

12:30 – *Speech Discrimination Abilities at Birth Predict Language Development: A Prospective fNIRS Study in Pre- and Fullterm Born Children,* **Lisa Bartha-Doering**, Medical University of Vienna

12:45 – *An fNIRS investigation on the 'external timing' of placebo analgesia and nocebo hyperalgesia*, **Francesco Campaci**, University of Turin

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Lunch Break: 13:00 - 14:30

Hands-on session PIONIRS: 14:30 - 15:30

Poster session 1: 15:30 - 16:30

PS1_01 – *Are babies' cries already language?* **Caroline Nallet**, University of Padova

PS1_02 – *Do infants detect prosodic violations in an unknown language at birth?* **Caterina Marino**, University of Padova

PS1_03 – *Effects of Maternal Gaze on Infant Brain Activity and Word Segmentation,* **Monica Vanoncini**, University of Potsdam & University of Vienna

PS1_04 – *Rhythmic discrimination of languages in infants with hearing loss,* **Gaia Lucarini**, University of Padova

PS1_05 – *Detecting cerebral hemodynamics oscillations using Time Domain fNIRS,* **Letizia Contini**, Politecnico di Milano

PS1_06 – *Laughing Together: Investigating the Impact of Laughter on Interpersonal Synchrony, Bonding, and Prosocial Behavior,* **Verena Schaefer**, University of Vienna

PS1_07 – *Tuning into harmony: unveiling the influence of social music listening on pleasure and Inter-Brain Synchrony*, **Federico Curzel**, Université de Lyon

PS1_08 – *Resting-state functional connectivity using fNIRS: From methodological optimization to exploring daily variations in healthy controls,* **Costanza Iester**, University of Genoa

PS1_09 – *Cortical Correlates of the Egocentric-Allocentric Spatial Switching Ability: an fNIRS Study,* **Renato Orti**, University of Campania "L. Vanvitelli"
PS1_10 – *Evaluating the effects of order and content information in phonological working memory using fNIRS: a pre-registered study,* **Annika Junker**, University of Padova

PS1_11 – *The reproducibility of infant fNIRS studies: a meta-analytic approach,* **Jessica Gemignani**, University of Padova

PS1_12 – *Combining diffuse optical tomography and continuous glucose monitoring to investigate alterations of resting state functional connectivity induced by glycemic variability in very preterm neonates: Preliminary results,* **Giacomo Bianco**, University of Padova

PS1_13 – *Speech Discrimination Abilities at Birth Predict Language Development: A Prospective fNIRS Study in Pre- and Fullterm Born Children,* **Lisa Bartha-Doering**, Medical University of Vienna

PS1_14 – *Resting-state functional connectivity at birth and neurodevelopmental outcome at 12 and 24 months of corrected age in a population of very preterm infants: Preliminary results,* **Elisa De Pietri**, University of Padova

PS1_15 – *An fNIRS investigation on the 'external timing' of placebo analgesia and nocebo hyperalgesia*, **Francesco Campaci**, University of Turin

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Coffee Break: 16:30 - 17:00

Oral Session 3: 17:00 - 18:00

Session Chair: **Guy A. Perkins**, University of Padova

17:00 – *Cognitive and sensorimotor contributions to manual dexterity: an fNIRS study during 9HPT performance,* **Laura Bonzano**, University of Genoa

17:15 – *The use of fNIRS to explore ADHD in children: lights and shadows from a 10-year experience at Medea NIRS Lab,* **Alessandro Crippa**, IRCCS Eugenio Medea

17:30 – *Processing of reversible sentences in late bilinguals of English: an fNIRS investigation,* **Martina Pucci**, Ca' Foscari University of Venice

17:45 – *Neuromarketing with fNIRS, assessing experiential consumption and measuring implicit desire for a product*, **Ippeita Dan**, Chuo University

Social dinner: 20:00

July 7 2023

Oral Session 4: 09:00 - 10:00

Session Chair: **Gaia Lucarini**, University of Padova

09:00 – *Investigation of Bimanual Coupling: Behavioral and Hemodynamic Evidence of Interference Effects,* **Costanza Iester**, University of Genoa

09:15 – *Studying Task-Free Functional Connectivity in Neonates using High-Density Diffuse Optical Tomography in Home Settings,* **Laura Carnevali**, University of Padova

09:30 – *Sensorimotor processing of numerical information: a functional near infrared spectroscopy (fNIRS) study,* **Mariagrazia Ranzini**, University of Padova

09:45 – *Selective Brain Responses to Human Motion in Infancy – an fNIRS approach using point-light walkers*, **Isabel C. Lisboa**, NOVA University Lisbon

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Coffee Break: 10:00 - 10:30

Invited speaker: 10:30 - 11:30

Session Chairs: **Simone Cutini & Sabrina Brigadoi**, University of Padova

11:00 – *Translating fNIRS from research labs to the real world,* **Alessandro Torricelli**, Politecnico di Milano

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Hands-on session BRAIN PRODUCTS: 11:30 - 12:30

Lunch Break: 12:30 - 14:00

Hands-on session NIRX: 14:00 - 15:00

Coffee Break: 15:00 - 15:30

Poster session 2: 15:30 - 16:30

PS2_16 – *Cognitive and sensorimotor contributions to manual dexterity: an fNIRS study during 9HPT performance,* **Laura Bonzano**, University of Genoa

PS2_17 – *Learning repetition-based regularities in speech: a NIRS study with 7-month-old infants,* **Gaia Lucarini**, University of Padova

PS2_18 – *The use of fNIRS to explore ADHD in children: lights and shadows from a 10-year experience at Medea NIRS Lab,* **Alessandro Crippa**, IRCCS Eugenio Medea

PS2_19 – *The neonate brain's sensitivity to repetition-based structure: specific to speech?,* **Caroline Nallet**, University of Padova

PS2_20 – *Processing of reversible sentences in late bilinguals of English: an fNIRS investigation,* **Martina Pucci**, Ca' Foscari University of Venice

PS2_21 – *Measuring brain activity in preparation and execution of driving countermeasures to unexpected road crossings: the concept of a simulation study in the CAVE environment,* **Giovanni Bruno**, University of Padova

PS2_22 – *Neuromarketing with fNIRS, assessing experiential consumption and measuring implicit desire for a product*, **Ippeita Dan**, Chuo University

PS2_23 – *Investigating the hemodynamic response to glycemic events in pre-term infants using diffuse optical tomography: preliminary results*, **Guy A. Perkins**, University of Padova

PS2_24 – *Investigation of Bimanual Coupling: Behavioral and Hemodynamic Evidence of Interference Effects,* **Costanza Iester**, University of Genoa

PS2_25 – *Comparison hemodynamic response during Valsalva maneuver using continuous wave and time domain diffuse correlation spectroscopy on healthy subject,* **Neda Mogharari**, Polish Academy of Sciences

PS2_26 – *Studying Task-Free Functional Connectivity in Neonates using High-Density Diffuse Optical Tomography in Home Settings,* **Laura Carnevali**, University of Padova

PS2_27 – *Number processing in stroke patients: a study of functional reorganization using fNIRS,* **Laura Danesin**, IRCCS San Camillo Hospital

PS2_28 – *Sensorimotor processing of numerical information: a functional near infrared spectroscopy (fNIRS) study,* **Mariagrazia Ranzini**, University of Padova

PS2_29 – *Do neonates generate separate word memories for different speakers?: A proposal,* **Emma Visibelli**, University of Padova

PS2_30 – *Direction Matters: Brain Responses to Point-light Walkers walking on different directions in relation to the perceiver*, **Isabel C. Lisboa**, NOVA University Lisbon

PS2_31 – *Maternal touch and infant brain response to affective and discriminative touch: a fNIRS Study*, **Juliana Serra**, University of Minho

PS2_32 – *Selective Brain Responses to Human Motion in Infancy – an fNIRS approach using point-light walkers,* **Isabel C. Lisboa**

Concluding remarks: 16:30 - 16:45

ABSTRACTS

Abstracts

PS1_01 – Are babies' cries already language?

Caroline Nallet (1), Gaia Lucarini (1), Irene de la Cruz-Pavía (2), Judit Gervain (1,3)

Affiliations:
(1) Department of Developmental and Social Psychology and Padova Neuroscience Center, University of Padua - Padua, Italy
(2) Department of Linguistics and Basque Studies, University of the Basque Country UPV/EHU - Vitoria-Gasteiz, Spain. Ikerbasque, Basque Foundation for Science - Bilbao, Spain.
(3) Integrative Neuroscience and Cognition Center, Université Paris Cité & CNRS - Paris, France.

Newborns and young babies communicate through cries. This has generated the hypothesis that there may be a developmental continuity between cries and our communication system, language. Indeed, a previous study found that French and German babies cry differently, the melody of their cries imitating the melodies of French and German, i.e. the languages their mothers spoke during pregnancy (Mampe et al., 2009), although these results have generated a debate and require further confirmation (Gustafson et al., 2017; Manfredi et al., 2019). In general, it remains controversial whether and, if yes, how cries may be linked with language. In the current study, we tested this hypothesis by investigating whether newborns' cries triggered similar neural processing as speech in adults as well as in newborns, i.e. listeners who themselves can produce cries.

Newborns exposed to French prenatally as well as Italian-speaking adults who do not speak French participated in the study. Adults unfamiliar with French were tested so that, similarly to newborns, they cannot process the linguistic content of the stimuli. The two groups were tested in the same paradigm and stimuli, and their brain activity was recorded using functional near-infrared spectroscopy (fNIRS), targeting the bilateral fronto-temporo-parietal regions. Participants were exposed to ten blocks of cries recorded from a different set of French newborns as well as spoken French sentences. Cries and sentences were matched in their acoustic properties (intensity and duration). The blocks of cries were composed of ten cries from ten different French newborns, whereas the blocks of speech were composed of ten sentences produced by ten different female native speakers of French. No sentence or cry was repeated during the study. The order of presentation of the blocks were intermixed and counter-balanced across infants.

Preliminary results from 28 adults and 25 newborns suggest that newborns have significantly heightened brain responses to cries compared to speech, while adults show a significantly more pronounced response to speech compared to cries. Further analyses will compare the response to cries and speech to baseline, respectively, to notably investigate the localization of the brain activations corresponding to the two types of stimuli. If confirmed, these preliminary results suggest that while cries are not processed identically to speech at either age, their processing may change during

development as a result of their changing relevance for communication and production. Infants' heightened responses to cries may be related to the fact that they are able to produce cries and use them for communication.

1. Gustafson GE, Sanborn SM, Lin H-C, Green JA. 2017. Newborns' cries are unique to individuals (but not to language environment). Infancy 22:736–47
2. Mampe B, Friederici AD, Christophe A, Wermke K. 2009. Newborns' cry melody is shaped by their native language. Curr. Biol. 19(23):1994–97
3. Manfredi C, Viellevoye R, Orlandi S, Torres-García A, Pieraccini G, Reyes-García CA. 2019. Automated analysis of newborn cry: relationships between melodic shapes and native language. Biomed. Signal Process. Control 53:101561

PS1_02 – Do infants detect prosodic violations in an unknown language at birth?

Caterina Marino (1,2), Jessica Gemignani (1,2), Anna Alvarez-Martinez (1,2), Judit Gervain (1,2,3)

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(3) Integrative Neuroscience and Cognition Center, Université Paris Cité & CNRS, Paris, France

Prosody, i.e., the melody and the rhythm of speech, is the fundamental organizing principle of spoken language. Previous studies demonstrated that, already at birth, infants are sensitive to prosodic components of speech (e.g., Abboub et al., 2016; Benavides-Varela & Gervain, 2017) and this early sensitivity may be particularly relevant for the acquisition of later grammatical, lexical and morphosyntactic abilities (e.g., Werker & Gervain, 2013; Gervain, 2018). Recently, Alvarez-Martinez and colleagues (2022) provided evidence for newborns' abilities to detect utterance-level prosodic violations in the language they heard prenatally, i.e., French. Similarly to adults, this discrimination ability was right-lateralized in the neonatal brain.
Are newborns also able to discriminate violations of prosodic contours in an unknown language or is this ability based on prenatal experience? To answer this question, we tested infants prenatally exposed to Italian with the same French stimuli as in Alvarez-Martinez et al., (2022). We used near-infrared spectroscopy (fNIRS) to measure brain responses in the frontal, temporal, and parietal areas bilaterally of 1-4-day-old Italian newborns (n = 25). We exposed them to standard (i.e., well-formed) and deviant (i.e., ill-formed) prosodic contours of French sentences. The deviant prosodic contour was obtained by time-reversing the standard one, and super-imposing it on the otherwise intact segmental information. Preliminary results suggest that Italian newborns display significant responses to French sentences with both standard and deviant prosody as compared to baseline, but show no difference between the two prosody conditions. This suggests that unlike for the prenatally exposed language, they are not able to detect prosodic violations. A direct statistical comparison of the brain responses in this study with those measured in the Alvarez-Martinez et al.'s study, currently under way, will contribute to understanding the role of prenatal experience in the processing of native and non-native prosody.

1. Abboub, N., Nazzi, T., & Gervain, J. (2016). Prosodic grouping at birth. Brain and language, 162, 46-59
2. Benavides-Varela, S., & Gervain, J. (2017). Learning word order at birth: A NIRS study. Developmental Cognitive Neuroscience, 25, 198-208.
3. Gervain, J., & Werker, J. F. (2013). Prosody cues word order in 7-month-old bilingual infants. Nature communications, 4(1), 1490.
4. Gervain, J. (2018). The role of prenatal experience in language development. Current Opinion in Behavioral Sciences, 21, 62-67.

5. Martinez-Alvarez, A., Benavides-Varela, S., Lapillonne, A., & Gervain, J. (2023). Newborns discriminate utterance-level prosodic contours. Developmental Science, 26(2), e13304.

PS1_03 – Effects of Maternal Gaze on Infant Brain Activity and Word Segmentation

Monica Vanoncini (1,2), Natalie Boll-Avetisyan (1), Birgit Elsner (1), Stefanie Höhl (2), Ezgi Kayhan (1,2,3)

Affiliations:
(1) University of Potsdam
(2) University of Vienna
(3) MPI for Human Cognitive and Brain Sciences, Leipzig

The social brain, consisting of those areas sensitive to social information, has been argued to "gate" the mechanisms involved in human language learning (Kuhl, 2007). Early interactions are guided by ostensive signals, such as gaze patterns. Infants are sensitive to social gaze from an early age (Batki et al., 2000) and have been found to make use of this sensitivity to learn a language (Çetinçelik et al., 2021). Speakers' social gaze enhances 6-month-olds' brain responses to multimodal communicative signals (Lloyd-Fox et al., 2015). However, little is known about how the infant brain processes different social gaze in naturalistic interactions and how this relates to infant word segmentation.

The main goals of the current study were to examine: (1) 9-month-olds' brain activity in relation to different types of social gaze during mother-infant interaction, and (2) whether social gaze linked with infant brain activity during a social interaction is associated with infants' word segmentation. Three types of gaze were considered: Mutual gaze (i.e., looking at each other at the same time), maternal social gaze (i.e., mother looking at infant), infant's social gaze (i.e., infant looking at mother). Functional near infrared spectroscopy (fNIRS) can be used for examining brain responses in combination with ostensive signals (Lloyd-Fox et al., 2010).

For experiment 1, we analysed data from 26 infants (M = 301 days; SD =12 days; 10 females) and their German-speaking mothers (M = 33.92 years; SD = 5.35). During free play of the 9-month-olds with their mothers, we recorded the social brain activity through fNIRS and micro-coded different gaze behaviors (i.e., mutual gaze, maternal or infant's social gaze) offline. Using multidimensional joint recurrence quantification analysis (MdJRQA; Wallot & Mønster, 2023), we examined which of the three gaze types was related to the highest concurrent infant's brain activity, in terms of Recurrence Rate (RR). Regression modeling revealed that maternal social gaze co-occurred more often with the infant's brain activity measured through fNIRS compared to the other gaze types.

For experiment 2, we analysed data from 40 infants (M = 301 days; SD = 12; 19 females) and their German-speaking mothers (M = 33.66 years; SD = 4.75 years). Infants' speech processing abilities were assessed with a word segmentation task. Using recurrence quantification analysis (RQA; Wallot & Leonardi, 2018) we found that maternal social gaze, linked with infant's brain activity, also was the gaze type that best

predicted infant's word segmentation in terms of Entropy (ENTR). Lower ENTR would reflect higher predictability, and vice versa.

The study highlights the connection between brain activity and maternal social gaze, and between maternal social gaze and infants' word segmentation performance. Overall, it shows how attaining properties of language is linked with the perception of ostensive signals exchanged in early interactions, and the use that infants make of these social signals (measured through fNIRS). Hence, our results speak to the idea that the social brain gates language learning. Finally, it demonstrates the potential of MdJRQA when investigating the coordination of categorical and continuous aspects in naturalistic interactions.

1. Batki, A., Baron-Cohen, S., Wheelwright, S., Connellan, J., & Ahluwalia, J. (2000). Is there an innate gaze module? Evidence from human neonates. Infant Behavior and Development, 23(2), 223–229. https://doi.org/10.1016/S0163-6383(01)00037-6

2. Çetinçelik, M., Rowland, C. F., & Snijders, T. M. (2021). Do the eyes have it? A systematic review on the role of eye gaze in infant language development. Frontiers in Psychology, 11, 589096. https://doi.org/10.3389/fpsyg.2020.589096

3. Kuhl, P. K. (2007). Is speech learning 'gated' by the social brain? Developmental Science, 10(1), 110–120. https://doi.org/10.1111/j.1467-7687.2007.00572.x

4. Lloyd-Fox, S., Blasi, A., & Elwell, C. E. (2010). Illuminating the developing brain: The past, present and future of functional near infrared spectroscopy. Neuroscience & Biobehavioral Reviews, 34(3), 269–284. https://doi.org/10.1016/j.neubiorev.2009.07.008

5. Lloyd-Fox, S., Széplaki-Köllőd, B., Yin, J., & Csibra, G. (2015). Are you talking to me? Neural activations in 6-month-old infants in response to being addressed during natural interactions. Cortex, 70, 35–48. https://doi.org/10.1016/j.cortex.2015.02.005

6. Wallot, S., & Leonardi, G. (2018). Analyzing multivariate dynamics using Cross-Recurrence Quantification Analysis (CRQA), Diagonal-Cross-Recurrence Profiles (DCRP), and Multidimensional 7. Recurrence Quantification Analysis (MdRQA) – A tutorial in R. Frontiers in Psychology, 9, 2232. https://doi.org/10.3389/fpsyg.2018.02232

7.Wallot, S., & Mønster, D. (2023). Multidimensional Joint Recurrence Quantification Analysis: Detecting coupling between time series of different dimensionalities (arXiv:2303.16907). arXiv. https://doi.org/10.48550/arXiv.2303.16907

PS1_04 – Rhythmic discrimination of languages in infants with hearing loss

Gaia Lucarini (1), Caroline Nallet (1), Davide Brotto (1), Alessandro Martini (1), Patrizia Trevisi (1), Judit Gervain (1,2)

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At birth, newborns show sensitivity to the rhythm of their native language, i.e. the language they heard prenatally, being able to discriminate it from a rhythmically different language (Pena et al. 2003, May et al., 2018). A current hypothesis (Gervain, 2018) suggests that prosody provides the basis of early speech perception and helps infants discover other linguistic units after birth, when the full-spectrum speech signal is available. Prenatal experience is thus hypothesized to be foundational for language learning. But what happens when prenatal experience is disrupted?
To investigate this, we are testing the ability of 0-10 month-old infants with hearing loss (HL) to discriminate their native language (Italian) from a rhythmically different unfamiliar language (English). Sentences in both languages are presented forward and backward. Backward speech, with perturbed temporal features, is a standardly used non-linguistic control (Pena et al. 2003). A control group of age-matched normal-hearing (NH) infants is also tested. Infants' brain responses are recorded using functional Near-Infrared Spectroscopy (fNIRS) covering the frontal, temporal and parietal regions, bilaterally.
Data collection is ongoing. Preliminary results (n=17 HL, n=18 NH) suggest that NH babies show overall larger responses than HL babies. In addition, it seems that Italian is triggering larger brain responses than English in the two groups.
If found, a deficit in prosodic perception in infants with hearing loss could provide theoretical insights into the role of prenatal and early postnatal experience in language development, as well as important applications for screening and intervention in this population.

1. Gervain J. 2018. Gateway to language: the perception of prosody at birth. In Boundaries Crossed, at the Interfaces of Morphosyntax, Phonology, Pragmatics and Semantics, ed. H Bartos, M den Dikken, Z Bánréti, T Váradi, pp. 373–84. Cham, Switz.: Springer
2. May L, Gervain J, Carreiras M, Werker JF. 2018. The specificity of the neural response to speech at birth. Dev. Sci.
3. Peña M, Maki A, Kovacic D, Dehaene-Lambertz G, Koizumi H, et al. 2003. Sounds and silence: an optical topography study of language recognition at birth. PNAS

PS1_05 – Detecting cerebral hemodynamics oscillations using Time Domain fNIRS

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(2) - Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche, Piazza Leonardo da Vinci 32, 20133 Milan, Italy.

Functional near-infrared spectroscopy (fNIRS) can non-invasively monitor periodic oscillations in hemodynamic signals recorded on the human brain cortex, revealing interesting physiological information. The typical devices employed for this application exploit the continuous wave (CW) and frequency domain (FD) fNIRS modalities. However, due to the phenomenon complexity and the heterogeneity of the tissue, the time domain (TD) fNIRS modality can represent a better option, since it is characterized by an increased depth sensitivity in single-channel acquisitions. So far, the main limitation of TD fNIRS is the lower signal-to-noise ratio when operating at the required sampling rate (>10Hz). A TD fNIRS device able to perform in-vivo measurements at acquisition rates up to 20 Hz and recently presented by the same authors could fill this technological gap.
In this work, the authors aim to prove the applicability of TD fNIRS in this field in two phases: first, a study based on simulated data was performed to define an acquisition protocol for in-vivo measurements and to support results interpretation, then, a measurement campaign on 13 healthy volunteers was carried out to study resting state oscillations during normal and forced breath.
In the first phase, numerical simulations were used to generate synthetic datasets by modelling the human head either as a homogeneous or a two-layer medium and exploiting the solutions of the diffusion equation for these two geometries. An interfiber distance of 4 cm was considered. Periodic perturbations of the concentrations of oxy- (O2Hb) and deoxy- (HHb) hemoglobin were imposed, determining changes in the medium absorption coefficient and hence in the photon distributions of time of flight (DTOFs). The data were analysed using different approaches, with multiple purposes. First, the raw signal power spectral density (PSD) was retrieved to determine the effect of multiple measurement parameters (acquisition time, sampling rate, and average photon count rate) on the technique sensitivity. Then, the depth sensitivity was evaluated using both a time windowing of the DTOFs and the time-dependent mean partial pathlength method to retrieve the concentrations of O2Hb and HHb within the medium.
In the second phase, two different protocols were used to acquire in-vivo data: acquisitions of 15 minutes were performed on the right frontal cortex of 13 healthy volunteers (28.5±4.1 years). The acquisition rate was set at 20 Hz and the interfiber distance at 4 cm. During the first acquisition, the subjects laid supine with a backrest

tilted at 30 degrees and breathed at their normal rate. During a second acquisition, the subjects were instructed to breathe at 5 BPM (0.083 Hz), following a metronome. The cardiac and breath cycles were also monitored using dedicated sensors. Overall, the results of the simulation study showed that the TD fNIRS allows for the detection and depth-localization of periodic fluctuations in the concentrations of cerebral O2Hb and HHb within the probed medium. The results obtained for the in-vivo measurements were homogeneous among the subjects and showed that the technique can detect periodic fluctuations in the signal, among which we can identify oscillations due to cardiac and respiratory activity.

1. Lange F. and Tachtsidis I. Clinical brain monitoring with time domain nirs: A review and future perspectives. Applied Sciences, 9(8), 2019.
2. R. Re, I. Pirovano, D. Contini, C. Amendola, L. Contini, L. Frabasile, P. Levoni, A. Torricelli and L. Spinelli. Reliable fast (20 Hz) acquisition rate by a TD fNIRS device: brain resting-state oscillation studies. Sensors, 2023
3. Obrig H., Neufang M., Wenzel R., Kohl M., Steinbrink J., Einhäupl K., and Villringer A. Spontaneous low frequency oscillations of cerebral hemodynamics and metabolism in human adults. NeuroImage, 2000.

PS1_06 – Laughing Together: Investigating the Impact of Laughter on Interpersonal Synchrony, Bonding, and Prosocial Behavior

Frederick Apmann, Verena Schaefer, Dr. Carolina Pletti

The poster presented will show the preliminary results of a study on the function of laughter in the context of interpersonal neuronal synchrony and further investigate the effects of laughter on prosocial intentions towards the partner. Laughter is a universal audio-visual expression of emotion often occurring during social interactions. Recent research highlighted laughter's role in facilitating bonding in groups of friends by eliciting endorphin release. Given its multimodal and rhythmic nature, laughter may be theorized to facilitate interpersonal neuronal synchrony, thereby fostering increased affiliation and prosociality between interaction partners. The present research employed fNIRS hyperscanning to test these hypotheses experimentally. Depending on the condition, pairs of strangers engaged in a funny or neutral interactive word game and were exposed to funny or neutral videos. Subsequently, participants engaged in 10 minutes of free interaction, during which interpersonal neural synchrony in the inferior frontal gyrus and temporoparietal junction was assessed. Following the interaction, participants completed questionnaires to measure rapport, liking, and propensity to prosociality toward their interaction partner. Preliminary results show that laughter increases neural synchrony in the inferior frontal gyrus, but this effect decreases towards the end of the free interaction phase. The findings of this study offer novel insights into the influence of laughter on neural synchrony, affiliation, and prosociality.

PS1_07 – Tuning into harmony: unveiling the influence of social music listening on pleasure and Inter-Brain Synchrony

Federico Curzel(1,2), Barbara Tillmann(2,3), Arnaud Fournel(1), Giacomo Novembre(4), Laura Ferreri(1,5)

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(2) Lyon Neuroscience Research Center (CRNL), INSERM, U1028, CNRS, UMR 5292, Université Claude Bernard Lyon1, Université de Lyon, Lyon, France
(3) LEAD CNRS UMR5022, Université de Bourgogne-Franche Comté
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Music represents throughout our lives one of the most pleasurable stimuli, which is also shared with others in social contexts. Both music and social interactions can activate the mesolimbic dopaminergic system (Ferreri et al., 2019; Wagner et al., 2015). Listening to music with a friend leads to higher perceived emotional intensity (Liljeström et al., 2012). However, the underlying neural mechanisms linking shared pleasure and social interactions remain unexplored. fNIRS hyperscanning enables the investigation of real-time neural dynamics between multiple brains (Czeszumski et al., 2020). Here, we aimed to investigate whether 1) sharing music with another person could increase pleasure responses and inter-brain synchrony (IBS), 2) the coherence of pairs' pleasure responses could predict the general pleasure, and 3) IBS could predict pleasure coherence.
In the present study, 36 pairs of friends listened to their favourite and experimental-selected music under two conditions: alone or together. Participants provided continuous pleasure ratings during music listening, and afterwards, overall pleasure ratings together with other emotional measures for each song. Pairs' closeness was measured by the Inclusion of Other in the Self scale (IOS, Aron et al., 1992). For each participant, the medial and lateral prefrontal cortex was monitored bilaterally with a 22 channels fNIRS system. The correlations between participants' continuous pleasure ratings were computed as a measure of pleasure coherence. fNIRS signals were preprocessed using Homer3 (Huppert et al., 2019). Wavelet Transform Coherence (WTC) was applied to assess the IBS between pairs of friends over the entire experiment and over song categories (Nguyen et al., 2021). The results were averaged over 4 Regions of Interest (ROIs).
Preliminary results suggest that participants' overall pleasure ratings were higher when pairs' continuous pleasure responses were highly correlated (p < .001) and when the relationship between the friends was closer (p = .04), in both conditions. However, overall pleasure responses were not modulated significantly across conditions. WTC analysis showed a significantly higher IBS when participants listened to music together

compared to when each participant listened on their own (p = .01), and pleasure coherence was positively predicted by IBS (p < .001).
In sum, participants' overall pleasure ratings were higher when there was a high pleasure coherence and when the friends had a closer relationship. Additionally, listening to music together resulted in significantly higher interbrain synchronization compared to listening individually, and pleasure coherence was significantly predicted by interbrain synchronization when friends were together.

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PS1_08 – Resting-state functional connectivity using fNIRS: From methodological optimization to exploring daily variations in healthy controls

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Resting-state functional connectivity (RSFC) has been mainly investigated with functional Magnetic Resonance Imaging. Functional near-infrared spectroscopy (fNIRS) is an alternative tool for the analysis of RSFC with the advantages of portability, noiselessness, and robustness to motion. Importantly, cortical RSFC could be acquired in ecological settings immediately before motor and/or cognitive tasks. Since the validity of signal pre-processing in the fNIRS field is an important issue, our first aim was to investigate the best approach to deal with motion artifacts (MAs) during resting-state recording. Our second aim was to assess possible differences in RSFC during the daytime by fNIRS in healthy controls. In fact, despite its potential impact, the time of day is rarely considered when brain activity is studied.
Comparison of motion correction techniques: Thirty-five healthy participants were recruited for a 15-minute resting-state fNIRS acquisition. They had to sit, stay still, and close their eyes. The array was composed of 50 standard 3cm-channels and 8 short-separation channels. Data acquired composed the real dataset (MAs <5%). Other four datasets were created in semi-simulation: real motion artifacts, extracted from the real dataset, were added to the real dataset, to achieve 10%, 15%, 20%, and 25% contamination of MAs. For each dataset and participant, the fNIRS signal was pre-processed with twelve different pipelines, which differed only for the motion correction technique used. The gold standard (GS) pipeline was the Discard pipeline applied to the real dataset. Each pipeline ended with a band-pass filter (0.009-0.08 Hz) and a regression of short-separation channel signals. The individual correlation matrix after each pipeline was obtained. Then, the group correlation matrix for each pipeline and dataset was computed. To compare different pipelines two metrics were assessed: the slope and the similarity coefficients. The former was computed between the Pearson correlation values of the GS and the tested pipeline. The higher the coefficient, the better the agreement between the pipelines. The latter was computed by performing a non-parametric test to evaluate statistics with the GS pipeline. Results suggest that

different pipelines could be applied without introducing bias when datasets are not heavily contaminated by MAs. However, when the percentage of MAs increases, some techniques might introduce bias. In conclusion, the Discard pipeline should be applied; if not possible, No Correction or Wavelet with high iqr is a good alternative.
Daily variations of RSFC: Forty-one healthy participants underwent the resting-state acquisition. The entire group was divided into two groups depending on the time of the session: 'Morning' and 'Afternoon'. The Discard pipeline was applied to the fNIRS signal. Then, concentration change signals of channels belonging to the same hemisphere and Brodmann's Area were averaged. For each group, the correlation matrix was obtained, and the statistical difference was performed. Two functional connections survived the statical comparison: the connection between left BA40 and right BA40 (Morning>Afternoon p=0.038) and between left BA7 and BA10 (Morning< Afternoon p=0.036). Results suggest the dependence of RSFC on the time of acquisition. Thus, the time of day should be considered when functional connectivity is investigated.

PS1_09 – Cortical Correlates of the Egocentric-Allocentric Spatial Switching Ability: an fNIRS Study

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Human beings represent spatial information in memory with respect to an egocentric (subject to object) and allocentric (object to object) frame of reference. Since the spatial environments in which we move and act are inherently complex, in our daily-life activities we constantly switch between egocentric- and allocentric-based spatial representations. This means that a flexible cooperation between both egocentric and allocentric reference frames is required to achieve several behavioural goals. To exemplify, when we use fork and knife together to cut and eat some food, the spatial representation of the fork could be referred with respect to our mouth or hand (egocentrically), but also with respect to the knife or the food itself (allocentrically). Previous studies aimed to investigate the neural underpinnings of spatial reference frames pointed out to a Fronto-Parietal network as principally subserving egocentric reference frame, and medio-temporal structures as mainly subserving allocentric reference frame.
Although such visuo-spatial process to translate spatial representations between egocentric and allocentric reference frames results diriment to fully interact with the surrounding spatial environments, to date it is still unclear which cortical regions subserve switching (different reference frames: from egocentric to allocentric; from allocentric to egocentric) and non-switching (same reference frame: only egocentric; only allocentric) spatial processes.
In the present study thirty-eight young adults undergone an ad hoc devised visuo-spatial working memory switching task (Ego-Allo Switching Task), while task related cortical hemodynamic activity was registered through the functional near-infrared spectroscopy (fNIRS) neuroimaging technique. Participants were asked to memorize triads of 3D geometrical objects and their relative positions. Thereafter, they were asked to provide two subsequent spatial judgments of relative distances – one after the other – about the same triad. This was made in two conditions: non-switching and switching. In the non-switching condition both spatial judgments regarded the same reference frame: egocentric (object X closest to you?), or allocentric (object X closest Y?). Instead, in the switching condition if the first spatial judgment regarded the egocentric reference frame, then the second regarded the allocentric one and vice versa. The brain cortical activity underling switching compared to non-switching visuo-

spatial processes was investigated by measuring the changes of relative concentrations of oxygenated and deoxygenated haemoglobin.
The results revealed that cortical activity subserving non-switching spatial judgments mostly resembled previous neuroimaging studies, showing patterns of cortical activity involving parieto-frontal regions for only-egocentric spatial judgments, instead patterns of activity involving temporal regions for only-allocentric ones. Instead, switching spatial judgments were found to be mostly supported by a generalized pattern of activity involving the frontal regions. More interestingly, the results revealed also that the translational process between reference frames involved also the cortical regions within the Temporo-Parietal Junction (i.e., Supramarginal and Superior Temporal gyri). Overall, the findings of the present works showed the involvement of the Temporo-Parietal Junction and of Frontal regions in the switching process between both egocentric and allocentric frames of reference. These results demonstrate that egocentric and allocentric spatial representations exist in parallel and cooperate.

PS1_10 – Evaluating the effects of order and content information in phonological working memory using fNIRS: a pre-registered study

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Phonological working memory (pWM) is crucial for language processing as it enables the maintenance and manipulation of verbal information. Retaining nonwords in WM is associated with brain activity over the superior temporal gyrus, inferior frontal gyrus, left precentral gyrus, left supplementary motor area, and inferior parietal lobe. This process entails keeping the items' identity (i.e., phonemes, syllables) and their order; however, its neural correlates remain largely unknown. The inferior frontal lobe, left supramarginal gyrus, and right intraparietal sulcus have been associated with order processing in WM in healthy populations, and a neuropsychological study with aphasia patients has revealed a double dissociation between item and order WM retention deficits, suggesting that distinct underlying neural mechanisms exist for the two processes. This study aims to further explore the possibility of a dissociated processing of order and content information in pWM and how WM load influences this process using fNIRS.

Twenty-five young Italian adults participate in a two-alternative forced-choice task while their brain activity over frontal, temporal, and parietal regions are recorded using functional near-infrared spectroscopy (fNIRS). The task involves a nonword recognition test with three levels of WM load (5, 7, and 9 CV syllables) in three conditions: no change, order change, and item change. A voice change control task is used to identify brain areas specifically involved in phonological processing. Between the presentation of each pair of nonwords, an unrelated processing episode is included to minimize subvocal rehearsal.

Based on previous research, we expect poorer behavioral performance for order change compared to item change conditions. This will be analyzed using a 3x3 ANOVA with the condition and WM load as factors. The fNIRS data analysis will identify the areas involved in pWM and estimate the effects of WM load and conditions in these regions. We hypothesize distinct patterns of brain activity in regions such as the inferior frontal lobe, left supramarginal gyrus, and right intraparietal sulcus during order and content change processing. Significant differences between control and experimental tasks will demonstrate the utility of fNIRS in the study of pWM. Additionally, our findings

will contribute to the understanding and modeling of pWM by identifying the neural mechanisms of order and content processing in nonword retention.

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PS1_11 – The reproducibility of infant fNIRS studies: a meta-analytic approach

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Introduction: The use of fNIRS has grown remarkably over the last three decades, especially in developmental cognitive neuroscience. As the volume of fNIRS research has grown, so has the concern for the reproducibility of its findings. Meta-analytic approaches are a powerful tool to assess the robustness of empirical findings and support theory building, but have been so far little applied to fNIRS data. In this work we describe a framework to aggregate across experimental findings to reveal the robustness of the effect of rule learning in infants (de la Cruz-Pavía & Gervain, 2021; Marcus et al., 1999) in the left temporal lobe and to investigate its sources of variability across studies, e.g. different laboratories, countries, NIRS machines etc., and across individuals.
Methods: We aggregated 19 fNIRS studies conducted in different laboratories (k=4), testing brain responses of infants to auditory stimuli presented as trisyllabic sequences, representing repetition- (e.g. ABB: ba-ge-ge) and diversity-based (e.g. ABC: mu-ba-ge) linguistic rules. The final sample included 355 newborns, 104 6-month-olds, 13 7-month-olds and 15 9-month-olds. After pre-processing all NIRS raw data with the routine described in Gemignani & Gervain (2021), effect sizes were computed for three effects of interest: brain responses to repetition-based rules vs. baseline (R vs 0), diversity-based rules vs. baseline (N vs 0) and repetition- vs. diversity-based rules (R vs N). The analysis was narrowed to responses measured from the left temporal lobe, given the well documented relevance of this area for speech processing and for the effect under investigation (Gervain, 2008; Gervain et al., 2012). The average magnitude of brain responses was compared to their between-subject variation to obtain meta-analytic effect sizes, and to their inter-trial variation to obtain infant-level effect sizes. In both cases, we explored how effects are moderated by the factors Laboratory, Age of the Participants and Rule Type, using meta-analytic and linear mixed effects models (Viechtbauer, 2010).
Results: The overall magnitude of the effect was 0.27 (95% CI=[0.144, 0.398], z=4.20, p<0.001) for the R vs 0 comparison, 0.18 (95% CI=[0.03, 0.33], z=2.35, p<0.05) for the N vs 0 comparison and 0.08 (95% CI=[-0.06, 0.22], z=1.14, ns) for the R vs N comparison. No analysis revealed a significant effect of Laboratory. Age was a significant moderator: responses to repetitions were larger in 6-month-olds than in newborns, then decreased for 7- and 9-month-olds.
Conclusion: Our meta-analysis quantified effect sizes of infants' responses to repetition- and

diversity-based rules in the left temporal area. The analysis revealed no significant variability attributable to Laboratory, indicating that effects were overall robust and reproducible across different Labs (in different countries and with different NIRS devices). Further, we found differential developmental trajectories for the two types of rules, thus demonstrating the value of employing meta-analytic techniques to identify theoretically relevant moderators and thus contribute to stronger theory-building on phenomena of interest.

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PS1_12 – Combining diffuse optical tomography and continuous glucose monitoring to investigate alterations of resting state functional connectivity induced by glycemic variability in very preterm neonates: Preliminary results

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Very preterm neonates (born before 32 weeks of gestation) are more exposed to critical glycemic variations in the first few days after delivery. Neonatal glycemic instability, defined as a series of hypo- and/or hyperglycemic events, seems to be associated with increased mortality and morbidity rate, as well as impaired neurological and cognitive development [1]. Previous studies have shown a relation between glucose values and cerebral hemodynamics [2]. Glucose is one of the most important cerebral metabolites; therefore, its decrease or excessive increase can lead to important cerebral hemodynamics variation which can affect brain development [3].
The aim of this work is to investigate whether glycemic events in very preterm neonates during the first days of life can modify and modulate the brain patterns of resting state functional connectivity.
The dataset consists of 47 very preterm neonates whose glycemic and hemodynamics data were collected at the Neonatal Intensive Care Unit of the University Hospital of Padova during the first week of life, starting from March 2020. The project and recruitment is still ongoing. The glycemic signal was acquired through a continuous glucose monitoring (CGM) device for a minimum of 20 hours to a maximum of 6 days; during this period, the brain hemodynamic signal was also acquired with diffuse optical tomography (DOT). The DOT device (NTS Gowerlabs) is composed of 8 sources and 8 detectors, for a total of 64 channels localized on the parietal, motor, superior occipital, superior temporal and posterior frontal brain areas. The glycemic signal was analyzed to identify and characterize all the glycemic events and the duration of the euglycemic intervals. Glycemic events were defined as: mild hypoglycemia (47-71 mg/dL), severe hypoglycemia (<47 mg/dL), mild hyperglycemia (145-180 mg/dL) and severe hyperglycemia (>180 mg/dL) [4]. From this analysis, 35 neonates were initially excluded based on the following criteria: presence of hypo- or hyperglycemia events before the first euglycemic interval or if the total time outside the euglycemia range was

below the 25th percentile computed on the entire selected population. For the cerebral hemodynamic analysis, two five-minute intervals were identified in the first and last euglycemic window, choosing the 5 min windows having the least number of bad channels and motion artifacts. DOT signals were pre-processed, removing bad channels and paying particular attention to the correction of motion artifacts through the implementation of an adaptive strategy based on physiological oscillations as suggested by Yang et al. [5]. The resting state functional connectivity analysis was then performed, and its results correlated with some metrics extracted from the glycemic signal (e.g., glycemic variability, number of hypoglycemic events, etc.). Some preliminary results of the correlation between changes in resting state pattern and the glucose variability occurring between the two DOT acquisitions will be presented. The presence of any correlation between glycemic events and variation of resting state functional connectivity may support future studies on glucose control and neurodevelopment of very preterm neonates.

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PS1_13 – Speech Discrimination Abilities at Birth Predict Language Development: A Prospective fNIRS Study in Pre- and Fullterm Born Children

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Background: Language deficits are among the most commonly reported cognitive deficits in preterm born children. Though prematurity is a risk factor for language developmental delay, gestational age at birth only explains 30-40 % of variance in verbal skills (Allotey et al. 2017). However, identifying children at risk for language developmental delay is important, as early intervention has been shown to be most effective. Hence, there is a need for early predictors of language outcome after preterm birth.
Auditory discrimination abilities are essential for normal language development and can be verified from the first days of life. Previous fNIRS studies of our research group have shown alterations of neural speech discrimination in preterm born infants at term-equivalent age (Bartha-Doering et al. 2019), with children born before the gestational age of 32 weeks being especially vulnerable to speech discrimination deficits at term (Alexopoulos et al. 2021). In the present study, we were thus interested in the predictive value of auditory speech discrimination at term and later language development. We hypothesized that auditory speech discrimination at birth predicts later language abilities.
Methods: We prospectively included 115 preterm and fullterm born neonates. In all infants, a fNIRS measurement was performed around 40 weeks of gestation. Hemodynamic responses were acquired using a Hitachi ETG-4000 optical topography system with 24 channels. We used a well-known speech discrimination paradigm of forward versus backward speech (Peña et al., 2010) that has already shown robust findings in full-term born neonates (Bartha-Doering et al. 2019; Alexopoulos et al. 2021; Alexopoulos et al. 2022).
Three years later, we re-invited all children with valid fNIRS data at the age of 3 years to evaluate their language development. Due to the COVID-pandemic, however, the drop-out rate was high (60%), resulting in 46 children with both fNIRS and follow-up data. In these children, a standardized test battery was used to test language

comprehension, language production, and verbal working memory. Parents were furthermore asked to rate their child's vocabulary and syntactic development using a standardized questionnaire.
Results: The last follow-up data were just acquired, and final analyses are currently running. However, preliminary statistical analyses point to a significant positive correlation of hemodynamic differences between conditions with language outcome. Thus, the better language discrimination at birth, the better the language abilities at three years of age. Furthermore, the more left lateralized the neonatal brain areas with the largest hemodynamic differences between forward and backward speech, the better the language outcome at three years of age. Final results of this study will be presented at the conference.

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PS1_14 – Resting-state functional connectivity at birth and neurodevelopmental outcome at 12 and 24 months of corrected age in a population of very preterm infants: Preliminary results

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Premature infants from the earliest years of life show high rates of deficits in language, cognitive, socio-emotional and sensorimotor development [1,2], but early detection mechanisms remain limited. Thanks to advances in neuroimaging techniques, it is now possible to investigate whether there might be a correlation between the risk of developing neurodevelopmental disorders and brain functional hemodynamic patterns present at birth. Among the available neuroimaging techniques, functional near-infrared spectroscopy is a non-invasive, cot-side, promising neuroimaging technique, which could be used to acquire resting state hemodynamic patterns (rs-fNIRS) defining the architecture of the brain's functional networks in new-borns [3].
The dataset for this study consists of 47 very preterm neonates (< 32 weeks gestational age or <1500 gr birth weight) whose hemodynamic data were collected at the Neonatal Intensive Care Unit of the Padova University Hospital during the first week of life, starting from March 2020. The research is based on a larger experimental design and recruitment is still ongoing. NIRS data were acquired with an NTS system (Gowerlabs) equipped with 8 sources and 8 detectors, for a total of 64 channels localized on the parietal, motor, superior occipital, superior temporal and posterior frontal brain areas. NIRS data were acquired continuously from a minimum of 20 hours to a maximum of 6 days after birth. The present work involved 24 of these preterm who were followed-up at 12 and 24 months of corrected age to evaluate their neurodevelopmental outcome.
At 12 months, cognitive, linguistic, motor and socio-emotional development was assessed using the Bayley III Scale of Infant and Toddler Development. Two further experimental tasks were used to investigate attention and visual recognition memory: the Gap-Overlap, to examine attentional processes, in particular disengagement and shifting of attention, and the Simultaneous Stream Change Detection Task, for visual recognition memory, i.e., the ability to retrieve a previously stored memory trace [4,5].

At 24 months, the same follow-up was performed, increasing the complexity of the tests in relation to the aptitude of a child of equivalent age. During the experimental tasks, high-density electroencephalographic data were recorded. Resting state functional connectivity was computed from the fNIRS data using a 5-minute time window identified while the patient was in a stable state and the NIRS signal was as stable as possible (with few motion artefacts and few noisy channels removed). Rs-fNIRS patterns were then reconstructed using a neonatal head model corresponding to the preterm gestational age. In order to reduce the dimensionality of the data to a small number of ROIs (Region Of Interest), seed-based functional connectivity analysis on selected ROIs was used and the FC matrix generated [3]. The metrics derived from the rs-fNIRS analysis are then correlated with behavioural indices measured during follow-ups to track possible developmental trajectories. Preliminary results from a few patients will be reported to highlight the development of the study and possible trends of the correlations.

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PS1_15 – An fNIRS investigation on the 'external timing' of placebo analgesia and nocebo hyperalgesia

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Background: Commonly known as the therapeutic effects derived from the administration of an inert pill, placebo effects are conceivable as "context effects" (Carlino et al., 2014): while a positive context can cause relief on patient' symptoms, a negative context may lead to a harshening of symptoms, i.e. a nocebo effect. Research on placebo and nocebo effects has mainly focused on how positive or negative contextual variables create expectancies that, in turn, affect pain perception. In the majority of placebo and nocebo studies, the manipulation of the expectation has mainly focused on the direction (e.g. "this treatment will increase/decrease pain") or magnitude (e.g. "this treatment will largely/poorly affect pain") of the effects. Only few studies have investigated the role of temporal information. Using both acute and sustained models of pain, recent studies have shown how placebo and nocebo effects are influenced and determined by temporal information about when the modulation of pain will occur (Camerone et al., 2021a; Camerone et al., 2021b). In these studies, precise temporal information about the effectiveness of the treatment have been delivered (e.g. "this treatment will be effective in 5 minutes"), and results showed that placebo and nocebo effects started precisely at the expected time point. The neurobiological basis of these phenomena remains unclear, thus we still do not know if specific brain activations (e.g. activation of the dorsolateral prefrontal cortex) are responsible of these effects.
The aim of this study is to replicate our previous data using fNIRS (functional near-infrared spectroscopy) technology in order to characterize the brain activations during the task.
Methods: 40 healthy volunteers were randomized in 5 groups; i.e. one control group, where no suggestions of analgesia/hyperalgesia were given, and four experimental groups which received different temporal information about the expected onset of analgesia/hyperalgesia. Depending on the group allocation, participants were informed that the application of an (inert) cream would have reduced (placebo groups) or amplified (nocebo groups) pain after 5 (Placebo5- and Nocebo5- group) or 20 (Placebo20- and Nocebo20- group) minutes. The nociceptive stimulation consisted in ten blocks of 25 stimuli delivered at the beginning of the experiment (baseline) and 10

(Test10) and 25 (Test25) minutes after cream application. After each block of stimuli, participants' pain intensity rating on a 0-10 scale were collected.
Results: From a behavioral point of view, we replicated the results from our previous studies (Camerone et al., 2021a), demonstrating that temporal cues affect the onset of placebo and nocebo effects. From a neurobiological point of view, fNIRS detected specific changes in different somatosensory and high-order cortices. The specific temporal effects of placebo and nocebo expectations will be presented and discussed.
Conclusions: our study opens up the possibility to study the placebo and nocebo effects using the innovative fNIRS technology, leading to a more ecological study approach of the placebo/nocebo effects.

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PS2_16 – Cognitive and sensorimotor contributions to manual dexterity: an fNIRS study during 9HPT performance

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Manual dexterity is referred to as the skill to perform fine motor movements. A standard method for evaluating manual dexterity in clinical setting in various neurological diagnoses is the Nine-Hole Peg Test (9-HPT), according to which a patient is asked to take nine pegs from a container, one by one, place them into nine holes on a board as quickly as possible, and then remove them, one by one, replacing them back into the container.
Notwithstanding manual dexterity is commonly addressed in the assessment of the sensorimotor domain, an extensive definition of manual dexterity should be considered, where the inclusion of cognitive aspects is underlined (Makofske, 2011). Here, we tried to discern between aspects dealing with the sensorimotor and cognitive domains in manual dexterity.
In a group of 28 healthy participants (28.39±8.87 years) we investigated, by using fNIRS, cortical activations elicited by the execution of the 9-HPT, in comparison with a novel active control condition we called 1-HPT, in which the pegs must be placed and removed using the same single hole. We used an array of 40 standard channels (3cm) covering prefrontal, sensorimotor and parietal areas, and 8 short-separation channels. The 9-HPT took significantly longer than the 1-HPT. A significant, positive, linear relationship was found between the time employed by a participant to complete the 9-HPT and that required for the 1-HPT (r = 0.73; p < 0.001), indicating that the participant's characteristics in performing the 1-HPT were similar to those shown during the 9-HPT. This could suggest that the sensorimotor component related to the phases of reaching, grasping and positioning the peg in the hole, as occurring in the 1-HPT, already outlined a profile of the participant when he/she was asked to perform a more complex manual dexterity task, such as the 9-HPT.
The strong linear relationship between the 9-HPT and the 1-HPT was mirrored by a similar pattern of cortical activation observed in the two tasks, including sensorimotor areas belonging to the network controlling reaching and grasping movements (Caliandro et al., 2021; Ranzini et al., 2022). Further, ipsilateral premotor and motor

areas were found to be active, in line with previous works showing an active role of the ipsilateral hemisphere in planning and executing unilateral limb movements (Bundy and Leuthardt, 2019).
Then, we identified two groups based on the difference between the execution time of the 9-HPT and the 1-HPT (ΔHPT). Participants showing a large ΔHPT presented significantly higher activation in prefrontal cortical areas (right BA10 and BA11) during 9-HPT and 1-HPT performance with respect to the participants with a small ΔHPT, who showed a deactivation in BA10. Unexpectedly, we observed a significant linear relationship between ΔHPT and right BA10 activity. This suggested that participants performing the 9-HPT more slowly than the 1-HPT were those recruiting prefrontal areas and implicitly exploiting the cognitive skills of planning, perhaps to find a motor strategy to better solve the test activating attentional and cognitive control processes, but at the expense of the time to accomplish a manual dexterity task.

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PS2_17 – Learning repetition-based regularities in speech: a NIRS study with 7-month-old infants

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Infants exhibit a robust capacity for learning rules from speech. By 6 months of age, they can encode both repetition- and diversity-based regularities between adjacent syllables (e.g., ABB: ‘‘mubaba” vs ABC: ‘‘mubage”, respectively; de la Cruz-Pavía & Gervain, 2021). By contrast, non-adjacent repetitions (e.g., ABA: “bamuba”) have been investigated only in newborns (Gervain et al., 2008), who fail to discriminate them from diversity-based controls (ABC).

Since non-adjacent dependencies play an important role in language, in this study we investigate if 7-month-old infants can discriminate non-adjacent repetitions from ABC controls using Near-Infrared Spectroscopy (NIRS). We compare a repetition-based ABA artificial grammar and an unstructured ABC control grammar. Infants’ brain responses are recorded from the frontal, temporal, and parietal regions, bilaterally.

Data collection is ongoing. Preliminary results from 13 babies (6 females, mean age: 210.4 days) suggest that infants encode both non-adjacent repetitions and diversity-based structures as compared to baseline in bilateral temporal areas.

If confirmed, these results suggest that infants are able to encode non-adjacent repetitions as early as 7 months of age, laying the foundations for grammar learning.

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PS2_18 – The use of fNIRS to explore ADHD in children: lights and shadows from a 10-year experience at Medea NIRS Lab

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The use of functional near-infrared spectroscopy (fNIRS) in cognitive neuroscience has drawn a steadily growing interest over the last few decades. This is due to the several advantages that fNIRS offers in respect to other neurofunctional techniques, especially for probing cortical activations in children with neurodevelopmental conditions (Mauri et al., 2018; Grazioli et al., 2019).
At Scientific Institute Medea we use fNIRS to investigate attention-deficit/hyperactivity disorder (ADHD) in school-aged children with two aims. Our first goal is to understand whether fNIRS could help in identifying ADHD children and correctly differentiating them from typically developing (TD) peers. Second, we aim to analyze whether the cerebral hemodynamic responses measured by fNIRS could be a reliable marker of the acute effects of stimulant medications. Here we would like to share our 10-year journey of evaluating more than 100 ADHD children with fNIRS, acknowledging the lights and the shadows we experienced through the years.
With respect to our first goal, we were able to describe peculiar cortical activations in independent ADHD samples during several cognitive tests, such as working memory task (Grazioli & Crippa et al., 2019), emotional continuous performance task (e-CPT; Mauri et al., 2020), and go/no-go task (Scaccabarozzi, Bianchi, et al., in preparation). Moreover, we demonstrated that a machine-learning classification approach to fNIRS data can reliably identify school-aged ADHD children, even supporting the diagnostic process (Crippa, Salvatore et al., 2017). However, despite some recent efforts, the lack of a widely accepted protocol for fNIRS data processing, in particular for motion correction, has limited the possibility to compare our results with previous works. To partially deal with this issue, we developed a preprocessing pipeline for reliably handling motion artifacts (Piazza et al., 2020).
With regard to our second aim, we found controversial results about differences in fNIRS activation related to stimulants administration. In one published work (Grazioli et al., 2021), no significant change was found regarding the brain hemodynamic activation during an e-CPT after the stimulant treatment, net of significant improvements in clinical/neuropsychological symptomatology. However, in a more recent study (Bianchi, Scaccabarozzi, et al., in preparation), we found stimulant-induced activations in the bilateral prefrontal cortex during a go/no-go task in a different sample of ADHD children. There might be many reasons for this discrepancy, as the studies were different in several methodological characteristics, such as cognitive task

and fNIRS device. Furthermore, the possibility that subcortical changes induced by stimulants could be more evident in brain regions not reachable by fNIRS remains an open question. Thus, despite some promising results, we feel that more work is needed in this area.

Our future directions at Medea NIRS Lab include both the application of integrated EEG–fNIRS approaches to overcome the limitations of the single-method technique and the use of fNIRS with freely moving participants in order to investigate more ecologically valid settings.

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PS2_19 – The neonate brain's sensitivity to repetition-based structure: specific to speech?

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Newborns are able to extract and learn repetition-based regularities from the speech input, i.e. they show greater brain activation in the bilateral temporal and left inferior frontal regions to trisyllabic pseudowords of the form AAB (e.g. “babamu”) than to random ABC sequences (e.g. “bamuge”; Gervain et al., 2008, 2012). Is this sensitivity specific to speech and language?

To answer this question, we tested whether newborns are sensitive to repetition-based regularities when those are implemented with musical tones. Twenty-three neonates listened to blocks of AAB and ABC tones sequences (fourteen blocks per condition and ten items per block) while their brain activity in the temporal, parietal and frontal areas was recorded using functional Near-Infrared Spectroscopy (fNIRS). Each of the 20 unique syllables comprising the stimuli in the original study with speech (Gervain et al. 2012) was mapped onto a different piano tone. Thus the paradigm, the frequency of occurrence and the distribution of the tones were identical to those of syllables in Gervain et al. (2012).

The permutation analysis over oxyHb concentration changes revealed four significant clusters of channels where brain activity differed between the AAB and the ABC conditions: one in temporal and one in fronto-parietal areas in both hemispheres. A linear mixed effects model over these clusters revealed a significant main effect of condition due to larger inverted (negative) responses to AAB than ABC. The main effect of time was also significant due to a general decrease in response amplitude over time.

These findings show that newborns’ ability to discriminate AAB from ABC sequences is not specific to speech – it also extends to musical tones. However, the neural response is markedly different. First, we observed a strong overall habituation pattern over time, whereas for speech an increase was present over the time course of the study. Second and relatedly, the repetition regularity gave rise to an inverted hemodynamic response, while it was canonical for speech. Thus newborns’ ability to detect reduplication is present in auditory modalities other than speech, but the underlying brain mechanisms may be different.

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PS2_20 – Processing of reversible sentences in late bilinguals of English: an fNIRS investigation

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A large body of psycholinguistic and neurolinguistic research has shown that non-canonical sentences such as passives (e.g., The man was being followed by the dog) are computationally harder to process (comprehend and produce) than canonical structures (see Walenski et al., 2018 and Europa et al., 2019 for review). We will report on an ongoing study (data collection is still underway) that uses fNIRS (NIRSport 2) to examine the neurocognitive correlates of reversible sentence comprehension in late bilingual speakers of English. The task is a sentence-picture verification task: participants see a picture depicting a transitive reversible event on the screen (e.g., “girl following boy”; “boy following girl”) along with an auditorily-presented description in either the active or passive voice that either matches or does not match the picture. The design is event-related, 2 (structure) x 2 (match) within-subjects. The fNIRS montage covers frontal and temporal areas bilaterally. Based on previous studies (Scherer et al., 2012; Mack et al., 2013), we predict activation in the left frontal areas during the processing of more complex sentences (mismatch condition and passive sentences), with stronger activation in the left inferior frontal gyrus (BA 44 e 45). We also predict activation in the contralateral area (RIFG) in conditions with higher processing demands.

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PS2_21 – Measuring brain activity in preparation and execution of driving countermeasures to unexpected road crossings: the concept of a simulation study in the CAVE environment

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In the complex driver-pedestrian interaction, the adoption of safe behaviors from both drivers and pedestrians is a key factor in reducing the risk of road accidents. Road crossing events are a high-level risk situation in urban environments, and albeit the prediction of pedestrians' intentions is eased by a number of factors, the activation of timely and appropriate countermeasures in response to dangerous pedestrian behaviors remains a challenging task for drivers. These countermeasures, such as emergency braking maneuvers, require an integrated collaboration of sensory, cognitive, decision-making and operational capabilities. At the brain level, an important role in the anticipation and planning of complex cognitive tasks is played by the dorsolateral prefrontal cortex (DLPFC). The present research project aims at investigating this aspect from the driver perspective, focusing on the act of pedestrian crossing in predicted (with crosswalks) or unpredicted road sections (i.e., jaywalking). Following a behavioral and neurocognitive perspective, we hypothesize of observing differences in the modalities of execution of driving countermeasures, coherently with the permissibility of the pedestrian crossing (jaywalking or non-jaywalking). Importantly, an increased activity of DLPCF is expected when facing jaywalkers, consistently with the literature on the role of this area. The present contribution is presented in the form of a concept poster. We are planning to recruit about 40 adult participants with a valid driving license. The sample will be equally balanced in terms of gender and age range, so to investigate potential behavioral and neural differences between young adults (18-30 years old) and adults (40-50 years old). The study will be conducted in an immersive CAVE setting (Cave Automatic Virtual Environment), and the driving scenario – fully programmed in SCANeR studio software - will be projected on a 6000x1080 screen. In a simulated urban scenario, participants will drive a vehicle with automatic transmission with the use of a Logitech G29 steering wheel, facing an oddball-like paradigm. Hemodynamic activity in the prefrontal and parietal areas will be monitored with NIRSport2, a portable and wireless tool in the context of

immersive and natural environments. Events of interest will be triggered from the SCANeR simulation software to Aurora fNIRS software across an ad-hoc Simulink model. Additionally, driving style, simulation sickness (SS) and levels of Presence will be assessed before and after the simulation task. The present research aims at providing new insights on the role of DLPFC in planning and executing complex behavioral tasks in reaction to critical stimuli. We aim to apply this investigation in the context of urban driving, as a highly stimulating environment, embedded in an experimental setting characterized by extreme ecological validity. Importantly, the integration of CAVE environment, simulated driving and wireless fNIRS assessment may provide practical information on the design and implementation of immersive multitool experimental studies.

PS2_22 – Neuromarketing with fNIRS, assessing experiential consumption and measuring implicit desire for a product

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Neuromarketing, an inter-disciplinary field combining neuroscience and marketing attracts a great deal of interest because it may provide a deeper understanding, compared to traditional methods, of purchasing behavior by elucidating its underlying neural basis. fNIRS is mobile, low cost, comfortable, and tolerant of body motion. All these merits imply its high potential in neuromarketing research. Here, we provide two recent examples. The first is on experiential consumption, which refers to purchases involving hedonic experiences. It is closely related to cognitive biases, and among them, we focus on the IKEA effect, which is a cognitive bias in which the maximum willingness to pay (WTP) for a product is high because the experience of assembling the product is highly valued. Here we present the first study exploring the neural substrates of the IKEA effect using fNIRS. Thirty healthy students, of which twenty-four were confirmed to have undergone the IKEA effect, were asked to perform a WTP evaluation task after assembling three types of do-it-yourself (DIY) products and handling three types of Non-DIY products. Their cerebral hemodynamic responses during the evaluation were measured using fNIRS. The cortical activation during evaluation of WTP for DIY and Non-DIY products exhibited marked differences. In addition to the R-IFG activation often reported for WTP evaluations, we revealed that other regions, in particular the L-IFG and L-MFG, were activated during the DIY condition. These areas are considered to be related to memory and attachment, which would serve as reasonable cognitive constituents for the IKEA effect. Thus, this study suggests that the value of experiential consumption can be assessed using fNIRS and provides a novel approach to neuromarketing. Second, while many studies have focused on explicit attitudes, few have targeted implicit aspects. To explore the possibility of measuring implicit desire for a product, we focused on functional impulsivity related to obtaining a product as a reward and devised a product-rewarded traffic light task (PRTLT). The PRTLT requires participants to take risks under time pressure in order for them to maximize rewards in the form of commercial products, with the brand of products being an independent variable. Thus, we explored the feasibility of applying a PRTLT in a neuromarketing context to implicitly measure the perceived value of products and supported our data with neurophysiological evidence obtained using fNIRS to concurrently monitor cortical activation. Thirty healthy students were asked to perform the PRTLT. We compared participants' functional impulsivity toward two different chocolate products that had obviously different values. Behavioral analysis confirmed that the expensive condition trended toward producing a higher PRTLT score than did the inexpensive condition. fNIRS analysis showed task-derived activation in the bilateral dorsolateral prefrontal cortex (DLPFC) and frontopolar cortex (FPC). Moreover, we found significant differences between expensive and inexpensive conditions in the cortical activations in the FPC and the left-DLPFC. These results imply that the two products evoked different functional

impulsivity, and the hemodynamic responses reflect that. Thus, we concluded that it is possible to measure demand for products using a PRTLT that evokes functional impulsivity.

PS2_23 – Investigating the hemodynamic response to glycemic events in pre-term infants using diffuse optical tomography: preliminary results

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Introduction:Very preterm neonates (< 32 weeks gestational age (GA)) are prone to experience glycemic events, in the form of hyper and hypo-glycemia. Current clinical practice entail measuring preterm's blood glucose concentrations (BGC) approximately twice a day. From these samples, clinicians aim to regulate BGC to maintain a euglycemia state. This practice doesn't consider any individual differences in the preterm such as the variability in thresholds for considering an event to be a hyper and hypo-glycemic event, which currently lacks consensus [1] and leaves time periods of up to 12 hours where the BGC isn't known. This project aims to investigate whether continuous glucose monitoring (CGM) can lead to better regulation of preterm BGC, leading to favourable outcomes of the preterm, and to investigate the relationship between hyper and hypo-glycemic episodes and brain haemodynamics in individual preterm's and collectively, using diffuse optical tomography (DOT). Methods: Very preterm infants with GA ≤ 32 weeks or birth weight ≤ 1500 gr were enrolled from March 2020 in the Neonatal Intensive Care Unit of the University Hospital of Padova. To date, 58 patients have been recruited with a median GA of 30 weeks and birth weight of 1310 gr. CGM was carried out on all patients and was acquired using a Medtronic CGM system inserted in the thigh after disinfection of the site. Patients were randomly assigned to the experimental or control group, and both groups had DOT and CGM data acquired, for a maximum of 6 days after birth. The experimental group had CGM unblinded, such that clinicians would be notified of any hyper-hypo glycemic event, whereas the control group followed standard clinical practice, and would only be notified of the newborn's glycemic concentration approximately twice a day.
Glucose data was sampled at 0.0033 Hz (one sample every 5 minutes) and episodes were classified in four different categories: severe hyper (>180 mg/dl), mild hyper (

145-180 mg/dl), mild hypo (72-47 mg/dl) and severe hypo (< 47 mg/dl). Events were defined based upon finding at least 3 consecutive samples in non-euglycemia and then finding 15-minute euglycemia baselines before and after these events. These were synchronised with the acquired DOT data.

The DOT data was acquired using a continuous wave device (NTS, Gowerlabs), consisting of 8 sources and 8 detectors, measuring at 10 Hz, for 64 measurable channels at 780 nm and 850 nm, distributed evenly across the scalp. The DOT data will be processed using Homer2 [2] and NIRFAST [3] processing streams on Matlab.

Results: So far 31 patients have been identified for potential CGM-DOT analysis. These patients have been classified into three groups: 1. only hypo-glycemic events, 2. only hyper-glycemic events and 3. both hypo and hyper- glycemic events. Here, we aim to present and compare a small selection of patient's haemodynamic responses in the three aforementioned groups to hyper and hypo-glycemic events.

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PS2_24 – Investigation of Bimanual Coupling: Behavioral and Hemodynamic Evidence of Interference Effects

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Introduction: The Circle-Line (C-L) drawing paradigm is employed to investigate the impact of hand movements on bimanual coupling. Participants are instructed to draw simultaneously with both hands. When they are asked to draw different figures (Circles with one hand and Lines with the other), the resulting trajectories of both shapes typically take on an oval form, indicating that the motor programs of the hands are intertwined. Bimanual movements have already been examined using fMRI. However, fNIRS offers a more ecologically valid means of exploring this task respecting the participant's writing position.
Methods: Thirty-eight healthy individuals (with a mean age of 32.4 ± 2.1 years) participated in an fNIRS study during the C-L task. They were instructed to draw continuous vertical lines or circles using both hands while blindfolded. Four experimental conditions were presented in random order: drawing lines with both hands (Line-Congruent), drawing circles with both hands (Circle-Congruent), drawing lines with the left hand and a circle with the other hand (Line-Incongruent), drawing circles with the left hand and a circle with the other hand (Circle-Incongruent). Ten trials were conducted for each condition (task duration of 11 ± 3 s; rest duration of 15 ± 2 s). The behavioral data were collected from the left hand, which drew on a tablet, and an ovalization index was calculated to indicate the distortion of the trajectory from the ideal figure. The fNIRS array comprised 50 3cm-channels and 8 short-separation channels. The fNIRS signal was pre-processed for each participant: channels with a low signal-to-noise ratio were discarded; the intensity data were transformed into attenuation changes, and motion artifacts were corrected using the wavelet motion correction technique. A band-pass filter of 0.01-3 Hz was applied, and the mean hemodynamic response for each task block, participant, and the channel was obtained using a General Linear Model (GLM) approach. Next, we averaged the channels that belonged to the same Brodmann's Area (BA). For each BA, the mean values of oxy-hemoglobin responses between 5 and 17 seconds after the stimulus onset were computed and used for statistical comparison. Additionally, for each subject and condition, we calculated the peak latency as the time when the hemodynamic function reached its

maximum to evaluate the activation time of the BA under various conditions. Results: The behavioral results revealed significant differences between the Incongruent and Congruent conditions, indicating that when participants performed Incongruent drawings, the resulting figures were more distorted. In addition, both the hemodynamic activity and the temporal analysis showed differences between the two conditions. In particular, the sensorimotor areas and the right premotor cortex presented higher activity during Incongruent tasks, and the peak activation was anticipated in Incongruent tasks than in the Congruent ones.
Conclusion: Our results are consistent with previous literature, showing activation of similar Brodmann's areas. The different activations observed in the C-L paradigm may be clarified by exploiting the higher temporal resolution of fNIRS compared to fMRI. Additional investigation is needed to understand whether there is a progression in area recruitment during a bimanual paradigm.

PS2_25 – Comparison hemodynamic response during Valsalva maneuver using continuous wave and time domain diffuse correlation spectroscopy on healthy subject

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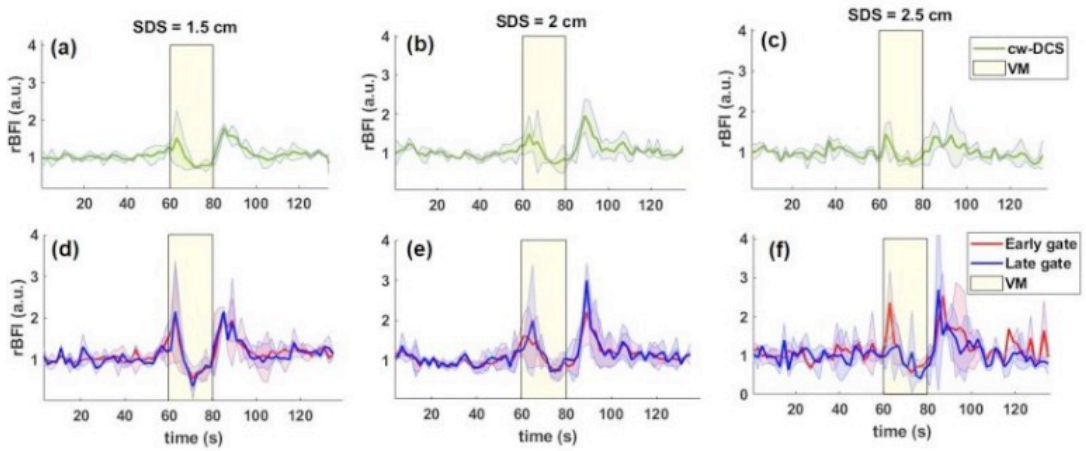
Cerebral blood flow (CBF) is a physiologically parameter that provide the needed oxygen to the brain maintain functional and structural integrity and is essential to be monitored in patient with traumatic brain injuries and disease. There are two optical method to evaluate CBF.
In continuous wave diffuse correlation spectroscopy (cw-DCS) tissue is assumed as a homogeneous structure which could be misleading in monitoring of the brain and discrimination of the detected photons based on their propagation path is not feasible with a single source-detector pair. This problem is compensated by increasing source-detector distance (SDS) to 2–3 cm [1]. To consider layered structure of the head, time domain diffuse correlation spectroscopy (td-DCS) has been introduced. This technique can offer increased sensitivity to cerebral hemodynamics and reduced contamination from extracerebral layers by differentiating photons based on their travel time in tissue. In td-DCS by selecting photons with different time of flight of photon (DTOF), it is possible to reveal the dynamics of superficial and deep layer [2].
In order to compare the hemodynamics response detected by cw and td-DCS technique, we performed experiments on a healthy adult volunteer and evaluated the BFI changes during Valsalva Manure (VM) which is one of the validated quantifying autonomic function tests. Each trial of measurements includes 1 min baseline followed by 20s VM and 1 min release. The trial was repeated two times at 3 different SDS. In this study, to analyze the data of td-DCS, DTOF peak was considered as zero time followed by $\sqrt{\Delta V}$ ns before peak as early gate and $\sqrt{\Delta V}$ ns after peak as late gate to reveal information from superficial and deep layer respectively. V (variance) of a DTOF which refers to the second centralized moment has been calculated based on the DTOF's statistical moments [3]. Following figure shows relative BFI (rBFI) changes during VM measured by cw and td-DCS simultaneously. rBFI is determined by dividing the measured BFI by the mean BFI of a 30-second baseline period.



rBFI changes measured during VM on a healthy subject at 3 SDSs measured using a,b,c) cw-DCS and d,e,f) td-DCS. The mean value and standard deviation (shaded area) has been calculated from two data set.

In cw-DCS it is expected that longer SDS is mostly sensitive to deep layer. Moreover, in td-DCS, increasing SDS leads to broadening the DTOF, larger $\sqrt{\Delta V}$ (wider gate) and higher ability to detect photons with longer pathlength which come from deep layer. According to literature [4] the hemodynamics response during VM includes four phase of BFI changes. This trend of BFI changes can be seen in all SDSs and there is no significant difference between changes in rBFI response at 3 SDSs measured by each method. As VM is a strong stimulation which may affects both BFI changes in superficial and deep layer, might be the reason that there is no significant difference between the BFI response at different SDS. Forthemore, in td-DCS, as the time of early and late gate are very close, the detected BFI changes are similar. According to results, rBFI measured by td-DCS shows higher peak when BFI changes in each phase which might be due to differences in laser source.

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PS2_26 – Studying Task-Free Functional Connectivity in Neonates using High-Density Diffuse Optical Tomography in Home Settings

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Understanding how the environment influences the developing brain is crucial for unravelling the complex interplay between nature and nurture in early life. The Perinatal Imaging Project in partnership with families (PIPKIN) study is a longitudinal investigation that aims to explore the impact of family context, including socioeconomic status, poverty-associated risk factors, parental mental health, and caregiving behaviours, on infants' cognitive and brain development. Spanning from pregnancy through the immediate postnatal period until infants reach five months of age, our study examines various aspects of cognitive and brain development, such as auditory habituation and novelty detection, visual social cognition, and functional connectivity using High-Density Diffuse Optical Tomography (HD-DOT) as a primary neuroimaging technique. Here we focus on the task-free functional connectivity paradigm, which allows us to uncover the intrinsic functional brain organization of the neonatal brain and investigate potential associations between its maturational trajectory and infants' early social context.

Task-free functional connectivity data was acquired in infants at three time points within the first month of life (N=16, mean age=6.1 days; N=18, mean age=14.2 days; N=17, mean age=32.6 days) during natural sleep, while being held by the experimenter. We used a HD-DOT system (LUMO, Gowerlabs) consisting of 12 tiles covering bilateral frontal and temporal regions. Each tile comprises 3 dual-wavelength LED sources and 4 photodiode detectors. The three-dimensional positions of the LUMO tiles were registered using photogrammetry.

We describe the challenges of HD-DOT neonatal task-free data acquisition, quality assessment, and pre- processing. Emphasizing the importance of rigorous online and offline data quality assessment procedures, we ensure the reliability of our measurements. Additionally, we discuss different data pre-processing pipelines, using different approaches for channel rejection and motion artifact detection and correction, to underscore their role in enhancing data quality and minimizing potential confounding factors. Along with the data quality assessment and pre-processing pipelines, examples of individual functional connectivity maps will be presented.

Preliminary findings demonstrate the feasibility of HD-DOT for data acquisition in the home setting, resulting in recordings of high quality and long duration. These highlight the potential of HD-DOT for studying functional connectivity in neonates, particularly within the naturalistic context of their homes. By expanding the investigation beyond

traditional research lab-based settings, our study underscores the significance of HD-DOT in studying neonatal brain development.

PS2_27 – Number processing in stroke patients: a study of functional reorganization using fNIRS

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Number processing is essential in our culture as everyday life activities often require using numbers for counting, measuring, and comparing. Deficits in mathematical abilities are frequent after brain damage. Lesions involving especially the parietal and the frontal regions have been shown to cause deficits in number processing tasks, such as transcoding, conceptual knowledge, or arithmetical facts and rules [1]. Due to the social and daily life impact of these deficits, understanding neural activity underlying numerical deficits and the relative recovery after brain damage may be of outstanding importance. Functional near-infrared spectroscopy (fNIRS) has gained increasing attention as a non-invasive modality to study changes in cerebral hemodynamics related to brain activity. In particular, due to its portability, easiness of use, and relatively low costs, fNIRS is being increasingly used in patients with stroke. Previous studies used fNIRS to explore network reorganization in motor recovery in subacute stroke patients and reported increased contralateral functional connectivity ([2], [3]). Here, we hypothesize that similar functional reorganization could occur in stroke patients with numerical deficits, in which changes in activity in the contralesional hemisphere could reflect compensatory processes for brain damage, increasing over time. Therefore, this exploratory study will investigate contralesional neural activity in stroke patients executing calculation tasks at consecutive time points. Thirty patients with subacute stroke (stroke onset <6 months) will be consecutively enrolled at the San Camillo Hospital and assessed for their numerical capacities with a neuropsychological battery including tests on number processing (Numerical Activities of Daily Living - NADL [4]). A group of 30 age-matched healthy adults will be enrolled as control. In both a baseline (t0) and a follow-up session after 1 month (t1), participants will perform an experimental (calculation) and a control task (reading of non-words) during fNIRS recording of neural activity over parietal and frontal areas with customized probe placement. Specifically, probe placement will mainly cover the intraparietal sulcus (4 sources and 4 detectors, 10 channels), and the precentral gyrus

(2 sources and 2 detectors, 4 channels). Control sensors will be placed on the temporal lobe (2 sources and 2 detectors, 4 channels) [5]. We expect that different patterns of activation will be correlated with numerical abilities. Namely, patients with numerical difficulties are expected to exhibit a larger functional reorganization (larger activity) in the contralesional parietal/central areas, compared both to healthy controls and patients without numerical deficits. Further, a positive association between increased activity in these areas and better behavioral performance at t1 as compared to t0 is also expected, as reflecting compensatory processes for the deficit.

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PS2_28 – Sensorimotor processing of numerical information: a functional near infrared spectroscopy (fNIRS) study

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Introduction. Previous behavioral and neuroimaging studies have shown that sensorimotor processes contribute to the development of mental representations of numerical magnitude. In a recent meta-analysis we have shown that number magnitude comparison and hand grasping share a partially overlapping neural substrate [1]. Overlapping brain regions include the intraparietal sulcus bilaterally, the supplementary motor area, and the left precentral gyrus. In this study we use fNIRS to investigate the activity of cortical areas associated with hand action and number processing. As compared to other neuroimaging techniques, fNIRS is less sensitive to movement artifacts, making it suitable for investigating neural activity during motor tasks.
Methods. Right-handed healthy adults (N > 50, age range: 18-40 y/o) executed motor (hand grasping or squeezing) and cognitive (number magnitude comparison or color detection) tasks during fNIRS recording (Nirscout-NIRx). A group of participants executed the motor tasks with their right hand, while another group used their left hand. We adopted an event-related design, the tasks were executed in a single session, and the order of tasks was fixed (order: color detection, number comparison, squeeze, grasp). After the fNIRS session, participants performed a series of tasks to estimate arithmetical abilities. Cortical activity was recorded with a customized array covering the frontoparietal networks of number processing and grasping [1]. The array consisted of 106 channels and 8 short-separation channels. fNIRS data were preprocessed with a standard pipeline consisting of motion correction, band-pass filtering, and hemodynamic response estimation via GLM with SS channel regression [2]. The different conditions were compared in those channels showing significant hemodynamic response as compared to baseline in both ΔHbO and ΔHbR (corrected for multiple comparisons).
Results. At the behavioural level, we observed the classical numerical distance effect in number comparison, a signature of number magnitude processing consisting of longer response latencies during comparison of close (e.g., 4 vs. 5) as compared to far (e.g., 1 vs. 5) numbers. Preliminary results on the participants which used the right hand to squeeze and grasp (N=30) indicate that cortical activity associated with both

hand actions and number comparison is observed in channels over the left parietal regions and in the pre-central gyrus. Furthermore, activity in some channels over the right parietal area was specific to number comparison and correlated with arithmetical performance.

Discussion. These findings highlight both common and specific neural activity associated with hand action and number processing. Overlapping activity in the left parietal lobe confirms previous observations [1], and number specific activity over the right parietal area is in line with claims about the role of the right hemisphere in number processing [3]. Further analyses will be performed to confirm these preliminary results. In particular, we will compare the results from the group of participants who used the left hand to the group using the right hand in grasp and squeeze, to control for the possibility that the current findings might be influenced by the hand used to perform the motor tasks.

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PS2_29 – Do neonates generate separate word memories for different speakers?: A proposal

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Language development requires the storage of linguistic content. While several studies show that young infants already have brain areas specialized for speech processing (Dehaene-Lambertz et al., 2002; Peña et al., 2003; Perani et al., 2011), little is known about the mechanism underlying verbal memory in infants. Benavides et al. (2011, 2012, 2017) used fNIRS to investigate the formation of verbal memories at birth. They showed that newborns habituated to a 2-syllables pseudoword could recognize it after a few minutes. Interestingly, recognition did not persist when neonates heard another word pronounced by the same speaker and with the same CVCV structure during the retention period (Benavides et al., 2011). However, natural language processing requires encoding different verbal content close in time, making it unlikely that verbal short-term memory in neonates is limited to words in isolation. Indeed, interference does not occur when a second word is presented during habituation (Benavides et al., 2017). Understanding which factors determine forgetting or memory consolidation of verbal memories is crucial for understanding the principles governing speech processing and language acquisition early on in life.

In the current proposal we present a study to investigate whether separated memory traces of linguistic stimuli can be generated when two acoustically different words are presented close in time. Specifically, we plan to test neonates in a habituation-interference-test protocol (Benavides et al., 2011, 2012, 2017) using a word uttered by a different speaker as interference, thus drastically differing in its acoustic features from the habituation word. We will record neural cortical activity over frontal, temporal, and parietal regions using a 42-channel fNIRS system (NIRx NIRSPort, wavelength=760 and 850 nm) with 16 sources and 15 detectors (source-detector distance approx. 2cm). We use a block design with each phase (habituation, interference, test) lasting 3 minutes and comprising 5 blocks of 6 words each (ISI 0.5-1.5 s, inter-block interval 25-35 s). We will implement a within-subject design by having two sessions separated by 9 minutes of silence: one condition in which neonates hear the same word during habituation and test and another condition with a novel word presented during the test phase. The order of the conditions and the words used in the different phases will be counterbalanced across participants. If this manipulation results in no interference, we expect different hemodynamic responses during the same vs different word conditions during the test (Benavides-Varela et al., 2011, 2012, 2017), especially over the right-frontal area as in adults (Fletcher & Henson, 2001; Rugg et al., 1996; Shallice et al., 1994) and older infants (Dehaene- Lambertz et al., 2002). Additionally, we expect a reduction of the HRs during habituation over temporal and frontal areas (Benavides-Varela et al., 2011, 2012, 2017; Nakano et al., 2009). The lack of interference would imply that

neonates retain the memory trace of the habituation word when the interference word has different acoustic features, possibly due to better memory separation.

PS2_30 – Direction Matters: Brain Responses to Point-light Walkers walking on different directions in relation to the perceiver

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One of most extraordinary human abilities is to understand other's people behaviors simply by looking at their movements. Humans are so skilled at perceiving, recognizing and understanding the motion of others that one brain area seems to be particularly sensitive to the perception of biological motion: the right posterior Superior Temporal Sulcus (rpSTS). The rpSTS is activated by the perception of human motion even when subjects only see a few dots attached to the major joints of a moving body (i.e., a point-light display). However, most of studies investigating biological motion perception employed point-light displays presented on a lateral view, thus, not facing the viewer. Very few studies investigated if the presentation of different directions of motion affects our response to point-light walkers. The rpSTS is central node of the social brain network thus we hypothesize that a walking approaching person, facing the viewer and potentially aiming to interact, might elicit stronger responses in this region. Using fNIRS we measured right and left pSTS responses to point-light walkers presented in four different viewpoints and translating in four directions: (1) frontal, approaching the viewer; (2) backwards, moving away from the viewer; (3) right-lateral, walking from left to right; and (4) left- lateral, walking from right to left. Subjects (N=27) in our study were asked to passively watch both coherent and scrambled versions of the point-light displays walking in the four directions while their brain activity was recorded (block design). A static image of the displays was used as baseline.
Our preliminary analysis showed that the rpSTS preferentially responds to the coherent displays in relation to the scrambled ones, replicating previous findings. Moreover, the frontal approaching coherent point-light walker elicited a stronger response in rpSTS; this response was specific to the coherent frontal display and was not associated with the scrambled version of this display.
Results from our study seem to indicate that direction of motion is important when perceiving point-light walkers.

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PS2_31 – Maternal touch and infant brain response to affective and discriminative touch: a fNIRS Study

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Keywords: Social touch; Infancy; Mother-infant interaction; Touch processing; Social-emotional development

Social touch is an essential modality in mother-infant social interactions, with significant implications for the infant's social, emotional, and physical well-being (Field et al., 2010; Field, 2019). Behavioral and physiological studies have consistently indicated a positive association between maternal touch and the early development of social skills. However, there is still a limited understanding of the neural mechanisms underlying this relationship, particularly during the first year of life. In this study, we explore whether the infant's early experience of maternal touch – estimated by measuring the frequency of maternal touch during a social interaction task – is associated with infants' cortical responses to affective and discriminative touch.

Mother-infant dyads were observed at 7 and 12 months during a free play without objects task. Each event of maternal touch was coded using an adapted version of the Mother Touch Scale (Beebe et al., 2010; Stepakoff, 2000; Serra et al., 2020) the proportion of the interaction time the mothers were touching the infant was computed from the event duration data. In a second task (data already published in Miguel et al., 2019), Functional near-infrared spectroscopy (fNIRS) was employed to measure the infant's neural activations to touch stimuli delivered by an experimenter. The fNIRS array had two areas: left somatosensory cortex and right temporal cortex (the array was designed to cover the posterior superior temporal sulcus, pSTS). The experimenter administered two kinds of tactile stimulation on the infants' forearm: affective and discriminative. Affective touch was performed using brush stimulation with a velocity of 8 cm/s, while discriminative touch was administered through light taps using a wooden block.

To examine the association between the proportion of interaction time with maternal touch and the infant's brain responses to affective and discriminative tactile stimuli we estimated linear mixed models that used the fNIRS activation as the dependent measure and proportion of maternal touch, age, and type of touch stimuli as predictors. Separate linear mixed models were fitted for each channel and chromophore (HbO2 and HHb). At seven months of age, infants exhibited brain activation in response to both affective and discriminative stimuli in channels positioned over the somatosensory region. However, no activation was observed in the channels placed in the right temporal cortex region in response to either affective or discriminative touch. At 12 months of age, infants displayed brain activation in channels located in both the somatosensory and right temporal cortex regions. Additionally, in line with findings observed in children (Brauer et al., 2016), a significant positive association was found

between maternal touch and infants' brain response to affective touch at 12 months in the right temporal cortex. Infants with mothers who provided more frequent touch in the play task, exhibited higher levels of brain activation in response to affective touch. Moreover, a significant negative association was observed between maternal touch and infants' brain response to discriminative touch at 12 months in the right temporal cortex.

Overall, this study provides evidence that tactile experiences during infancy, provided by the mothers, might shape the infant's brain responses to both affective and discriminative touch stimuli in the superior temporal sulcus (STS).

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PS2_32 – Selective Brain Responses to Human Motion in Infancy – an fNIRS approach using point-light walkers

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Biological motion perception—our capacity to perceive the intrinsic motion of humans and animals—has been implicated as a precursor in infancy of later social-cognitive development. Neuroimaging studies conducted with adults found that biological motion is processed differently in the human brain from other types of motion; in particular, the right posterior Superior Temporal Sulcus (rpSTS) consistently activates to intact point-light walkers, but not to other visual controls. However, our knowledge of how this cortical specialization to biological motion emerges and develops is still very limited.
Here, we present the results from two fNIRS studies investigating right STS responses to biological motion in 7-month-old infants. In both studies, we employed a block design where infants passively viewed an intact point-light walker, and a set of different visual controls, while their brain activity was recorded using fNIRS. In the first study, we contrasted the intact display with a scrambled point-light walker. In the second study, we contrasted the intact display with an inverted and rigid point-light walker. Our two studies successfully replicated the same result: a significant increase in the concentration of oxygenated hemoglobin (HbO) in the right STS region associated to the intact point-light walker; this activation pattern was absent in the control conditions. Our findings not only confirm previous behavioral data but also shed light on the development of an early specialized brain response to biological motion.