fNIRS publications on PubMed: Apr 1, 2021 - June 30, 2021

Felipe Orihuela-Espina

Methodology. Searches were made in PubMed constraining the search period between Apr 1, 2021 and June 30, 2021. These were later processed for readability but no records were otherwise added or removed. In the preparation of this file, the following searches have been executed:

- fNIRS

Chen T(1)(2), Zhao C(1)(2), Pan X(1)(2), Qu J(1)(2), Wei J(1)(2), Li C(1)(2), Liang Y(1)(2)(3), Zhang X(1)(2)(4).

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Decoding different working memory states during an operation span task from prefrontal fNIRS signals.

Understanding Mental Health and Cognitive Restructuring With Ecological Neuroscience.

Crum J.

Front Psychiatry. Jun 18;12:
doi: 10.3389/fpsyt.2021. eCollection 2021.

Neuroimaging and neuropsychological methods have contributed much toward an understanding of the information processing systems of the human brain in the last few decades, but to what extent do cognitive neuroscientific findings represent and generalize to the inter- and intra-brain dynamics engaged in adapting to naturalistic situations? If it is not marked, and experimental designs lack ecological validity, then this stands to potentially impact the practical applications of a paradigm. In no other domain is this more important to acknowledge than in human clinical neuroimaging research, wherein reduced ecological validity could mean a loss in clinical utility. One way to improve the generalizability and representativeness of findings is to adopt a more "real-world" approach to the development and selection of experimental designs and neuroimaging techniques to investigate the clinically-relevant phenomena of interest. For example, some relatively recent developments to neuroimaging techniques such as functional near-infrared spectroscopy (fNIRS) make it possible to create experimental designs using naturalistic tasks that would otherwise not be possible within the confines of a conventional laboratory. Mental health, cognitive interventions, and the present challenges to investigating the brain during treatment are discussed, as well as how the ecological use of fNIRS might be helpful in bridging the explanatory gaps to understanding the cultivation of mental health.

Narrowband Resting-State fNIRS Functional Connectivity in Autism Spectrum Disorder.

Sun W, Wu X, Zhang T, Lin F, Sun H, Li J.
Front Hum Neurosci. Jun 15;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Hemispheric asymmetry in the power spectrum of low-frequency spontaneous hemodynamic fluctuations has been previously observed in autism spectrum disorder (ASD). This observation may imply a specific narrow-frequency band in which individuals with ASD could show more significant alteration in resting-state functional connectivity (RSFC). To test this assumption, we evaluated narrowband RSFC at several frequencies for functional near-infrared spectroscopy signals recorded from the bilateral temporal lobes on 25 children with ASD and 22 typically developing (TD) children. In several narrow-frequency bands, we observed altered interhemispheric RSFC in ASD. However, in the band of 0.01-0.02 Hz, more mirrored channel pairs (or cortical sites) showed significantly weaker RSFC in the ASD group. Receiver operating characteristic analysis further demonstrated that RSFC in the narrowband of 0.01-0.02 Hz might have better differentiation ability between the ASD and TD groups. This may indicate that the narrowband RSFC could serve as a characteristic for the prediction of ASD.

Internal Consistency of Sway Measures via Embedded Head-Mounted Accelerometers: Implications for Neuromotor Investigations.
Lapointe AP, Ritchie JN, Vitali RV, Burma JS, Soroush A, Oni I, Dunn JF.
Sensors (Basel). Jun 30;21(13):
doi: 10.3390/s21134492.

Accelerometers are being increasingly incorporated into neuroimaging devices to enable real-time filtering of movement artifacts. In this study, we evaluate the reliability of sway metrics derived from these accelerometers in a standard eyes-open balance assessment to determine their utility in multimodal study designs. Ten participants equipped with a head-mounted accelerometer performed an eyes-open standing condition on 7 consecutive days. Sway performance was quantified with 4 standard metrics: root-mean-square (RMS) acceleration, peak-to-peak (P2P) acceleration, jerk, and ellipse area. Intraclass correlation coefficients (ICC) quantified reliability. P2P in both the mediolateral (ICC = 0.65) and anteroposterior (ICC = 0.67) planes yielded the poorest reliability. Both ellipse area and RMS exhibited good reliability, ranging from 0.76 to 0.84 depending on the plane. Finally, jerk displayed the highest reliability with an ICC value of 0.95. Moderate to excellent reliability was observed in all sway metrics. These findings demonstrate that head-mounted accelerometers, commonly found in neuroimaging devices, can be used to reliably assess sway. These data validate the use of head-mounted accelerometers in the assessment of motor control alongside other measures of brain activity such as electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS).

Brain Activity-Based Metrics for Assessing Learning States in VR under Stress among Firefighters: An Explorative Machine Learning Approach in Neuroergonomics.
Abujelala M, Karthikeyan R, Tyagi O, Du J, Mehta RK.
Brain Sci. Jun 30;11(7):
doi: 10.3390/brainsci11070885.

The nature of firefighters‘ duties requires them to work for long periods under unfavorable conditions. To perform their jobs effectively, they are required to endure long hours of extensive, stressful training. Creating such training environments is very expensive and it is difficult to guarantee trainees’ safety. In this study, firefighters are trained in a virtual environment that includes virtual perturbations such as fires, alarms, and smoke. The objective of this paper is to use machine learning methods to discern encoding and retrieval states in firefighters during a visuospatial episodic memory task and explore which regions of the brain provide suitable signals to solve this classification problem. Our results show that the Random

Forest algorithm could be used to distinguish between information encoding and retrieval using features extracted from fNIRS data. Our algorithm achieved an F-1 score of 0.844 and an accuracy of 79.10% if the training and testing data are obtained at similar environmental conditions. However, the algorithm's performance dropped to an F-1 score of 0.723 and accuracy of 60.61% when evaluated on data collected under different environmental conditions than the training data. We also found that if the training and evaluation data were recorded under the same environmental conditions, the RPM, LDLPFC, RDLPFC were the most relevant brain regions under non-stressful, stressful, and a mix of stressful and non-stressful conditions, respectively.

Motor Cortical Activation Assessment in Progressive Multiple Sclerosis Patients Enrolled in Gait Rehabilitation: A Secondary Analysis of the RAGTIME Trial Assisted by Functional Near-Infrared Spectroscopy.

Lamberti N, Manfredini F, Baroni A, Crepaldi A, Lavezzi S, Basaglia N, Straudi S.

Diagnostics (Basel). Jun 9;11(6):
doi: 10.3390/diagnostics11061068.

This study aimed to determine cortical activation responses to two different rehabilitative programs, as measured through functional near-infrared spectroscopy (fNIRS). As a secondary analysis of the RAGTIME trial, we studied 24 patients with progressive multiple sclerosis (MS) and severe disability who were randomized to a regimen of robot-assisted gait training (RAGT) or overground walking (OW). Cortical activation during a treadmill walking task, assessed through fNIRS recordings from the motor and premotor cortexes (M1/PM), was calculated as the area under the curve (AUC) of oxyhemoglobin for each hemisphere and the total area (Tot-OxyAUC). Gait speed, endurance, and balance were also measured, along with five healthy control subjects. At baseline, Tot-OxyAUC during walking was significantly increased in MS patients compared to healthy people and was significantly higher for those with more severe disabilities; it was also inversely correlated with physical performance. After rehabilitation, significant opposite variations in Tot-OxyAUC were observed, with activity levels being increased after OW and decreased after RAGT (+242,080 361,902 and -157,031 172,496 arbitrary units, respectively; $p = 0.002$), particularly in patients who were trained at a lower speed. Greater reductions in the cortical activation of the more affected hemisphere were significantly related to improvements in gait speed ($r = -0.42$) and endurance ($r = -0.44$). Cortical activation, assessed through fNIRS, highlighted the brain activity in response to the type and intensity of rehabilitation.

Real-World fNIRS Brain Activity Measurements during Ashtanga Vinyasa Yoga.

Dybvik H, Steinert M.

Brain Sci. Jun 3;11(6):
doi: 10.3390/brainsci11060742.

Functional near-infrared spectroscopy (fNIRS) is often praised for its portability and robustness towards motion artifacts. While an increasing body of fNIRS research in real-world environments is emerging, most fNIRS studies are still conducted in laboratories, and do not incorporate larger movements performed by participants. This study extends fNIRS applications in real-world environments by conducting a single-subject observational study of a yoga practice with considerable movement (Ashtanga Vinyasa Yoga) in a participant's natural environment (their apartment). The results show differences in cognitive load (prefrontal cortex activation) when comparing technically complex postures to relatively simple ones, but also some contrasts with surprisingly little difference. This study explores the boundaries of real-world cognitive load measurements, and contributes to the empirical knowledge base of using fNIRS in realistic settings. To the best of our knowledge, this is the first demonstration of fNIRS brain imaging recorded during any moving yoga practice. Future work with fNIRS should take advantage of this by accomplishing

studies with considerable real-world movement.

Hemodynamic Response to Three Types of Urban Spaces before and after Lockdown during the COVID-19 Pandemic.

Olszewska-Guizzo A, Mukoyama A, Naganawa S, Dan I, Husain SF, Ho CS, Ho R.

Int J Environ Res Public Health. Jun 6;18(11):
doi: 10.3390/ijerph18116118.

(1) Background: Prolonged lockdowns with stay-at-home orders have been introduced in many countries since the outbreak of the COVID-19 pandemic. They have caused a drastic change in the everyday lives of people living in urbanized areas, and are considered to contribute to a modified perception of the public space. As research related to the impact of COVID-19 restrictions on mental health and well-being emerges, the associated longitudinal changes of brain hemodynamics in healthy adults remain largely unknown. (2) Methods: this study examined the hemodynamic activation patterns of the prefrontal and occipital cortices of 12 participants (5 male, Mage = 47.80, SDage = 17.79, range 25 to 74, and 7 female, Mage = 39.00, SDage = 18.18, range 21 to 65) passively viewing videos from three urban sites in Singapore (Urban Park, Neighborhood Landscape and City Center) at two different time points-T1, before the COVID-19 pandemic and T2, soon after the lockdown was over. (3) Results: We observed a significant and marginally significant decrease in average oxyhemoglobin (Oxy-Hb) over time for each of the visual conditions. For both green spaces (Urban Park and Neighborhood Landscape), the decrease was in the visual cortex, while for the City Center with no green elements, the marginal decrease was observed in the visual cortex and the frontal eye fields. (4) Conclusions: The results suggest that the COVID-19-related lockdown experienced by urban inhabitants may have contributed to decreased brain hemodynamics, which are further related to a heightened risk of mental health disorders, such as depression or a decline in cognitive functions. Moreover, the busy City Center scenes induced a hemodynamic pattern associated with stress and anxiety, while urban green spaces did not cause such an effect. Urban green scenes can be an important factor to offset the negative neuropsychological impact of busy urban environments post-pandemic.

A Guide to Parent-Child fNIRS Hyperscanning Data Processing and Analysis.

Nguyen T, Hoehl S, Vrticka P.

Sensors (Basel). Jun 13;21(12):
doi: 10.3390/s21124075.

The use of functional near-infrared spectroscopy (fNIRS) hyperscanning during naturalistic interactions in parent-child dyads has substantially advanced our understanding of the neurobiological underpinnings of human social interaction. However, despite the rise of developmental hyperscanning studies over the last years, analysis procedures have not yet been standardized and are often individually developed by each research team. This article offers a guide on parent-child fNIRS hyperscanning data analysis in MATLAB and R. We provide an example dataset of 20 dyads assessed during a cooperative versus individual problem-solving task, with brain signal acquired using 16 channels located over bilateral frontal and temporo-parietal areas. We use MATLAB toolboxes Homer2 and SPM for fNIRS to preprocess the acquired brain signal data and suggest a standardized procedure. Next, we calculate interpersonal neural synchrony between dyads using Wavelet Transform Coherence (WTC) and illustrate how to run a random pair analysis to control for spurious correlations in the signal. We then use RStudio to estimate Generalized Linear Mixed Models (GLMM) to account for the bounded distribution of coherence values for interpersonal neural synchrony analyses. With this guide, we hope to offer advice for future parent-child fNIRS hyperscanning investigations and to enhance replicability within the field.

Monitoring the haemodynamic response to visual stimulation in glaucoma patients.
Re R(#), Messenio D(#), Marano G(#), Spinelli L, Pirovano I, Contini D, Colombo R, Boracchi P, Biganzoli E, Cubeddu R, Torricelli A.
Sci Rep. Jun 30;11(1):
doi: 10.1038/s41598-021-92857-x.

In this paper, we used time-domain functional near infrared spectroscopy (TD-fNIRS) to evaluate the haemodynamic response function (HRF) in the occipital cortex following visual stimulation in glaucomatous eyes as compared to healthy eyes. A total of 98 subjects were enrolled in the study and clinically classified as healthy subjects, glaucoma patients (primary open-angle glaucoma) and mixed subjects (i.e. with a different classification for the two eyes). After quality check data were used from HRF of 73 healthy and 62 glaucomatous eyes. The amplitudes of the oxygenated and deoxygenated haemoglobin concentrations, together with their latencies with respect to the stimulus onset, were estimated by fitting their time course with a canonical HRF. Statistical analysis showed that the amplitudes of both haemodynamic parameters show a significant association with the pathology and a significant discriminating ability, while no significant result was found for latencies. Overall, our findings together with the ease of use and noninvasiveness of TD-NIRS, make this technique a promising candidate as a supporting tool for a better evaluation of the glaucoma pathology.

Intelligent Recognition of Hospital Image Based on Deep Learning: The Relationship between Adaptive Behavior and Family Function in Children with ADHD.
Zhao H, Chen J, Lin Y.
J Healthc Eng. Jun 4;2021:
doi: 10.1155/2021/eCollection 2021.

Chronic diseases are gradually becoming the main threat to human health. By designing an efficient hospital management platform to quickly identify the corresponding chronic diseases, it can effectively reduce the labor cost, improve the accuracy of disease identification, and improve treatment efficiency. ADHD is a common behavioral disorder in school-age children, and it is also one of the most common chronic health problems in this period. The internationally recognized prevalence of ADHD is 3%-9%. ADHD often brings adverse effects on children's life and studying and at the same time increases difficulties for their families. Therefore, this paper designs an intelligent management platform for public hospitals based on a deep learning algorithm, evaluates the current situation and influencing factors of ADHD children through the child adaptive behavior scale and the family function assessment scale, and designs its intelligent platform by using a new technology of fNIRS. According to the nonlinearity and unsteadiness of the fNIRS signal, this paper proposes a motion noise removal method based on EMD algorithm methods: to automatically identify children with ADHD and improve the cognitive function of children with ADHD by intervention technology. The data are from the outpatients of the Department of Child Psychology of the First People's Hospital of Tianshui City in Gansu Province in 2018. The results showed that there were significant differences in the adaptive behavior scale (CABS) and fad scores between the two groups. In the seven dimensions of family function, there were significant differences between the two groups ($P < 0.01$). fNIRS management platform can effectively identify ADHD patients with high recognition accuracy. The intelligent management platform can significantly reduce the number of physical examination personnel, prolong the diagnosis and treatment time, reduce a lot of repetitive work, and improve the efficiency of diagnosis and treatment. At the same time, this technology also provides great help for better research and improvement of ADHD patients and provides a reference for the information intelligent construction of modern hospitals.

Functional near-infrared spectroscopy in developmental psychiatry: a review of atten-

tion deficit hyperactivity disorder.

Goss LK, Bell SW, Hosseini SMH.

Eur Arch Psychiatry Clin Neurosci. Jun
doi: 10.1007/s00406-021-01288- Online ahead of print.

Research has linked executive function (EF) deficits to many of the behavioral symptoms of attention deficit hyperactivity disorder (ADHD). Evidence of the involvement of EF impairment in ADHD is corroborated by accumulating neuroimaging studies, specifically functional magnetic resonance imaging (fMRI) studies. However, in recent years, functional near-infrared spectroscopy (fNIRS) has become increasingly popular in ADHD research due to its portability, high ecological validity, resistance to motion artifacts, and cost-effectiveness. While numerous studies throughout the past decade have used fNIRS to examine alterations in neural correlates of EF in ADHD, a qualitative review of the reliability of these findings compared with those reported using gold-standard fMRI measurements does not yet exist. The current review aims to fill this gap in the literature by comparing the results generated from a qualitative review of fNIRS studies (children and adolescents ages 6-16years old) to a meta-analysis of comparable fMRI studies and examining the extent to which the results of these studies align in the context of EF impairment in ADHD. The qualitative analysis of fNIRS studies of ADHD shows a consistent hypoactivity in the right prefrontal cortex in multiple EF tasks. The meta-analysis of fMRI data corroborates altered activity in this region and surrounding areas during EF tasks in ADHD compared with typically developing controls. These findings indicate that fNIRS is a promising functional brain imaging technology for examining alterations in cortical activity in ADHD. We also address the disadvantages of fNIRS, including limited spatial resolution compared with fMRI.

Gender Differences in Transnational Brand Purchase Decision Toward Mixed Culture and Original Culture Advertisements: An fNIRS Study.

Duan L, Ai H, Yang L, Xu L, Xu P.

Front Psychol. Jun 15;12:
doi: 10.3389/fpsyg.2021. eCollection 2021.

Culture strategy is very important for transnational brand marketing. Functional near-infrared spectroscopy (fNIRS) is a promising brain imaging modality for neuromarketing research. In the present study, we used fNIRS to explore the neural correlates of consumers' purchase decision on different cross-culture marketing strategies. Forty Chinese participants watched transnational brands and products advertised with photographs of the brands' original culture (the original culture advertisements) and advertised with photographs of Chinese culture (the mixed culture advertisements), respectively. The behavioral results showed that the female participants showed significantly higher purchase rate when watching the original culture advertisements than the mixed culture advertisements, whereas the male participants did not show significant preference between these two types. The fNIRS results further revealed that for the female participants, watching mixed culture advertisements evoked significant positive activation in the left dorsolateral prefrontal cortex and negative activation in the medial prefrontal cortex, which was not found in the male participants. These findings suggest possible cognitive and emotional differences between men and women in purchase decision making toward different cross-culture marketing strategy. The present study also demonstrates the great potential of fNIRS in neuromarketing research.

Variability in Infants' Functional Brain Network Connectivity Is Associated With Differences in Affect and Behavior.

Kelsey CM, Farris K, Grossmann T.

Front Psychiatry. Jun 9;12:
doi: 10.3389/fpsyt.2021. eCollection 2021.

Variability in functional brain network connectivity has been linked to individual differences in cognitive, affective, and behavioral traits in adults. However, little is known about the developmental origins of such brain-behavior correlations. The current study examined functional brain network connectivity and its link to behavioral temperament in typically developing newborn and 1-month-old infants (M [age] = 25 days; N = 75) using functional near-infrared spectroscopy (fNIRS). Specifically, we measured long-range connectivity between cortical regions approximating fronto-parietal, default mode, and homologous-interhemispheric networks. Our results show that connectivity in these functional brain networks varies across infants and maps onto individual differences in behavioral temperament. Specifically, connectivity in the fronto-parietal network was positively associated with regulation and orienting behaviors, whereas connectivity in the default mode network showed the opposite effect on these behaviors. Our analysis also revealed a significant positive association between the homologous-interhemispheric network and infants' negative affect. The current results suggest that variability in long-range intra-hemispheric and cross-hemispheric functional connectivity between frontal, parietal, and temporal cortex is associated with individual differences in affect and behavior. These findings shed new light on the brain origins of individual differences in early-emerging behavioral traits and thus represent a viable novel approach for investigating developmental trajectories in typical and atypical neurodevelopment.

Use-Dependent Prosthesis Training Strengthens Contralateral Hemodynamic Brain Responses in a Young Adult With Upper Limb Reduction Deficiency: A Case Report.

Borrell JA, Copeland C, Lukaszek JL, Fraser K, Zuniga JM.

Front Neurosci. Jun 11;15:

doi: 10.3389/fnins.2021. eCollection 2021.

The purpose of the current case study was to determine the influence of an 8-week home intervention training utilizing a partial hand prosthesis on hemodynamic responses of the brain and gross dexterity in a case participant with congenital unilateral upper-limb reduction deficiency (ULD). The case participant (female, 19 years of age) performed a gross manual dexterity task (Box and Block Test) while measuring brain activity (functional near-infrared spectroscopy; fNIRS) before and after an 8-weeks home intervention training. During baseline, there was a broad cortical activation in the ipsilateral sensorimotor cortex and a non-focalized cortical activation in the contralateral hemisphere, which was non-focalized, while performing a gross manual dexterity task using a prosthesis. After the 8-week home intervention training, however, cortical activation shifted to the contralateral motor cortex while cortical activation was diminished in the ipsilateral hemisphere. Specifically, the oxygenated hemodynamics (HbO) responses increased in the medial aspects of the contralateral primary motor and somatosensory cortices. Thus, these results suggest that an 8-week prosthetic home intervention was able to strengthen contralateral connections in this young adult with congenital partial hand reduction. This was supported by the case participant showing after training an increased flexor tone, increased range of motion of the wrist, and decreased times to complete various gross dexterity tasks. Changes in HbO responses due to the home intervention training follow the mechanisms of use-dependent plasticity and further guide the use of prostheses as a rehabilitation strategy for individuals with ULD.

Cerebral Hemodynamic Responses to the Difficulty Level of Ambulatory Tasks in Patients With Parkinson's Disease: A Systematic Review and Meta-Analysis.

Lin JP, Feng HS, Zhai H, Shen X.

Neurorehabil Neural Repair. Jun 25:

doi: 10.1177/Online ahead of print.

Background. Ambulatory tasks are the important components of balance training which effectively improve postural stability and functional activities in persons with Parkinson's disease (PD). The difficulty

level of an ambulatory task is usually set in the form of attention, direction, speed, or amplitude requirement. Objectives. This study aimed to explore the neural mechanisms of cerebral hemodynamic responses to the difficulty level of ambulatory tasks in persons with PD. Methods. We included ten studies that examined cerebral hemodynamic responses during ambulatory tasks at different difficulty levels in persons with PD. The change in hemodynamic responses was synthesized and meta-analyzed. Results. Patients during "ON" medication had higher relative change in oxygenated hemoglobin (?HBO2) in the prefrontal cortex in response to difficulty levels of ambulatory tasks, which is comparable to that in healthy elderly individuals. However, patients during "OFF" medication did not show cortical activation in response to difficulty levels. During the lower-difficulty tasks, patients during "ON" medication demonstrated higher ?HBO2 than healthy elderly participants and patients during "OFF" medication. Factors found to significantly contribute to the heterogeneity across studies included subjects' type and cognitive status, task duration, setting, and filter used for functional near-infrared spectroscopy (fNIRS) data pre-processing. Conclusions. The findings suggest that ambulatory task at a higher difficulty level could be necessary to train the cortical capacity of PD persons, which should be conducted during "ON" medication; meanwhile, the contributing factors to the heterogeneity of studies would be useful as a reference when designing comparable fNIRS studies.

Disrupted signal variability of spontaneous neural activity in children with attention-deficit/hyperactivity disorder.

Hu Z, Liu L, Wang M, Jia G, Li H, Si F, Dong M, Qian Q, Niu H.

Biomed Opt Express. Apr 29;12(5):3037-

doi: 10.1364/BOE. eCollection May 1.

Brain signal variability (BSV) has shown to be powerful in characterizing human brain development and neuropsychiatric disorders. Multiscale entropy (MSE) is a novel method for quantifying the variability of brain signal, and helps elucidate complex dynamic pathological mechanisms in children with attention-deficit/hyperactivity disorder (ADHD). Here, multiple-channel resting-state functional near-infrared spectroscopy (fNIRS) imaging data were acquired from 42 children with ADHD and 41 healthy controls (HCs) and then BSV was calculated for each participant based on the MSE analysis. Compared with HCs, ADHD group exhibited reduced BSV in both high-order and primary brain functional networks, e.g., the default mode, frontoparietal, attention and visual networks. Intriguingly, the BSV aberrations negatively correlated with ADHD symptoms in the frontoparietal network and negatively correlated with reaction time variability in the frontoparietal, default mode, somatomotor and attention networks. This study demonstrates a wide alternation in the moment-to-moment variability of spontaneous brain signal in children with ADHD, and highlights the potential for using MSE metric as a disease biomarker.

The effects of target size and error rate on the cognitive demand and stress during augmented reality interactions.

Kia K, Hwang J, Kim IS, Ishak H, Kim JH.

Appl Ergon. Jun 22;97:

doi: 10.1016/j.apergo.2021.Online ahead of print.

This study investigated the effects of target size and error rate on cognitive demand during augmented reality (AR) interactions. In a repeated-measures laboratory study, twenty participants performed two AR tasks (omni-directional pointing and cube placing) with different target sizes and error rates. During the AR tasks, we measured cerebral oxygenation using functional near-infrared spectroscopy (fNIRS), perceived workload using the NASA-TLX questionnaire, stress using the Short Stress State Questionnaire, and task performance (task completion time). The results showed that the AR tasks with more interaction errors increased cerebral oxygenation, perceived workload, and task completion time while the target size

significantly affected physical demand and task completion time. These results suggest that appropriate target sizes and low system errors may reduce potential cognitive demand in AR interactions.

Prefrontal cortex activation during dual-task walking in older adults is moderated by thickness of several cortical regions.

Ross D, Wagshul ME, Izzetoglu M, Holtzer R.

Geroscience. Jun

doi: 10.1007/s11357-021-00379-Online ahead of print.

Dual tasking, a defined facet of executive control processes, is subserved, in part, by the prefrontal cortex (PFC). Previous functional near-infrared spectroscopy (fNIRS) studies revealed elevated PFC oxygenated hemoglobin (HbO2) under Dual-Task-Walk (DTW) compared to Single-Task Walk (STW) conditions. Based on the concept of neural inefficiency (i.e., greater activation coupled with similar or worse performance), we hypothesized that decreased cortical thickness across multiple brain regions would be associated with greater HbO2 increases from STW to DTW. Participants were 55 healthy community-dwelling older adults, whose cortical thickness was measured via MRI. HbO2 levels in the PFC, measured via fNIRS, were assessed during active walking under STW and DTW conditions. Statistical analyses were adjusted for demographics and behavioral performance. Linear mixed-effects models revealed that the increase in HbO2 from STW to DTW was moderated by cortical thickness in several regions. Specifically, thinner cortex in specific regions of the frontal, parietal, temporal, and occipital lobes, cingulate cortex, and insula was associated with greater increases in HbO2 levels from single to dual-task walking. In conclusion, participants with thinner cortex in regions implicated in higher order control of walking employed greater neural resources, as measured by increased HbO2, in the PFC during DTW, without demonstrating benefits to behavioral performance. To our knowledge, this is the first study to examine cortical thickness as a marker of neural inefficiency during active walking.

Sleep deprivation alters task-related changes in functional connectivity of the frontal cortex: A near-infrared spectroscopy study.

Mukli P, Csipo T, Lipecz A, Stylianou O, Racz FS, Owens CD, Perry JW, Tarantini S, Sorond FA, Kellawan JM, Purebl G, Yang Y, Sonntag WE, Csiszar A, Ungvari ZI, Yabluchanskiy A.

Brain Behav. Jun 22:e

doi: 10.1002/brb3.Online ahead of print.

Sleep deprivation (SD) is known to be associated with decreased cognitive performance; however, the underlying mechanisms are poorly understood. As interactions between distinct brain regions depend on mental state, functional brain networks established by these connections typically show a reorganization during task. Hence, analysis of functional connectivity (FC) could reveal the task-related change in the examined frontal brain networks. Our objective was to assess the impact of SD on static FC in the prefrontal and motor cortices and find whether changes in FC correlate with changes in neuropsychological scores. Healthy young male individuals (n=10, 27.63.7years of age) participated in the study. A battery of tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB) and 48 channel functional near-infrared spectroscopy (fNIRS) measurements were performed before and after 24hr of SD. Network metrics were obtained by graph theoretical analysis using the fNIRS records in resting state and during finger-tapping sessions. During task, SD resulted in a significantly smaller decrease in the number and strength of functional connections (characterizing FC) in the frontal cortex. Changes in the global connection strengths correlated with decreased performance in the paired association learning test. These results indicate a global impact of SD on functional brain networks in the frontal lobes.

Guiding functional near-infrared spectroscopy optode-layout design using individual (f)MRI data: effects on signal strength.

Benitez-Andonegui A, Lhrs M, Nagels-Coune L, Ivanov D, Goebel R, Sorger B.

Neurophotonics. Apr;8(2):
doi: 10.1117/1.NPh.8.2.Epub Jun 17.

Significance: Designing optode layouts is an essential step for functional near-infrared spectroscopy (fNIRS) experiments as the quality of the measured signal and the sensitivity to cortical regions-of-interest depend on how optodes are arranged on the scalp. This becomes particularly relevant for fNIRS-based brain-computer interfaces (BCIs), where developing robust systems with few optodes is crucial for clinical applications. Aim: Available resources often dictate the approach researchers use for optode-layout design. We investigated whether guiding optode layout design using different amounts of subject-specific magnetic resonance imaging (MRI) data affects the fNIRS signal quality and sensitivity to brain activation when healthy participants perform mental-imagery tasks typically used in fNIRS-BCI experiments. Approach: We compared four approaches that incrementally incorporated subject-specific MRI information while participants performed mental-calculation, mental-rotation, and inner-speech tasks. The literature-based approach (LIT) used a literature review to guide the optode layout design. The probabilistic approach (PROB) employed individual anatomical data and probabilistic maps of functional MRI (fMRI)-activation from an independent dataset. The individual fMRI (iFMRI) approach used individual anatomical and fMRI data, and the fourth approach used individual anatomical, functional, and vascular information of the same subject (fVASC). Results: The four approaches resulted in different optode layouts and the more informed approaches outperformed the minimally informed approach (LIT) in terms of signal quality and sensitivity. Further, PROB, iFMRI, and fVASC approaches resulted in a similar outcome. Conclusions: We conclude that additional individual MRI data lead to a better outcome, but that not all the modalities tested here are required to achieve a robust setup. Finally, we give preliminary advice to efficiently using resources for developing robust optode layouts for BCI and neurofeedback applications.

Effects of high-intensity interval exercise and moderate-intensity continuous exercise on executive function of healthy young males.

Zhu Y, Sun F, Chiu MM, Siu AY.

Physiol Behav. Jun 19;239:
doi: 10.1016/j.physbeh.2021. Online ahead of print.

PURPOSE: This study compared the executive function (EF) performance induced by moderate-intensity continuous exercise (MICE) versus high-intensity interval exercise (HIIE), under two exercise modalities (i.e., running vs. cycling), and explored whether the changes in EF performance were related to the hemodynamics response of the cerebral prefrontal area of the brain. METHODS: In a randomized cross-over design, 16 male participants completed 4 main trials, i.e., 40min of moderate-intensity continuous running (MICR) or cycling (MICC) with 60% maximal oxygen consumption (VO2max), 33min of high-intensity interval running (HIIR) or cycling (HIIC). For HIIR or HIIC trials, the exercise intensity was 60% VO2max for the first 5min, followed by four 4-minute bouts of exercise at 90% VO2max, separated by 3-minute active recovery at 60% VO2max. EF was assessed via the Eriksen Flanker task (EFT) before (Pre), immediately after (Post 0), and 10min after exercise (Post 10). Functional near-infrared spectroscopy (fNIRS) measured oxygenated hemoglobin (O2Hb) and deoxygenated hemoglobin (HHb) concentrations in the prefrontal area. Each main trial measured the concentrations of blood glucose and lactate, heart rate, and rate of perceived exertion. RESULTS: (1) Compared to the reaction time in EFT during the pretest, the corresponding reaction time was shorter at Post 10 ($P < 0.01$) but not at Post 0 ($P=0.06$). Specifically, reaction time was shorter at Post 10 than in the pretest in HIIC ($P=0.04$), MICC ($P=0.01$), and HIIR ($P < 0.01$) but not MICR. (2) The fNIRS results revealed that O2Hb concentrations in the left dorsolateral prefrontal cortex area were much lower during Post 10 than during the pretest. (3) The blood lactate concentrations were not associated with EF performance regarding both accuracy and reaction

time. CONCLUSION: Compared to the pretest, EF was greater after the 10-minute rest during recovery but not immediately after exercise. The different HIIE or MICE protocols adopted in the present study may elicit minor differences regarding their effects on EF.

Neural Mechanism of Shentai Tea Polyphenols on Cognitive Improvements for Individuals with Subjective Cognitive Decline: A Functional Near-Infrared Spectroscopy Study.

Ni L, Zhao M, Hu Z, Yang K, Zhao X, Niu H, Lin H.

J Alzheimers Dis. Jun
doi: 10.3233/JAD-Online ahead of print.

BACKGROUND: A growing awareness about non-pharmacological intervention for cognitively impaired individuals may represent an alternative therapeutic approach that is actively accepted by patients with very early stage of Alzheimer's disease. Understanding the neural basis of non-pharmacological intervention is a crucial step toward wide use for patients with cognitive disorders. OBJECTIVE: To investigate the underlying neural mechanism of shentai tea polyphenols in subjects with subjective cognitive decline (SCD) using functional near-infrared spectroscopy (fNIRS). METHODS: A total number of 36 patients with SCD participated in the study and received supplementation with shentai tea polyphenols for three months. All participants underwent a series of tests on neuropsychological function and fNIRS assessment during n-back tasks at baseline and follow-up. RESULTS: After intervention with shentai tea polyphenols in SCD, increased cerebral activity was observed in left dorsolateral prefrontal cortex (DLPFC), left premotor cortex (PMC), left primary somatosensory cortex (PSC), right inferior frontal gyrus (IFG), and premotor cortex (PMC). Moreover, shentai tea polyphenols intervention of three months significantly improved SCD subjects' cognitive functions (memory, language, and subjective cognitive ability) and depression condition. We further found that the improvement of HAMD and AVLT-R scores had positive correlations with increased brain activity in right IFG and left DLPFC, respectively. CONCLUSION: This study provides new evidence that the frontal cortex was found to be specifically activated after non-pharmacological intervention of shentai tea polyphenols in SCD, which may be associated with cognitive enhancement and mental wellbeing. These findings provide important implications for the selection of shentai tea polyphenols interventions for SCD.

Probing depression, schizophrenia, and other psychiatric disorders using fNIRS and the verbal fluency test: A systematic review and meta-analysis.

Yeung MK, Lin J.

J Psychiatr Res. Jun 12;140:416-
doi: 10.1016/j.jpsychires.2021.06. Online ahead of print.

Accessible neuroimaging tools that can identify specific frontal lobe dysfunction associated with psychiatric disorders could be useful for improving disease diagnosis and prognosis and treatment development. Functional near-infrared spectroscopy (fNIRS), in conjunction with the verbal fluency test (VFT), has emerged as an inexpensive and convenient method for understanding psychiatric disorders. However, questions remain regarding the specificity and uniqueness of fNIRS measurements for different disorders and the soundness of the methods applied previously. To address these knowledge gaps, we conducted a systematic review and meta-analysis of fNIRS studies using the VFT to probe psychiatric disorders. A literature search was conducted using PubMed and PsycINFO on October 27, 2020. Overall, 82% and 49% of the 121 included studies reported significantly reduced changes in oxyhemoglobin concentrations (HbO) and significantly fewer produced words during the VFT in psychiatric patients compared with healthy controls, respectively. For most psychiatric disorders, changes in HbO are more sensitive than changes in deoxyhemoglobin concentrations and VFT performance to detect psychopathologies. In addition, meta-analyses

based on the proportion of channels that exhibited significant differences in HbO changes between patients and controls and on the effect sizes of group differences consistently showed that for major depression and schizophrenia, hypoactivation could be found across the frontotemporal regions, but its topographical distribution is disorder-specific. Thus, the fNIRS-VFT paradigm holds promise for understanding, detecting, and differentiating psychiatric disorders, and has the potential for developing accessible neuroimaging biomarkers for different psychiatric disorders. The findings are discussed with regard to the strengths and weaknesses of the applied methods, following by recommendations.

Correcting physiological noise in whole-head functional near-infrared spectroscopy.

Zhang F, Cheong D, Khan AF, Chen Y, Ding L, Yuan H.

J Neurosci Methods. Jun 17;360:
doi: 10.1016/j.jneumeth.2021. Online ahead of print.

BACKGROUND: Functional near-infrared spectroscopy (fNIRS) has been increasingly employed to monitor cerebral hemodynamics in normal and diseased conditions. However, fNIRS suffers from its susceptibility to superficial activity and systemic physiological noise. The objective of the study was to establish a noise reduction method for fNIRS in a whole-head montage. NEW METHOD: We have developed an automated denoising method for whole-head fNIRS. A high-density montage consisting of 109 long-separation channels and 8 short-separation channels was used for recording. Auxiliary sensors were also used to measure motion, respiration and pulse simultaneously. The method incorporates principal component analysis and general linear model to identify and remove a globally uniform superficial component. Our denoising method was evaluated in experimental data acquired from a group of healthy human subjects during a visually cued motor task and further compared with a minimal preprocessing method and three established denoising methods in the literature. Quantitative metrics including contrast-to-noise ratio, within-subject standard deviation and adjusted coefficient of determination were evaluated. RESULTS: After denoising, whole-head topography of fNIRS revealed focal activations concurrently in the primary motor and visual areas. COMPARISON WITH EXISTING METHODS: Analysis showed that our method improves upon the four established preprocessing methods in the literature. CONCLUSIONS: An automatic, effective and robust preprocessing pipeline was established for removing physiological noise in whole-head fNIRS recordings. Our method can enable fNIRS as a reliable tool in monitoring large-scale, network-level brain activities for clinical uses.

Workplace design-related stress effects on prefrontal cortex connectivity and neurovascular coupling.

Alyan E, Saad NM, Kamel N, Rahman MA.

Appl Ergon. Oct;96:
doi: 10.1016/j.apergo.2021.Epub Jun 15.

This study aims to evaluate the effect of workstation type on the neural and vascular networks of the prefrontal cortex (PFC) underlying the cognitive activity involved during mental stress. Workstation design has been reported to affect the physical and mental health of employees. However, while the functional effects of ergonomic workstations have been documented, there is little research on the influence of workstation design on the executive function of the brain. In this study, 23 healthy volunteers in ergonomic and non-ergonomic workstations completed the Montreal imaging stress task, while their brain activity was recorded using the synchronized measurement of electroencephalography and functional near-infrared spectroscopy. The results revealed desynchronization in alpha rhythms and oxygenated hemoglobin, as well as decreased functional connectivity in the PFC networks at the non-ergonomic workstations. Additionally, a significant increase in salivary alpha-amylase activity was observed in all participants at the non-ergonomic workstations, confirming the presence of induced stress. These findings suggest that work-

station design can significantly impact cognitive functioning and human capabilities at work. Therefore, the use of functional neuroimaging in workplace design can provide critical information on the causes of workplace-related stress.

Group-level cortical functional connectivity patterns using fNIRS: assessing the effect of bilingualism in young infants.

Blanco B, Molnar M, Carreiras M, Collins-Jones LH, Vidal E, Cooper RJ, Caballero-Gaudes C.

Neurophotonics. Apr;8(2):
doi: 10.1117/1.NPh.8.2.Epub Jun 12.

Significance: Early monolingual versus bilingual experience induces adaptations in the development of linguistic and cognitive processes, and it modulates functional activation patterns during the first months of life. Resting-state functional connectivity (RSFC) is a convenient approach to study the functional organization of the infant brain. RSFC can be measured in infants during natural sleep, and it allows to simultaneously investigate various functional systems. Adaptations have been observed in RSFC due to a lifelong bilingual experience. Investigating whether bilingualism-induced adaptations in RSFC begin to emerge early in development has important implications for our understanding of how the infant brain's organization can be shaped by early environmental factors. Aims: We attempt to describe RSFC using functional near-infrared spectroscopy (fNIRS) and to examine whether it adapts to early monolingual versus bilingual environments. We also present an fNIRS data preprocessing and analysis pipeline that can be used to reliably characterize RSFC in development and to reduce false positives and flawed results interpretations. Methods: We measured spontaneous hemodynamic brain activity in a large cohort (N =99) of 4-month-old monolingual and bilingual infants using fNIRS. We implemented group-level approaches based on independent component analysis to examine RSFC, while providing proper control for physiological confounds and multiple comparisons. Results: At the group level, we describe the functional organization of the 4-month-old infant brain in large-scale cortical networks. Unbiased group-level comparisons revealed no differences in RSFC between monolingual and bilingual infants at this age. Conclusions: High-quality fNIRS data provide a means to reliably describe RSFC patterns in the infant brain. The proposed group-level RSFC analyses allow to assess differences in RSFC across experimental conditions. An effect of early bilingual experience in RSFC was not observed, suggesting that adaptations might only emerge during explicit linguistic tasks, or at a later point in development.

Abnormal functional connectivity within the prefrontal cortex in interstitial cystitis/bladder pain syndrome (IC/BPS): A pilot study using resting state functional near-infrared spectroscopy (rs-fNIRS).

Pang D, Liao L.

Neurourol Urodyn. Jun
doi: 10.1002/nau.Online ahead of print.

PURPOSE: To investigate the abnormalities of functional connectivity (FC) within the prefrontal cortex (PFC) of patients with interstitial cystitis/bladder pain syndrome (IC/BPS) based on resting state functional near-infrared spectroscopy (rs-fNIRS) data using FC matrix analysis. MATERIALS AND METHODS: Ten patients with IC/BPS (females, 9; mean age, 56.9 12.432 years) and 15 age- and gender-matched healthy controls (HC) (females, 12; mean age, 55.067 7.46 years) participated in this rs-fNIRS study. Two rs-fNIRS scans were performed (when the bladder was empty and when the desire to void was strong). The Pearson's correlation coefficient between the time series of the 22 channels was calculated to obtain a 22 22 FC matrix for each subject. A two-sample t-test ($p < .05$) was performed to compare group differences in the FC matrix between patients with IC/BPS and HC. RESULTS: FC was significantly decreased within the PFC in the IC/BPS group based on a two-sample t-test ($p < .05$) compared with HC. FC decreased

in a wider range of brain regions during the strong desire to void state (4 brain regions and 28 edges) when compared with the empty bladder state (3 brain regions and 18 edges). CONCLUSION: FC abnormalities in IC/BPS patients may lead to frontal lobe disorders involved in processing sensory integration, motivation drive, emotional control, and decision-making whether to urinate, leading to urinary control dysfunction manifested as typical clinical IC/BPS symptoms. Our results may provide new insight into the pathogenesis of IC/BPS and new brain biomarkers for diagnosis.

Bidirectional connectivity between Broca's area and Wernicke's area during interactive verbal communication.

Ono Y, Zhang X, Noah JA, Dravida S, Hirsch J.

Brain Connect. Jun

doi: 10.1089/brain.2020.Online ahead of print.

AIM: This investigation aims to advance understanding of the neural dynamics that underlie live and natural interactions during spoken dialogue between two-individuals. INTRODUCTION: The underlying hypothesis is that functional connectivity between canonical speech areas in the human brain will be modulated by social interaction. METHODS: Granger causality was applied to compare directional connectivity across Broca's and Wernicke's Areas during verbal conditions consisting of interactive and non-interactive communication. Thirty-three pairs of healthy adult participants alternately talked and listened to each other while performing an object naming and description task that was either interactive or not during hyperscanning with functional near-infrared spectroscopy (fNIRS). In the non-interactive condition, the speaker named and described a picture-object without reference to the partner's description. In the interactive condition the speaker performed the same task but included an interactive response about the preceding comments of the partner. Causality measures of hemodynamic responses from Broca's and Wernicke's Areas were compared between real, surrogate, and shuffled trials within dyads. RESULTS: The interactive communication was characterized by bidirectional connectivity between Wernicke's and Broca's Areas of the listener's brain. Whereas, this connectivity was unidirectional in the speaker's brain. In the case of the non-interactive condition, both speaker's and listener's brains showed unidirectional top-down (Broca's Area to Wernicke's Area) connectivity. CONCLUSION: Together, directional connectivity as determined by Granger analysis reveals bidirectional flow of neuronal information during dynamic two-person verbal interaction for processes that are active during listening (reception) and not during talking (production). Findings are consistent with prior contrast findings (general linear model) showing neural modulation of the receptive language system associated with Wernicke's Area during two-person live interaction.

Neural and biomechanical tradeoffs associated with human-exoskeleton interactions.

Zhu Y, Weston EB, Mehta RK, Marras WS.

Appl Ergon. Oct;96:

doi: 10.1016/j.apergo.2021.Epub Jun 11.

Industrial passive low-back exoskeletons have gained recent attention as ergonomic interventions to manual handling tasks. This research utilized a two-armed experimental approach (single vs dual-task paradigms) to quantify neural and biomechanical tradeoffs associated with short-term human-exoskeleton interaction (HEI) during asymmetrical lifting in twelve healthy adults balanced by gender. A dynamic, electromyography-assisted spine model was employed that indicated statistical, but marginal, biomechanical benefits of the tested exoskeleton, which diminished with the introduction of the cognitive dual-task. Using Near Infrared Spectroscopy (fNIRS)-based brain connectivity analyses, we found that the tested exoskeleton imposed greater neurocognitive and motor adaptation efforts by engaging action monitoring and error processing brain networks. Collectively, these findings indicate that a wearer's biomechanical

response to increased cognitive demands in the workplace may offset the mechanical advantages of exoskeletons. We also demonstrate the utility of ambulatory fNIRS to capture the neural cost of HEI without the need for elaborate dual-task manipulations.

Dynamic inter-brain synchrony in real-life inter-personal cooperation: A functional near-infrared spectroscopy hyperscanning study.

Li R, Mayseless N, Balters S, Reiss AL.

Neuroimage. Jun 11;238:

doi: 10.1016/j.neuroimage.2021. Online ahead of print.

How two brains communicate with each other during social interaction is highly dynamic and complex. Multi-person (i.e., hyperscanning) studies to date have focused on analyzing the entire time series of brain signals to reveal an overall pattern of inter-brain synchrony (IBS). However, this approach does not account for the dynamic nature of social interaction. In the present study, we propose a data-driven approach based on sliding windows and k-mean clustering to capture the dynamic modulation of IBS patterns during interactive cooperation tasks. We used a portable functional near-infrared spectroscopy (fNIRS) system to measure brain hemodynamic response between interacting partners (20 dyads) engaged in a creative design task and a 3D model building task. Results indicated that inter-personal communication during naturalistic cooperation generally presented with a series of dynamic IBS states along the tasks. Compared to the model building task, the creative design task appeared to involve more complex and active IBS between multiple regions in specific dynamic IBS states. In summary, the proposed approach stands as a promising tool to distill complex inter-brain dynamics associated with social interaction into a set of representative brain states with more fine-grained temporal resolution. This approach holds promise for advancing our current understanding of the dynamic nature of neurocognitive processes underlying social interaction.

Insights from a laboratory and naturalistic investigation on stress, rumination and frontal brain functioning in MDD: An fNIRS study.

Rosenbaum D, Int-Veen I, Laicher H, Torka F, Kroczek A, Rubel J, Lawyer G, Brger Z, Bihlmaier I, Storchak H, Velten-Schurian K, Dresler T, Tglich R, Schopp B, Nrk HC, Derntl B, Nieratschker V, Fallgatter AJ, Ehlis AC.

Neurobiol Stress. May 24;15:

doi: 10.1016/j.ynstr.2021. eCollection Nov.

Recent research has emphasized rumination as an important maintaining factor in various mental disorders. However, operationalization and therefore induction of rumination in experimental settings poses a major challenge in terms of ecological validity. As stress seems to play a key role in everyday situations eliciting rumination, we conducted two stress paradigms while assessing behavioral and neurophysiological measures. Aiming to replicate previous findings on induced rumination by means of the Trier Social Stress Test (TSST) and comparing them to physiological (pain) stress, a clinical sample of patients with Major Depressive Disorder (MDD; n=22) and healthy controls (HC; n=23) was recruited. Cortical blood oxygenation was assessed during the stress paradigms using functional near-infrared spectroscopy (fNIRS). Further, we used ecological momentary assessment (EMA) of stress, rumination and mood to be able to correlate ruminative responses during induced stress and everyday rumination. Our results showed that social stress but not physiological stress induced depressive rumination in MDD but not in HC. Further, rumination reactivity in response to social stress but not to physiological stress was significantly associated with rumination reactivity in everyday life as assessed with EMA. With respect to cortical oxygenation, MDD subjects showed hypoactivity in the Cognitive Control Network during the TSST, which mediated the differences between MDD and HC in post-stress rumination. Our findings emphasize

the role of negative social triggers in depressive rumination and validate the TSST as an induction method for depressive rumination. The results inform future developments in psychotherapeutic treatment for depressive rumination.

Shining new light on sensory brain activation and physiological measurement in seals using wearable optical technology.

McKnight JC, Ruesch A, Bennett K, Bronkhorst M, Balfour S, Moss SEW, Milne R, Tyack PL, Kainerstorfer JM, Hastie GD.

Philos Trans R Soc Lond B Biol Sci. Aug 2;376(1830):
doi: 10.1098/rstb.2020.Epub Jun 14.

Sensory ecology and physiology of free-ranging animals is challenging to study but underpins our understanding of decision-making in the wild. Existing non-invasive human biomedical technology offers tools that could be harnessed to address these challenges. Functional near-infrared spectroscopy (fNIRS), a wearable, non-invasive biomedical imaging technique measures oxy- and deoxyhaemoglobin concentration changes that can be used to detect localized neural activation in the brain. We tested the efficacy of fNIRS to detect cortical activation in grey seals (Halichoerus grypus) and identify regions of the cortex associated with different senses (vision, hearing and touch). The activation of specific cerebral areas in seals was detected by fNIRS in responses to light (vision), sound (hearing) and whisker stimulation (touch). Physiological parameters, including heart and breathing rate, were also extracted from the fNIRS signal, which allowed neural and physiological responses to be monitored simultaneously. This is, to our knowledge, the first time fNIRS has been used to detect cortical activation in a non-domesticated or laboratory animal. Because fNIRS is non-invasive and wearable, this study demonstrates its potential as a tool to quantitatively investigate sensory perception and brain function while simultaneously recording heart rate, tissue and arterial oxygen saturation of haemoglobin, perfusion changes and breathing rate in free-ranging animals. This article is part of the theme issue 'Measuring physiology in free-living animals (Part I)'.

Effects of Acute Dance and Aerobic Exercise on Drug Craving and Food Reward in Women with Methamphetamine Dependence.

Zhou YU, Finlayson G, Liu X, Zhou Q, Liu T, Zhou C.

Med Sci Sports Exerc. Jun
doi: 10.1249/MSS.Online ahead of print.

INTRODUCTION: Drug dependence causes an overestimation of drug-related stimuli and an underestimation of non-drug-related stimuli, such as food. The purpose of this study was to investigate the effects of acute moderate-intensity dance and aerobic exercise on drug craving, appetite, prefrontal neural activation to food cues and food reward in women with MA dependence. METHODS: Thirty-nine women who met the DSM-V MA dependence criteria participated in the experiment and were randomly assigned to either a dance (n = 20) or exercise (n = 19) group. A moderate-intensity (65% 75% Max HR) 35-minute dance or treadmill intervention counterbalanced with a reading control session were conducted. After the intervention or control, subjective drug craving was measured before and after exposure to drug-related cues. Visual analog scales (VAS) were used to measure subjective feelings of appetite. Participants then completed a visual food cue paradigm while using Functional Near-Infrared Spectroscopy (fNIRS) to monitor prefrontal blood oxygen changes. Finally, the Leeds Food Preference Questionnaire (LFPQ) was used to measure reward responses to different categories of food. RESULTS: The results showed that the dance and exercise interventions reduced subjective craving for drugs after being exposed to drug cues ($P = 0.019$). Implicit wanting ($P < 0.001$) and relative preferences ($P = 0.001$) for high-calorie savoury foods were all increased after interventions relative to control. Compared with the control session,

the left dorsolateral prefrontal cortex (P = 0.020) was activated when viewing high-calorie foods after moderate-intensity aerobic exercise. CONCLUSIONS: The current results support the use of moderate-intensity exercise as a therapeutic intervention to restore the balance between drug and non-drug rewards by decreasing cue-induced MA craving and increasing food reward.

Prefrontal Functional Connectivity During the Verbal Fluency Task in Patients With Major Depressive Disorder: A Functional Near-Infrared Spectroscopy Study.

Dong SY, Choi J, Park Y, Baik SY, Jung M, Kim Y, Lee SH.

Front Psychiatry. May 21;12:

doi: 10.3389/fpsyt.2021. eCollection 2021.

Deviations in activation patterns and functional connectivity have been observed in patients with major depressive disorder (MDD) with prefrontal hemodynamics of patients compared with healthy individuals. The graph-theoretical approach provides useful network metrics for evaluating functional connectivity. The evaluation of functional connectivity during a cognitive task can be used to explain the neurocognitive mechanism underlying the cognitive impairments caused by depression. Overall, 31 patients with MDD and 43 healthy individuals completed a verbal fluency task (VFT) while wearing a head-mounted functional near-infrared spectroscopy (fNIRS) devices. Hemodynamics and functional connectivity across eight prefrontal subregions in the two groups were analyzed and compared. We observed a reduction in prefrontal activation and weaker overall and interhemispheric subregion-wise correlations in the patient group compared with corresponding values in the control group. Moreover, efficiency, the network measure related to the effectiveness of information transfer, showed a significant between-group difference [t (71.64) = 3.66, corrected $p < 0.001$] along with a strong negative correlation with depression severity (rho = -0.30, p = 0.009). The patterns of prefrontal functional connectivity differed significantly between the patient and control groups during the VFT. Network measures can quantitatively characterize the reduction in functional connectivity caused by depression. The efficiency of the functional network may play an important role in the understanding of depressive symptoms.

Genetic variation in the oxytocin system and its link to social motivation in human infants.

Krol KM, Namaky N, Monakhov MV, Lai PS, Ebstein R, Grossmann T.

Psychoneuroendocrinology. May 29;131:

doi: 10.1016/j.psyneuen.2021.Online ahead of print.

Frontal brain asymmetry has been linked to motivational processes in infants and adults, with left lateralization reflecting motivation to approach and right lateralization reflecting motivation to withdraw. We examined the hypothesis that variability in infants' social motivation may be linked to genetic variation in the oxytocin system. Eleven-month-old infants' brain responses and looking preferences to smiling and frowning individuals were assessed in conjunction with a polymorphism in CD38 (rs3796863) linked to autism spectrum disorder (ASD) and reduced oxytocin. Frontal brain asymmetry and looking preferences differed as a function of CD38 genotype. While non-risk A-allele carriers displayed left lateralization to smiling faces (approach) and a heightened looking preference for the individual who smiled, infants with the CC (ASD risk) genotype displayed withdrawal from smiling faces and a preference for the individual who frowned. Findings demonstrate that the oxytocin system is linked to brain and behavioral markers of social motivation in infancy.

Abnormally reduced frontal cortex activity during Trail-Making-Test in prodromal

parkinson's disease-a fNIRS study.
Hofmann A, Rosenbaum D, Int-Veen I, Ehlis AC, Brockmann K, Dehnen K, von Thaler AK, Berg D, Fallgatter AJ, Metzger FG; TREND Study Consortium.
Neurobiol Aging. Apr 28;105:148-
doi: 10.1016/j.neurobiolaging.2021.04.Online ahead of print.

Parkinson's Disease (PD) is a neurodegenerative disorder leading to typical motor as well as a range of non-motor symptoms, including cognitive decline mainly characterized by executive deficits. The latter are known to appear years before the typical motor signs, thus representing the prodromal phase of PD. However, appropriate methods for measuring executive dysfunction in this context are not well established yet. Traditionally, executive performance is associated with frontal structures. Here, we investigated prodromal, early PD patients and healthy controls regarding their executive functioning on the behavioral and neural level, measured by the Trail-Making-Test (TMT) combined with functional near-infrared spectroscopy. We observed significantly reduced neural activity in the right dorsolateral prefrontal cortex within PD patients compared to controls completing the TMT-A and -B in contrast to the TMT-C, but no differences on a behavioral level. These promising results need to be confirmed and checked for reliability in future studies to extend the spectrum of markers applied in prodromal PD.

Maternal Sensitivity and Infant Neural Response to Touch: an fNIRS Study.
Mateus V, Osrio A, Oliveira Miguel H, Cruz S, Sampaio A.
Soc Cogn Affect Neurosci. Jun 4:nsab
doi: 10.1093/scan/nsabOnline ahead of print.

The mother's attunement to her infant's emotional needs influences her use of touching behaviors during mother-infant interactions. Moreover, maternal touch appears to modulate infants' physiological responses to affective touch. However, little is known about the impact of maternal sensitivity on infants' touch processing at a brain level. This study explored the association between maternal sensitivity when infants (N = 24) were 7 months old and their patterns of cortical activation to touch at 12 months. Brain activation was measured using functional near-infrared spectroscopy (fNIRS). Changes in oxy (HbO2)- and deoxy (HHb)-hemoglobin concentrations were measured in the left somatosensory cortex and right temporal cortex while infants received two types of tactile stimulation - affective and discriminative touch. Results showed that lower maternal sensitivity was associated with a higher HbO2 response for discriminative touch over the temporal region. Additionally, infants of less sensitive mothers tended to present a higher response in HbO2 for affective touch over the somatosensory region. These findings suggest that less sensitive interactions might result in lower exposure to maternal touch, which can be further related to infant's neural processing of touch.

Correlating functional near-infrared spectroscopy with underlying cortical regions of 0-, 1-, and 2-year-olds using theoretical light propagation analysis.
Cai L, Okada E, Minagawa Y, Kawaguchi H.
Neurophotonics. Apr;8(2):
doi: 10.1117/1.NPh.8.2.Epub May 31.

Significance: The establishment of a light propagation analysis-based scalp-cortex correlation (SCC) between the scalp location of the source-detector (SD) pair and brain regions is essential for measuring functional brain development in the first 2 years of life using functional near-infrared spectroscopy (fNIRS). Aim: We aimed to reveal the optics-based SCC of 0-, 1-, and 2-year-olds (yo) and the suitable SD distance for this age period. Approach: Light propagation analyses using age-appropriate head models were conducted on SD pairs at 10-10 fiducial points on the scalp to obtain optics-based SCC and its metrics: the number of corresponding brain regions (NCBR), selectivity and sensitivity of the most likely corre-

sponding brain region (MLCBR), and consistency of the MLCBR across developmental ages. Moreover, we assessed the suitable SD distances for 0-, 1-, and 2-yo by simultaneously considering the selectivity and sensitivity of the MLCBR. Results: Age-related changes in the SCC metrics were observed. For instance, the NCBR of 0-yo was larger than that of 1- and 2-yo. Conversely, the selectivity of 0-yo was lower than that of 1- and 2-yo. The sensitivity of 1-yo was higher than that of 0-yo at 15- to 30-mm SD distances and higher than that of 2-yo at 10-mm SD distance. Notably, the MLCBR of the fiducial points around the longitudinal fissure was inconsistent across age groups. An SD distance between 15 and 25mm was found to be appropriate for satisfying both sensitivity and selectivity requirements. In addition, this work provides reference tables of optics-based SCC for 0-, 1-, and 2-yo. Conclusions: Optics-based SCC will be informative in designing and explaining child developmental studies using fNIRS. The suitable SD distances were between 15 and 25mm for the first 2 years of life.

Neuroimaging and DNA Methylation: An Innovative Approach to Study the Effects of Early Life Stress on Developmental Plasticity.

Mariani Wigley ILC, Mascheroni E, Peruzzo D, Giorda R, Bonichini S, Montirosso R.

Front Psychol. May 17;12:

doi: 10.3389/fpsyg.2021. eCollection 2021.

DNA methylation plays a key role in neural cell fate and provides a molecular link between early life stress and later-life behavioral phenotypes. Here, studies that combine neuroimaging methods and DNA methylation analysis in pediatric population with a history of adverse experiences were systematically reviewed focusing on: targeted genes and neural correlates; statistical models used to examine the link between DNA methylation and neuroimaging data also considering early life stress and behavioral outcomes. We identified 8 studies that report associations between DNA methylation and brain structure/functions in infants, school age children and adolescents faced with early life stress condition (e.g., preterm birth, childhood maltreatment, low socioeconomic status, and less-than optimal caregiving). Results showed that several genes were investigated (e.g., OXTR, SLC6A4, FKBP5, and BDNF) and different neuroimaging techniques were performed (MRI and f-NIRS). Statistical model used ranged from correlational to more complex moderated mediation models. Most of the studies (n = 5) considered DNA methylation and neural correlates as mediators in the relationship between early life stress and behavioral phenotypes. Understanding what role DNA methylation and neural correlates play in interaction with early life stress and behavioral outcomes is crucial to promote theory-driven studies as the future direction of this research fields.

Pain Management for Dental Medicine in 2021: Opioids, Coronavirus and Beyond.

Scrivani SJ, Keith DA, Kulich RJ, DaSilva AF, Donoff RB, Handa S, Holland N, Lerman MA, McCauley JL, Reisner L, Resnick CM, Stohler CS, Vasciannie A, Fortino M, Schatman ME.

J Pain Res. May 24;14:1371-

doi: 10.2147/JPR.SeCollection 2021.

Over the past year our attention has inevitably been on the coronavirus pandemic, the health and welfare of our families, patients, and office staffs as well as the re-opening of our dental practices. In addition, the opioid crisis continues, is very likely to worsen as a result of the pandemic and continues to be a challenge to Dentistry. National public health issues and healthcare disparities continue and have created a global concern for providing evidence-based, adequate pain management in the dental setting. We have brought together a group of national thought leaders and experts in this field who will share their insights on the current state of opioid prescribing in Dentistry and describe some of the exciting work being done in advancing pain management. The learning objectives for this conference proceedings were: Describing the implications of current public health concerns for safe and effective pain management

in dental medicine.Identifying risk factors and understanding the current guidelines for the use of opioid and non-opioid medications in dental medicine.Analyzing the interprofessional collaborations necessary for effective pain management in dental medicine.Recognizing the challenges and opportunities brought about by the COVID-19 pandemic for the dental profession.Applying evidence-based strategies for managing the complex pain patient in the dental setting.Appraising new and future modalities for the assessment and management of orofacial pain.

Classification of Prefrontal Cortex Activity Based on Functional Near-Infrared Spectroscopy Data upon Olfactory Stimulation.

Chen CH, Shyu KK, Lu CK, Jao CW, Lee PL.

Brain Sci. May 26;11(6):
doi: 10.3390/brainsci11060701.

The sense of smell is one of the most important organs in humans, and olfactory imaging can detect signals in the anterior orbital frontal lobe. This study assessed olfactory stimuli using support vector machines (SVMs) with signals from functional near-infrared spectroscopy (fNIRS) data obtained from the prefrontal cortex. These data included odor stimuli and air state, which triggered the hemodynamic response function (HRF), determined from variations in oxyhemoglobin (oxyHb) and deoxyhemoglobin (deoxyHb) levels; photoplethysmography (PPG) of two wavelengths (raw optical red and near-infrared data); and the ratios of data from two optical datasets. We adopted three SVM kernel functions (i.e., linear, quadratic, and cubic) to analyze signals and compare their performance with the HRF and PPG signals. The results revealed that oxyHb yielded the most efficient single-signal data with a quadratic kernel function, and a combination of HRF and PPG signals yielded the most efficient multi-signal data with the cubic function. Our results revealed superior SVM analysis of HRFs for classifying odor and air status using fNIRS data during olfaction in humans. Furthermore, the olfactory stimulation can be accurately classified by using quadratic and cubic kernel functions in SVM, even for an individual participant data set.

The Validation of a Portable Functional NIRS System for Assessing Mental Workload.

Saikia MJ, Besio WG, Mankodiya K.

Sensors (Basel). May 31;21(11):
doi: 10.3390/s21113810.

Portable functional near-infrared spectroscopy (fNIRS) systems have the potential to image the brain in naturalistic settings. Experimental studies are essential to validate such fNIRS systems. Working memory (WM) is a short-term active memory that is associated with the temporary storage and manipulation of information. The prefrontal cortex (PFC) brain area is involved in the processing of WM. We assessed the PFC brain during n-back WM tasks in a group of 25 college students using our laboratory-developed portable fNIRS system, WearLight. We designed an experimental protocol with 32 n-back WM task blocks with four different pseudo-randomized task difficulty levels. The hemodynamic response of the brain was computed from the experimental data and the evaluated brain responses due to these tasks. We observed the incremental mean hemodynamic activation induced by the increasing WM load. The left-PFC area was more activated in the WM task compared to the right-PFC. The task performance was seen to be related to the hemodynamic responses. The experimental results proved the functioning of the WearLight system in cognitive load imaging. Since the portable fNIRS system was wearable and operated wirelessly, it was possible to measure the cognitive load in the naturalistic environment, which could also lead to the development of a user-friendly brain-computer interface system.

Bimodal Data Fusion of Simultaneous Measurements of EEG and fNIRS during Lower Limb Movements.

Al-Quraishi MS, Elamvazuthi I, Tang TB, Al-Qurishi M, Adil SH, Ebrahim M.

Brain Sci. May 27;11(6):
doi: 10.3390/brainsci11060713.

Electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) have temporal and spatial characteristics that may complement each other and, therefore, pose an intriguing approach for brain-computer interaction (BCI). In this work, the relationship between the hemodynamic response and brain oscillation activity was investigated using the concurrent recording of fNIRS and EEG during ankle joint movements. Twenty subjects participated in this experiment. The EEG was recorded using 20 electrodes and hemodynamic responses were recorded using 32 optodes positioned over the motor cortex areas. The event-related desynchronization (ERD) feature was extracted from the EEG signal in the alpha band (8-11) Hz, and the concentration change of the oxy-hemoglobin (oxyHb) was evaluated from the hemodynamics response. During the motor execution of the ankle joint movements, a decrease in the alpha (8-11) Hz amplitude (desynchronization) was found to be correlated with an increase of the oxyHb ($r = -0.64061$, $p < 0.00001$) observed on the Cz electrode and the average of the fNIRS channels (ch28, ch25, ch32, ch35) close to the foot area representation. Then, the correlated channels in both modalities were used for ankle joint movement classification. The result demonstrates that the integrated modality based on the correlated channels provides a substantial enhancement in ankle joint classification accuracy of 93.01 5.60% ($p < 0.01$) compared with single modality. These results highlight the potential of the bimodal fNIR-EEG approach for the development of future BCI for lower limb rehabilitation.

An fNIRS Investigation of Masculinity, Femininity, and Sex on Nonparents' Empathic Response to Infant Cries.

Ng X, Ng LY, Gabrieli G, Azhari A, Neoh MJY, Esposito G.

Brain Sci. May 14;11(5):
doi: 10.3390/brainsci11050635.

According to societal stereotypes, the female sex and people who are more feminine have been considered to be more empathic than males and people who are more masculine. Therefore, females and feminine individuals are expected to respond more empathically to an infant's cries. While this hypothesis was tested using self-report scales, it has not been explored thoroughly in terms of prefrontal cortex (PFC) activity, which may be a more objective means of measuring empathy. Specifically, the medial PFC (mPFC) is involved in social cognitive processing and thus a good proxy to measure the level of empathy. This study aims to (1) assess if the empathic response, in terms of medial PFC (mPFC) activity, to infant cries differ between sexes; (2) investigate if the empathic response is moderated by levels of masculinity and femininity. Functional near-infrared spectroscopy (fNIRS) was used to measure nonparent participants' (18 males, 20 females) mPFC response to infant cries of different pitches (high and low). The Toronto Empathy Questionnaire was used to measure trait empathy and Bem's Sex Role Inventory was used to measure the level of masculinity and femininity. Results revealed that biological sex had no significant effect on the empathic response towards infant cries of varying pitch. Furthermore, masculinity, not femininity, was correlated with an increase in empathic response in the mPFC to high but not low-pitch infant cries. We reason that this is because of the higher aversiveness and inflicted pain associated with higher-pitched cries, which induces more emotional and physical pain that masculine individuals seek to avoid. Overall, the results suggest that greater masculinity would imply greater mentalizing and processing of empathy-related information.

The Mood-Improving Effect of Viewing Images of Nature and Its Neural Substrate.

Yamashita R, Chen C, Matsubara T, Hagiwara K, Inamura M, Aga K, Hirotsu M, Seki T, Takao A, Nakagawa E, Kobayashi A, Fujii Y, Hirata K, Ikei H, Miyazaki Y, Nakagawa S.
Int J Environ Res Public Health. May 20;18(10):
doi: 10.3390/ijerph18105500.

It has been recently suggested that contact with nature improves mood via reducing the activity of the prefrontal cortex. However, the specific regions within the prefrontal cortex that underlie this effect remain unclear. In this study, we aimed to identify the specific regions involved in the mood-improving effect of viewing images of nature using a 52-channel functional near-infrared spectroscopy (fNIRS). Specifically, we focused on the orbitofrontal cortex (OFC) and dorsolateral prefrontal cortex (dlPFC), two regions associated with affective processing and control. In a randomized controlled crossover experiment, we assigned thirty young adults to view images of nature and built environments for three minutes each in a counterbalanced order. During image viewing, participants wore a fNIRS probe cap and had their oxyhemoglobin (oxy-Hb) measured. Immediately following each image viewing, participants indicated their mood in terms of comfortableness, relaxation, and vigor. Results showed that viewing images of nature significantly increased comfortableness and relaxation but not vigor compared to viewing images of built environments, with a large effect size. Meanwhile, the concentration of oxy-Hb in only the right OFC and none of the other regions significantly decreased while viewing the images of nature compared to built environments, with a medium effect size. We speculate that viewing images of nature improves mood by reducing the activity of or calming the OFC. Since the OFC is hyperactive in patients with depression and anxiety at rest, contact with nature might have therapeutic effects for them.

Data Processing in Functional Near-Infrared Spectroscopy (fNIRS) Motor Control Research.

Dans PW, Foglia SD, Nelson AJ.
Brain Sci. May 9;11(5):
doi: 10.3390/brainsci11050606.

FNIRS pre-processing and processing methodologies are very important-how a researcher chooses to process their data can change the outcome of an experiment. The purpose of this review is to provide a guide on fNIRS pre-processing and processing techniques pertinent to the field of human motor control research. One hundred and twenty-three articles were selected from the motor control field and were examined on the basis of their fNIRS pre-processing and processing methodologies. Information was gathered about the most frequently used techniques in the field, which included frequency cutoff filters, wavelet filters, smoothing filters, and the general linear model (GLM). We discuss the methodologies of and considerations for these frequently used techniques, as well as those for some alternative techniques. Additionally, general considerations for processing are discussed.

The Role of Visual Features in Text-Based CAPTCHAs: An fNIRS Study for Usable Security.

Mlazimoglu E, akir MP, Acartrk C.
Comput Intell Neurosci. May 4;2021:
doi: 10.1155/2021/ eCollection 2021.

To mitigate dictionary attacks or similar undesirable automated attacks to information systems, developers mostly prefer using CAPTCHA challenges as Human Interactive Proofs (HIPs) to distinguish between human users and scripts. Appropriate use of CAPTCHA requires a setup that balances between robustness and usability during the design of a challenge. The previous research reveals that most usability studies have used accuracy and response time as measurement criteria for quantitative analysis. The present study aims at applying optical neuroimaging techniques for the analysis of CAPTCHA design.

The functional Near-Infrared Spectroscopy technique was used to explore the hemodynamic responses in the prefrontal cortex elicited by CAPTCHA stimulus of varying types. The findings suggest that regions in the left and right dorsolateral and right dorsomedial prefrontal cortex respond to the degrees of line occlusion, rotation, and wave distortions present in a CAPTCHA. The systematic addition of the visual effects introduced nonlinear effects on the behavioral and prefrontal oxygenation measures, indicative of the emergence of Gestalt effects that might have influenced the perception of the overall CAPTCHA figure.

Prefrontal Cortex Activation During Motor Sequence Learning Under Interleaved and Repetitive Practice: A Two-Channel Near-Infrared Spectroscopy Study.

Immink MA, Pointon M, Wright DL, Marino FE.

Front Hum Neurosci. May 14;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Training under high interference conditions through interleaved practice (IP) results in performance suppression during training but enhances long-term performance relative to repetitive practice (RP) involving low interference. Previous neuroimaging work addressing this contextual interference effect of motor learning has relied heavily on the blood-oxygen-level-dependent (BOLD) response using functional magnetic resonance imaging (fMRI) methodology resulting in mixed reports of prefrontal cortex (PFC) recruitment under IP and RP conditions. We sought to clarify these equivocal findings by imaging bilateral PFC recruitment using functional near-infrared spectroscopy (fNIRS) while discrete key pressing sequences were trained under IP and RP schedules and subsequently tested following a 24-h delay. An advantage of fNIRS over the fMRI BOLD response is that the former measures oxygenated and deoxygenated hemoglobin changes independently allowing for assessment of cortical hemodynamics even when there is neurovascular decoupling. Despite slower sequence performance durations under IP, bilateral PFC oxygenated and deoxygenated hemoglobin values did not differ between practice conditions. During test, however, slower performance from those previously trained under RP coincided with hemispheric asymmetry in PFC recruitment. Specifically, following RP, test deoxygenated hemoglobin values were significantly lower in the right PFC. The present findings contrast with previous behavioral demonstrations of increased cognitive demand under IP to illustrate a more complex involvement of the PFC in the contextual interference effect. IP and RP incur similar levels of bilateral PFC recruitment, but the processes underlying the recruitment are dissimilar. PFC recruitment during IP supports action reconstruction and memory elaboration while RP relies on PFC recruitment to maintain task variation information in working memory from trial to trial. While PFC recruitment under RP serves to enhance immediate performance, it does not support long-term performance.

Dual-task walking and automaticity after Stroke: Insights from a secondary analysis and imaging sub-study of a randomised controlled trial.

Collett J, Fleming MK, Meester D, Al-Yahya E, Wade DT, Dennis A, Salvan P, Meaney A, Cockburn J, Dawes J, Johansen-Berg H, Dawes H.

Clin Rehabil. May 30:
doi: 10.1177/ Online ahead of print.

OBJECTIVE: To test the extent to which initial walking speed influences dual-task performance after walking intervention, hypothesising that slow walking speed affects automatic gait control, limiting executive resource availability. DESIGN: A secondary analysis of a trial of dual-task (DT) and single-task (ST) walking interventions comparing those with good (walking speed ?0.8 m s-1, n = 21) and limited (walking speed <0.79 m s-1, n = 24) capacity at baseline. SETTING: Community. SUBJECTS: Adults six-months post stroke with walking impairment. INTERVENTIONS: Twenty sessions of 30 minutes treadmill walking over 10 weeks with (DT) or without (ST) cognitive distraction. Good and limited groups were formed

regardless of intervention received. MAIN MEASURES: A two-minute walk with (DT) and without (ST) a cognitive distraction assessed walking. fNIRS measured prefrontal cortex activation during treadmill walking with (DT) and without (ST) Stroop and planning tasks and an fMRI sub-study used ankle-dorsiflexion to simulate walking. RESULTS: ST walking improved in both groups (?baseline: Good = 8.9 13.4 m, limited = 5.38.9 m, Group time = P < 0.151) but only the good walkers improved DT walking (?baseline: Good = 10.4 13.9 m, limited = 1.3 7.7 m, Group time = P < 0.025). fNIRS indicated increased ispilesional prefrontal cortex activation during DT walking following intervention (P = 0.021). fMRI revealed greater DT cost activation for limited walkers, and increased resting state connectivity of contralesional M1 with cortical areas associated with conscious gait control at baseline. After the intervention, resting state connectivity between ipsilesional M1 and bilateral superior parietal lobe, involved in integrating sensory and motor signals, increased in the good walkers compared with limited walkers. CONCLUSION: In individual who walk slowly it may be difficult to improve dual-task walking ability.Registration: ISRCTN50586966.

The use of broad vs restricted regions of interest in functional near-infrared spectroscopy for measuring cortical activation to auditory-only and visual-only speech.

Shader MJ, Luke R, Gouailhardou N, McKay CM.

Hear Res. Jul;406:
doi: 10.1016/j.heares.2021.Epub Apr 28.

As an alternative to fMRI, functional near-infrared spectroscopy (fNIRS) is a relatively new tool for observing cortical activation. However, spatial resolution is reduced compared to fMRI and often the exact locations of fNIRS optodes and specific anatomical information is not known. The aim of this study was to explore the location and range of specific regions of interest that are sensitive to detecting cortical activation using fNIRS in response to auditory- and visual-only connected speech. Two approaches to a priori region-of-interest selection were explored. First, broad regions corresponding to the auditory cortex and occipital lobe were analysed. Next, the fNIRS Optode Location Decider (fOLD) tool was used to divide the auditory and visual regions into two subregions corresponding to distinct anatomical structures. The Auditory-A and -B regions corresponded to Heschl's gyrus and planum temporale, respectively. The Visual-A region corresponded to the superior occipital gyrus and the cuneus, and the Visual-B region corresponded to the middle occipital gyrus. The experimental stimulus consisted of a connected speech signal segmented into 12.5-sec blocks and was presented in either an auditory-only or visual-only condition. Group-level results for eight normal-hearing adult participants averaged over the broad regions of interest revealed significant auditory-evoked activation for both the left and right broad auditory regions of interest. No significant activity was observed for any other broad region of interest in response to any stimulus condition. When divided into subregions, there was a significant positive auditory-evoked response in the left and right Auditory-A regions, suggesting activation near the primary auditory cortex in response to auditory-only speech. There was a significant positive visual-evoked response in the Visual-B region, suggesting middle occipital gyrus activation in response to visual-only speech. In the Visual-A region, however, there was a significant negative visual-evoked response. This result suggests a significant decrease in oxygenated hemoglobin in the superior occipital gyrus as well as the cuneus in response to visual-only speech. Distinct response characteristics, either positive or negative, in adjacent subregions within the temporal and occipital lobes were fairly consistent on the individual level. Results suggest that temporal regions near Heschl's gyrus may be the most advantageous location in adults for identifying hemodynamic responses to complex auditory speech signals using fNIRS. In the occipital lobe, regions corresponding to the facial processing pathway may prove advantageous for measuring positive responses to visual speech using fNIRS.

Aerobic Exercise Combined With Transcranial Direct Current Stimulation Over the

Prefrontal Cortex in Parkinson Disease: Effects on Cortical Activity, Gait, and Cognition.

Conceio NR, Gobbi LTB, Nbrega-Sousa P, Orcioli-Silva D, Beretta VS, Lirani-Silva E, Okano AH, Vitrio R.

Neurorehabil Neural Repair. May 28:
doi: 10.1177/Online ahead of print.

BACKGROUND: Since people with Parkinson disease (PD) rely on limited prefrontal executive resources for the control of gait, interventions targeting the prefrontal cortex (PFC) may help in managing PD-related gait impairments. Transcranial direct current stimulation (tDCS) can be used to modulate PFC excitability and improve prefrontal cognitive functions and gait. OBJECTIVE: We investigated the effects of adding anodal tDCS applied over the PFC to a session of aerobic exercise on gait, cognition, and PFC activity while walking in people with PD. METHODS: A total of 20 people with PD participated in this randomized, double-blinded, sham-controlled crossover study. Participants attended two 30-minute sessions of aerobic exercise (cycling at moderate intensity) combined with different tDCS conditions (active- or sham-tDCS), 1 week apart. The order of sessions was counterbalanced across the sample. Anodal tDCS (2 mA for 20 minutes [active-tDCS] or 10 s [sham-tDCS]) targeted the PFC in the most affected hemisphere. Spatiotemporal gait parameters, cognitive functions, and PFC activity while walking were assessed before and immediately after each session. RESULTS: Compared with the pre-assessment, participants decreased step time variability (effect size: -0.4), shortened simple and choice reaction times (effect sizes: -0.73 and -0.57, respectively), and increased PFC activity in the stimulated hemisphere while walking (effect size: 0.54) only after aerobic exercise + active-tDCS. CONCLUSION: The addition of anodal tDCS over the PFC to a session of aerobic exercise led to immediate positive effects on gait variability, processing speed, and executive control of walking in people with PD.

Motor Cortex Activation During Writing in Focal Upper-Limb Dystonia: An fNIRS Study.

Pra R, Balardin J, de Faria DD, Paulo AM, Sato JR, Baltazar CA, Borges V, Azevedo Silva SMC, Ferraz HB, de Carvalho Aguiar P.

Neurorehabil Neural Repair. May 28:
doi: 10.1177/Online ahead of print.

BACKGROUND: Functional imaging studies have associated dystonia with abnormal activation in motor and sensory brain regions. Commonly used techniques such as functional magnetic resonance imaging impose physical constraints, limiting the experimental paradigms. Functional near-infrared spectroscopy (fNIRS) offers a new noninvasive possibility for investigating cortical areas and the neural correlates of complex motor behaviors in unconstrained settings. METHODS: We compared the cortical brain activation of patients with focal upper-limb dystonia and controls during the writing task under naturalistic conditions using fNIRS. The primary motor cortex (M1), the primary somatosensory cortex (S1), and the supplementary motor area were chosen as regions of interest (ROIs) to assess differences in changes in both oxyhemoglobin (oxy-Hb) and deoxyhemoglobin (deoxy-Hb) between groups. RESULTS: Group average activation maps revealed an expected pattern of contralateral recruitment of motor and somatosensory cortices in the control group and a more bilateral pattern of activation in the dystonia group. Between-group comparisons focused on specific ROIs revealed an increased activation of the contralateral M1 and S1 cortices and also of the ipsilateral M1 cortex in patients. CONCLUSIONS: Overactivity of contralateral M1 and S1 in dystonia suggest a reduced specificity of the task-related cortical areas, whereas ipsilateral activation possibly indicates a primary disorder of the motor cortex or an endophenotypic pattern. To our knowledge, this is the first study using fNIRS to assess cortical activity in dystonia during the writing task under natural settings, outlining the potential of this technique for monitoring sensory and motor retraining in dystonia rehabilitation.

Looking Back at the Next 40 Years of ASD Neuroscience Research.

McPartland JC, Lerner MD, Bhat A, Clarkson T, Jack A, Koohsari S, Matuskey D, McQuaid GA, Su WC, Trevisan DA.

J Autism Dev Disord. May
doi: 10.1007/s10803-021-05095-Online ahead of print.

During the last 40years, neuroscience has become one of the most central and most productive approaches to investigating autism. In this commentary, we assemble a group of established investigators and trainees to review key advances and anticipated developments in neuroscience research across five modalities most commonly employed in autism research: magnetic resonance imaging, functional near infrared spectroscopy, positron emission tomography, electroencephalography, and transcranial magnetic stimulation. Broadly, neuroscience research has provided important insights into brain systems involved in autism but not yet mechanistic understanding. Methodological advancements are expected to proffer deeper understanding of neural circuitry associated with function and dysfunction during the next 40years.

Analysis methods for measuring passive auditory fNIRS responses generated by a block-design paradigm.

Luke R, Larson E, Shader MJ, Innes-Brown H, Van Yper L, Lee AKC, Sowman PF, McAlpine D.

Neurophotonics. Apr;8(2):
doi: 10.1117/1.NPh.8.2.Epub May 22.

Significance: Functional near-infrared spectroscopy (fNIRS) is an increasingly popular tool in auditory research, but the range of analysis procedures employed across studies may complicate the interpretation of data. Aim: We aim to assess the impact of different analysis procedures on the morphology, detection, and lateralization of auditory responses in fNIRS. Specifically, we determine whether averaging or generalized linear model (GLM)-based analysis generates different experimental conclusions when applied to a block-protocol design. The impact of parameter selection of GLMs on detecting auditory-evoked responses was also quantified. Approach: 17 listeners were exposed to three commonly employed auditory stimuli: noise, speech, and silence. A block design, comprising sounds of 5s duration and 10 to 20s silent intervals, was employed. Results: Both analysis procedures generated similar response morphologies and amplitude estimates, and both indicated that responses to speech were significantly greater than to noise or silence. Neither approach indicated a significant effect of brain hemisphere on responses to speech. Methods to correct for systemic hemodynamic responses using short channels improved detection at the individual level. Conclusions: Consistent with theoretical considerations, simulations, and other experimental domains, GLM and averaging analyses generate the same group-level experimental conclusions. We release this dataset publicly for use in future development and optimization of algorithms.

Multimodal measurement approach to identify individuals with mild cognitive impairment: study protocol for a cross-sectional trial.

Grssler B, Herold F, Dordevic M, Gujar TA, Darius S, Bckelmann I, Mller NG, Hkelmann A.

BMJ Open. May 25;11(5):e
doi: 10.1136/bmjopen-2020-046879.

INTRODUCTION: The diagnosis of mild cognitive impairment (MCI), that is, the transitory phase between normal age-related cognitive decline and dementia, remains a challenging task. It was observed that a multimodal approach (simultaneous analysis of several complementary modalities) can improve the classification accuracy. We will combine three noninvasive measurement modalities: functional near-infrared spectroscopy (fNIRS), electroencephalography and heart rate variability via ECG. Our aim is to explore neurophysiological correlates of cognitive performance and whether our multimodal approach can

aid in early identification of individuals with MCI. METHODS AND ANALYSIS: This study will be a cross-sectional with patients with MCI and healthy controls (HC). The neurophysiological signals will be measured during rest and while performing cognitive tasks: (1) Stroop, (2) N-back and (3) verbal fluency test (VFT). Main aims of statistical analysis are to (1) determine the differences in neurophysiological responses of HC and MCI, (2) investigate relationships between measures of cognitive performance and neurophysiological responses and (3) investigate whether the classification accuracy can be improved by using our multimodal approach. To meet these targets, statistical analysis will include machine learning approaches.This is, to the best of our knowledge, the first study that applies simultaneously these three modalities in MCI and HC. We hypothesise that the multimodal approach improves the classification accuracy between HC and MCI as compared with a unimodal approach. If our hypothesis is verified, this study paves the way for additional research on multimodal approaches for dementia research and fosters the exploration of new biomarkers for an early detection of nonphysiological age-related cognitive decline. ETHICS AND DISSEMINATION: Ethics approval was obtained from the local Ethics Committee (reference: 83/19). Data will be shared with the scientific community no more than 1 year following completion of study and data assembly. TRIAL REGISTRATION NUMBER: ClinicalTrials.gov, NCT04427436, registered on 10 June 2020, https://clinicaltrials.gov/ct2/show/study/NCT04427436.

Monitoring anesthesia using simultaneous functional Near Infrared Spectroscopy and Electroencephalography.

Vijayakrishnan Nair V, Kish BR, Yang HS, Yu Z, Guo H, Tong Y, Liang Z.

Clin Neurophysiol. Jul;132(7):1636-

doi: 10.1016/j.clinph.2021.03. Epub Apr 17.

OBJECTIVE: This study aims to understand the neural and hemodynamic responses during general anesthesia in order to develop a comprehensive multimodal anesthesia depth monitor using simultaneous functional Near Infrared Spectroscopy (fNIRS) and Electroencephalogram (EEG). METHODS: 37 adults and 17 children were monitored with simultaneous fNIRS and EEG, during the complete general anesthesia process. The coupling of fNIRS signals with neuronal signals (EEG) was calculated. Measures of complexity (sample entropy) and phase difference were also quantified from fNIRS signals to identify unique fNIRS based biomarkers of general anesthesia. RESULTS: A significant decrease in the complexity and power of fNIRS signals characterize the anesthesia maintenance phase. Furthermore, responses to anesthesia vary between adults and children in terms of neurovascular coupling and frontal EEG alpha power. CONCLUSIONS: This study shows that fNIRS signals could reliably quantify the underlying neuronal activity under general anesthesia and clearly distinguish the different phases throughout the procedure in adults and children (with less accuracy). SIGNIFICANCE: A multimodal approach incorporating the specific differences between age groups, provides a reliable measure of anesthesia depth.

Transcranial brain atlas for school-aged children and adolescents.

Zhang Z, Li Z, Xiao X, Zhao Y, Zuo XN, Zhu C.

Brain Stimul. May 23;14(4):895-

doi: 10.1016/j.brs.2021.05.Online ahead of print.

BACKGROUND: Both fNIRS optodes and TMS coils are placed on the scalp, while the targeted brain activities are inside the brain. An accurate cranio-cortical correspondence is crucial to the precise localization of the cortical area under imaging or stimulation (i.e. transcranial locating), as well as guiding the placement of optodes/coils (i.e. transcranial targeting). However, the existing normative cranio-cortical correspondence data used as transcranial references are predominantly derived from the adult population, and whether and how correspondence changes during childhood and adolescence is currently unclear. OBJECTIVE: This study aimed to build the age-specific cranio-cortical correspondences for

school-aged children and adolescents and investigate its differences to adults. METHODS: Age-specific transcranial brain atlases (TBAs) were built with age groups: 6-8, 8-10, 10-12, 12-14, 14-16, and 16-18 years. We compared the performance in both transcranial locating and targeting when using the age-appropriate TBA versus the adult TBA (derived from adult population) for children. RESULTS: These atlases provide age-specific probabilistic cranio-cortical correspondence at a high resolution (average scalp spacing of 2.8mm). Significant differences in cranio-cortical correspondence between children/adolescents and adults were found: the younger the child, the greater the differences. For children (aged 6-12 years), locating and targeting errors when using the adult TBA reached 10mm or more in the bilateral temporal lobe and frontal lobe. In contrast, the age-matched TBA reduced these errors to 4-5mm, an approximately 50% reduction in error. CONCLUSION: Our work provides an accurate and effective anatomical reference for studies in children and adolescents.

A New Statistical Approach for fNIRS Hyperscanning to Predict Brain Activity of Preschoolers' Using Teacher's.

Barreto C, Bruneri GA, Brockington G, Ayaz H, Sato JR.

Front Hum Neurosci. May 7;15:

doi: 10.3389/fnhum.2021. eCollection 2021.

Hyperscanning studies using functional Near-Infrared Spectroscopy (fNIRS) have been performed to understand the neural mechanisms underlying human-human interactions. In this study, we propose a novel methodological approach that is developed for fNIRS multi-brain analysis. Our method uses support vector regression (SVR) to predict one brain activity time series using another as the predictor. We applied the proposed methodology to explore the teacher-student interaction, which plays a critical role in the formal learning process. In an illustrative application, we collected fNIRS data of the teacher and preschoolers' dyads performing an interaction task. The teacher explained to the child how to add two numbers in the context of a game. The Prefrontal cortex and temporal-parietal junction of both teacher and student were recorded. A multivariate regression model was built for each channel in each dyad, with the student's signal as the response variable and the teacher's ones as the predictors. We compared the predictions of SVR with the conventional ordinary least square (OLS) predictor. The results predicted by the SVR model were statistically significantly correlated with the actual test data at least one channel-pair for all dyads. Overall, 29/90 channel-pairs across the five dyads (18 channels 5 dyads = 90 channel-pairs) presented significant signal predictions withthe SVR approach. The conventional OLS resulted in only 4 out of 90 valid predictions. These results demonstrated that the SVR could be used to perform channel-wise predictions across individuals, and the teachers' cortical activity can be used to predict the student brain hemodynamic response.

Acute VR competitive cycling exercise enhanced cortical activations and brain functional network efficiency in MA-dependent individuals.

Qi L, Yin Y, Bu L, Tang Z, Tang L, Dong G.

Neurosci Lett. Jul 13;757:

doi: 10.1016/j.neulet.2021.Epub May 21.

BACKGROUND: Methamphetamine (MA) dependence is associated with elevated rates cognitive impairment in MA users. The objective of the present study was to investigate the effects of virtual reality (VR) competitive cycling excise on the neurocognitive functions and on negative affectivity of MA-dependent individuals. METHODS: Thirty MA-dependent individuals performed a colour-word Stroop task and underwent a profile of mood states (POMS) scale assessment both before and after a 10 min VR competitive cycling exercise. Functional near-infrared spectroscopy (fNIRS) were recorded during the pre-and post-exercise Stroop tasks and during rest. RESULTS: After acute exercise, neural activity, along

with improved Stroop performance, was enhanced significantly in the dorsolateral prefrontal cortex. Also observed during post-exercise Stroop tasks was a more efficient network architecture in the topological organization of brain networks than during the pre-exercise Stroop tasks. As for resting states before versus after exercisethe, we detected an increased functional connectivity between the prefrontal cortex and the motor cortex after exercise. CONCLUSIONS: These results suggest that an acute bout of VR competitive cycling exercise facilitates executive information processing by enhancing task-related cortical activations and brain functional network efficiency in MA-dependent individuals.

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fNIRS & e-drum: An ecological approach to monitor hemodynamic and behavioural effects of rhythmic auditory cueing training.

Curzel F, Brigadoi S, Cutini S.

Brain Cogn. Jul;151:

doi: 10.1016/j.bandc.2021.Epub May 18.

Converging evidence suggests a beneficial effect of rhythmic music-therapy in easing motor dysfunctions. Nevertheless, the neural systems underpinning both the direct effect and the influence of rhythm on movement control and execution during training in ecological settings are still largely unknown. In this study, we propose an ecological approach to monitor brain activity and behavioural performance during rhythmic auditory cueing short-term training. Our approach envisages the combination of functional near-infrared spectroscopy (fNIRS), which is a non-invasive neuroimaging technique that allows unconstrained movements of participants, with electronic drum (e-drum), which is an instrument able to collect behavioural tapping data in real time. The behavioural and brain effects of this short-term training were investigated on a group of healthy participants, who well tolerated the experimental settings, since none of them withdrew from the study. The rhythmic auditory cueing short-term training improved beat regularity and decreased group variability. At the group level, the training resulted in a reduction of brain activity primarily in premotor areas. Furthermore, participants with the highest behavioural improvement during training showed the smallest reduction in brain activity. Overall, we conclude that our study could pave the way towards translating the proposed approach to clinical settings.

An effective classification framework for brain-computer interface system design based on combining of fNIRS and EEG signals.

Alhudhaif A.

PeerJ Comput Sci. May 6;7:e

doi: 10.7717/peerj-cs.eCollection 2021.

BACKGROUND: The brain-computer interface (BCI) is a relatively new but highly promising special field that is actively used in basic neuroscience. BCI includes interfaces for human-computer communication based directly on neural activity concerning mental processes. Fundamental BCI components consist of different units. In the first stage, the EEG and NIRS signals obtained from the individuals are preprocessed, and the signals are brought to a certain standard. METHODS: In order to realize proposed framework, a dataset containing Motor Imaginary and Mental Activity tasks are prepared with Electroencephalography (EEG) and Near-Infrared Spectroscopy (NIRS) signal. First of all, HbO and HbR curves are obtained from NIRS signals. Hbo, HbR, HbO+HbR, EEG, EEG+HbO and EEG+HbR features tables are created with the features obtained by using HbO, HbR, and EEG signals, and feature weighted is carried out with the k-Means clustering centers based attribute weighting method (KMCC-based) and the k-Means clustering centers difference based attribute weighting method (KMCCD-based). Linear Discriminant Analysis (LDA), Support Vector Machine (SVM), and k-Nearest Neighbors algorithm (kNN) classifiers are used to see the classifier differences in the study. RESULTS: As a result of this study, an accuracy rate of 99.7% (with kNN classifier and KMCCD-based weighting) is obtained in the data set of Motor Imaginary.

Similarly, an accuracy rate of 99.9% (with SVM and kNN classifier and KMCCD-based weighting) is obtained in the Mental Activity dataset. The weighting method is used to increase the classification accuracy, and it has been shown that it will contribute to the classification of EEG and NIRS BCI systems. The results show that the proposed method increases classifiers' performance, offering less processing power and ease of application. In the future, studies could be carried out by combining the k-Means clustering center-based weighted hybrid BCI method with deep learning architectures. Further improved classifier performances can be achieved by combining both systems.

Increased cognitive workload evokes greater neurovascular coupling responses in healthy young adults.

Csipo T, Lipecz A, Mukli P, Bahadli D, Abdulhussein O, Owens CD, Tarantini S, Hand RA, Yabluchanska V, Kellawan JM, Sorond F, James JA, Csiszar A, Ungvari ZI, Yabluchanskiy A.

PLoS One. May 19;16(5):e

doi: 10.1371/journal.pone. eCollection 2021.

Understanding how the brain allocates resources to match the demands of active neurons under physiological conditions is critically important. Increased metabolic demands of active brain regions are matched with hemodynamic responses known as neurovascular coupling (NVC). Several methods that allow non-invasive assessment of brain activity in humans detect NVC and early detection of NVC impairment may serve as an early marker of cognitive impairment. Therefore, non-invasive NVC assessments may serve as a valuable tool to detect early signs of cognitive impairment and dementia. Working memory tasks are routinely employed in the evaluation of cognitive task-evoked NVC responses. However, recent attempts that utilized functional near-infrared spectroscopy (fNIRS) or transcranial Doppler sonography (TCD) while using a similar working memory paradigm did not provide convincing evidence for the correlation of the hemodynamic variables measured by these two methods. In the current study, we aimed to compare fNIRS and TCD in their performance of differentiating NVC responses evoked by different levels of working memory workload during the same working memory task used as cognitive stimulation. Fourteen healthy young individuals were recruited for this study and performed an n-back cognitive test during TCD and fNIRS monitoring. During TCD monitoring, the middle cerebral artery (MCA) flow was bilaterally increased during the task associated with greater cognitive effort. fNIRS also detected significantly increased activation during a more challenging task in the left dorsolateral prefrontal cortex (DLPFC), and in addition, widespread activation of the medial prefrontal cortex (mPFC) was also revealed. Robust changes in prefrontal cortex hemodynamics may explain the profound change in MCA blood flow during the same cognitive task. Overall, our data support our hypothesis that both TCD and fNIRS methods can discriminate NVC evoked by higher demand tasks compared to baseline or lower demand tasks.

Shedding light on neuroscience: Two decades of functional near-infrared spectroscopy applications and advances from a bibliometric perspective.

Devezas MM.

J Neuroimaging. May

doi: 10.1111/jon.Online ahead of print.

Functional near-infrared spectroscopy (fNIRS) is a noninvasive optical brain-imaging technique that detects changes in hemoglobin concentration in the cerebral cortex. fNIRS devices are safe, silent, portable, robust against motion artifacts, and have good temporal resolution. fNIRS is reliable and trustworthy, as well as an alternative and a complement to other brain-imaging modalities, such as electroencephalography or functional magnetic resonance imaging. Given these advantages, fNIRS has become a well-established tool for neuroscience research, used not only for healthy cortical activity but also as a biomarker during clinical assessment in individuals with schizophrenia, major depressive disorder, bipolar disease, epilepsy,

Alzheimer's disease, vascular dementia, and cancer screening. Owing to its wide applicability, studies on fNIRS have increased exponentially over the last two decades. In this study, scientific publications indexed in the Web of Science databases were collected and a bibliometric-type methodology was developed. For this purpose, a comprehensive science mapping analysis, including top-ranked authors, journals, institutions, countries, and co-occurring keywords network, was conducted. From a total of 2310 eligible documents, 6028 authors and 531 journals published fNIRS-related papers, Fallgatter published the highest number of articles and was the most cited author. University of Tbingen in Germany has produced the most trending papers since 2000. USA was the most prolific country with the most active institutions, followed by China, Japan, Germany, and South Korea. The results also revealed global trends in emerging areas of research, such as neurodevelopment, aging, and cognitive and emotional assessment.

Photobiomodulation Enhances Memory Processing in Older Adults with Mild Cognitive Impairment: A Functional Near-Infrared Spectroscopy Study.

Chan AS, Lee TL, Hamblin MR, Cheung MC.

J Alzheimers Dis. May

doi: 10.3233/JAD-Online ahead of print.

BACKGROUND: Recent studies of photobiomodulation (PBM) in patients with cognitive or psychological disorders (including traumatic brain injury, stroke, and dementia) have yielded some encouraging results. OBJECTIVE: In this study, we aimed to investigate the effect of a single stimulation on memory in older adults with mild cognitive impairment (MCI). METHODS: After PBM, hemodynamic changes, as a measure of functional brain activity, were evaluated using functional near-infrared spectroscopy (fNIRS). Eighteen subjects who met the criteria of MCI were randomly assigned to control and experimental groups. A single real or sham PBM session was administered to the forehead of each patient in the experimental and control groups, respectively. All subjects performed a visual memory span test before and after the stimulation, and their hemodynamic responses during the tasks were measured using fNIRS. RESULTS: The results showed that among the MCI subjects, only those who received PBM, but not those who received the sham stimulation, demonstrated significant improvement in the visual memory performance and a reduction in the hemodynamic response during the tasks. CONCLUSION: These findings suggest that PBM may reduce the cognitive efforts needed to complete tasks that require high memory loads, and thus improve the cognitive performance of individuals with MCI.

Resting-state brain networks in neonatal hypoxic-ischemic brain damage: a functional near-infrared spectroscopy study.

Zhang S, Peng C, Yang Y, Wang D, Hou X, Li D.

Neurophotonics. Apr;8(2):

doi: 10.1117/1.NPh.8.2.Epub May 14.

Significance: There is an emerging need for convenient and continuous bedside monitoring of full-term newborns with hypoxic-ischemic brain damage (HIBD) to determine whether early intervention is required. Functional near-infrared spectroscopy (fNIRS)-based resting-state brain network analysis, which could provide an effective evaluation method, remains to be extensively studied. Aim: Our study aims to verify the feasibility of fNIRS-based resting-state brain networks for evaluating brain function in infants with HIBD to provide a new and effective means for clinical research in neonatal HIBD. Approach: Thirteen neonates with HIBD were scanned using fNIRS in the resting state. The brain network properties were explored to attempt to extract effective features as recognition indicators. Results: Compared with healthy controls, newborns with HIBD showed decreased brain functional connectivity. Specifically, there were severe losses of long-range functional connectivity of the contralateral parietal-temporal lobe, contralateral parietal-frontal lobe, and contralateral parietal lobe. The node degree showed a widespread decrease in

the left frontal middle gyrus, left superior frontal gyrus dorsal, and right central posterior gyrus. However, newborns with HIBD showed a significantly higher local network efficiency (* $p<0.05$). Subsequently, network indicators based on small-worldness, local efficiency, modularity, and normalized clustering coefficient were extracted for HIBD identification with the accuracy observed as 79.17%. Conclusions: Our findings indicate that fNIRS-based resting-state brain network analysis could support early HIBD diagnosis.

Review of Multi-Modal Imaging in Urea Cycle Disorders: The Old, the New, the Borrowed, and the Blue.

Sen K, Anderson AA, Whitehead MT, Gropman AL.

Front Neurol. Apr 28;12:
doi: 10.3389/fneur.2021.eCollection 2021.

The urea cycle disorders (UCD) are rare genetic disorder due to a deficiency of one of six enzymes or two transport proteins that act to remove waste nitrogen in form of ammonia from the body. In this review, we focus on neuroimaging studies in OTCD and Arginase deficiency, two of the UCD we have extensively studied. Ornithine transcarbamylase deficiency (OTCD) is the most common of these, and X-linked. Hyperammonemia (HA) in OTCD is due to deficient protein handling. Cognitive impairments and neurobehavioral disorders have emerged as the major sequelae in Arginase deficiency and OTCD, especially in relation to executive function and working memory, impacting pre-frontal cortex (PFC). Clinical management focuses on neuroprotection from HA, as well as neurotoxicity from other known and yet unclassified metabolites. Prevention and mitigation of neurological injury is a major challenge and research focus. Given the impact of HA on neurocognitive function of UCD, neuroimaging modalities, especially multi-modality imaging platforms, can bring a wealth of information to understand the neurocognitive function and biomarkers. Such information can further improve clinical decision making, and result in better therapeutic interventions. In vivo investigations of the affected brain using multimodal neuroimaging combined with clinical and behavioral phenotyping hold promise. MR Spectroscopy has already proven as a tool to study biochemical aberrations such as elevated glutamine surrounding HA as well as to diagnose partial UCD. Functional Near Infrared Spectroscopy (fNIRS), which assesses local changes in cerebral hemodynamic levels of cortical regions, is emerging as a non-invasive technique and will serve as a surrogate to fMRI with better portability. Here we review two decades of our research using non-invasive imaging and how it has contributed to an understanding of the cognitive effects of this group of genetic conditions.

Vector Phase Analysis Approach for Sleep Stage Classification: A Functional Near-Infrared Spectroscopy-Based Passive Brain-Computer Interface.

Arif S, Khan MJ, Naseer N, Hong KS, Sajid H, Ayaz Y.

Front Hum Neurosci. Apr 30;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

A passive brain-computer interface (BCI) based upon functional near-infrared spectroscopy (fNIRS) brain signals is used for earlier detection of human drowsiness during driving tasks. This BCI modality acquired hemodynamic signals of 13 healthy subjects from the right dorsolateral prefrontal cortex (DPFC) of the brain. Drowsiness activity is recorded using a continuous-wave fNIRS system and eight channels over the right DPFC. During the experiment, sleep-deprived subjects drove a vehicle in a driving simulator while their cerebral oxygen regulation (CORE) state was continuously measured. Vector phase analysis (VPA) was used as a classifier to detect drowsiness state along with sleep stage-based threshold criteria. Extensive training and testing with various feature sets and classifiers are done to justify the adaptation of threshold criteria for any subject without requiring recalibration. Three statistical features (mean oxyhemoglobin, signal peak, and the sum of peaks) along with six VPA features (trajectory slopes of VPA indices) were used. The average accuracies for the five classifiers are 90.9% for discriminant analysis, 92.5%

for support vector machines, 92.3% for nearest neighbors, 92.4% for both decision trees, and ensembles over all subjects' data. Trajectory slopes of CORE vector magnitude and angle: m(—R—) and m(?R) are the best-performing features, along with ensemble classifier with the highest accuracy of 95.3% and minimum computation time of 40 ms. The statistical significance of the results is validated with a p-value of less than 0.05. The proposed passive BCI scheme demonstrates a promising technique for online drowsiness detection using VPA along with sleep stage classification.

Decoding Multiple Sound-Categories in the Auditory Cortex by Neural Networks: An fNIRS Study.

Yoo SH, Santosa H, Kim CS, Hong KS.

Front Hum Neurosci. Apr 28;15:

doi: 10.3389/fnhum.2021. eCollection 2021.

This study aims to decode the hemodynamic responses (HRs) evoked by multiple sound-categories using functional near-infrared spectroscopy (fNIRS). The six different sounds were given as stimuli (English, non-English, annoying, nature, music, and gunshot). The oxy-hemoglobin (HbO) concentration changes are measured in both hemispheres of the auditory cortex while 18 healthy subjects listen to 10-s blocks of six sound-categories. Long short-term memory (LSTM) networks were used as a classifier. The classification accuracy was 20.38 4.63% with six class classification. Though LSTM networks' performance was a little higher than chance levels, it is noteworthy that we could classify the data subject-wise without feature selections.

Shedding light on pain for the clinic: a comprehensive review of using functional near-infrared spectroscopy to monitor its process in the brain.

Hu XS, Nascimento TD, DaSilva AF.

Pain. Apr

doi: 10.1097/j.pain.Online ahead of print.

Pain is a complex experience that involves sensation, emotion, and cognition. The subjectivity of the traditional pain measurement tools has expedited the interest in developing neuroimaging techniques to monitor pain objectively. Among noninvasive neuroimaging techniques, functional near-infrared spectroscopy (fNIRS) has balanced spatial and temporal resolution; yet, it is portable, quiet, and cost-effective. These features enable fNIRS to image the cortical mechanisms of pain in a clinical environment. In this article, we evaluated pain neuroimaging studies that used the fNIRS technique in the past decade. Starting from the experimental design, we reviewed the regions of interest, probe localization, data processing, and primary findings of these existing fNIRS studies. We also discussed the fNIRS imaging's potential as a brain surveillance technique for pain, in combination with artificial intelligence and extended reality techniques. We concluded that fNIRS is a brain imaging technique with great potential for objective pain assessment in the clinical environment.

Network reorganization during verbal fluency task in fronto-temporal epilepsy: A functional near-infrared spectroscopy study.

Tung H, Lin WH, Lan TH, Hsieh PF, Chiang MC, Lin YY, Peng SJ.

J Psychiatr Res. Jun;138:541-

doi: 10.1016/j.jpsychires.2021.05. Epub May 8.

This is the first study to use functional near-infrared spectroscopy (fNIRS) to investigate how the lateralization of the epileptogenic zone affects the reconfiguration of task-related network patterns. Eleven

left fronto-temporal epilepsy (L-FTE) and 11 right fronto-temporal epilepsy (R-FTE), as well as 22 age- and gender-matched controls, were enrolled. Signals from 52-channel fNIRS were recorded while the subject was undertaking verbal fluency tasks (VFTs), which included categorical (CFT) and letter (LFT) fluency tasks. Three analytic methods were used to study the network topology: network-based analysis, hub identification, and proportional threshold to select the top 20% strongest connections for both graph theory parameters and clinical correlation. Performance of CFT is accomplished primarily using the ventral pathway, and bilateral ventral pathways are augmented in fronto-temporal epilepsy patients by strengthening the inter-hemispheric connections, especially for R-FTE. LFT mainly employed the dorsal pathway, and further prioritized the left dorsal pathway in strengthening intra-hemispheric connections in fronto-temporal epilepsy, especially L-FTE. The top 20% of the strongest connections only present differences in CFT network compared with the controls. R-FTE increased inter-hemispheric network density, while L-FTE decreased inter-hemispheric average characteristic path length. Accumulative seizure burden only affects L-FTE network. Better LFT performance and longer educational years seem to promote left fronto-temporal networks, and decreased the demand from RR intra-hemispheric connectivity in L-FTE. LFT scores in R-FTE are maintained by preserved RR intra-hemispheric networks. However, CFT scores and educational years seem to have no effect on the CFT network topology in both FTE.

Foreign Language Learning as Cognitive Training to Prevent Old Age Disorders? Protocol of a Randomized Controlled Trial of Language Training vs. Musical Training and Social Interaction in Elderly With Subjective Cognitive Decline.

Nijmeijer SE, van Tol MJ, Aleman A, Keijzer M.

Front Aging Neurosci. Apr 27;13:
doi: 10.3389/fnagi.2021. eCollection 2021.

Introduction: With aging comes a reduction of cognitive flexibility, which has been related to the development of late-life depression and progression of general cognitive decline. Several factors have been linked to attenuating such decline in cognitive flexibility, such as education, physical exercise and stimulating leisure activities. Speaking two or more languages has recently received abundant attention as another factor that may build up cognitive reserve, thereby limiting the functional implications of compromised cognition that accompany old age. With the number of older adults reaching record levels, it is important to attenuate the development of old-age disorders. Learning to speak a foreign language might offer a powerful tool in promoting healthy aging, but up to date effect studies are sparse. Here, the protocol that forms the foundation of the current study is presented. The present study aims to: (1) examine the effects of a foreign language training on cognitive flexibility and its neural underpinnings, and on mental health; and (2) assess the unique role of foreign language training vs. other cognitive or social programs. Method: One-hundred and ninety-eight Dutch elderly participants reporting subjective cognitive decline are included and randomized to either a language intervention, a music intervention, or a social control intervention. During 3 to 6 months, the language group learns English, the music group learns to play the guitar and the social group participates in social meetings where art workshops are offered. At baseline, at a 3-month follow-up, and at 6 months after termination of the training program, clinical, cognitive and brain activity measurements (combined EEG and fNIRS methods) are taken to assess cognitive flexibility and mental health. Discussion: This is the first trial addressing combined effects of language learning in elderly on cognition, language proficiency, socio-affective measures, and brain activity in the context of a randomized controlled trial. If successful, this study can provide insights into how foreign language training can contribute to more cognitively and mentally healthy years in older adulthood. Clinical Trial Registration: The trial is registered at the Netherlands Trial Register, July 2, 2018, trial number NL7137. https://www.trialregister.nl/trial/7137.

Team-work, Team-brain: Exploring synchrony and team interdependence in a nine-person drumming task via multiparticipant hyperscanning and inter-brain network topology with fNIRS.

Liu T, Duan L, Dai R, Pelowski M, Zhu C.

Neuroimage. Aug 15;237:
doi: 10.1016/j.neuroimage.2021.Epub May 10.

Teamwork is indispensable in human societies. However, due to the complexity of studying ecologically valid synchronous team actions, requiring multiple members and a range of subjective and objective measures, the mechanism underlying the impact of synchrony on team performance is still unclear. In this paper, we simultaneously measured groups of nine-participants' (total N=180) fronto-temporal activations during a drum beating task using functional near infrared spectroscopy (fNIRS)-based hyperscanning and multi-brain network modeling, which can assess patterns of shared neural synchrony and attention/information sharing across entire teams. Participants (1) beat randomly without considering others' drumming (random condition), (2) actively coordinated their beats with the entire group without other external cue (team-focus condition), and (3) beat together based on a metronome (shared-focus condition). Behavioral data revealed higher subjective and objective measures of drum-beat synchronization in the team-focus condition, as well as higher felt interdependence. The fNIRS data revealed that participants in the team-focus condition also showed higher interpersonal neural synchronization (INS) and higher Global Network Efficiency in their left TPJ and mPFC. Higher left TPJ Global Network Efficiency also predicted higher actual synchrony in the team-focus condition, with an effect size roughly 1.5 times that of subjective measures, but not in the metronome-enabled shared-focus condition. This result suggests that shared mental representations with high efficiency of information exchange across the entire team may be a key component of synchrony, adding to the understanding of the actual relation to team work.

Hearing brain evaluated using near-infrared spectroscopy in congenital toxoplasmosis.

Bertachini ALL(#), Januario GC(#), Novi SL, Mesquita RC, Silva MAR, Andrade GMQ, de Resende LM, de Miranda DM.

Sci Rep. May 12;11(1):
doi: 10.1038/s41598-021-89481-0.

Congenital toxoplasmosis (CT) is a known cause of hearing loss directly caused by Toxoplasma gondii. Hearing loss might result from sensory, neural, or sensorineural lesions. Early treated infants rarely develop hearing loss, but retinochoroidal lesions, intracranial calcifications and hydrocephalus are common. In this study, we aimed to evaluate the brain evoked hemodynamic responses of CT and healthy infants during four auditory stimuli: mother infant directed speech, researcher infant directed speech, mother reading and researcher recorded. Children underwent Transitionally Evoked Otoacoustic Emission Auditory Testing and Automated Brainstem Auditory Response tests with normal auditory results, but with a tendency for greater latencies in the CT group compared to the control group. We assessed brain hemodynamics with functional near-infrared spectroscopy (fNIRS) measurements from 61 infants, and we present fNIRS results as frequency maps of activation and deactivation for each stimulus. By evaluating infants in the three first months of life, we observed an individual heterogeneous brain activation pattern in response to all auditory stimuli for both groups. Each channel was activated or deactivated in less than 30% of children for all stimuli. There is a need of prospective studies to evaluate if the neurologic or auditory changes course with compromise of children outcomes.

Speaker-Listener Neural Coupling Reveals an Adaptive Mechanism for Speech Comprehension in a Noisy Environment.

Li Z, Li J, Hong B, Nolte G, Engel AK, Zhang D.

Cereb Cortex. May 10:bhab
doi: 10.1093/cercor/bhabOnline ahead of print.

Comprehending speech in noise is an essential cognitive skill for verbal communication. However, it remains unclear how our brain adapts to the noisy environment to achieve comprehension. The present study investigated the neural mechanisms of speech comprehension in noise using an functional near-infrared spectroscopy-based inter-brain approach. A group of speakers was invited to tell real-life stories. The recorded speech audios were added with meaningless white noise at four signal-to-noise levels and then played to listeners. Results showed that speaker-listener neural couplings of listener's left inferior frontal gyri (IFG), that is, sensorimotor system, and right middle temporal gyri (MTG), angular gyri (AG), that is, auditory system, were significantly higher in listening conditions than in the baseline. More importantly, the correlation between neural coupling of listener's left IFG and the comprehension performance gradually became more positive with increasing noise level, indicating an adaptive role of sensorimotor system in noisy speech comprehension; however, the top behavioral correlations for the coupling of listener's right MTG and AG were only obtained in mild noise conditions, indicating a different and less robust mechanism. To sum up, speaker-listener coupling analysis provides added value and new sight to understand the neural mechanism of speech-in-noise comprehension.

A Methodological Review of fNIRS in Driving Research: Relevance to the Future of Autonomous Vehicles.

Balters S, Baker JM, Geeseman JW, Reiss AL.

Front Hum Neurosci. Apr 22;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

As automobile manufacturers have begun to design, engineer, and test autonomous driving systems of the future, brain imaging with functional near-infrared spectroscopy (fNIRS) can provide unique insights about cognitive processes associated with evolving levels of autonomy implemented in the automobile. Modern fNIRS devices provide a portable, relatively affordable, and robust form of functional neuroimaging that allows researchers to investigate brain function in real-world environments. The trend toward "naturalistic neuroscience" is evident in the growing number of studies that leverage the methodological flexibility of fNIRS, and in doing so, significantly expand the scope of cognitive function that is accessible to observation via functional brain imaging (i.e., from the simulator to on-road scenarios). While more than a decade's worth of study in this field of fNIRS driving research has led to many interesting findings, the number of studies applying fNIRS during autonomous modes of operation is limited. To support future research that directly addresses this lack in autonomous driving research with fNIRS, we argue that a cogent distillation of the methods used to date will help facilitate and streamline this research of tomorrow. To that end, here we provide a methodological review of the existing fNIRS driving research, with the overarching goal of highlighting the current diversity in methodological approaches. We argue that standardization of these approaches will facilitate greater overlap of methods by researchers from all disciplines, which will, in-turn, allow for meta-analysis of future results. We conclude by providing recommendations for advancing the use of such fNIRS technology in furthering understanding the adoption of safe autonomous vehicle technology.

Short-Term High-Intensity Interval Exercise Promotes Motor Cortex Plasticity and Executive Function in Sedentary Females.

Hu M, Zeng N, Gu Z, Zheng Y, Xu K, Xue L, Leng L, Lu X, Shen Y, Huang J.

Front Hum Neurosci. Apr 23;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Previous research has demonstrated that regular exercise modulates motor cortical plasticity and cog-

nitive function, but the influence of short-term high-intensity interval training (HIIT) remains unclear. In the present study, the effect of short-term HIIT on neuroplasticity and executive function was assessed in 32 sedentary females. Half of the participants undertook 2 weeks of HIIT. Paired-pulse transcranial magnetic stimulation (ppTMS) was used to measure motor cortical plasticity via short intracortical inhibition (SICI) and intracortical facilitation (ICF). We further adapted the Stroop task using functional near-infrared spectroscopy (fNIRS) to evaluate executive function in the participants. The results indicated that, compared with the control group, the HIIT group exhibited decreased ICF. In the Stroop task, the HIIT group displayed greater activation in the left dorsolateral prefrontal cortex (DLPFC) and left orbitofrontal cortex (OFC) even though no significant difference in task performance was observed. These findings indicate that short-term HIIT may modulate motor cortical plasticity and executive function at the neural level.

Neural synchrony predicts children's learning of novel words.

Piazza EA, Cohen A, Trach J, Lew-Williams C.

Cognition. May 6;214:
doi: 10.1016/j.cognition.2021.Online ahead of print.

Social interactions, such as joint book reading, have a well-studied influence on early development and language learning. Recent work has begun to investigate the neural mechanisms that underlie shared representations of input, documenting neural synchrony (measured using intersubject temporal correlations of neural activity) between individuals exposed to the same stimulus. Neural synchrony has been found to predict the quality of engagement with a stimulus and with communicative cues, but studies have yet to address how neural synchrony among children may relate to real-time learning. Using functional near-infrared spectroscopy (fNIRS), we recorded the neural activity of 45 children (3.5-4.5years) during joint book reading with an adult experimenter. The custom children's book contained four novel words and objects embedded in an unfolding story, as well as a range of narrative details about object functions and character roles. We observed synchronized neural activity between child participants during book reading and found a positive correlation between learning and intersubject neural synchronization in parietal cortex, an area implicated in narrative-level processing in adult research. Our findings suggest that signature patterns of neural engagement with the dynamics of stories facilitate children's learning.

Color-dependent changes in humans during a verbal fluency task under colored light exposure assessed by SPA-fNIRS.

Zohdi H, Egli R, Guthruf D, Scholkmann F, Wolf U.

Sci Rep. May 6;11(1):
doi: 10.1038/s41598-021-88059-0.

Light evokes robust visual and nonvisual physiological and psychological effects in humans, such as emotional and behavioral responses, as well as changes in cognitive brain activity and performance. The aim of this study was to investigate how colored light exposure (CLE) and a verbal fluency task (VFT) interact and affect cerebral hemodynamics, oxygenation, and systemic physiology as determined by systemic physiology augmented functional near-infrared spectroscopy (SPA-fNIRS). 32 healthy adults (17 female, 15 male, age: 25.5 4.3years) were exposed to blue and red light for 9min while performing a VFT. Before and after the CLE, subjects were in darkness. We found that this long-term CLE-VFT paradigm elicited distinct changes in the prefrontal cortex and in most systemic physiological parameters. The subjects' performance depended significantly on the type of VFT and the sex of the subject. Compared to red light, blue evoked stronger responses in cerebral hemodynamics and oxygenation in the visual cortex. Color-dependent changes were evident in the recovery phase of several systemic physiological parameters. This study showed that the CLE has effects that endure at least 15min after cessation of the CLE. This under-

lines the importance of considering the persistent influence of colored light on brain function, cognition, and systemic physiology in everyday life.

Combined real-time fMRI and real time fNIRS brain computer interface (BCI): Training of volitional wrist extension after stroke, a case series pilot study.

Matarasso AK, Rieke JD, White K, Yusufali MM, Daly JJ.

PLoS One. May 6;16(5):e
doi: 10.1371/journal.pone. eCollection 2021.

OBJECTIVE: Pilot testing of real time functional magnetic resonance imaging (rt-fMRI) and real time functional near infrared spectroscopy (rt-fNIRS) as brain computer interface (BCI) neural feedback systems combined with motor learning for motor recovery in chronic severely impaired stroke survivors. APPROACH: We enrolled a four-case series and administered three sequential rt-fMRI and ten rt-fNIRS neural feedback sessions interleaved with motor learning sessions. Measures were: Arm Motor Assessment Tool, functional domain (AMAT-F; 13 complex functional tasks), Fugl-Meyer arm coordination scale (FM); active wrist extension range of motion (ROM); volume of activation (fMRI); and fNIRS HbO concentration. Performance during neural feedback was assessed, in part, using percent successful brain modulations during rt-fNIRS. MAIN RESULTS: Pre-/post-treatment mean clinically significant improvement in AMAT-F (.49 0.22) and FM (10.0 3.3); active wrist ROM improvement ranged from 20 to 50. Baseline to follow-up change in brain signal was as follows: fMRI volume of activation was reduced in almost all ROIs for three subjects, and for one subject there was an increase or no change; fNIRS HbO was within normal range, except for one subject who increased beyond normal at post-treatment. During rt-fNIRS neural feedback training, there was successful brain signal modulation (42%-78%). SIGNIFICANCE: Severely impaired stroke survivors successfully engaged in spatially focused BCI systems, rt-fMRI and rt-fNIRS, to clinically significantly improve motor function. At the least, equivalency in motor recovery was demonstrated with prior long-duration motor learning studies (without neural feedback), indicating that no loss of motor improvement resulted from substituting neural feedback sessions for motor learning sessions. Given that the current neural feedback protocol did not prevent the motor improvements observed in other long duration studies, even in the presence of fewer sessions of motor learning in the current work, the results support further study of neural feedback and its potential for recovery of motor function in stroke survivors. In future work, expanding the sophistication of either or both rt-fMRI and rt-fNIRS could hold the potential for further reducing the number of hours of training needed and/or the degree of recovery. ClinicalTrials.gov ID: NCT02856035.

Quantitative evaluation of frequency domain measurements in high density diffuse optical tomography.

Perkins GA, Eggebrecht AT, Dehghani H.

J Biomed Opt. May;26(5):
doi: 10.1117/1.JBO.26.5.056001.

SIGNIFICANCE: High density diffuse optical tomography (HD-DOT) as applied in functional near-infrared spectroscopy (fNIRS) is largely limited to continuous wave (CW) data. Using a single modulation frequency, frequency domain (FD) HD-DOT has recently demonstrated better localization of focal activation as compared to CW data. We show that combining CW and FD measurements and multiple modulation frequencies increases imaging performance in fNIRS. AIM: We evaluate the benefits of multiple modulation frequencies, combining different frequencies as well as CW data in fNIRS HD-DOT. APPROACH: A layered model was used, with activation occurring within a cortex layer. CW and FD measurements were simulated at 78, 141, and 203MHz with and without noise. The localization error, full width half maximum, and effective resolution were evaluated. RESULTS: Across the average of the

three metrics, at 141MHz, FD performed 8.4% better than CW, and the combination of CW and FD was 21.7% better than CW. FD measurements at 203MHz performed 5% better than 78MHz. Moreover, the three combined modulation frequencies of FD and CW performed up to 3.92% better than 141MHz alone. CONCLUSIONS: We show that combining CW and FD measurements offers better performance than FD alone, with higher modulation frequencies increasing accuracy. Combining CW and FD measurements at multiple modulation frequencies yields the best overall performance.

Tablet Use Affects Preschoolers' Executive Function: fNIRS Evidence from the Dimensional Change Card Sort Task.

Li H, Wu D, Yang J, Luo J, Xie S, Chang C.

Brain Sci. Apr 29;11(5):

doi: 10.3390/brainsci11050567.

This study aims to examine the impact of heavy use of tablets on preschoolers' executive function during the Dimensional Change Card Sort (DCCS) task using the functional near-infrared spectroscopy (fNIRS). Altogether, 38 Chinese preschoolers (Mage = 5.0 years, SD = 0.69 years, 17 girls) completed the tasks before the COVID-19 lockdown. Eight children never used tablets, while 16 children were diagnosed as the 'heavy-user'. The results indicated that: (1) the 'non-user' outperformed the 'heavy-user' with a significantly higher correct rate in the DCCS task; (2) the two groups differed significantly in the activation of the prefrontal cortex (BA 9): the 'non-user' pattern is normal and healthy, whereas the 'heavy-user' pattern is not normal and needs further exploration.

The Neurophysiological Processing of Music in Children: A Systematic Review With Narrative Synthesis and Considerations for Clinical Practice in Music Therapy.

Bower J, Magee WL, Catroppa C, Baker FA.

Front Psychol. Apr 15;12:

doi: 10.3389/fpsyg.2021. eCollection 2021.

Introduction: Evidence supporting the use of music interventions to maximize arousal and awareness in adults presenting with a disorder of consciousness continues to grow. However, the brain of a child is not simply a small adult brain, and therefore adult theories are not directly translatable to the pediatric population. The present study aims to synthesize brain imaging data about the neural processing of music in children aged 0-18 years, to form a theoretical basis for music interventions with children presenting with a disorder of consciousness following acquired brain injury. Methods: We conducted a systematic review with narrative synthesis utilizing an adaptation of the methodology developed by Popay and colleagues. Following the development of the narrative that answered the central question "what does brain imaging data reveal about the receptive processing of music in children?", discussion was centered around the clinical implications of music therapy with children following acquired brain injury. Results: The narrative synthesis included 46 studies that utilized EEG, MEG, fMRI, and fNIRS scanning techniques in children aged 0-18 years. From birth, musical stimuli elicit distinct but immature electrical responses, with components of the auditory evoked response having longer latencies and variable amplitudes compared to their adult counterparts. Hemodynamic responses are observed throughout cortical and subcortical structures however cortical immaturity impacts musical processing and the localization of function in infants and young children. The processing of complex musical stimuli continues to mature into late adolescence. Conclusion: While the ability to process fundamental musical elements is present from birth, infants and children process music more slowly and utilize different cortical areas compared to adults. Brain injury in childhood occurs in a period of rapid development and the ability to process music following brain injury will likely depend on pre-morbid musical processing. Further, a significant brain injury may disrupt the developmental trajectory of complex music processing. However, complex music processing may emerge

earlier than comparative language processing, and occur throughout a more global circuitry.

Deep Neural Network to Differentiate Brain Activity Between Patients With First-Episode Schizophrenia and Healthy Individuals: A Multi-Channel Near Infrared Spectroscopy Study.

Chou PH, Yao YH, Zheng RX, Liou YL, Liu TT, Lane HY, Yang AC, Wang SC.

Front Psychiatry. Apr 15;12:
doi: 10.3389/fpsyt.2021. eCollection 2021.

Backgrounds: Reduced brain cortical activity over the frontotemporal regions measured by near infrared spectroscopy (NIRS) has been reported in patients with first-episode schizophrenia (FES). This study aimed to differentiate between patients with FES and healthy controls (HCs) on basis of the frontotemporal activity measured by NIRS with a support vector machine (SVM) and deep neural network (DNN) classifier. In addition, we compared the accuracy of performance of SVM and DNN. Methods: In total, 33 FES patients and 34 HCs were recruited. Their brain cortical activities were measured using NIRS while performing letter and category versions of verbal fluency tests (VFTs). The integral and centroid values of brain cortical activity in the bilateral frontotemporal regions during the VFTs were selected as features in SVM and DNN classifier. Results: Compared to HCs, FES patients displayed reduced brain cortical activity over the bilateral frontotemporal regions during both types of VFTs. Regarding the classifier performance, SVM reached an accuracy of 68.6%, sensitivity of 70.1%, and specificity of 64.6%, while DNN reached an accuracy of 79.7%, sensitivity of 88.8%, and specificity of 74.9% in the classification of FES patients and HCs. Conclusions: Compared to findings of previous structural neuroimaging studies, we found that using DNN to measure the NIRS signals during the VFTs to differentiate between FES patients and HCs could achieve a higher accuracy, indicating that NIRS can be used as a potential marker to classify FES patients from HCs. Future additional independent datasets are needed to confirm the validity of our model.

Depression Analysis and Recognition based on Functional Near-infrared Spectroscopy.

Wang R, Hao Y, Yu Q, Chen M, Humar I, Fortino G.

IEEE J Biomed Health Inform. Apr 30;PP.
doi: 10.1109/JBHI.2021. Online ahead of print.

DOI: 10.1109/JBHI.2021.3076762 PMID: 33929968

Neural Processing of Cognitive Control in an Emotionally Neutral Context in Anxiety Patients.

Knig N, Steber S, Borowski A, Bliem HR, Rossi S.

Brain Sci. Apr 26;11(5):
doi: 10.3390/brainsci11050543.

Impaired cognitive control plays a crucial role in anxiety disorders and is associated with deficient neural mechanisms in the fronto-parietal network. Usually, these deficits were found in tasks with an emotional context. The present study aimed at investigating electrophysiological and vascular signatures from event-related brain potentials (ERPs) and functional near-infrared spectroscopy (fNIRS) in anxiety patients versus healthy controls during an inhibition task integrated in an emotionally neutral context. Neural markers were acquired during the completion of a classical Eriksen flanker task. The focus of data analysis has been the ERPs N200 and P300 and fNIRS activations in addition to task performance. No behavioral or neural group differences were identified. ERP findings showed a larger N2pc and a delayed

and reduced P300 for incongruent stimuli. The N2pc modulation suggests the reorienting of attention to salient stimuli, while the P300 indicates longer lasting stimulus evaluation processes due to increased task difficulty. FNIRS did not result in any significant activation potentially suggesting a contribution from deeper brain areas not measurable with fNIRS. The missing group difference in our non-emotional task indicates that no generalized cognitive control deficit but rather a more emotionally driven deficit is present in anxiety patients.

Comparison of Activation in the Prefrontal Cortex of Native Speakers of Mandarin by Ability of Japanese as a Second Language Using a Novel Speaking Task.

Cong L, Miyaguchi H, Ishizuki C.

Healthcare (Basel). Apr 2;9(4):

doi: 10.3390/healthcare9040412.

Evidence shows that second language (L2) learning affects cognitive function. Here in this work, we compared brain activation in native speakers of Mandarin (L1) who speak Japanese (L2) between and within two groups (high and low L2 ability) to determine the effect of L2 ability in L1 and L2 speaking tasks, and to map brain regions involved in both tasks. The brain activation during task performance was determined using prefrontal cortex blood flow as a proxy, measured by functional near-infrared spectroscopy (fNIRS). People with low L2 ability showed much more brain activation when speaking L2 than when speaking L1. People with high L2 ability showed high-level brain activation when speaking either L2 or L1. Almost the same high-level brain activation was observed in both ability groups when speaking L2. The high level of activation in people with high L2 ability when speaking either L2 or L1 suggested strong inhibition of the non-spoken language. A wider area of brain activation in people with low compared with high L2 ability when speaking L2 is considered to be attributed to the cognitive load involved in code-switching L1 to L2 with strong inhibition of L1 and the cognitive load involved in using L2.

Effects of acute psychosocial stress on interpersonal cooperation and competition in young women.

Zhang R, Zhou X, Feng D, Yuan D, Li S, Lu C, Li X.

Brain Cogn. Jul;151:

doi: 10.1016/j.bandc.2021.Epub Apr 27.

Although tend-and-befriend is believed to be the dominant stress response in women, little is known regarding the effects of acute psychosocial stress on different dynamic social interactions. To measure these effects, 80 female participants were recruited, paired into the dyads, and instructed to complete cooperative and competitive key-pressing tasks after experiencing acute stress or a control condition. Each dyad of participants should press the key synchronously when the signal was presented in the cooperative task and as fast as possible in the competitive task. During the tasks, brain activities of prefrontal and right temporo-parietal areas were recorded from each dyad using functional near-infrared spectroscopy (fNIRS). The results showed that acute psychosocial stress evidently promoted competitive behavior, accompanied by increased interpersonal neural synchronization (INS) in the right dorsolateral prefrontal cortex. Despite the lack of a significant difference in the overall cooperation rate, the response time difference between two stressed participants markedly declined over time with more widespread INS in the prefrontal cortex, suggesting that there ensued cooperative improvement among stressed women. These findings behaviorally and neurologically revealed context-dependent response patterns to psychosocial stress in women during dynamic social interactions.

Longitudinal infant fNIRS channel-space analyses are robust to variability parameters at the group-level: An image reconstruction investigation.

Collins-Jones LH, Cooper RJ, Bulgarelli C, Blasi A, Katus L, McCann S, Mason L, Mbye E, Touray E, Ceesay M, Moore SE, Lloyd-Fox S, Elwell CE; BRIGHT Study Team.

Neuroimage. Aug 15;237:
doi: 10.1016/j.neuroimage.2021.Epub Apr 26.

The first 1000days from conception to two-years of age are a critical period in brain development, and there is an increasing drive for developing technologies to help advance our understanding of neurodevelopmental processes during this time. Functional near-infrared spectroscopy (fNIRS) has enabled longitudinal infant brain function to be studied in a multitude of settings. Conventional fNIRS analyses tend to occur in the channel-space, where data from equivalent channels across individuals are combined, which implicitly assumes that head size and source-detector positions (i.e. array position) on the scalp are constant across individuals. The validity of such assumptions in longitudinal infant fNIRS analyses, where head growth is most rapid, has not previously been investigated. We employed an image reconstruction approach to analyse fNIRS data collected from a longitudinal cohort of infants in The Gambia aged 5- to 12-months. This enabled us to investigate the effect of variability in both head size and array position on the anatomical and statistical inferences drawn from the data at both the group- and the individual-level. We also sought to investigate the impact of group size on inferences drawn from the data. We found that variability in array position was the driving factor between differing inferences drawn from the data at both the individual- and group-level, but its effect was weakened as group size increased towards the full cohort size (N=53 at 5-months, N=40 at 8-months and N=45 at 12-months). We conclude that, at the group sizes in our dataset, group-level channel-space analysis of longitudinal infant fNIRS data is robust to assumptions about head size and array position given the variability in these parameters in our dataset. These findings support a more widespread use of image reconstruction techniques in longitudinal infant fNIRS studies.

Effects of Transcranial Direct Current Stimulation (tDCS) on Cognitive Performance and Cerebral Oxygen Hemodynamics: A Systematic Review.

Figeys M, Zeeman M, Kim ES.

Front Hum Neurosci. Apr 7;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Background: There is increasing evidence to support the efficacy of transcranial direct current stimulation (tDCS) applications in cognitive augmentation and rehabilitation. Neuromodulation achieved with tDCS may further regulate regional cerebral perfusion affiliated through the neurovascular unit; however, components of cerebral perfusion decrease across aging. A novel neuroimaging approach, functional near-infrared spectroscopy (fNIRS), can aid in quantifying these regional perfusional changes. To date, the interaction of the effects of tDCS on cognitive performance across the lifespan and obtained fNIRS hemodynamic responses remain unknown. Objective: This review aims to examine the effects of tDCS on cognitive performance and fNIRS hemodynamic responses within the context of cognitive aging. Methods: Six databases were searched for studies. Quality appraisal and data extraction were conducted by two independent reviewers. Meta-analysis was carried out to determine overall and subgroup effect sizes. Results: Eight studies met inclusion criteria. The overall effect size demonstrates that tDCS can alter cognitive performance and fNIRS signals, with aging being a potential intermediary in tDCS efficacy. Conclusion: From the studies included, the effects of tDCS on cognitive performance and fNIRS metrics are most prominent in young healthy adults and appear to become less robust with increasing age. Given the small number of studies included in this review further investigation is recommended.

How Mother-Child Interactions are Associated with a Child's Compliance.

Zhao H, Cheng T, Zhai Y, Long Y, Wang Z, Lu C.

Cereb Cortex. Apr 24:bhab
doi: 10.1093/cercor/bhabOnline ahead of print.

While social interaction between a mother and her child has been found to play an important role in the child's committed compliance, the underlying neurocognitive process remains unclear. To investigate this process, we simultaneously recorded and assessed brain activity in 7-year-old children and in children's mothers or strangers during a free-play task using functional near-infrared spectroscopy-based hyperscanning. The results showed that a child's committed compliance was positively associated with the child's responsiveness but was negatively associated with mutual responsiveness and was not associated with the mother's responsiveness during mother-child interactions. Moreover, interpersonal neural synchronization (INS) at the temporoparietal junction mediated the relationship between the child's responsiveness and the child's committed compliance during mother-child interactions when the child's brain activity lagged behind that of the mother. However, these effects were not found during stranger-child interactions, nor were there significant effects in the mother-child pair when no real interactions occurred. Finally, we found a transfer effect of a child's committed compliance from mother-child interactions to stranger-child interactions via the mediation of mother-child INS, but the opposite did not occur. Together, these findings suggest that a child's responsiveness during mother-child interactions can significantly facilitate her or his committed compliance by increasing mother-child INS.

Low-Frequency Magnetic Stimulation of Shenmen Acupoint Reduces Blood Oxygen Levels in the Prefrontal Cortex of Healthy Subjects: A Near-Infrared Brain Functional Imaging Study.

Yuan J, Zheng Z, Cao Y, Chen J, Li YY, Lei YL.

Chin J Integr Med. Apr
doi: 10.1007/s11655-021-3291-z. Online ahead of print.

OBJECTIVE: To explore the effect of low-frequency magnetic stimulation at Shenmen (HT 7) acupoint on blood oxygen levels in the prefrontal cortex of healthy subjects. METHODS: Functional near-infrared spectroscopy (fNIRS) technology was used to collect real-time data of oxygenated hemoglobin (oxy-Hb) in the prefrontal cortex of 16 healthy subjects at resting state and low-frequency magnetic stimulation of Shenmen. The mean and integral values of blood oxygen concentration were analyzed. RESULTS: Compared with the resting state, the mean and integral values of blood oxygen concentration were decreased during the task period, recovery period, and the whole process in the magnetic stimulation of Shenmen acupoint ($P<0.05$). In particular, the difference was statistically significant in the recovery period ($P<0.01$). CONCLUSIONS: The prefrontal cortex was widely activated and produced an immediate effect by reducing the local blood oxygen concentration at low-frequency magnetic stimulation of Shenmen acupoint, which verifies the sedative effect of Shenmen acupoint.

Effect of Neurofeedback Facilitation on Poststroke Gait and Balance Recovery: A Randomized Controlled Trial.

Mihara M, Fujimoto H, Hattori N, Otomune H, Kajiyama Y, Konaka K, Watanabe Y, Hiramatsu Y, Sunada Y, Miyai I, Mochizuki H.

Neurology. May 25;96(21):e2587-e
doi: 10.1212/WNL. Epub Apr 20.

Comment in Neurology. 2021 May 25;96(21):975-976.

Cortical haemodynamic response during the verbal fluency task in patients with bipolar disorder and borderline personality disorder: a preliminary functional near-infrared spectroscopy study.

Husain SF, Tang TB, Tam WW, Tran BX, Ho CS, Ho RC.

BMC Psychiatry. Apr 20;21(1):
doi: 10.1186/s12888-021-03195-1.

BACKGROUND: Functional near-infrared spectroscopy (fNIRS) is an emerging neuroimaging modality that provides a direct and quantitative assessment of cortical haemodynamic response during a cognitive task. It may be used to identify neurophysiological differences between psychiatric disorders with overlapping symptoms, such as bipolar disorder (BD) and borderline personality disorder (BPD). Hence, this preliminary study aimed to compare the cerebral haemodynamic function of healthy controls (HC), patients with BD and patients with BPD. METHODS: Twenty-seven participants (9 HCs, 9 patients with BD and 9 patients with BPD) matched for age, gender, ethnicity and education were recruited. Relative oxy-haemoglobin and deoxy-haemoglobin changes in the frontotemporal cortex was monitored with a 52-channel fNIRS system during a verbal fluency task (VFT). VFT performance, clinical history and symptom severity were also noted. RESULTS: Compared to HCs, both patient groups had lower mean oxy-haemoglobin in the frontotemporal cortex during the VFT. Moreover, mean oxy-haemoglobin in the left inferior frontal region is markedly lower in patients with BPD compared to patients with BD. Task performance, clinical history and symptom severity were not associated with mean oxy-haemoglobin levels. CONCLUSIONS: Prefrontal cortex activity is disrupted in patients with BD and BPD, but it is more extensive in BPD. These results provide further neurophysiological evidence for the separation of BPD from the bipolar spectrum. fNIRS could be a potential tool for assessing the frontal lobe function of patients who present with symptoms that are common to BD and BPD.

Effects of acute exercise at different intensities on fine motor-cognitive dual-task performance while walking: A functional near-infrared spectroscopy study.

Park SY, Reinl M, Schott N.

Eur J Neurosci. Apr
doi: 10.1111/ejn.Online ahead of print.

Studies on the effects of acute exercises on cognitive functions vary greatly and depend on the duration and intensity of exercise and the type of cognitive tasks. This study aimed to investigate the neural correlates that underpin the acute effects of high-intensity interval (HIIE) versus moderate-intensity continuous exercise (MCE) on fine motor-cognitive performance while walking (dual-task, DT) in healthy young adults. Twenty-nine healthy right-handers (mean age: 25.1years4.04; 7 female) performed the digital trail-making-test (dTMT) while walking (5km/h) before and after acute exercise. During task performance, the hemodynamic activation of the frontopolar area (FPA), dorsolateral prefrontal (DLPFC), and motor cortex (M1) was recorded using functional near-infrared spectroscopy (fNIRS). Both HIIE and MCE resulted in improved dTMT performance, as reflected by an increase in the number of completed circles and a reduction in the time within and between circuits (reflecting improvements in working memory, inhibition, and decision making). Notably, HIIE evoked higher cortical activity on all brain areas measured in the present study than the MCE group. To our knowledge, these results provide the first empirical evidence using a mobile neuroimaging approach that both HIIE and MCE improve executive function during walking, likely mediated by increased activation of the task-related area of the prefrontal cortex and the ability to effectively use, among other things, high fitness levels as neural enrichment resources.

Dysfunction in interpersonal neural synchronization as a mechanism for social impairment in autism spectrum disorder.

Quiones-Camacho LE, Fishburn FA, Belardi K, Williams DL, Huppert TJ, Perlman SB.
Autism Res. Apr
doi: 10.1002/aur.Online ahead of print.

Social deficits in autism spectrum disorder (ASD) have been linked to atypical activation of the mentalizing network. This work, however, has been limited by a focus on the brain activity of a single person during computerized social tasks rather than exploring brain activity during in vivo interactions. The current study assessed neural synchronization during a conversation as a mechanism for social impairment in adults with ASD (n = 24) and matched controls (n = 26). Functional near-infrared spectroscopy (fNIRS) data were collected from the prefrontal cortex (PFC) and tempoparietal junction (TPJ). Participants self-reported on their social communication and videos of the interaction were coded for utterances and conversational turns. As expected, controls showed more neural synchrony than participants with ASD in the TPJ. Also as expected, controls showed less social communication impairment than participants with ASD. However, participants with ASD did not have fewer utterances compared with control subjects. Overall, less neural synchrony in the TPJ was associated with higher social impairment and marginally fewer utterances. Our findings advance our understanding of social difficulties in ASD by linking them to decreased neural synchronization of the TPJ. LAY SUMMARY: The coordination of brain responses is important for efficient social interactions. The current study explored the coordination of brain responses in neurotypical adults and adults with ASD to investigate if difficulties in social interactions are related to difficulties coordinating brain responses in ASD. We found that participants with ASD had more difficulties coordinating brain responses during a conversation with an interacting partner. Additionally, we found that the level of coordination in brain responses was linked to problems with social communication.

Effect of muscle fatigue on brain activity in healthy individuals.
Takahashi R, Fujita K, Kobayashi Y, Ogawa T, Teranishi M, Kawamura M.
Brain Res. Aug 1;1764:
doi: 10.1016/j.brainres.2021.Epub Apr 8.

Fatigue is affected by both peripheral and central factors. However, the interrelationship between muscle fatigue and brain activity has not yet been clarified. This study aimed to clarify the effect of muscle fatigue due to sustained pinch movement on brain activity in healthy individuals using functional near-infrared spectroscopy (fNIRS). Ten healthy adults participated in the study. Pinch movement of isometric contraction was the task to be performed, and electromyogram of the first dorsal interosseous muscle and brain activity by fNIRS were measured in this period. The median power frequency (MdPF) was calculated as an index of muscle fatigue and the oxygen-Hb value in the bilateral premotor and motor areas was calculated as an index of brain activity. As a result, MdPF showed a significant decrease in the middle and later phases compared with that in the early phase ($p<0.05$, $p<0.001$, respectively) and a significant decrease in the later phase compared with that in the middle phase ($p<0.05$). The oxygen-Hb values in the motor cortex were not significantly different between the analysis sections. The oxygen-Hb values in the premotor cortex was significantly increased in the later phase ($p<0.05$) compared with that in the early phase. The premotor cortex was found to be specifically activated during muscle fatigue.

Erratum to: Effects of prefrontal theta burst stimulation on neuronal activity and subsequent eating behavior: an interleaved rTMS and fNIRS study.
Fatakdawala I, Ayaz H, Safati AB, Sakib MN, Hall PA.
Soc Cogn Affect Neurosci. Apr 8:nsab
doi: 10.1093/scan/nsabOnline ahead of print.

DOI: 10.1093/scan/nsab040 PMID: 33831210

The duration of intrauterine development influences discrimination of speech prosody in infants.

Alexopoulos J, Giordano V, Janda C, Benavides-Varela S, Seidl R, Doering S, Berger A, Bartha-Doering L.

Dev Sci. Apr 4:e
doi: 10.1111/desc.Online ahead of print.

Auditory speech discrimination is essential for normal language development. Children born preterm are at greater risk of language developmental delays. Using functional near-infrared spectroscopy at term-equivalent age, the present study investigated early discrimination of speech prosody in 62 neonates born between week 23 and 41 of gestational age (GA). We found a significant positive correlation between GA at birth and neural discrimination of forward versus backward speech at term-equivalent age. Cluster analysis identified a critical threshold at around week 32 of GA, pointing out the existence of subgroups. Infants born before week 32 of GA exhibited a significantly different pattern of hemodynamic response to speech stimuli compared to infants born at or after week 32 of GA. Thus, children born before the GA of 32weeks are especially vulnerable to early speech discrimination deficits. To support their early language development, we therefore suggest a close follow-up and additional speech and language therapy especially in the group of children born before week 32 of GA.

Changes in prefrontal cortical activity and turning in response to dopaminergic and cholinergic therapy in Parkinson's disease: A randomized cross-over trial.

Vitorio R, Stuart S, Giritharan A, Quinn J, Nutt JG, Mancini M.

Parkinsonism Relat Disord. May;86:10-
doi: 10.1016/j.parkreldis.2021.03.Epub Mar 27.

INTRODUCTION: Cholinergic dysfunction contributes to mobility deficits in Parkinson's disease (PD). People with PD rely on limited prefrontal executive-attentional resources for the control of locomotion, including turning. Cortical and behavioral responses to cholinergic augmentation during turning remains unclear. We examined prefrontal cortex (PFC) activity while turning-in-place and spatiotemporal measures of turns in response to usual dopaminergic medication and adjunct cholinergic augmentation. METHODS: This study consisted of a single-site, randomized, double-blind crossover trial. Twenty PD participants were assessed in the levodopa-off state and then randomized to either levodopa+donepezil (5mg) or levodopa+placebo treatments for two weeks followed by a 2-week washout before crossover. The primary outcome was change from off state in PFC activity while turning-in-place (assessed with functional near-infrared spectroscopy). Secondary outcomes were changes in spatiotemporal turning measures (assessed with body-worn inertial measurement units) and accuracy in the secondary task. RESULTS: Nineteen participants completed the trial. While levodopa+placebo had no effect on PFC activity when turning-in-place with a dual-task, levodopa+donepezil led to a large reduction in PFC activity (effect size, -0.82). Spatiotemporal measures of turning improved with both treatments, with slightly greater effect sizes observed for levodopa+donepezil. Additionally, the accuracy in the concurrent cognitive task improved only with levodopa+donepezil (effect size, 0.63). CONCLUSION: The addition of cholinergic therapy with donepezil (5mg/day for 2 weeks) to standard dopaminergic therapy reduced the burden on prefrontal executive-attentional resources while turning with a dual-task and improved secondary task accuracy and turning.

Effects of passive and active training modes of upper-limb rehabilitation robot on cortical activation: a functional near-infrared spectroscopy study.

Zheng J, Shi P, Fan M, Liang S, Li S, Yu H.

Neuroreport. Apr 7;32(6):479-
doi: 10.1097/WNR.0000000000001615.

OBJECTIVE: The purpose of this study is to investigate the cortical activation during passive and active training modes under different speeds of upper extremity rehabilitation robots. METHODS: Twelve healthy subjects completed the active and passive training modes at various speeds (0.12, 0.18, and 0.24 m/s) for the right upper limb. The functional near-infrared spectroscopy (fNIRS) was used to measure the neural activities of the sensorimotor cortex (SMC), premotor cortex (PMC), supplementary motor area (SMA), and prefrontal cortex (PFC). RESULTS: Both the active and passive training modes can activate SMC, PMC, SMA, and PFC. The activation level of active training is higher than that of passive training. At the speed of 0.12 m/s, there is no significant difference in the intensity of the two modes. However, at the speed of 0.24 m/s, there are significant differences between the two modes in activation levels of each region of interest (ROI) ($P < 0.05$) (SMC: $F = 8.90$, $P = 0.003$; PMC: $F = 8.26$, $P = 0.005$; SMA: $F = 5.53$, $P = 0.023$; PFC: $F = 9.160$, $P = 0.003$). CONCLUSION: This study mainly studied on the neural mechanisms of active and passive training modes at different speeds based on the end-effector upper-limb rehabilitation robot. Slow, active training better facilitated the cortical activation associated with cognition and motor control.See Video Abstract, http://links.lww.com/WNR/A621.

Effect of force accuracy on hemodynamic response: an fNIRS study using fine visuomotor task.

Zheng Y, Tian B, Zhang Y, Wang D.

J Neural Eng. Apr 20;18(5).
doi: 10.1088/1741-2552/abf399.

Objective. Despite converging neuroimaging studies investigating how neural activity is modulated by various motor related factors, such as movement velocity and force magnitude, little has been devoted to identifying the effect of force accuracy. This study thus aimed to investigate the effect of task difficulty on cortical neural responses when participants performed a visuomotor task with varying demands on force accuracy.Approach. Fourteen healthy adults performed a set of force generation operations with six levels of force accuracy. The participants held a pen-shaped tool and moved the tool along a planar ring path, meanwhile producing a constant force against the plane under visual guidance. The required force accuracy was modulated by allowable tolerance of the force during the task execution. We employed functional near-infrared spectroscopy to record signals from bilateral prefrontal, sensorimotor and occipital areas, used the hemoglobin concentration as indicators of cortical activation, then calculated the effective connectivity across these regions by Granger causality.Main results.We observed overall stronger activation (oxy-hemoglobin concentration,$p= 0.015$) and connectivity ($p< 0.05$) associated with the initial increase in force accuracy, and the diminished trend in activation and connectivity when participants were exposed to excessive demands on accurate force generation. These findings suggested that the increasing task difficulty would be only beneficial for the mental investment up to a certain point, and above that point neural responses would show patterns of lower activation and connections, revealing mental overload at excessive task demands.Significance.Our results provide the first evidence for the inverted U-shaped effect of force accuracy on hemodynamic responses during fine visuomotor tasks. The insights obtained through this study also highlight the essential role of inter-region connectivity alterations for coping with task difficulty, enhance our understanding of the underlying motor neural processes, and provide the groundwork for developing adaptive neurorehabilitation strategies.

The impact of TMS-enhanced cognitive control on forgiveness processes.

Maier MJ, Rosenbaum D, Brne M, Fallgatter AJ, Ehlis AC.

Brain Behav. May;11(5):e

doi: 10.1002/brb3.Epub Mar 30.

BACKGROUND: Cognitive control is thought to be necessary for forgiveness processes. MATERIALS AND METHODS: To examine this correlation, highly impulsive participants, who often fail to inhibit feelings of revenge, received activating theta burst stimulation (TBS) of a classical cognitive control region of the brain, the right dorsolateral prefrontal cortex (rDLPFC). For testing forgiveness ability participants received verum TBS versus sham TBS in a randomized, double-blinded, within-subjects design. In both sessions, they first learned that there are fair and unfair opponents in an ultimatum game, and subsequently played a dictator game with reversed roles with the option to revenge or forgive the opponents from the previous game. RESULTS: Contrary to our hypothesis, activating TBS did not increase forgiving behavior toward unfair opponents. However, it increased the generosity toward previously fair opponents. CONCLUSION: As an explanation it is discussed that the TBS can only affect "cold" emotions such as greed, but not the "hot" emotions such as anger.

Decoding of semantic categories of imagined concepts of animals and tools in fNIRS.

Rybr M, Poli R, Daly I.

J Neural Eng. Apr 27;18(4).
doi: 10.1088/1741-2552/abf2e5.

Objective.Semantic decoding refers to the identification of semantic concepts from recordings of an individual's brain activity. It has been previously reported in functional magnetic resonance imaging and electroencephalography. We investigate whether semantic decoding is possible with functional near-infrared spectroscopy (fNIRS). Specifically, we attempt to differentiate between the semantic categories of animals and tools. We also identify suitable mental tasks for potential brain-computer interface (BCI) applications.Approach.We explore the feasibility of a silent naming task, for the first time in fNIRS, and propose three novel intuitive mental tasks based on imagining concepts using three sensory modalities: visual, auditory, and tactile. Participants are asked to visualize an object in their minds, imagine the sounds made by the object, and imagine the feeling of touching the object. A general linear model is used to extract hemodynamic responses that are then classified via logistic regression in a univariate and multivariate manner.Main results.We successfully classify all tasks with mean accuracies of 76.2% for the silent naming task, 80.9% for the visual imagery task, 72.8% for the auditory imagery task, and 70.4% for the tactile imagery task. Furthermore, we show that consistent neural representations of semantic categories exist by applying classifiers across tasks.Significance.These findings show that semantic decoding is possible in fNIRS. The study is the first step toward the use of semantic decoding for intuitive BCI applications for communication.

Applications of brain imaging methods in driving behaviour research.

Haghani M, Bliemer MCJ, Farooq B, Kim I, Li Z, Oh C, Shahhoseini Z, MacDougall H.

Accid Anal Prev. May;154:
doi: 10.1016/j.aap.2021.Epub Mar 23.

Applications of neuroimaging methods have substantially contributed to the scientific understanding of human factors during driving by providing a deeper insight into the neuro-cognitive aspects of driver brain. This has been achieved by conducting simulated (and occasionally, field) driving experiments while collecting driver brain signals of various types. Here, this sector of studies is comprehensively reviewed at both macro and micro scales. At the macro scale, bibliometric aspects of these studies are analysed. At the micro scale, different themes of neuroimaging driving behaviour research are identified and the findings within each theme are synthesised. The surveyed literature has reported on applications of four major brain imaging methods. These include Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), Functional Near-Infrared Spectroscopy (fNIRS) and Magnetoencephalography (MEG), with the

first two being the most common methods in this domain. While collecting driver fMRI signal has been particularly instrumental in studying neural correlates of intoxicated driving (e.g. alcohol or cannabis) or distracted driving, the EEG method has been predominantly utilised in relation to the efforts aiming at development of automatic fatigue/drowsiness detection systems, a topic to which the literature on neuroergonomics of driving particularly has shown a spike of interest within the last few years. The survey also reveals that topics such as driver brain activity in semi-automated settings or neural activity of drivers with brain injuries or chronic neurological conditions have by contrast been investigated to a very limited extent. Potential topics in driving behaviour research are identified that could benefit from the adoption of neuroimaging methods in future studies. In terms of practicality, while fMRI and MEG experiments have proven rather invasive and technologically challenging for adoption in driving behaviour research, EEG and fNIRS applications have been more diverse. They have even been tested beyond simulated driving settings, in field driving experiments. Advantages and limitations of each of these four neuroimaging methods in the context of driving behaviour experiments are outlined in the paper.

CNN-based classification of fNIRS signals in motor imagery BCI system.

Ma T, Wang S, Xia Y, Zhu X, Evans J, Sun Y, He S.

J Neural Eng. Apr 9;18(5).
doi: 10.1088/1741-2552/abf187.

Objective. Development of a brain-computer interface (BCI) requires classification of brain neural activities to different states. Functional near-infrared spectroscopy (fNIRS) can measure the brain activities and has great potential for BCI. In recent years, a large number of classification algorithms have been proposed, in which deep learning methods, especially convolutional neural network (CNN) methods are successful. fNIRS signal has typical time series properties, we combined fNIRS data and kinds of CNN-based time series classification (TSC) methods to classify BCI task.Approach. In this study, participants were recruited for a left and right hand motor imagery experiment and the cerebral neural activities were recorded by fNIRS equipment (FOIRE-3000). TSC methods are used to distinguish the brain activities when imagining the left or right hand. We have tested the overall person, single person and overall person with single-channel classification results, and these methods achieved excellent classification results. We also compared the CNN-based TSC methods with traditional classification methods such as support vector machine.Main results. Experiments showed that the CNN-based methods have significant advantages in classification accuracy: the CNN-based methods have achieved remarkable results in the classification of left-handed and right-handed imagination tasks, reaching 98.6% accuracy on overall person, 100% accuracy on single person, and in the single-channel classification an accuracy of 80.1% has been achieved with the best-performing channel.Significance. These results suggest that using the CNN-based TSC methods can significantly improve the BCI performance and also lay the foundation for the miniaturization and portability of training rehabilitation equipment.

Closed-loop neurostimulation for affective symptoms and disorders: An overview.

Guerrero Moreno J, Biazoli CE Jr, Baptista AF, Trambaiolli LR.

Biol Psychol. Apr;161:
doi: 10.1016/j.biopsycho.2021.Epub Mar 20.

Affective and anxiety disorders are the most prevalent and incident psychiatric disorders worldwide. Therapeutic approaches to these disorders using non-invasive brain stimulation (NIBS) and analogous techniques have been extensively investigated. In this paper, we discuss the combination of NIBS and neurofeedback in closed-loop setups and its application for affective symptoms and disorders. For this, we first provide a rationale for this combination by presenting some of the main original findings of NIBS, with a primary focus on transcranial magnetic stimulation (TMS), and neurofeedback, including protocols

based on electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). Then, we provide a scope review of studies combining real-time neurofeedback with NIBS protocols in the so-called closed-loop brain state-dependent neuromodulation (BSDS). Finally, we discuss the concomitant use of TMS and real-time functional near-infrared spectroscopy (fNIRS) as a possible solution to the current limitations of BSDS-based protocols for affective and anxiety disorders.

Cortical Activity Underlying Gait Improvements Achieved With Dopaminergic Medication During Usual Walking and Obstacle Avoidance in Parkinson Disease.

Orcioli-Silva D, Vitrio R, Nbrega-Sousa P, Beretta VS, Conceio NRD, Oliveira AS, Pereira MP, Gobbi LTB.

Neurorehabil Neural Repair. May;35(5):406-
doi: 10.1177/Epub Mar 23.

BACKGROUND: Dopaminergic medication improves gait in people with Parkinson disease (PD). However, it remains unclear if dopaminergic medication modulates cortical activity while walking. OBJECTIVE: We investigated the effects of dopaminergic medication on cortical activity during unobstructed walking and obstacle avoidance in people with PD. METHODS: A total of 23 individuals with PD, in both off (PDOFF) and on (PDON) medication states, and 30 healthy older adults (control group [CG]) performed unobstructed walking and obstacle avoidance conditions. Cortical activity was acquired through a combined functional near-infrared spectroscopy electroencephalography (EEG) system, along with gait parameters, through an electronic carpet. Prefrontal cortex (PFC) oxygenated hemoglobin (HbO2) and EEG absolute power from FCz, Cz, and CPz channels were calculated. RESULTS: HbO2 concentration reduced for people with PDOFF during obstacle avoidance compared with unobstructed walking. In contrast, both people with PDON and the CG had increased HbO2 concentration when avoiding obstacles compared with unobstructed walking. Dopaminergic medication increased step length, step velocity, and and ? power in the CPz channel, regardless of walking condition. Moreover, dopaminergic-related changes (ie, on-off) in FCz/CPz ? power were associated with dopaminergic-related changes in step length for both walking conditions. CONCLUSIONS: PD compromises the activation of the PFC during obstacle avoidance, and dopaminergic medication facilitates its recruitment. In addition, PD medication increases sensorimotor integration during walking by increasing posterior parietal cortex (CPz) activity. Increased ? power in the CPz and FCz channels is correlated with step length improvements achieved with dopaminergic medication during unobstructed walking and obstacle avoidance in PD.

Brain hemodynamic response in Examiner-Examinee dyads during spatial short-term memory task: an fNIRS study.

Panico F, De Marco S, Sagliano L, D'Olimpio F, Grossi D, Trojano L.

Exp Brain Res. May;239(5):1607-
doi: 10.1007/s00221-021-06073-Epub Mar 22.

The Corsi Block-Tapping test (CBT) is a measure of spatial working memory (WM) in clinical practice, requiring an examinee to reproduce sequences of cubes tapped by an examiner. CBT implies complementary behaviors in the examiners and the examinees, as they have to attend a precise turn taking. Previous studies demonstrated that the Prefrontal Cortex (PFC) is activated during CBT, but scarce evidence is available on the neural correlates of CBT in the real setting. We assessed PFC activity in dyads of examiner-examinee participants while completing the real version of CBT, during conditions of increasing and exceeding workload. This procedure allowed to investigate whether brain activity in the dyads is coordinated. Results in the examinees showed that PFC activity was higher when the workload approached or reached participants' spatial WM span, and lower during workload conditions that were largely below or above their span. Interestingly, findings in the examiners paralleled the ones in the examinees, as ex-

aminers' brain activity increased and decreased in a similar way as the examinees' one. In the examiners, higher left-hemisphere activity was observed suggesting the likely activation of non-spatial WM processes. Data support a bell-shaped relationship between cognitive load and brain activity, and provide original insights on the cognitive processes activated in the examiner during CBT.

Exploring the SenseMaking Process through Interactions and fNIRS in Immersive Visualization.

Galati A, Schoppa R, Lu A.

IEEE Trans Vis Comput Graph. May;27(5):2714-
doi: 10.1109/TVCG.2021.Epub Apr 15.
DOI: 10.1109/TVCG.2021.3067693 PMID: 33750695

The impact of acute exercise on implicit cognitive reappraisal in association with left dorsolateral prefronta activation: A fNIRS study.

Zhang Y, Shi W, Wang H, Liu M, Tang D.

Behav Brain Res. May 21;406:
doi: 10.1016/j.bbr.2021.Epub Mar 15.

Despite findings showing that acute exercise may help enhance emotion regulation, the neurophysiological mechanisms of these effects remain poorly understood. In this study, we examined whether acute exercise influences cognitive emotion regulation, and, in particular, an implicit cognitive reappraisal. Twenty sedentary young women were randomly assigned to either a control group (n = 10) or an exercise group (n = 10). Participants underwent an implicit cognitive reappraisal task twice, before and after the 30-min acute exercise or control, alongside functional near-infrared spectroscopy recordings (NIRS). The left dorsolateral prefrontal cortex (dlPFC) and left orbital frontal cortex (OFC) were activated during implicit cognitive reappraisal at baseline, but only the left dlPFC activation was linked with behavioral performance. Acute exercise enhanced the activation of these regions, reflective of the partial neural bases of implicit cognitive reappraisal, in the left dlPFC and left OFC, but did not alter the behavioral performance. Results also showed that acute exercise moderated the positive effect of left dlPFC activation on implicit cognitive reappraisal performance; specifically, this effect was stronger in the exercise group. In conclusion, the enhanced activation of the left dlPFC by acute exercise and the increased link between behavioral performance and its neural indices may point to acute exercise as a promoter of implicit cognitive reappraisal.

Comparing different pre-processing routines for infant fNIRS data.

Gemignani J, Gervain J.

Dev Cogn Neurosci. Apr;48:
doi: 10.1016/j.dcn.2021.Epub Mar 11.

Functional Near Infrared Spectroscopy (fNIRS) is an important neuroimaging technique in cognitive developmental neuroscience. Nevertheless, there is no general consensus yet about best pre-processing practices. This issue is highly relevant, especially since the development and variability of the infant hemodynamic response (HRF) is not fully known. Systematic comparisons between analysis methods are thus necessary. We investigated the performance of five different pipelines, selected on the basis of a systematic search of the infant NIRS literature, in two experiments. In Experiment 1, we used synthetic data to compare the recovered HRFs with the true HRF and to assess the robustness of each method against increasing levels of noise. In Experiment 2, we analyzed experimental data from a published study,

which assessed the neural correlates of artificial grammar processing in newborns. We found that with motion artifact correction (as opposed to rejection) a larger number of trials were retained, but HRF amplitude was often strongly reduced. By contrast, artifact rejection resulted in a high exclusion rate but preserved adequately the characteristics of the HRF. We also found that the performance of all pipelines declined as the noise increased, but significantly less so than if no pre-processing was applied. Finally, we found no difference between running the pre-processing on optical density or concentration change data. These results suggest that pre-processing should thus be optimized as a function of the specific quality issues a give dataset exhibits.

Towards Neuroscience of the Everyday World (NEW) using functional Near-Infrared Spectroscopy.

von Lhmann A, Zheng Y, Ortega-Martinez A, Kiran S, Somers DC, Cronin-Golomb A, Awad LN, Ellis TD, Boas DA, Ycel MA.

Curr Opin Biomed Eng. Jun;18:
doi: 10.1016/j.cobme.2021.Epub Feb 3.

Functional Near-Infrared Spectroscopy (fNIRS) assesses human brain activity by noninvasively measuring changes of cerebral hemoglobin concentrations caused by modulation of neuronal activity. Recent progress in signal processing and advances in system design, such as miniaturization, wearability and system sensitivity, have strengthened fNIRS as a viable and cost-effective complement to functional Magnetic Resonance Imaging (fMRI), expanding the repertoire of experimental studies that can be performed by the neuroscience community. The availability of fNIRS and Electroencephalography (EEG) for routine, increasingly unconstrained, and mobile brain imaging is leading towards a new domain that we term "Neuroscience of the Everyday World" (NEW). In this light, we review recent advances in hardware, study design and signal processing, and discuss challenges and future directions towards achieving NEW.

Negative mood is associated with decreased prefrontal cortex functioning during working memory in young adults.

Yeung MK, Lee TL, Chan AS.

Psychophysiology. Jun;58(6):e
doi: 10.1111/psyp.Epub Mar 4.

The prefrontal-subcortical model of emotion regulation postulates that decreased prefrontal cortex (PFC) functioning may underlie the emergence of clinical affective disorders. In addition, accumulated evidence suggests that there is considerable variability in negative affect in the nonclinical population. This study examined whether negative affective symptoms were associated with decreased PFC functioning in nonclinical young adults. Forty college students aged 18-24years (ten males) underwent an n-back paradigm (i.e., a frontal executive task) with a working memory (WM) load (i.e., 3-back) and a vigilance control condition (i.e., 0-back) while their hemodynamics changes in the lateral and medial PFC on both sides were monitored using a 16-channel functional near-infrared spectroscopy (fNIRS) system. They also filled out the Depression Anxiety Stress Scales (DASS) to estimate the levels of their negative emotions in the preceding week. Young adults exhibited an increased concentration of oxyhemoglobin and a decreased concentration of deoxyhemoglobin (i.e., activation), primarily in the lateral PFC, in response to the WM load (i.e., 3-back>0-back). Importantly, higher DASS scores indicating higher levels of recent negative mood, especially depression and stress rather than anxiety symptoms, correlated with lower WM-related activation in the lateral PFC. Thus, recent negative mood is associated with decreased lateral PFC functioning during the executive control of WM in healthy young adults. Our findings suggest that decreased PFC functioning is also present in the nonclinical population with increased levels of negative mood and that fNIRS is a promising tool for elucidating individual differences in negative affective symptoms.

Pain Induced Changes in Brain Oxyhemoglobin: A Systematic Review and Meta-Analysis of Functional NIRS Studies.

Hall M, Kidgell D, Perraton L, Morrissey J, Jaberzadeh S.

Pain Med. Jun 4;22(6):1399-
doi: 10.1093/pm/pnaa453.

BACKGROUND: Neuroimaging studies show that nociceptive stimuli elicit responses in an extensive cortical network. Functional near-infrared spectroscopy (fNIRS) allows for functional assessment of changes in oxyhemoglobin (HbO), an indirect index for cortical activity. Unlike functional magnetic resonance imaging (fMRI), fNIRS is portable, relatively inexpensive, and allows subjects greater function. No systematic review or meta-analysis has drawn together the data from existing literature of fNIRS studies on the effects of experimental pain on oxyhemoglobin changes in the superficial areas of the brain. OBJECTIVES: To investigate the effects of experimental pain on brain fNIRS measures in the prefrontal-cortex and the sensory-motor-area; to determine whether there is a difference in oxyhemodynamics between the prefrontal-cortex and sensory-motor-area during pain processing; to determine if there are differences in HbO between patients with centralized persistent pain and healthy controls. METHODS: Studies that used fNIRS to record changes in oxyhemodynamics in prefrontal-cortex or sensory-motor-cortex in noxious and innoxious conditions were included. In total, 13 studies were included in the meta-analysis. RESULTS: Pain has a significantly greater effect on pre-frontal-cortex and sensory-motor areas than nonpainful stimulation on oxyhemodynamics. The effect of pain on sensory-motor areas was greater than the effect of pain on the prefrontal-cortex. There was an effect of centralized pain in the CPP group on oxyhemodynamics from a noxious stimulus compared to control's response to pain. CONCLUSIONS: Pain affects the prefrontal and sensory-motor cortices of the brain and can be measured using fNIRS. Implications of this study may lead to a simple and readily accessible objective measure of pain.

Neural correlates of spontaneous deception in a non-competitive interpersonal scenario: A functional near-infrared spectroscopy (fNIRS) study.

Lin XA, Wang C, Zhou J, Sai L, Fu G.

Brain Cogn. Jun;150:
doi: 10.1016/j.bandc.2021.Epub Feb 25.

This study aims to examine neural correlates of spontaneous deception in a non-competitive interpersonal situation, and the difference in neural correlates between spontaneous deception and instructed deception using functional near-infrared spectroscopy (fNIRS). We used a modified poker game in which participants freely decided whether sending a piece of truthful/deceptive information to other participants. In the instructed session, participants sent truthful/deceptive information per the instructions. In this non-competitive interpersonal situation in the orbitofrontal cortex (OFC) and dorsolateral prefrontal cortex (DLPFC), deception produced higher neural activities than truth-telling. In addition, spontaneous deception exhibited higher neural activities than instructed deception in the frontopolar area, DLPFC, and frontal eye fields. Spontaneous truth-telling produced higher neural activities than instructed truth-telling in frontal eye fields and frontopolar area. This study provides evidence about neural correlates of spontaneous deception during non-competitive interpersonal scenarios and the difference between spontaneous deception and instructed deception.

Adversity is Linked with Decreased Parent-Child Behavioral and Neural Synchrony.

Hoyniak CP, Quiones-Camacho LE, Camacho MC, Chin JH, Williams EM, Wakschlag LS, Perlman SB.

Dev Cogn Neurosci. Apr;48:
doi: 10.1016/j.dcn.2021.Epub Feb 19.

Parent-child synchrony-parent-child interaction patterns characterized by contingent social responding, mutual responsivity, and co-regulation-has been robustly associated with adaptive child outcomes. Synchrony has been investigated in both behavioral and biological frameworks. While it has been demonstrated that adversity can influence behavioral parent-child synchrony, the neural mechanisms by which this disruption occurs are understudied. The current study examined the association between adversity, parent-child behavioral synchrony, and parent-child neural synchrony across lateral prefrontal cortical regions using functional near-infrared spectroscopy hyperscanning during a parent-child interaction task that included a mild stress induction followed by a recovery period. Participants included 115 children (ages 4-5) and their primary caregivers. Parent-child behavioral synchrony was quantified as the amount time the dyad was synchronous (e.g., reciprocal communication, coordinated behaviors) during the interaction task. Parent-child neural synchrony was examined as the hemodynamic concordance between parent and child lateral PFC activation. Adversity was examined across two, empirically-derived domains: sociodemographic risk (e.g., family income) and familial risk (e.g., household chaos). Adversity, across domains, was associated with decreased parent-child behavioral synchrony across task conditions. Sociodemographic risk was associated with decreased parent-child neural synchrony in the context of experimentally-induced stress. These findings link adversity to decreased parent-child behavioral and neural synchrony.

Multivariate analysis of the systemic response to auditory stimulation: An integrative approach.

Muoz-Caracuel M, Muoz V, Ruz-Martnez FJ, Di Domenico D, Brigadoi S, Gmez CM.

Exp Physiol. Apr;106(4):1072-
doi: 10.1113/EPEpub Mar 10.

NEW FINDINGS: What is the central question of this study? Auditory stimulation produces a response in different physiological systems: cardiac, peripheral blood flow, electrodermal, cortical and peripheral haemodynamic responses and auditory event-related potentials. Do all these subsystems covary when responding to auditory stimulation, suggesting a unified locus of control, or do they not covary, suggesting independent loci of control for these physiological responses? What is the main finding and its importance? Auditory sensory gating reached a fixed level of neural activity independently of the intensity of auditory stimulation. The use of multivariate techniques revealed the presence of different regulatory mechanisms for the different physiologically recorded signals. ABSTRACT: We studied the effects of an increasing amplitude of auditory stimulation on a variety of autonomic and CNS responses and their possible interdependence. The subjects were stimulated with an increasing amplitude of auditory tones while the auditory event-related potentials (ERPs), the cortical and extracerebral functional near-infrared spectroscopy (fNIRS) signal of standard and short separation channel recordings, the peripheral pulse measured by photoplethysmography, heart rate and electrodermal responses were recorded. Trials with eight tones of equal amplitude were presented. The results showed a parallel increase of activity in ERPs, fNIRS and peripheral responses with the increase in intensity of auditory stimulation. The ERPs, measured as peak-to-peak N1-P2, showed an increase in amplitude with auditory stimulation and a high attenuation from the first presentation with respect to the second to eighth presentations. Peripheral signals and standard and short channel fNIRS responses showed a decrease in amplitude in the high-intensity auditory stimulation conditions. Principal components analysis showed independent sources of variance for the recorded signals, suggesting independent control of the recorded physiological responses. The present results suggest a complex response associated to the increase of auditory stimulation with a fixed amplitude for ERPs, and a decrease in the peripheral and cortical haemodynamic response, possibly mediated by activation of the sympathetic nervous system, constituting a defensive reflex to excessive auditory stimulation.

Targeting brain regions of interest in functional near-infrared spectroscopy-Scalp-cortex

correlation using subject-specific light propagation models.
Cai L, Nitta T, Yokota S, Obata T, Okada E, Kawaguchi H.
Hum Brain Mapp. May;42(7):1969-
doi: 10.1002/hbm.Epub Feb 23.

Targeting specific brain regions of interest by the accurate positioning of optodes (emission and detection probes) on the scalp remains a challenge for functional near-infrared spectroscopy (fNIRS). Since fNIRS data does not provide any anatomical information on the brain cortex, establishing the scalp-cortex correlation (SCC) between emission-detection probe pairs on the scalp and the underlying brain regions in fNIRS measurements is extremely important. A conventional SCC is obtained by a geometrical point-to-point manner and ignores the effect of light scattering in the head tissue that occurs in actual fNIRS measurements. Here, we developed a sensitivity-based matching (SBM) method that incorporated the broad spatial sensitivity of the probe pair due to light scattering into the SCC for fNIRS. The SCC was analyzed between head surface fiducial points determined by the international 10-10 system and automated anatomical labeling brain regions for 45 subject-specific head models. The performance of the SBM method was compared with that of three conventional geometrical matching (GM) methods. We reveal that the light scattering and individual anatomical differences in the head affect the SCC, which indicates that the SBM method is compulsory to obtain the precise SCC. The SBM method enables us to evaluate the activity of cortical regions that are overlooked in the SCC obtained by conventional GM methods. Together, the SBM method could be a promising approach to guide fNIRS users in designing their probe arrangements and in explaining their measurement data.

Mind the food: behavioural characteristics and imaging signatures of the specific handling of food objects.
Max SM, Schroeder PA, Blechert J, Giel KE, Ehlis AC, Plewnia C.
Brain Struct Funct. May;226(4):1169-
doi: 10.1007/s00429-021-02232- Epub Feb 16.

In our world with nearly omnipresent availability of attractive and palatable high-calorie food, the struggle against overweight and obesity is a major individual and public health challenge. Preference for unhealthy food and eating-related habits have a strong influence on health, suggesting that high-calorie food triggers fast and near-automatic reaching and grasping movements. Therefore, it is important to better understand the specific neural mechanisms that control the handling of food involving a coordinated interplay between sensoric, motoric, and cognitive subsystems. To this end, 30 healthy participants(BMI: 22.86kg/m2; BMI range: 19-30kg/m2; 23 females) were instructed to collect one of two concurrently presented objects (food vs. office tools) by manual movement in virtual reality (VR) and on a touchscreen. Parallel to the task in VR, regional brain activity was measured by functional near-infrared spectroscopy (fNIRS). In the VR and on the touchscreen, stimulus recognition and selection were faster for food than for office tools. Yet, food was collected more slowly than office tools when measured in VR. On the background of increased brain activity in the right dorsolateral prefrontal cortex (dlPFC) during food trials, this suggests more behavioural control activity during handling foods. In sum, this study emphasizes the role of the right dlPFC in faster recognition and selection of food as part of a food-valuation network, more controlled handling of food in the VR which highlights the relevance of medium for modelling food-specific embodied cognitions.

Neural basis for egalitarian sharing in five-to six-year-old children.
Meng X, Moriguchi Y.
Neuropsychologia. Apr 16;154:
doi: 10.1016/j.neuropsychologia.2021.Epub Feb 9.

Preferring fair resource distribution reflects human cooperative nature, but its neural correlates in young children are not well known. We investigated the neural mechanism of egalitarian resource sharing in five-to six-year-old children to examine the possibility that early egalitarianism requires behavioral control to inhibit selfish impulses. In Study 1, children participated in a behavioral control task in which they either needed or did not need to inhibit their impulsive behavioral responses in order to quickly press a key. They subsequently allocated their resources to strangers by choosing a 2:2, 3:1, or 4:0 distribution. The activation of the dorsolateral prefrontal (dlpfc) regions was recorded by functional near-infrared spectroscopy measurements. We found that dlpfc regions were activated during cognitive tasks involving behavioral control and also during the equal, but not the more selfish, allocations. There was no difference among these allocations. The results did not show evidence of an ego depletion effect on children's sharing behavior, which predicts that children will share less after their behavioral control is taxed in a cognitive task (i.e., their self-control resource depleted). Study 2 showed no activation of the dlpfc regions during third-party equal allocations in which there was no conflict between fairness and self-interest in the distribution of resources. Overall, we showed that costly equal sharing in young children relates to the activation of dlpfc regions. These results suggest that costly equal allocation has a common neural basis with behavioral control in five-to six-year-old children, implying that early egalitarian sharing requires dealing with conflicts between maximizing self-interest and following moral norms.

The Time for Translation of Mobile Brain and Body Imaging to People With Stroke Is Now.

Greeley B, Hanada G, Boyd LA, Peters S.

Phys Ther. Jun 1;101(6):pzab
doi: 10.1093/ptj/pzab058.

DOI: 10.1093/ptj/pzab058 PMID: 33561281

Neurodevelopmental effects of childhood malnutrition: A neuroimaging perspective.

Galler JR, Bringas-Vega ML, Tang Q, Rabinowitz AG, Musa KI, Chai WJ, Omar H, Abdul Rahman MR, Abd Hamid AI, Abdullah JM, Valds-Sosa PA.

Neuroimage. May 1;231:
doi: 10.1016/j.neuroimage.2021.Epub Feb 5.

Approximately one in five children worldwide suffers from childhood malnutrition and its complications, including increased susceptibility to inflammation and infectious diseases. Due to improved early interventions, most of these children now survive early malnutrition, even in low-resource settings (LRS). However, many continue to exhibit neurodevelopmental deficits, including low IQ, poor school performance, and behavioral problems over their lifetimes. Most studies have relied on neuropsychological tests, school performance, and mental health and behavioral measures. Few studies, in contrast, have assessed brain structure and function, and to date, these have mainly relied on low-cost techniques, including electroencephalography (EEG) and evoked potentials (ERP). The use of more advanced methods of neuroimaging, including magnetic resonance imaging (MRI) and functional near-infrared spectroscopy (fNIRS), has been limited by cost factors and lack of availability of these technologies in developing countries, where malnutrition is nearly ubiquitous. This report summarizes the current state of knowledge and evidence gaps regarding childhood malnutrition and the study of its impact on neurodevelopment. It may help to inform the development of new strategies to improve the identification, classification, and treatment of neurodevelopmental disabilities in underserved populations at the highest risk for childhood malnutrition.

The only-child effect in the neural and behavioral signatures of trust revealed by fNIRS hyperscanning.

Wu S, Cai S, Xiong G, Dong Z, Guo H, Han J, Ye T.

Brain Cogn. Apr;149:
doi: 10.1016/j.bandc.2021.Epub Feb 1.

In daily life, trust is important in interpersonal interactions. However, little is known about interpersonal brain synchronization with respect to trust; in particular, the differences between individuals with and without siblings are not clear. Therefore, this study applied functional near-infrared spectroscopy hyperscanning in a sequential reciprocal-trust task. We divided pairs of participants (strangers) into two groups according to their only-child status. The two strangers interacted with one another in an online trust game while their brain activities in the medial prefrontal cortex (mPFC) and the right temporoparietal junction (rTPJ) were measured. The behavioral results revealed that compared with the non-only-child group, the only-child group exhibited lower repayment, less reciprocation, and less cooperative decisions during the process. In addition, the brain imaging results showed that the interpersonal synchronization of the mPFC in the only-child group was significantly weaker than that in the non-only-child group. Our findings demonstrate neurobehavioral support for the only-child effect in terms of the trust by revealing that an only child shows less trust than does a non-only-child, resulting in lower inter-brain coherence.

Measures of prefrontal functional near-infrared spectroscopy in visuomotor learning.

Tinga AM, Clim MA, de Back TT, Louwerse MM.

Exp Brain Res. Apr;239(4):1061-
doi: 10.1007/s00221-021-06039-Epub Feb 2.

Functional near-infrared spectroscopy (fNIRS) is a promising technique for non-invasively assessing cortical brain activity during learning. This technique is safe, portable, and, compared to other imaging techniques, relatively robust to head motion, ocular and muscular artifacts and environmental noise. Moreover, the spatial resolution of fNIRS is superior to electroencephalography (EEG), a more commonly applied technique for measuring brain activity non-invasively during learning. Outcomes from fNIRS measures during learning might therefore be both sensitive to learning and to feedback on learning, in a different way than EEG. However, few studies have examined fNIRS outcomes in learning and no study to date additionally examined the effects of feedback. To address this apparent gap in the literature, the current study examined prefrontal cortex activity measured through fNIRS during visuomotor learning and how this measure is affected by task feedback. Activity in the prefrontal cortex decreased over the course of learning while being unaffected by task feedback. The findings demonstrate that fNIRS in the prefrontal cortex is valuable for assessing visuomotor learning and that this measure is robust to task feedback. The current study highlights the potential of fNIRS in assessing learning even under different task feedback conditions.

Load-dependent relationships between frontal fNIRS activity and performance: A data-driven PLS approach.

Meidenbauer KL, Choe KW, Cardenas-Iniguez C, Huppert TJ, Berman MG.

Neuroimage. Apr 15;230:
doi: 10.1016/j.neuroimage.2021.Epub Jan 24.

Neuroimaging research frequently demonstrates load-dependent activation in prefrontal and parietal cortex during working memory tasks such as the N-back. Most of this work has been conducted in fMRI, but functional near-infrared spectroscopy (fNIRS) is gaining traction as a less invasive and more flexible alternative to measuring cortical hemodynamics. Few fNIRS studies, however, have examined how working memory load-dependent changes in brain hemodynamics relate to performance. The current

study employs a newly developed and robust statistical analysis of task-based fNIRS data in a large sample, and demonstrates the utility of data-driven, multivariate analyses to link brain activation and behavior in this modality. Seventy participants completed a standard N-back task with three N-back levels (N=1, 2, 3) while fNIRS data were collected from frontal and parietal cortex. Overall, participants showed reliably greater fronto-parietal activation for the 2-back versus the 1-back task, suggesting fronto-parietal fNIRS measurements are sensitive to differences in cognitive load. The results for 3-back were much less consistent, potentially due to poor behavioral performance in the 3-back task. To address this, a multivariate analysis (behavioral partial least squares, PLS) was conducted to examine the interaction between fNIRS activation and performance at each N-back level. Results of the PLS analysis demonstrated differences in the relationship between accuracy and change in the deoxyhemoglobin fNIRS signal as a function of N-back level in eight mid-frontal channels. Specifically, greater reductions in deoxyhemoglobin (i.e., more activation) were positively related to performance on the 3-back task, unrelated to accuracy in the 2-back task, and negatively associated with accuracy in the 1-back task. This pattern of results suggests that the metabolic demands correlated with neural activity required for high levels of accuracy vary as a consequence of task difficulty/cognitive load, whereby more automaticity during the 1-back task (less mid-frontal activity) predicted superior performance on this relatively easy task, and successful engagement of this mid-frontal region was required for high accuracy on a more difficult and cognitively demanding 3-back task. In summary, we show that fNIRS activity can track working memory load and can uncover significant associations between brain activity and performance, thus opening the door for this modality to be used in more wide-spread applications.

Recent findings on neurofeedback training for auditory hallucinations in schizophrenia.
Hirano Y, Tamura S.
Curr Opin Psychiatry. May 1;34(3):245-
doi: 10.1097/YCO.0000000000000693.

PURPOSE OF REVIEW: To provide recent evidence on real-time neurofeedback (NFB) training for auditory verbal hallucinations (AVH) in schizophrenia patients. RECENT FINDINGS: NFB is a promising technique that allows patients to gain control over their AVH by modulating their own speech-related/language-related networks including superior temporal gyrus (STG) and anterior cingulate cortex (ACC) using fMRI, fNIRS and EEG/MEG. A recent limited number of studies showed that while an EEG-based NFB study failed to regulate auditory-evoked potentials and reduce AVH, downregulation of STG hyperactivity and upregulation of ACC activity with fMRI-based NFB appear to alleviate treatment-resistant AVH in schizophrenia patients. A deeper understanding of AVH and development of more effective methodologies are still needed. SUMMARY: Despite recent innovations in antipsychotics, many schizophrenia patients continue to suffer from treatment-resistant AVH and social dysfunctions. Recent studies suggested that real-time NFB shows promise in enabling patients to gain control over AVH by regulating their own speech-related/language-related networks. Although fMRI-NFB is suitable for regulating localized activity, EEG/MEG-NFB are ideal for regulating the ever-changing AVH. Although there are still many challenges including logistic complexity and burden on patients, we hope that such innovative real-time NFB trainings will help patients to alleviate severe symptoms and improve social functioning.

Validating the use of functional Near-Infrared Spectroscopy in monkeys: The case of brain activation lateralization in Papio anubis.
Debracque C, Gruber T, Lacoste R, Grandjean D, Meguerditchian A.
Behav Brain Res. Apr 9;403:
doi: 10.1016/j.bbr.2021.Epub Jan 19.

Hemispheric asymmetries have long been seen as characterizing the human brain; yet, an increasing

number of reports suggest the presence of such brain asymmetries in our closest primate relatives. However, most available data in non-human primates have so far been acquired as part of neurostructural approaches such as MRI, while comparative data in humans are often dynamically acquired as part of neurofunctional studies. In the present exploratory study in baboons (Papio anubis), we tested whether brain lateralization could be recorded non-invasively using a functional Near-Infrared Spectroscopy (fNIRS) device in two contexts: motor and auditory passive stimulations. Under light propofol anaesthesia monitoring, three adult female baboons were exposed to a series of (1) left- versus right-arm passive movement stimulations; and (2) left- versus right-ear versus stereo auditory stimulations while recording fNIRS signals in the related brain areas (i.e., motor central sulcus and superior temporal cortices respectively). For the sensorimotor condition our results show that left-arm versus right-arm stimulations induced typical contralateral difference in hemispheric activation asymmetries in the three subjects. For the auditory condition, we also revealed typical human-like patterns of hemispheric asymmetries in one subject, namely a leftward lateralization for right ear stimulations for all three channels. Overall, our findings support the use of fNIRS to investigate brain processing in non-human primates from a functional perspective, opening the way for the development of non-invasive procedures in non-human primate brain research.

Effects of Motor Tempo on Frontal Brain Activity: An fNIRS Study.

Gurin SMR, Vincent MA, Karageorghis CI, Delevoye-Turrell YN.

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doi: 10.1016/j.neuroimage.2020.Epub Jan 6.

People are able to modify the spontaneous pace of their actions to interact with their environment and others. This ability is underpinned by high-level cognitive functions but little is known in regard to the brain areas that underlie such temporal control. A salient practical issue is that current neuroimaging techniques (e.g., EEG, fMRI) are extremely sensitive to movement, which renders challenging any investigation of brain activity in the realm of whole-body motor paradigms. Within the last decade, the noninvasive imaging method of functional near-infrared spectroscopy (fNIRS) has become the reference tool for experimental motor paradigms due to its tolerance to motion artefacts. In the present study, we used a continuous-wave fNIRS system to record the prefrontal and motor hemodynamic responses of 16 participants, while they performed a spatial-tapping task varying in motor complexity and externally-paced tempi (i.e., 300 ms, 500 ms, 1200 ms). To discriminate between physiological noise and cerebral meaningful signals, the physiological data (i.e., heart and respiratory rates) were recorded so that frequency bands of such signals could be regressed from the fNIRS data. Particular attention was taken to control the precise position of the optodes in reference to the cranio-cerebral correlates of the NIR channels throughout the experimental session. Results indicated that fast pacing relied on greater activity of the motor areas whereas moving at close-to-spontaneous pace placed a heavier load on posterior prefrontal processes. These results provide new insight concerning the role of frontal cognitive control in modulating the pacing of voluntary motor behaviors.

Detection of functional connectivity in the brain during visuo-guided grip force tracking tasks: A functional near-infrared spectroscopy study.

Zheng X, Luo J, Deng L, Li B, Li L, Huang DF, Song R.

J Neurosci Res. Apr;99(4):1108-

doi: 10.1002/jnr.Epub Dec 23.

The functional connectivity (FC) between multiple brain regions during tasks is currently gradually being explored with functional near-infrared spectroscopy (fNIRS). However, the FC present during grip force tracking tasks performed under visual feedback remains unclear. In the present study, we used fNIRS to measure brain activity during resting states and grip force tracking tasks at 25%, 50%, and

75% of maximum voluntary contraction (MVC) in 11 healthy subjects, and the activity was measured from four target brain regions: the left prefrontal cortex (lPFC), right prefrontal cortex (rPFC), left sensorimotor cortex (lSMC), and right sensorimotor cortex (rSMC). We determined the FC between these regions utilizing three different methods: Pearson's correlation method, partial correlation method, and a pairwise maximum entropy model (MEM). The results showed that the FC of lSMC-rSMC and lPFC-rPFC (interhemispheric homologous pairs) were significantly stronger than those of other brain region pairs. Moreover, FC of lPFC-rPFC was strengthened during the 75% MVC task compared to the other task states and the resting states. The FC of lSMC-lPFC and rSMC-rPFC (intrahemispheric region pairs) strengthened with a higher task load. The results provided new insights into the FC between brain regions during visuo-guided grip force tracking tasks.

One-Dimensional Statistical Parametric Mapping Identifies Impaired Orthostatic Cerebrovascular and Cardiovascular Response in Frailty Index.

Maguire F, Romero-Ortuno R, O'Connor JD, Reilly RB, Knight SP, Kenny RA.

J Gerontol A Biol Sci Med Sci. Apr 30;76(5):885-

doi: 10.1093/gerona/glaa315.

BACKGROUND: Orthostasis is a potent physiological stressor which adapts with age. The age-related accumulation of health deficits in multiple physiological systems may impair the physiological response to orthostasis and lead to negative health outcomes such as falls, depression, and cognitive decline. Research to date has focused on changes with orthostasis at prespecified intervals of time, without consideration for whole signal approaches. METHODS: One-dimensional statistical parametric mapping identified regions in time of significant association between variables of interest using a general linear model. Frailty index operationalized accumulated health and social deficits using 32-items from a computer-assisted interview. This study examined the association of frailty index on blood pressure, heart rate, and cerebral oxygenation during an orthostatic test in a sample of 2742 adults aged 50 or older from The Irish Longitudinal Study on Ageing. RESULTS: Frailty index was seen to be negatively associated with cerebral oxygenation changes from baseline over a period of 7 seconds ($p = .036$). Heart rate and systolic blood pressure were positively and negatively associated with frailty index over periods of 17 seconds ($p = .001$) and 10 seconds ($p = .015$), respectively. CONCLUSIONS: Statistical parametric mapping demonstrated these significant regions of cerebral oxygenation during orthostasis provide indirect evidence of impaired autoregulation associated with frailty. Statistical parametric mapping also replicated prior relationships in heart rate and systolic blood pressure associated with a higher frailty index. These findings highlight the utility of 1-dimensional statistical parametric modeling in identifying significant regions of interest in physiological recordings.

Transcranial brain atlas-based optimization for functional near-infrared spectroscopy optode arrangement: Theory, algorithm, and application.

Zhao Y, Xiao X, Jiang YH, Sun PP, Zhang Z, Gong YL, Li Z, Zhu CZ.

Hum Brain Mapp. Apr 15;42(6):1657-

doi: 10.1002/hbm.Epub Dec 17.

The quality of optode arrangement is crucial for group imaging studies when using functional near-infrared spectroscopy (fNIRS). Previous studies have demonstrated the promising effectiveness of using transcranial brain atlases (TBAs), in a manual and intuition-based way, to guide optode arrangement when individual structural MRI data are unavailable. However, the theoretical basis of using TBA to optimize optode arrangement remains unclear, which leads to manual and subjective application. In this study, we first describe the theoretical basis of TBA-based optimization of optode arrangement using a mathematical framework. Second, based on the theoretical basis, an algorithm is proposed for automatically arranging optodes on a virtual scalp. The resultant montage is placed onto the head of each participant guided by a

low-cost and portable navigation system. We compared our method with the widely used 10/20-system-assisted optode arrangement procedure, using finger-tapping and working memory tasks as examples of both low- and high-level cognitive systems. Performance, including optode montage designs, locations on each participant's scalp, brain activation, as well as ground truth indices derived from individual MRI data were evaluated. The results give convergent support for our method's ability to provide more accurate, consistent and efficient optode arrangements for fNIRS group imaging than the 10/20 method.

Development of the neural processing of vocal emotion during the first year of life.
Zhao C, Schiessl I, Wan MW, Chronaki G, Abel KM.
Child Neuropsychol. Apr;27(3):333-
doi: 10.1080/09297049.2020. Epub Dec 8.

Human infants are "wired" to respond to social information, an important capacity for survival. The ability to discriminate vocal emotion in others is likely to play a key role in successful social interactions with caregivers, which facilitate the rapid social-communicative development that infants typically undergo in the latter half of their first year. Infants have voice-sensitive brain regions that have been shown previously to be responsive to emotional prosody by 7months. This study aimed to investigate the developmental trajectory of vocal emotion processing in temporal regions using functional near-infrared spectroscopy (fNIRS) to measure brain sensitivity to angry, happy, and neutral vocalizations in the same infant at 6, 9, and 12months. We found significant and increasing temporal cortical activation in response to vocal emotional stimuli over the three time points, suggesting consistent enhanced responses for happy compared to angry vocalizations, and vocal anger sensitivity is developing incrementally. The findings suggest that the neural processing of angry and happy prosody may follow distinct developmental pathways and is gradually "tuned" to become specialized between 6 and 12months. This first longitudinal study of vocal emotion brain processing between 6 and 12months highlights the need for more research to understand what drives typical and atypical social cognitive development across infancy and for follow-up into the second year.

Altered Brain Activation in Youth following Concussion: Using a Dual-task Paradigm.
Urban K, Schudlo L, Keightley M, Alain S, Reed N, Chau T.
Dev Neurorehabil. Apr;24(3):187-
doi: 10.1080/17518423.2020. Epub Oct 4.

A concussion is known as a functional injury affecting brain communication, integration, and processing. There is a need to objectively measure how concussions disrupt brain activation while completing ecologically relevant tasks.The objective of this study was to compare brain activation patterns between concussion and comparison groups (non-concussed youth) during a cognitive-motor single and dual-task paradigm utilizing functional near-infrared spectroscopy (fNIRS) in regions of the frontal-parietal attention network and compared to task performance.Youth with concussion generally exhibited hyperactivation and recruitment of additional brain regions in the dorsal lateral prefrontal (DLPFC), superior (SPC) and inferior parietal cortices (IPC), which are associated with processing, information integration, and response selection. Additionally, hyper- or hypo-activation patterns were associated with slower processing speed on the cognitive task. Our findings corroborate the growing literature suggesting that neural recovery may be delayed compared to the restoration of behavioral performance post-concussion.Concussion, near-infrared spectroscopy, dual-task paradigm, cognitive, motor, brain activation.

Functional Brain Imaging Reliably Predicts Bimanual Motor Skill Performance in a

Standardized Surgical Task.
Gao Y, Yan P, Kruger U, Cavuoto L, Schwaitzberg S, De S, Intes X.
IEEE Trans Biomed Eng. Jul;68(7):2058-
doi: 10.1109/TBME.2020. Epub Jun 18.
DOI: 10.1109/TBME.2020.3014299 PMID: 32755850 [Indexed for MEDLINE]

Functional near-infrared spectroscopy (fNIRS) as a tool to assist the diagnosis of major psychiatric disorders in a Chinese population.
Wei Y(#), Chen Q(#), Curtin A, Tu L, Tang X, Tang Y, Xu L, Qian Z, Zhou J, Zhu C, Zhang T, Wang J.
Eur Arch Psychiatry Clin Neurosci. Jun;271(4):745-
doi: 10.1007/s00406-020-01125-y. Epub Apr 11.

Advances in neuroimaging have promised the development of specific and objective biomarkers for the diagnosis and treatment of psychiatric disorders. Recently, functional near-infrared spectroscopy (fNIRS) has been used during cognitive tasks to measure cortical dysfunction associated with mental illnesses such as Schizophrenia (SCH), Major-Depressive disorder (MD) and Bipolar Disorder (BD). We investigated the ability of fNIRS as a clinically viable tool to successfully distinguish healthy individuals from those with major psychiatric disorders. 316 patients with major psychiatric disorders (198 SCH/54 MD/64 BP) and 101 healthy controls were included in this study. Changes in oxygenated-hemoglobin during a Chinese language verbal fluency test were measured using a 52-channel fNIRS machine over the bilateral temporal and frontal lobe areas. We evaluated the ability of two task-evoked features selected from prior studies the Integral and Centroid values, to identify individuals with major diagnoses. Both the integral value of frontal and centroid value of temporal showed sensitivity in classifying individuals with mental disorders from healthy controls. However, using a combined index featuring both the integral value and centroid value to differentiate psychiatric disorders from healthy controls with an AUC of 0.913, differentiate individuals with mood disorders from healthy controls showed an AUC of 0.899, while for schizophrenia the AUC was 0.737. Our data suggest that fNIRS can be used as a candidate biomarker during differential diagnosis individuals with mood or psychosis disorders and offer a step towards individualization of treatment.

Similarities and Differences Between Native and Non-native Speakers' Processing of Formulaic Sequences: A Functional Near-Infrared Spectroscopy (fNIRS) Study.
Zhao L, Yasunaga D, Kojima H.
J Psycholinguist Res. Apr;50(2):397-
doi: 10.1007/s10936-019-09655-w.

The present study reported an experiment examining whether both native speakers (NSs) and non-native speakers (NNSs) give formulaic sequences (FSs) priority over novel phrases in processing, as the dual route model has postulated. In this experiment, NSs and NNSs were asked to read Japanese versions of semi-transparent restricted collocations (e.g., kenka-o uru 'pick a fight (acc)'), novel phrases (e.g., tomato-o uru 'sell tomatoes (acc)'), and violated phrases (e.g., kenka-o sagasu 'find out a fight (acc)'); and they judged the naturalness of these sequences. Participants' reaction times were measured, as well as their cortical activation. The results revealed that, for the NSs, collocations required shorter reaction times and elicited less cortical activation than the novel stimuli. For NNSs, collocations similarly required shorter reaction times, but they elicited greater cortical activation than novel phrases. These results support the dual route model, both for NSs and NNSs.